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Context-oriented Product Development:
Collaboration between the Business and Engineering Domain

An Investigation with a Focus on Project & Engineering-Based Organisations

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DOCTORIAL THESIS

Context-Oriented Product Development: Collaboration between the Business and Engineering Domain

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Timo LAUDAN

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Abstract

Early requirements analysis in context of project- and engineering-based organisations deals with the establishment of the top-level definition of the project's product. Literature shows that communication and coordination is challenging in conjunction with visualisation and representation of knowledge in a cross-community constellation of business and Product Development (PD) teams concerned with early requirements analysis. Recently debated formalisms insight software and systems engineering community produce (coherent) intentional models that aim at increasing rationalisation and confidence in engineering definitions using the concept of goals. But most goal-oriented approaches fall short in establishing usable intentional structures that are able to provide the transparency for supporting continuously business-engineering evolutions within collaboration and knowledge conversions along a PD process. In this sense, the present thesis provides a complementing approach that emphasises on business and engineering collaboration and knowledge conversions. In this context a knowledge-driven concept is proposed that anchors a value-oriented organisation of intentional structures (i.e. business needs and expectations) and traces to engineering definitions. In addition, this concept serves the organisation and representation of knowledge and illustrates how to perform valuation and verifications of intentional structures implemented in forms of requirements.

This work was developed along a hybrid action research methodology that employs an empirical study and two industrial application cases.

Key words: Project- and engineering-based organisation, systems engineering, early requirements analysis, knowledge management, intentional modelling, business and engineering collaboration and knowledge conversion

Abbreviations

BC	Business Community
BD	Business Descriptions
BM	Business Management
BNE	Business Needs and Expectation
BNE-B	BNE-Benefit
BNE-C	BNE-Context
BNE-F	BNE-Focus
BNE-P	BNE-Perspective
BD	Business Descriptions
CAD	Computer Aided Design
CAIRO	Conflicting, Attached, Influencing, Required, Overlapping
CAPE	Computer Aided Probabilistic Evaluation
CCL	Consistency and Completeness Loop
CDF	Cumulative Probability Density Function
CoCoOn	Collaboration, Context, Ontology
COPD	Context-oriented Product Development
CREV	Collaborative Requirements Elicitation and Validation
CREWS	Cooperative Requirements Engineering With Scenarios
CSCW	Computer Supported Cooperative Work
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
DAU	Defence Acquisition University
DOORS	Dynamic Object-Oriented Requirement System
EC	Engineering Community
ED	Engineering Definitions
e-Collaboration	Electronic Collaboration
EDI	Exploitation, Dissemination and IPR (EDI)
EES	Enabling Engineering Services
EV	Expected Value
EX	Excess
EVD	Expectation Value Degree
FBCM	Fact Based Collaboration Modelling Methodology
FEL	Front-End Loading
GD	Generic Distribution
GLOBE	Gain, Look, Observe, understand Behaviours, Experiment
GORE	Goal-oriented Requirements Engineering
GPM	Gesellschaft für Projekt-Management
GUI	Graphical User Interface

HRI	Horizontal Requirement Interdependencies
I	Content
ID	Identity
IEC	International Electro-technical Commission
IIBA	International Institute of Business Analysis
INCOSE	International Council on Systems Engineering
ISO	International Standards Organisation
IEEE	Institute of Electrical and Electronics Engineers
IS	Information System
ISO	International Standardisation Organisation
IT	Information Technology
JAD	Joint Application Development
KAOS	Knowledge Acquisition in Automated Specification
Knowledge-CoCoOn	Knowledge Collaboration-Context-Ontology
KPI	Key Performance Indicator
IIP	Information Integration Process
M	Message
MIB	Message in a Box
NASA	National Aeronautics and Space Administration
ND	Normal Distribution
OBS	Organisational Breakdown Structure
OED	Oxford English Dictionary
PBS	Product Breakdown Structure
PC	Project Coordinator
PD	Product Development
PDCA	Plan-Do-Check-Act, Deming wheel (concept of continuous improvement)
PDF	Probability Density Function
PLC	Project Life Cycle
PM	Project Management
PMBoK	Project Management Body of Knowledge
PMI	Project management Institute
PRINCE	Projects in controlled environment
QFD	Quality Function Deployment
QTC	Quality, Time, Cost
RE	Requirements Engineering
RM&E	Requirements Management & Engineering
R&T	Research and Technology
RV	Random Variables
S	Significance
SE	Systems Engineering
SECI	Socialisation-Externalisation-Combination-Internalisation

SN	Skewness
S_T	Situation
TLAR	Top-level Aircraft Requirements
TRL	Technological Readiness Level
TPV	Total Perceived Value
TPBV	Total Perceived Business Value
TPFV	Total Perceived Functional Value
UD	Uniform Distribution
UML	Unified Modelling Language
UVA	Utility Value Analysis
UVF	Utility Value Function
VAC	Virtual Aircraft
VC	Variation Coefficient
VID	VIACE Integration Database
VITC	VIVACE Integration Technical Committee
VIVACE	Value Improvement through an Aeronautical Collaborative Enterprise

Table of Content

List of Figures

List of Tables

1 Introduction: *Establishing the Research Baseline*

The first part of this chapter outlines a problem-situation and envisioned improvements contributing to both the community of research and practice. It is shown that recently more and more attention is paid by industry to product developments and its early phases, and that there is an emerging question of how to be more efficient in conducting this phase. Contextually, a lot of attraction in the scientific domain is paid to intentional modelling approaches (i.e. goal-oriented approaches), which investigate on improving front-end negotiations between business management and product development (PD) teams before entering into the process of "heavy" product specifications. However, those approaches take goals for granted. The link to the justifying organisational level and its stakeholders' intentions is not considered enough in such models. This work adds the notion of transparency to the current scientific debate dealing with the alignment of requirements and business intentions and opens the discussion of integrating and updating, visualising and reconciling Business/Requirements Engineering's knowledge evolutions with the aim to converge towards a coherent (adequate, complete, consistent) product definition in the front-end area of the PD process – a collective representation of knowledge.

The second part of this chapter introduces the organisation of the present thesis in form and content, and outlines the applied research methodology. The research methodology, which underlies this work, is a hybrid form of action research using synergies of spontaneous observations (through operational work), organised observations (through expert interviews) and experimentations (through application cases); and describes a closed loop of inductive and deductive reasoning as a cognitive shift from research design to design practice conversely.

1.1 Research Background and Agenda

1.1.1 Globalisation Forces

The world of work underlies dynamic impacts and changes. Global competition and permanently emerging market opportunities is driving force for manufacturing enterprises to co-locate production sites, facilities and engineering closer to desired markets (Ye 2002). At the onset of industrialisation, industrial society's skills and cognitive capabilities were concentrated and co-located and not a matter of geographical dispersions and rather homogeneous (Kraus 1980). Both information technology advances and emerging business globalisation (i.e. internationalisation of markets) inspire industries' strategic and technological roadmaps. In combination with market and technological changes, the dynamic evolutions in the social axis towards individualisation and better education dictate the profile of educational adequacy and required cognitive capabilities. Technology advances; market globalisation, and social/demographic changes are interrelated and evolving simultaneously. At the same time (inter-) organisational structures and strategies are evolving and adapting in a societal-economical-political context (Andriessen 2003).

Since current and future organisations' competitive situation underlies an ongoing business globalisation and shortened development cycle, the miracle of 'do the right *thin**K**s* the first time' needs to become more manifest in future.

1.1.2 Project-Based Organisations

The elementary mission of a project-based organisation is to engage all involved project individuals to collaborate and share the vision to deliver the needed and expected product.

In recent years, project management has been identified to become more and more important for business from various industry branches. Project work in companies has increased from being, between 5 to 10% ten years ago to approximately 30% today (GMP 2008). The amount of project work is expected to increase further and in some companies it may reach 75% over the next ten years (Schoof 2006). Projects are economically important for an organisation, both as direct value-earners and as future expected incomes, but also as means for carrying out organisational changes (Maylor 2001) and improving resources efficiency. A shift in value-adding activity from repetitive work to project-based organisations has been noted (Kerzner 1998; Peters 1999). For many businesses the key success factor is to deliver the right product to the market ahead of competitors, and even development costs is secondary to product timelines (Stevens et al. 1998). Moreover organisations today are in a complex situation having to face an ongoing business globalisation, information technology (IT) advances and speeding time-to-market (Specht/Beckmann 2004; Stoneburner 1999; Wysocki 2003). This dynamic trend infuses a rapid change in project management principles. Project management is demanded to support collaboration among people working at different sites, different times and/or different locations, while IT advancements support the distributed and virtual project teams (Romano et al. 2002).

In past decades, many projects have revealed poor performance in terms of reaching scope, quality, time and cost objectives (PMI 1992). Traditional project management focuses on management, scheduling and project outcomes (Chen et al. 2003) resulting into an overemphasized management of inputs and outputs and an underemphasized management of the project-work by itself (Turner 2000; Maylor 2001). Evaristo/van Fenema (1999) declare traditional project management further as an instance focusing on a single project at a single location and put emphasis on scheduling, planning and tracking. Likewise, Helbrough (1995) states that one of the major changes in project management over the last 25 years has been the use of computerised tools and methods and in future, the most significant change in project management may be the use of *collaboration*. Project management may shift away from the tradition of a stringent project execution in a bureaucratic and planning oriented or just executing manner. However, vanguard project management approaches like extreme or adaptive project management approaches dealing with complex situations (Wysocki 2003) aiming at the integration and collaboration of technologies, and supporting levels of interaction, communication and coordination (Maylor 2001; PMI 2004; Turner 1998). These authors centre the dimension human or stakeholder within management focuses, rather than following the resource management approach. Current and future project management will be more concerned with project work and processes, and collaboration in social context will become essential for organisation’s success (Romano et al. 2002).

1.1.3 Industrial Challenges in Project's Product Developments

The prevalent cited Standish Group Int., Inc. put amongst others great emphasis in surveying organisations success quotes in conducting projects. The samples included large, medium, and small companies across major industry segments within the US, e.g. banking, securities, manufacturing, retail, wholesale, health care, insurance, services, and local, state, and federal organisations. For purposes of Standish Group's survey, projects were classified into three resolution types: *successful* (project completed in time, on budget, and within the expected features and functionalities), *challenged* (project is completed and operational but over budget and time, offering fewer features and functionalities than expected) and *failed*.

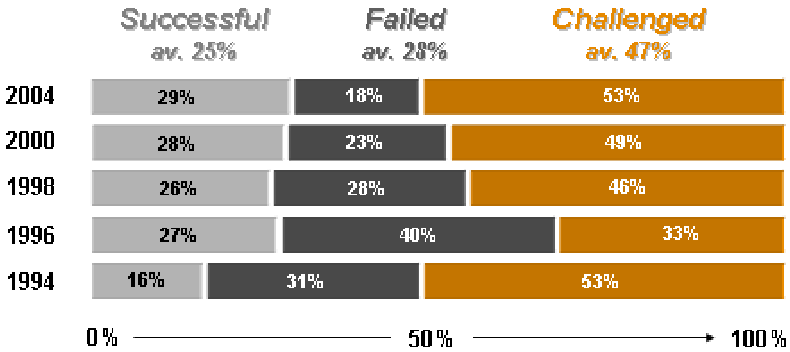

Figure 1: Project success quotes (Standish Group 1995; 1999; 2002; 2004)[1]

The figure above shows that over the last decades surveyed organisations' projects did not vary dramatically in terms of project success quotes. The results from 1994 and 1996 show some deviations from the average. Standish Group's report from 1995 documented the surveyed results from 1994 and identified the lack of requirements engineering (RE)[2] – product development teams which are concerned with requirements development – efforts as main source why 53% of the projects were challenged. However, the situation is evaluated quite similar within each report. This is perhaps due to the fact that means for handling product developments progressively open new opportunities towards effectiveness and efficiency, but at the same time environmental situations change equally in dimensions of technology advances and globalisation effects (as described previously).

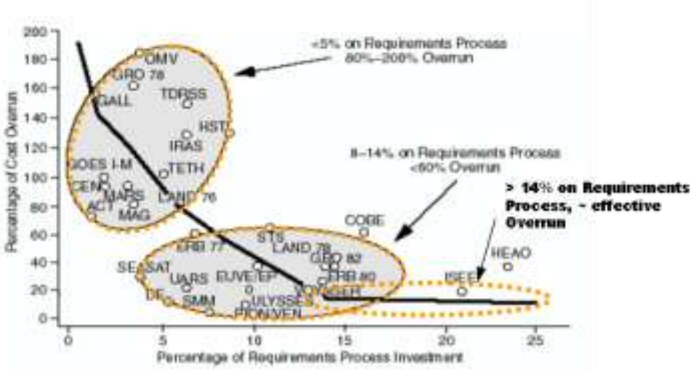

Figure 2: Effects of requirements process investment on program costs (adapted from Young 2001)

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[1] Standish Group Chaos Reports, http://www.standishgroup.com

[2] Cf. "Requirements engineering is the branch of software engineering concerned with the real-world goals for, services provided by, and constraints on a large and complex software-intensive system. It is also concerned with the relationship of these factors to precise specifications of system behaviour, and to their evolution over time and across system families" (Zave 1997).

In contrast, to Standish Group's surveys the following study dealt with the evaluation of a number of NASA projects (Figure 2) within the dimensions of cost overruns and requirements process costs.

It is clear that this survey does not provide a valid proof out of this particular context. Nonetheless, it is one example showing likely relations between resources spent for requirement engineering activities. This comparison shows some characteristic areas as follows:

- Effort less than 5% for the requirement process investment: survey and administration of requirements[3], resulted into a cost overrun within the program cost of 80-200%
- Investment in the requirement process of 8-14% resulted into a cost overrun of less than 60%
- Increasing requirement process investment greater than 14% does not effectively influences the cost overruns

1.1.4 Research Agenda

The previous section 1.1.3 discussed some empirical results in regards to project- and engineering-based organisations' challenges. Requirements engineering was discussed as one major driver challenging industries within the product development process. RE is a branch of software engineering (Zave 1997) and is about gathering and eliciting information from the inside and the outside of project-based organisation, defining, validating related stakeholder requirements that the product or system is supposed to solve and provide those to organisation's members[4].

The aim of this section is now to reflect upon the current scientific debate and provide an understanding of related works and future trends. But before entering into challenging fields that deal with requirements analysis[5], some historic cornerstones of this research domain are pointed. Sommerville provides in his landmark article (Sommerville 2005) from 2005 a historically review and future trends in regards to the discipline of RE.

- **1970s** delivered a requirements statement language[6]
- **1980s** evoke object-oriented modelling (UML-Unified Modelling Language)
- **1990s** brought-up intentional modelling like viewpoint-oriented approaches to elicitation and analysis, goal-oriented approaches, and RE process improvement
- **Situation at present and future evolution** is concerned with progressive product complexity confronted with a changing business environment, which means that new requirements might emerge and existing requirements might change every week or day.

[3] SEFGuide (2000) states "Requirements are a statement of the problem to be solved. Unconstrained and non-integrated requirements are seldom sufficient for designing a solution."

[4] Sommerville (2005) states, "Before developing any system, you must understand what the system is supposed to do and how its use can support the goals of the individuals or business that will pay for that system. This involves understanding the application domain; the system's operational constraints; the specific functionality required by the stakeholder."

[5] There is no common agreement in regards to requirements analysis, the RE process. Pohl (1996) defines requirements *elicitation*, *negotiation*, *specification*, and *validation* as main tasks to be performed by RE.

[6] Cf. Mylopoulos et al. (1999): „Requirements Engineering was born in the Mid 1970s“

This outline provides a first glance on research efforts conducted in parallel to industrial challenges highlighted. The subsequent sections are devoted to prove and extend this historical review, while analysing some articles in context of challenges which relate to fields of RE in project-based organisations. Thereby papers from research disciplines like software and systems engineering science, and also from organisation and knowledge science were identified as relevant. These papers were reviewed and during this analysis three dimensions of requirements analysis: *elicitation*, *completeness & consistency*, and *communication & coordination* (including knowledge visualisation) were identified and paper contents (i.e. key issues) were organised accordingly. These dimensions, i.e. challenging fields are discussed coherently within the attributes *Background*, *Techniques in Use*, and *Gaps and Opportunities*.

1.1.4.1 Challenge One: Elicitation of Requirements

Background. Elicitation is the activity that is concerned with determining stakeholders and their needs. *"Initial research efforts focussed on the requirements definition facet and address 'what questions' only, recent attempts have been made to develop approaches that support the requirements elicitation facet ('why questions')"* (Rolland et al. 1999). Hickey/Davis 2002 state that a unified model of the elicitation process is not yet defined, and which centres the role of knowledge—integrate tacit knowledge which expert analysts use, while applying and selecting elicitation techniques.

Some techniques in use

- Goals: to elicit high-level stakeholder concerns that the systems is expected to achieve
- Scenario models: to describe behavioural system properties
- Viewpoints analysis: to collect and organise requirements from a number of different viewpoints (e.g. Sommerville/Sawyer 1997)
- Collaborative requirements workshops such as Joint Application Development (JAD, e.g. Wood/Silver 1995)
- Collaborative Requirements Elicitation and Validation (CREV, e.g. Dean et al. 1997-1998), which defines how activity data scenario models work together with prototypes to generate requirements

Gaps and opportunities. Hickey/Davis (2002) state that *"[...] requirements researchers highlight the need to explore knowledge acquisition techniques in addition to traditional requirements elicitation techniques"*, which means to capitalise knowledge gained from applying one or another elicitation technique.

1.1.4.2 Challenge Two: Completeness and Consistency of Requirements

Background. Zave (1997) stated already in 1997 the question *"How can requirements engineers be sure that they haven't left out any important people, viewpoints, issues, facts, etc. out of their investigations?"* Carson et al. (2004) argue that requirements drive system design and operation, and it is obvious that requirements should be complete, and developing a complete set of requirements is equivalent to completely stating the problem to be solved. Measures for completeness indicate thereby the fitness for purpose, classifying the degree to which extent needs, goals, and/or mission of the system are "covered" in terms of requirements. *"At the same time another area of research has emerged that recognises the importance of guaranteeing requirements quality by goals for customers"* Yamamoto (2006). Liu/Yu (2004) state that explicit goal representations in requirements models provide a criterion for requirements completeness, i.e. the intentional model of goals provides context for requirements on which completeness can be evaluated. In addition Kokune et al. (2006) state *"when examining the validity, especially completeness, of software requirements, it is necessary to check if software functional requirements are consistent with business goals and business processes"*.

Some techniques in use

- Template or checklist approach, e.g. requirement quality characteristics (e.g. DOD 1985/IEEE 1993, Denger/Olsson 2005; Halligan 1993)
- Quality Function Deployment (QFD, e.g. Akao 1994) and prototyping involving users
- Use cases, functional analysis techniques based on the mission and concept of operation establishing what the system must do
- Review processes
- Goal-oriented Requirements Engineering (GORE, e.g. van Lamsweerde 2001; Anton/Potts 1998)
- Stakeholder identification and interface quantification
- Scenario analysis
- Non-Functional Requirements Analysis (e.g. Chung et al. 1999)
- Graphical goal modelling and notation (e.g. Liu/Yu 2004)
- FBCM[7] method (Kokone et al. 2006) to evaluate the completeness of the fundamental goals and objectives to IT system development improving business processes in intra- as well as in inter-organisations

Gaps and opportunities

- Sommerville (2005) says that *"academic research aimed at supporting completeness and consistency, but hasn't had yet major impact on practice"*. In accordance, Carson et al. (2004) argues to *"develop and validate a methodology that can produce a complete set of requirements and that can determine the completeness of a set of requirements"*.
- Fewer researches are recognised to the validity or completeness of business strategy consideration. Kokone et al. (2006) propose a proven approach and states that *"future work will include strategic modelling with business process modelling method"*. Gonzalez/Diaz (2007) emphasise that *"organisational concerns must be taken into account and RE approaches must provide new ways of elicitation"*.
- Karlsson et al. (2007) addresses consistency, i.e. fluctuating and conflicting requirements still as a challenge for requirements engineering.

[7] FBCM is an acronym and stand for Fact Based Collaboration Modelling Methodology. The FBCM is a Strategy modelling method for the validation of software requirements.

1.1.4.3 Challenge Three: Communication and Coordination

Background. Dougherty (1992) found in her survey from 1992 that in unsuccessful cases of new product developments, differences in interpretation centred around three characteristically themes why teams failed:

- Firstly, business planner worried about positioning against competition while the field person worried about the right potential customer
- Next, people's understanding of the development process itself was different
- Lastly, organisational roles have different "thought-worlds"

Boland/Tenkasi (1995) argue *"integration of knowledge in knowledge-intensive firms is not a problem of simply combining, sharing or making data commonly available. It is a problem of perspective taking in which the unique thought-worlds of different communities of knowing are made visible and accessible to others. In order to integrate knowledge through perspective taking, communication systems must first support diversity of knowledge through the differentiation provided by perspective making within communities of knowing. Only after a perspective is differentiated and strengthened can it be reflect upon and represented so the actors in other communities of knowing have something to integrate through a perspective taking communication".*

In addition, Boehm et al. (1998) state, *"to deliver systems rapidly that meet customer needs is key challenge to reconcile customer expectations with developer capabilities".* They further found that "the most important outcome of product definition is not a rigorous specification, but a team of stakeholders with enough trust and shared vision to adapt effectively to unexpected changes". In addition, Kavakli/Loucopoulos (2003) thinks, *"very few approaches so far support stakeholder involvement in the goal modelling process. In particular there is a lack of techniques for identifying potential stakeholders".*

Karlsson et al. (2007) surveyed a coordination and communication gap in project-and engineering based organisations, especially between stakeholders (in particular marketing was mentioned) and developers. That yields to the circumstance that 'marketing' elicit and document requirements. In contrast to customer-oriented organisations, they surveyed some distinguishing features specific for market-oriented organisations:

- Writing understandable requirements and understanding the stated requirements suggestions is more complex when dealing with diverse stakeholders who express their needs more vaguely
- Individual stakeholder characteristics, various potential customers and users on a large and open market who contribute to some challenges, there is a constant flow of requirements
- Natural language can have different meanings for different organisational roles

Some techniques in use

- Win-Win Approach (Boehm et al. 1998): support negotiation between customers and software suppliers towards a satisfactory (win-win) system specifications
- Problem Frame Analysis, Context Analysis
- Group discussions: to converge towards complete requirements
- Techniques for requirements prioritisation and effort estimation
- Requirements traceability and interdependency

- Grouping requirements into bundles (cluster): to ease requirements structuring and work portioning
- Visualisation of organisational knowledge (e.g. Eppler/Burkhard 2004)

Gaps and opportunities

- Karlson et al. (2007) conclude that communication and coordination are still corner stones in software development and project success depends heavily on the skills of the individuals involved and have a larger impact than technical problems when it comes to requirements engineering.
- Kavakli/Loucopoulos (2003) perceive that there is a lack of means that enables to perform stakeholder cooperation within the product development process.
- Karlson et al. (2007) argue further that a primary focus relies on market-driven developments in RE is not investigated. Further most challenges are of *organisational* and *social* nature rather than technical one, and address the following questions: *"How to make marketing and development communicate regarding requirements? How to encourage people to change their way of working"*.
- Eppler/Burkhard (2004) mention that communication between the many different organisations' participants (business management, project management, systems and speciality engineering groups) and their specific professional backgrounds is a major problem in organisations. Visualisation could act as a sort of mediating instance towards inter-functional knowledge communication and helping to make differing assumptions visible and communicable while common contexts (visual frameworks) help to bridge different backgrounds.

1.1.4.4 Concluding Remarks

The author perceives that most recent discussions on the topic of requirements annals are orienting on elaborating concepts and models devoted to the real world—*organisations' intents*. Those organisational/business intents (namely top-down perspective, answering to the 'why' question[8]) are *modelled* for contextualisation and as justification baseline of requirements (namely bottom-up perspective, answering to the 'how' question). It is an extension to traditional RE models, which pretty much focussed on systems and user-interactions exclusively. Whereby much effort - in particular industrial - has been spent on the logical breakdown, management, dissemination and proof on the level of implementation of requirements without being strongly connected to the organisation and its business intents. Current attempts aim at considering business management agendas within engineering definitions (e.g. requirements, architecture) and conversely. Rigorous attraction is still paid to so-called Goal-Oriented RE (GORE) approaches[9]. It is perceived by the author, that

[8] *Why* and *How* questions are prevalent explanations used in the domain of RE to provide a pictorially distinction between business intents and requirements.

[9] Some related works on this topic are: KAOS (Knowledge Acquisition in Automated Specification, Dardenne et al. 1993), which is a state-oriented approach modelling system behavioural condition using the concept of goals and agent, activities and events (Mylopoulos et al. 1999). In contrast, TROPOS (Mylopoulos et al. 2001, Tropos is derived from the Greek, which means "way of doing things") is an enhanced approach. It is an agent-oriented software development methodology using agents, goals, plan and various other knowledge concepts (El Ghazi 2007). CREWS (Cooperative

those approaches are more extensively discussed in software engineering related communities (e.g. IEEE[10]) - rather than in the systems engineering community (e.g. INCOSE[11]) judging on the amount of publications available - which have a particular focus on *Information Systems (IS) and IT infrastructure*[12]. These approaches aim at analysing organisations' intentions in terms of goals, so that the IS meet expectations, and business/IT alignment (mapping business process goals into system goals) will be achieved (Gonzáles/Diaz 2007) as well as business processes improved (Kavakli 2004).

In general, there are two versions of projects which could contain a potential level of innovation[13], something *new* in a sense (see section 2.5.3.1): a project that envisions at improving or optimising organisational business processes (i.e. process innovation) as discussed above, or projects that are delivering tradable objects[14] (i.e. product innovation). To the knowledge of the author, intentional modelling and relating GORE approaches found minor attraction in terms of *product innovations* as defined in the context just before. Another aspect raised by Karlsson et al. (2007) highlights that an emphasis is put on customer-driven, rather than on market-oriented organisations which have additional aggravating influences on communication & coordination, but also on elicitation and completeness & consistency.

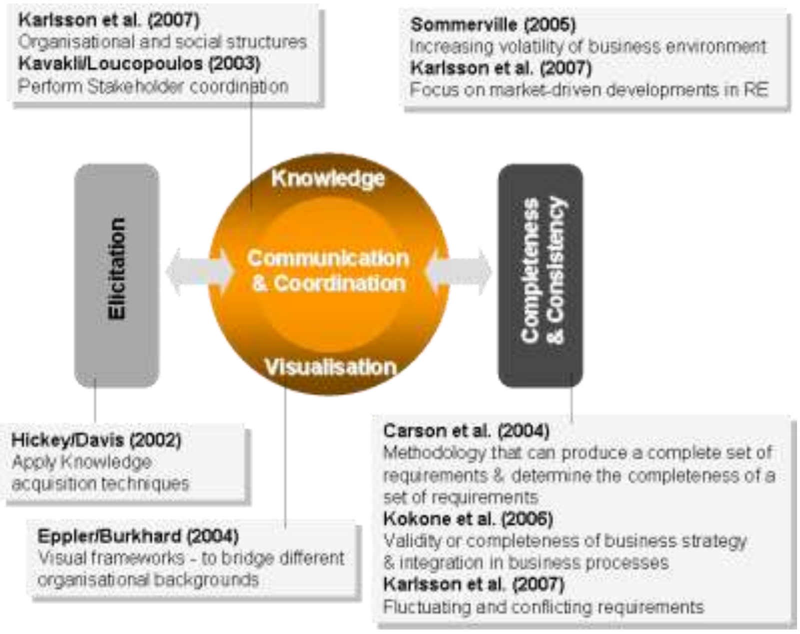

Figure 3: A brief synopsis of challenges in requirements analysis

Requirements Engineering With Scenarios or CREWS L'Ecritoire (Rolland et al. (1999) coupling scenarios and goals and is towards eliciting functional requirements.

[10] Wikipedia (2008) states that *"The Institute of Electrical and Electronics Engineers or IEEE (read eye-triple-e) is an international non-profit, professional organization for the advancement of technology related to electricity."*, available from http://en.wikipedia.org/wiki/Ieee, Internet, accessed 22 February 2008

[11] Wikipedia (2008) states that *"The International Council on Systems Engineering or INCOSE (pronounced as in-co-see) is a non-profit membership organization dedicated to the advancement of systems engineering and to raise the professional stature of systems engineers."* available from http://en.wikipedia.org/wiki/INCOSE, Internet, accessed 22 February 2008

[12] Cf. Agouridas et al. (2006) state "The majority of requirements engineering literature deals with the development of software intensive systems."

[13] Innovation is referred to by DeRosa et al. (2006) in the synonym of *differentiation*.

[14] Refers to something that can be traded with a quantity and a price in some markets.

To sum up, recent scientific debates and cognitions in context of the challenging RE areas are focussing on *front-end negotiations*[15]. Hereby, most efforts are devoted to so called 'intentional modelling' which aims at converging towards a stabilised and aligned baseline which considers both organisational and marketplace intents (objectives) and related requirements elaboration before entering into detailed specifications. The facet of communication and coordination is perceived by the author as central aspect in conjunction with the visualisation/representation of knowledge in regards to business intents aligned towards complete true, engineered requirements (and conversely) as drawn in Figure 3. Thereby, the consideration of organisational and marketplace structures is mandatory to be considered in this facet.

In this work the focus relies on the interaction between business management[16] and product development teams concerned with the elaboration of high-level product requirements. The consistency and completeness loop between an organisation and marketplace structures is not subject of the present work.

But before entering into the illustration of the present research problem and purpose, the notion of business intent shall be clarified. In this work, "a business intent" shall be defined as being composed of two components: *need* and *expectation*.

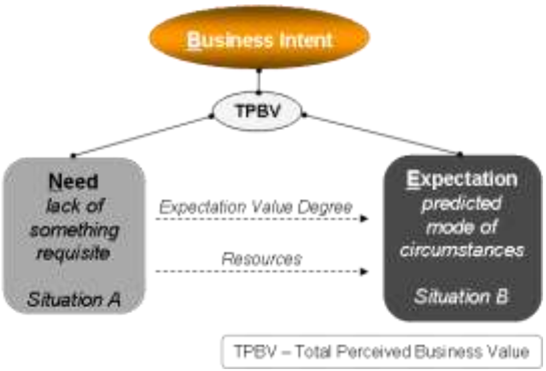

Figure 4: The notion of business intent

The notion of "need" is defined in accordance to Merriam-Webster[17] as *"a lack of something requisite [...]"* and considers an identified business problematic to be solved or a situation to be improved. The notion of "expectation" is defined as *"a strong belief about something that will happen or be the case"* OED (2003) and characterises the visionary outlook defining the horizon in a predicted mode of circumstances. In consequence, a business intent is a sketch of *Business Needs and Expectations* (BNE, see Figure 4) and is further defined in chapter 4. A business intent is associated with a Total Perceived Business Value (TPBV), which results from the comparison of current needs (at situation A) and future expectations (at situation B), and is characterised through two main features:

- *Expectation Value Degree*: the level of change in product/service features to be available at situation B and capable to create the expected value, benefit for business management and its members

[15] Front-end negotiations are often referred to the notion of early requirements and considers early RE activities that are concerned with reconciling business problems, opportunities and requirements.

[16] Business management acts on organisational level elaborating business related product intents, and who are also representatives and entities for stakeholders identified in the organisation's environment (see section 2.5.3.1)

[17] Online, available from http://www.merriam-webster.com/dictionary/need, accessed 8th February 2008

- *Resources*[18]: required human expertise (cognitive capabilities), hard- and software, facilities, machines, temporal assets, and so forth

In the following section the research problem and purpose of this work will be described.

1.2 Outline of the Present Research Problem and Purpose

Despite the previous discussions it is still not clear how organisational intents (i.e. business "descriptions"[19]) and product requirements (engineering "definitions") are maintained and valuated towards completeness and consistency throughput the PD process and how organisational intents can be established in a way to serve as measurement instance for business intent fulfilment interlinked with product requirements. Further, a clarification seems to be still needed on how mental evolutions throughout organisational structures of business management and product development (PD) teams concerned with requirements analysis on product level (i.e. RE) are at best established, maintained and visualised, in particular in the volatile front-end phase of the PD process. Also, the notion of *transparency* in terms of integrating and updating, visualising and reconciling Business/RE knowledge evolutions (PD process front-end area) is not perceived clearly within current requirements analysis approaches. Rather current intentional models are focussing merely on modelling goals as such for matters of completeness and consistency providing organisational context for requirements, and answering *why* questions. Nonetheless, the question of why is only partially answered. Namely, for what reasons have objectives[20] been established as they are? What is missing here, are sorts of justification dossiers and respective people which contain contextual information about why goals have been stated as they are—equal to requirements, goals are not coming out of nowhere, but nonetheless often taken for granted within most approaches[21]. It is clear that BNEs relevant for new upcoming (complex) product innovations are not justified via the existence of business stakeholders and their announcements on organisational level only. Rather, it is experienced within the two industrial application cases (see chapter 5) that those are managed within various types of documents—in this work called justification dossiers. Mostly, organisational intents managed in related justification dossiers lack a proof by engineering (PD Teams, "external" community) and leads to an apparent certainty only based on the justification dossier's existence. Business intents discussed within those distributed documents can complement, overlap or drive new intents. In order to converge towards a clear objectives baseline some analysis efforts transversal to the single justification dossiers are required.

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[18] The aspect of resources is not going to be further investigated.

[19] Loosely speaking the reconciliation process from BNEs to product requirements is compared with an increased level of formalisation towards the end product. Thus BNEs are outlined as *Business description* and product requirements as *Engineering Definitions* (see Figure 5).

[20] Goals and objectives are used in synonyms of each other.

[21] Cf. Agouridas et al. (2006) state, „Goal-driven techniques […] do not support the derivation of intent-driven goals. […] Goals, and their corresponding solutions, are neither systematically derived from stakeholder from stakeholder needs, nor demonstrably traceable to stakeholder intents. Instead goals are taken for granted and formalized through specification languages that allow development of low-level software design requirements."

The present work is devoted to highlight currently perceived less investigated aspects in RE as communication and coordination, and knowledge visualisation. Hereby, the aim is to investigate on a representation format which supports in a suppressed but efficient way, the elaboration of shared (accepted and understood) business intents across its members on project level providing an "understandable", consistent and complete baseline towards which product requirements can be developed by PD teams.

The following paragraphs outline the problem and purpose to be tackle in this work, which are built upon the experiences gathered from the outline of the scientific debate and the arguments gathered from real world observations (see section 1.5.2 and chapter 3).

Outline of the situation to be improved (see Figure 5)

The early requirements phase is characterised through non-existence of design artefacts and product models (e.g. system, physical, geometrical). Decisions in regards to organisational intents might change since the availability of more accurate and useful information increases throughout the PD process[22, 23].

- Nonetheless, **the reconciliation process of BNE and requirements is challenging** since both are managed merely quasi-independently of each other or often only managed and maintained in forms of requirements developed by PD teams. Rather PD teams collect information (sometimes vague and mostly informal) from everywhere and attempt to perform the validation of those themselves, evolve and develop engineering definition dossiers which are managed quasi-independently from organisation's intents.

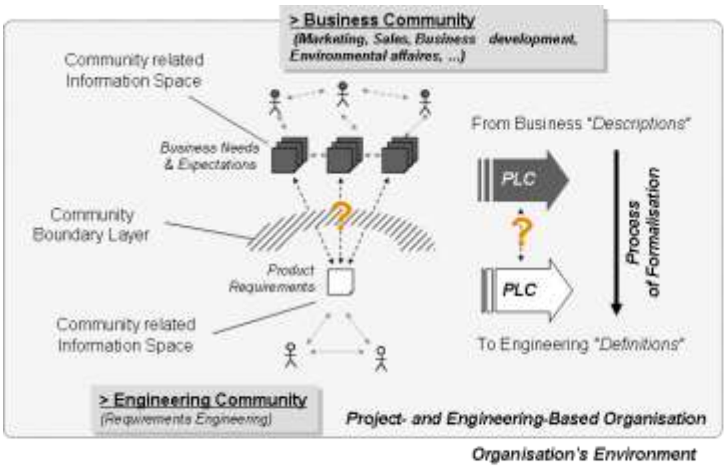

Figure 5: A brief outline of the principle problem

- **Flat and non-contextualised representation (*macro-viewing on documents)* of business intents** across different organisational members and in front of PD teams, i.e. RE, which are also not always accessible. However, the structure of each explicit (codified) knowledge base (community related information space) is differently and difficult to mentally access in particular for RE as an 'external' community.

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[22] However, along the PD process environmental conditions evolve and could change in contrast to initial assumptions respective to business descriptions and engineering definitions.

[23] Cf. Browning (2002) "[…] getting the right information in the right place at the right time."

- Codified knowledge is stored in **different sorts of information formats and spaces,** and physical IT access is not always given for the community of engineering
- **PD teams often lose the justifying connection** to business intentions throughout the PD process resulting into repetitive interpretation cycles between business and engineering. Sometimes this is realised in a progressive state of the PD process due to the fact that the level of BNE is not sufficiently organised and maintained as a unit together with engineering definitions, i.e. requirements
- PD teams concerned with requirements are often **unsure if they implemented business intents completely and consistent in forms of engineering definitions as expected on organisational level**
- **Difficult to prove and trust the correct implementation of BNE in engineering processes** and information spaces once BNE are only managed in form of requirements and architectures and so forth

The *community boundary layer* is a sort of transition area characterising the critical pass, a shift from one thought-world to another. As quintet essence, Figure 5 outlines the described shift from '*black'* (business intents) to '*white'* (top-level product requirements) requiring an intermediate step. The subsequent paragraph will draw this intermediate step as a so-called *synthetic meeting place* area.

Outline of the thesis purpose (Figure 6) – Take full advantage of others domain knowledge

The purpose of this thesis is to investigate in the transition area and develop a *Business Needs and Expectation Engine* serving for collaboration and knowledge conversion between the domain of Business and Engineering. This area outlines an integrated top-level product definition as reflexive mirror of business members' intentions and PD teams' requirements, which is capable of following and supporting reconciliation of both evolutions and converging towards a complete and consistent product definition.

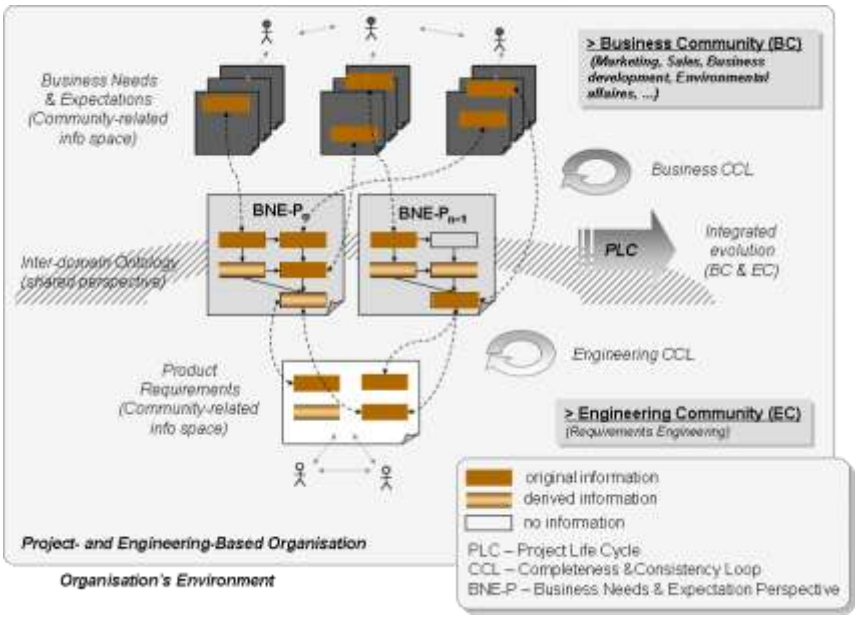

Figure 6: Outline of the thesis purpose

- **Context**
  - **Sense-making & negotiation forum** that acts as an engine for collaboration and knowledge conversion between the domain of business (e.g. marketing, strategy, regulations, environmental affaires) and engineering (i.e. requirements engineering) – a collective representation of knowledge.
  - **Cohesive awareness** between business' descriptions and engineering's definitions elaborating the product definition baseline: a means to support adequacy in knowledge conversions in terms of BNE to high-level Requirements and conversely throughout the project life cycle and in context of the project's product.
- **Objectives**
  - To integrate both the business community perspective and the RE perspective including the identification of each others boundary objects and to allow (qualitative) propagation of changes across representations of both business descriptions and engineering definitions
  - To provide a synthesised and customised representation (inter-domain ontology, microscopic-viewing on documents) of BNE community related knowledge spaces in conjunction with high-level product requirements for closed evolution
  - To support reflexive associativity between BNEs and the first level of product requirements
  - To develop adequate knowledge transmission mechanisms for better understanding communities' detailed and specialised knowledge spaces.
- **Capabilities required**
  - A **methodological approach to specify and organise** perceived business needs & expectations in alignment with "true engineered" requirements.
  - **Traceability mechanisms - Fast pace update of BNE and high level requirements elaborated**: Interconnected and reflexive knowledge representation forum through which business and engineering can progressively evolve in cohesion and effectively update each other's "thought-worlds" and converge towards a stabilised and controlled situation (in terms of BNE & requirements); Provide business roles controlled insights in engineering developments and vice versa and develop mutual and robust understandings (e.g. during change propagations).
  - **Goal conflict and resolution mechanisms**: Relaxation and stabilisation of BNE before entering into "heavy" specifications.
  - **Evaluation engine** to measure and estimate BNE fulfilment in relation with assigned requirements and architectures.

- **Expected Benefits**

  Resource (Cost, Time)

  – Fast pace and reflexive update of BNE and elaborated high level requirements (perhaps more front-end iterations but efforts apparently create a shared inter-domain product definition). Avoid late and heavy iterations in progressive stages of the PD process.

  Quality (Performance of Work)

  – Improved evaluation of high-level product definition enabling a 'confident' transition into detailed engineering definitions, more detailed specifications

  – Increased transparency drives progressive activation of front-end negotiations across business members and PD teams

  – A commonly shared (accepted and understood) high-level product orientation and communication baseline towards which business members and PD teams can activate all their efforts

1.3 Research Question

The challenge of requirements analysis has been identified in the field of communication and coordination, and knowledge representation in a cross-community constellation. In consequence, this work treats the situation between business and engineering as communities of knowing investigating on a knowledge representation forum, a synthetic meeting place which is built upon concepts from knowledge science[24]. Whereby, the overall research theme orients principally on collective and explicit as well as implicit knowledge development in regards to the project's product investigating interconnected evolutions of organisational structures (business management roles and requirements engineering).

In this context, the main research question investigated in this work is stated as follows:

> *How to organise collaboration and knowledge conversion between business management and PD Teams concerned with the elaboration of top-level product requirements?*

Under the umbrella of this main research question two further questions are raised as follows:

(i) *How to find coherence (adequacy, completeness and consistency) within the evolution of the project's product on the level of business and engineering?*

(ii) *How to maintain and trace knowledge evolutions in context of the project's product between business and engineering?*

The set of questions will guide further discussions within subsequent chapters.

[24] Nonetheless, the model that is going to be developed shall be allowed to integrate (conceptually) existing models of both the domain of business and engineering.

1.4 Research Limitation

In the frame of the present research work the following delimitations have been made:

- Particular focus relies at the project's onset and the interaction between business management acting on organisational level and product development teams concerned with the elaboration of high-level product definition in forms of requirements. The consistency and completeness loop between the organisation and market- and customer-structures is thereby not considered.
- Emphasis on product development teams (engineering community) concerned with requirements development on product level
- Propositions are orienting on project- and engineering-based organisations
- Focussing on product innovations rather than business process innovations

1.5 Roadmap and Methodological Approach of the Research Work

1.5.1 Discussion Plan

The thesis is arranged in six chapters (Figure 7), with the present introductory chapter serving as chapter one.

Chapter 1 - Introduction: Research Baseline

This chapter aimed at positioning the thesis in a scientific context. Current research efforts and trends were reflected in the area of requirements analysis. It has been shown that the field of requirements analysis put great efforts on intentional modelling. Nonetheless it lacks in facets of communication and coordination, and reflexive knowledge representation through organisational structures and roles within business and engineering. Also an integrated and evolutionary knowledge representation for business and RE is not clearly set up. To serve this issue, chapter 2 provides a synopsis of associating concepts.

Chapter 2 - Theoretical Background: Concepts, Models and Principles

This chapter aims at reviewing theoretical concepts identified as relevant for constructing a knowledge representation forum for communication and coordination providing transparency across organisational structures of business and engineering. Thereby, the notion of knowledge and knowledge conversion respectively is the central aspect. The periphery is built on concepts of collaboration, context and ontology. Lastly, the construct of a project- and engineering based organisation is discussed on basis of ISO/IEC 15288 Systems Life Cycle Standard and previous concepts are reflected accordingly.

Chapter 3 - Empirical Study: VIVACE

This chapter discusses the results of a qualitative empirical study (semi-structured experts' interviews) conducted in the environment of a large European research project called VIVACE (Value Improvement through a Virtual Aeronautical Collaborative Enterprise). The interviews were conducted after the first year of this thesis, and at that stage the research focus was not concretised completely.

In this context, the aim of the empirical study was twofold. Firstly, the aim was to gain deepen insights and improved understandings of organisational structures and collaboration facets in a social contexts. For that issue a deductive approach (no hypothesises) was applied in regard to a set of open questions stated during the interviews. Secondly, with the evolution of the thesis and the increasing clarification of the research purpose the empirical findings were condensed and form the research context accordingly.

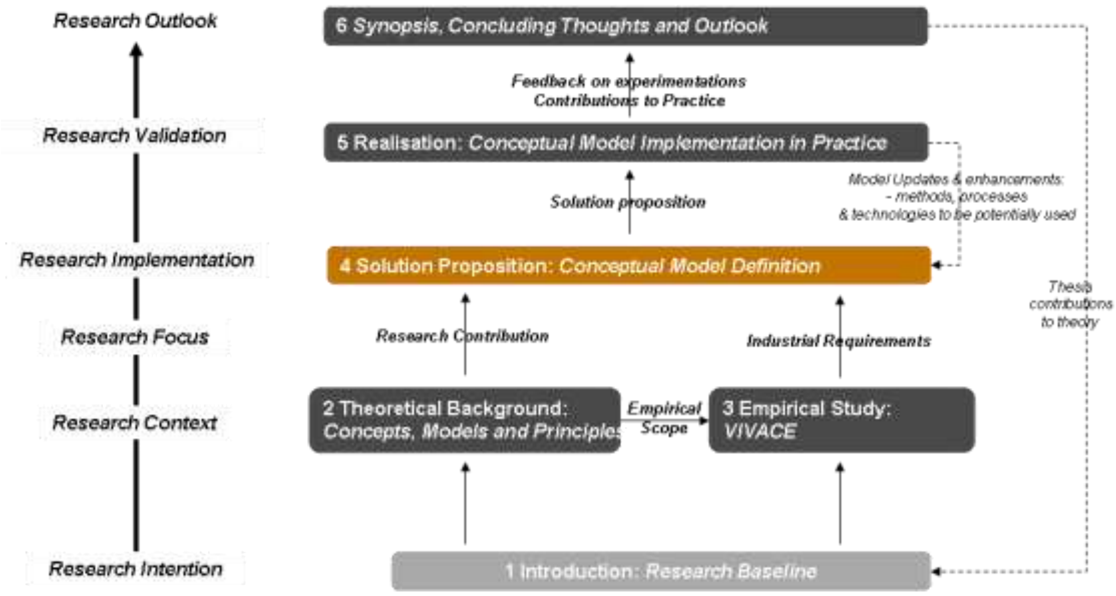

Figure 7: Discussion plan

Chapter 4 - Solution Proposition: Conceptual Model Definition

This chapter consolidates the concepts discussed in chapter 2 within a construct that is called Knowledge-CoCoOn (**Co**llaboration, **Co**ntext and **On**tology). The consolidated construct contains all components establishing a "synthetic meeting place", a knowledge representation forum that acts as an engine for collaboration in knowledge conversion between the domains of business and engineering inside an organisation. The notion of collaboration provides clarification on interactions between two knowledge bearers converging with their different perspectives towards an integrated definition of the project's product. The construct of ontology provides thereby a customised structure and the foundation for associativity/organisation of inter-domain synthesised knowledge bases. In addition, the construct of context is devoted to the content component of knowledge that is going to be associated to the ontological component.

Based on this conceptual integration of knowledge constructs and the utilisation of the message concept, a BNE-P information model is proposed for organising interactions and knowledge conversions between the business and engineering domain on product level.

Chapter 5 - Realisation: Conceptual Model Implementation in Practice

This chapter aims at the validation and proof of the conceptual model introduced previously based on two industrial application cases associated with empirical world problem-situations and aiming at establishing cohesive product definitions. The first application case is devoted to the environment of

VIVACE aiming at organising various partly different business intents as an example of an inter-organisational environment. This application case is twofold in its investigation focus. One part is dealing with the proof of model applicability as such within its classes and attributes. The second part is a specific investigation of an evaluation mechanism for a BNE-Perspective. The second application case will be a proof of concept conducted in the industrial environment of *AIRBUS* serving as an example of an intra-organisation, while a specific investigation will analyse engineering's boundary object, i.e. requirements

The experimented results, applied methods, processes and technologies within organisational structures lead finally to an updated and enhanced view on the proposed conceptual model as proposed in chapter 4.

Chapter 6 - Synopsis, Concluding Thoughts and Outlook

This chapter finally reflects the work and its overall epistemological results. Thesis contributions to both practice and research, and references at which stage those where gained are synopsised. A final conclusion discusses and evaluates this work as a whole and discusses important contributions gained in regards to the research agenda as outlined in chapter 1. Subsequently, an outlook is given as an extension of the research horizon discussing further perspectives and open issues in the field of requirements analysis and intentional modelling for project and engineering-based organisations.

Since the organisation of the present thesis report in regards to contents has been outlined, the following section is devoted to provide an overview in regards to the organisation of the thesis and the research methodology applied and followed throughout the thesis.

1.5.2 Research Organisation and Methodology

Research Organisation

Cognitions can be gained in two ways through *thinking* and *experiencing*. This work embodies both as a mental shift from *research* to *practice* and vice-versa (see Figure 8).

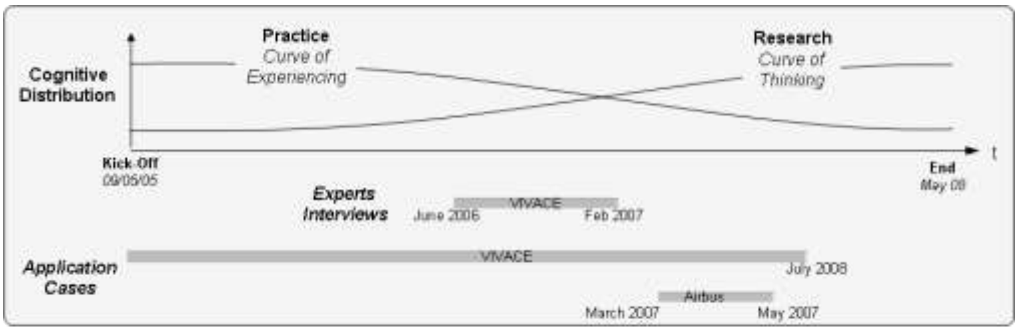

Figure 8: Cognitive distribution over time

In the role of an *Industrial Ph.D. Student* the author spent one major part of resources taking responsibilities on problem-solving tasks devoted to the real world – industrial environments and associated projects respectively. Gathered experiences stimulated research activities and the continuous formation of the research framework as a closed and reflexive loop of interactions.

Experts' interviews have been conducted within the environment of VIVACE in order to gain broader and deeper understandings (of functional and social behaviours) and converge towards an increased awareness of potential industrial requirements (see chapter 3). Two industrial application cases served to experiment and validate research results and drawback improvements on initial developed improvement models.

In coherence to above discussed situational conditions along the thesis, the following paragraph outlines the research methodology constituting the kernel of this research work.

Research Methodology

In literature a number of different research approaches are discussed. Bra/Vidgen (1999) provide a research framework for Information System (IS) research organising methods in dimensions of *predicting*, *understanding* and *changing* real world (empirical, organisational) problem-situations, e.g. field- and quasi-experiments, hard and soft case studies, and action research.

With respect to the outlined situational role of the author (being industrial Ph.D. student) the *Action Research* approach is selected and applied in this work. Generally, this research methodology is characterised through coupling both *research* and *action*. The methodology describes a reflexive understanding, planning and **changing** (applying problem-solving actions towards improvements) of empirical world problem-situations and requires a high degree of researcher's involvement. As a result out of this research methodology, contributions are given to both the community of research and practice based on insights gained through changes initiated and investigated.

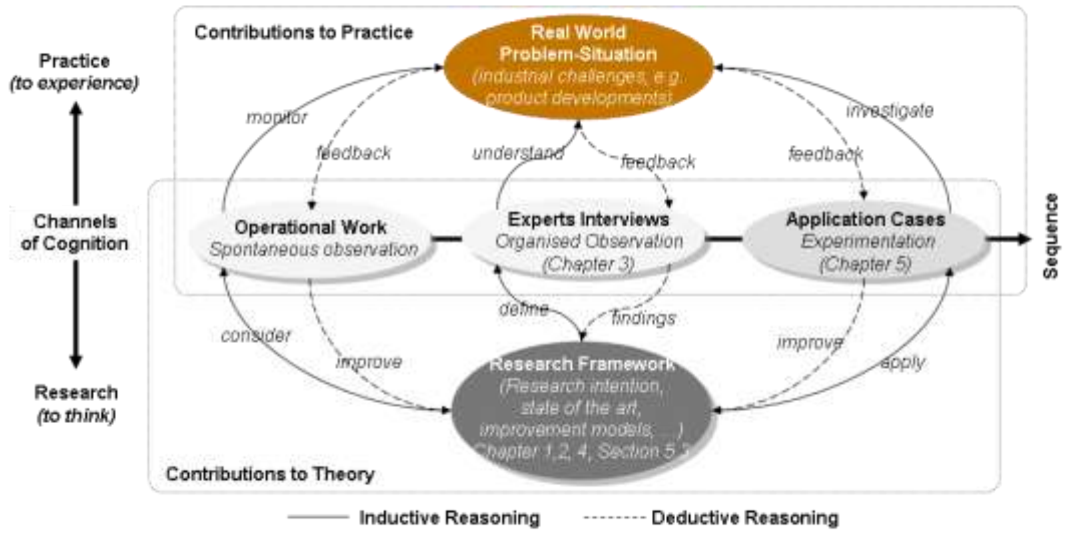

Figure 9: GLOBE Hybrid Action Research Methodology

In this work an active, but partially limited intention of changing industrial problem situations was envisioned and feasible. Thus, the action research methodology defined for this work uses synergies of

- *Spontaneous observations*[25] through operational work monitoring real-world problem-situations while considering features of the research framework and in turn improve it (implicitly),
- *Organised observations* through qualitative surveying methodologies (see chapter 3), i.e. the experts interviews which aimed at providing understandings of real-world problem-situations and in turn improve the research framework (explicitly), and
- *Experimentations* through application cases (see chapter 5), i.e. investigate improvement models (see chapter 4) based on two industrial challenges and in turn improve it (explicitly).

These three *channels of cognition* have been used to activate a hybrid form of action research, defined as mutually shifting from research (theory) to practice. Generally, the present action research methodology embodies the following activities:

- **G**ain understandings of the current scientific debate in the frame of the present research topic and understand current research ambitions (trends),
- **L**ook for existing assets (state-of-the art) and analyse new research opportunities for potential contributions towards theory,
- **O**bserve (monitor and understand) real world problem-situations potentially to be changed, understand
- **B**ehaviours and build improvement models, and
- **E**xperiment (investigate) improvement models in real world problem-situations and feedback experiences to research frameworks.

The *GLOBE Hybrid Action Research Methodology* (see Figure 9) characteristically defined for this work describes a closed loop of inductive and deductive reasoning – a cognitive shift from research design to design practice and conversely.

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[25] In contrast to organised observations and experimentations, this cognitive channel in not considered to be discussed within a specific indicated section. Rather respective experiences are incorporated in according sections.

2 Theoretical Background: *Concepts, Models and Principles*

This chapter establishes the theoretical foundation of the thesis and discusses relevant concepts for constructing the research framework (see Figure 10).

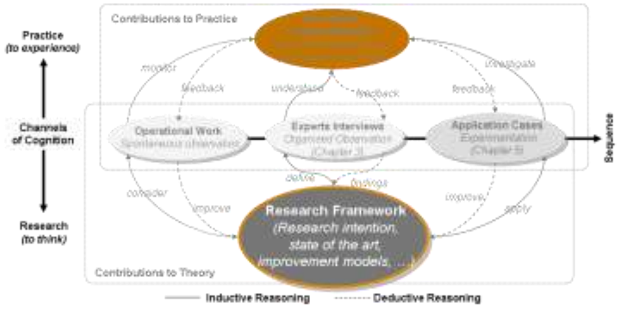

Figure 10: GLOBE Hybrid Action Research Methodology – Research Framework

Relevant concepts, models and principles are debated in an organisational context. Those were identified as mandatory for establishing a synthetic meeting place, a knowledge representation forum for supporting collaboration and knowledge conversion between the business and engineering domain.

Chapter 2 'Theoretical Background: Concepts and Models' is organised in six sections.

***Section 2.1 to 2.4** introduces and discusses the concept of collaboration, knowledge, ontology and context. Those are theoretical constructs that are of relevance for the thesis and in particular the solution proposition introduced in chapter 4.*

***Section 2.5** reflects the introduced concepts in an organisational context.*

***Section 2.6** synopsise and concludes on the concepts, models and principles as well as the organisational context discussed.*

2.1 The Concept of Collaboration: *Cooperation, Communication, Coordination and Group Awareness*

"Nothing new that is really interesting comes without collaboration."
—James Watson, Nobel prize for double helix discovery

This section is devoted to highlight the concept of collaboration and is organised as follows:

- *2.1.1 Introduction and Definition*
- *2.1.2 Collaboration Building Blocks*
- *2.1.3 Synopsis and Conclusion*

2.1.1 Introduction and Definition

The notion of *collaboration*[26] is multidimensional and complex. But what does collaboration mean? In fact, collaboration is a contemporary issue debated multifaceted and in various contexts[27]: social, economical (market), and technical, within both the scientific community and in practice.

The Oxford English Dictionary (OED, 2003) is a universally valid source and comprehensive dictionary that comprises some of the commonly debated aspects of the notion collaboration *"as action of working with someone to produce something"*. The first part of the given definition *"The action of working together with someone"* implies a process involving at minimum two people working together. Someone implies further that these people are unknown or unspecified, but which not always is the case during an act of collaboration. The act of working with someone should normally have a reason or purpose—a shared (understood and accepted) objective (solve a problem or improve a situation potentially in a new way). Moreover, the second part of the definition "to produce something" is in fact the shared objective and correlates with constructing an outcome (e.g. product, process, results, etc.) while having worked together.

In social science the notion of collaboration is discussed in the context of *interaction*. Bahrdt (2000) defines interaction as reciprocal social action to build consensus about a common action-goal between two or more persons, whereby each partner orients his action on the others past, present, or expected future actions. Interaction here centralises the associativity in other people's actions and according to Bahrdt (2000) it is further required that each partner understands and thus is enabled to contribute to the common goal. Obviously, collaboration actors and their interactivity centralises the notion of knowledge. In this context, organisational theory provides a more specific perspective on collaboration. It is a process of shared creation bringing two or more individual expertises together not only to let them work together, but also to integrate them and stimulate mental processes towards discovery—Collaboration becomes a necessary technique to master the unknown (Schrage 1995). Elsen (2007) stresses the importance of a defined collaboration process towards a commonly shared

[26] Merriam-Webster: Etymology: late Latin *collaboratus*, from Latin *com-* + *laborare* to labour, originated 1871, available from http://www.merriam-webster.com/dictionary/collaboration, Internet, accessed 6 December 2007

[27] E.g. collaboration in organisations (Kraus 1980), Collaboration technologies (Andriessen 2003), Engineering collaboration in a distributed virtual enterprise (Ye 2002).

objective or result; otherwise collaboration is reduced to an incoherent "schmooze". However, collaboration appears on different levels within different constraints: expertise, time, money, competition and conventional wisdom, that it is difficult to parse the collaboration process logically (Schrage 1995).

In the frame of the present work collaboration is defined as follows:

> ***Collaboration.*** *Two or more individuals act jointly trying to solve a problem or improve a situation, potentially in a new way, while exchanging knowledge in an organised way and using their cognitive capabilities.*
>
> *Own Definition*

This notion of collaboration considers the human dimension, rather than the implementation of collaboration in technology debated as e-Collaboration[28].

2.1.2 Collaboration Building Blocks

Collaboration is frequently mentioned in synonyms of cooperation, communication and coordination. Herein, a clarification and delimitation is needed. A general distinction is given by the OED (2003) defining these three terms as follows:

> ***Cooperation.*** *The action or process of working together to the same end.*
>
> ***Communication.*** *The imparting or exchanging of information by speaking, writing, or using some other medium.*
>
> ***Coordination.*** *The organisation of elements of a complex body or activity so as to enable them to work together effectively.*
>
> *Source: Oxford English Dictionary 2003*

Considering the general definition given by the OED for cooperation, communication, and coordination, they have all in common to support collaboration as the act of working together, but at different dimensions. In fact, these are components of collaboration (cf. Elsen 2007) that are introduced by Teufel et al. (1995) within the 3C-Model as comprising areas for supporting technologies (Computer Supported Cooperative Work[29]) in cooperation (e.g. multi-user editors), communication (e.g. conference systems) and coordination (e.g. group-calendar). Lastly, the 3-C model considers an integrated multifaceted technology area embracing all components of

[28] Kock (2005) writes that *"Electronic collaboration (e-collaboration) is operationally defined here as collaboration using electronic technologies among different individuals to accomplish a common task".*

[29] Wikipedia: *"[...] On the one hand, many authors consider that CSCW and groupware are synonyms. On the other hand, different authors claim that while groupware refers to real computer-based systems, CSCW focuses on the study of tools and techniques of groupware as well as their psychological, social, and organizational effects. [...] CSCW is a generic term, which combines the understanding of the way people work in groups with the enabling technologies of computer networking, and associated hardware, software, services and techniques"*, Available from http://en.wikipedia.org/wiki/Computer_supported_cooperative_work, Internet, accessed 6 December 2007

collaboration. Elsen (2007) adds a further dimension to the concept of collaboration namely "group-awareness", which originates from the phenomenon called emergence[30] (see Figure 11).

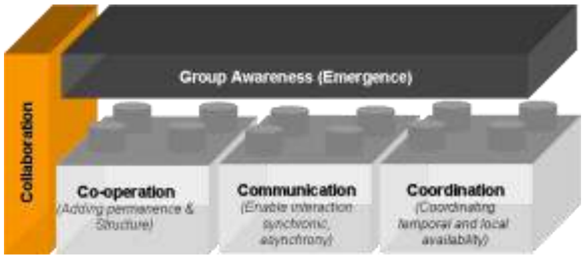

Figure 11: Collaboration Building Blocks (adapted from Elsen 2007)

Within this model, group awareness represents the emergent result of a collaboration process comprising cooperation, communication, and coordination and describes a commonly shared (understood and accepted) objective for collaboration between two or more people (see definition above). Secondly, group awareness itself could lead to an emergent case itself (cf. Elsen 2007). This means that a number of collaborations on the same level of emergence (e.g. N+1) could be part of a higher ambitioned collaboration process involving again two or more people (see Figure 12).

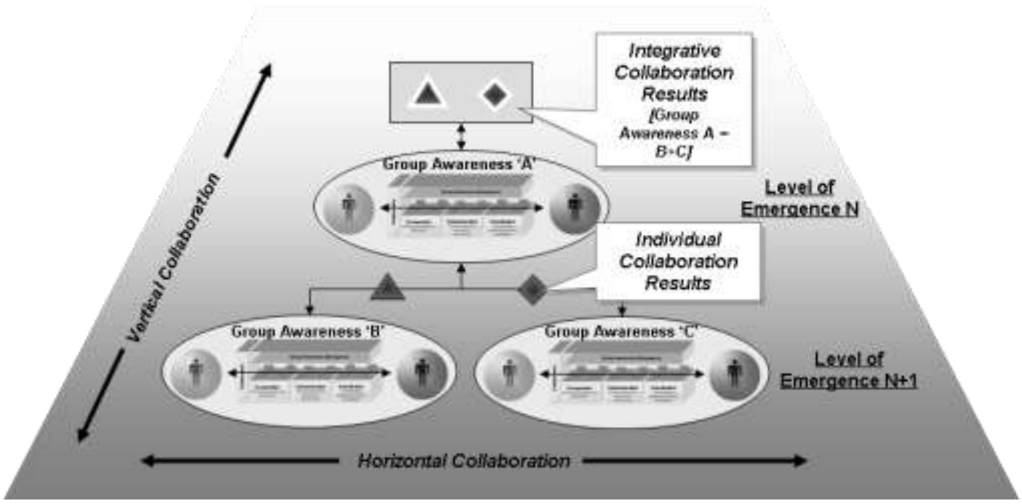

Figure 12: Model of horizontal and vertical collaboration

Then different collaboration processes could appear at different levels of emergence (N, N+1, etc., e.g. at different project levels: task-, work package-, project level) and are introduced here as *vertical collaboration*. Kraus (1980) declares collaboration as a cooperative venture that assumes shared power and collective decision making based on the individual's talent and cognitive capabilities, rather than role and function based authority. A distinction of collaboration in horizontal and vertical collaboration is not (inconclusively) associated to hierarchical roles or functions based empowerment only, it is rather a decomposition of a complex collaboration case differentiated into effective collaboration cases. Integration of the single collaboration cases is the reflexive consequence of collaboration decomposition and aims towards an emergent collaboration result that requires management effort/attention in maintaining interfaces between the single collaborations on the same or on different levels of granularity.

---

[30] Better known from systems theory and Aristotle's metaphor "*the whole is more than the sum of its parts*".

2.1.3 Synopsis and Conclusion

The idea of collaboration in all its dimensions aims at synergising individual talents and their cognitive capabilities benefiting as individuals but also as a collective. Collaboration can provide their participants an environment to meet problem partners helping to create alliances for strengthening group awareness and helping organisation to unify methods, processes and tools to a certain extent. This circumstance is highlighted in a subsequent section discussing knowledge conversion in an organisational context (see section 2.2.3). However, people involved in an act of collaboration are aiming to solve (domain) specific and concrete problems fast and effectively. It could appear that people in a collaboration process are mentally not capable or simply not interested in serving collaboration in a higher order (2nd case of group-awareness: integrated collaboration). Perhaps they don't share or can't imagine the grand vision and wish to follow their individual ambitions. It could be also a matter of time evolving mentally and converge towards a level of mutual understanding and trust throughout a process of collaboration[31]. Moreover, collaboration is spatiotemporal dependent (e.g. different geographical locations) and has impacts on collaboration building blocks: cooperation, communication, coordination, and individual's usage. Collaboration in an organisational context is more detailed explored within section 2.5.

2.2 The Concept of Knowledge: *Evolutionary Stages, Essential Knowledge Types and Organisational Knowledge Mobilisation*

"We can know more than we can tell."
—Michael Polanyi[32], Nobel Prize in Chemistry

This section is devoted to highlight the concept of knowledge and is organised as follows:

- *2.2.1 Introduction and Definition*
- *2.2.2 Essential Types of Organisational Knowledge*
- *2.2.3 Organisational Knowledge Conversion*
- *2.2.4 Synopsis and Conclusion*

2.2.1 Introduction and Definition

The previously explained act of collaboration between two or more people is considered as a process of interactions comprising the exchange knowledge. Tiwana (2002) illustrates that industrial firms were much focussed on data reasonable due to the technological evolution towards electronic data processing and refining them into

[31] cf. Schrage (1995): "*the thing that matters most is that the collaborators possesses a modicum of mutual trust that they each adding value and genuine desire to solve the problem at hand or create something new"*

[32] Wikipedia (2007): *"Michael Polanyi (1891, Budapest – 1976) was a Hungarian–British polymath whose thought and work extended across physical chemistry, economics, and philosophy. He was a Fellow of the Royal Society and a Fellow of Merton College, Oxford",* Internet, available from http://en.wikipedia.org/wiki/Michael _Polanyi, accessed 9 January 2008

information (management) systems. Then, firms converged towards understanding handling data and percolate data (i.e. information) and were confronted with the next obstacle, which is utilising the amount of information, by itself. In this sense what is knowledge, how to gain knowledge and what to do with knowledge?

The answers shall be given through the classical and often in theory denoted concept of the knowledge pyramid. The pyramid according to Eppich et al. (2002)[33] consists of five evolutionary stages: symbols/signals, data, information, knowledge, action. Figure 13 illustrates the terminological hierarchy from symbols/signals towards action. Whereby, each intermediate stage: data, information, and knowledge, requires an additive to attain a next higher stage in the evolution (enrichment) of knowledge.
Unfortunately, the community of knowledge has no commonly shared understanding of these terms and provide various different but no unambiguous definition and delimitation for the notions of data, information and knowledge. Rather the terms data, information, and knowledge are usually used as interchangeable terms.

Firstly, *symbols/signals* are reasonable due to the fact that data is not coming from nowhere—data cannot be measured or detected as such. Data is rather the result of a measurement, indication or observation based on symbols or signals at a certain point of time[34]. *Data* is conversion of signals into something potentially interpretable[35, 36] (e.g. providing syntax to a set of alpha-numeric symbols, or physical units to a signal). Faber (2007) mentions (in accordance to Hildebrand (1995) and amongst others) that data have an objective and quantitative dimension. The OED (2003) defines data further as “facts and statistics collected together for reference or analysis”. Both definitions have in common that they describe data as a sort of broad collection of things, which have no subjective meaning. *Information* is the next hierarchical stage and pre-requisite for knowledge. Drucker (1999) says that information is “data endowed with relevance and purpose”. This means that information in comparison to data has a subjective dimension and is an evaluation of its usefulness by an individual[37].

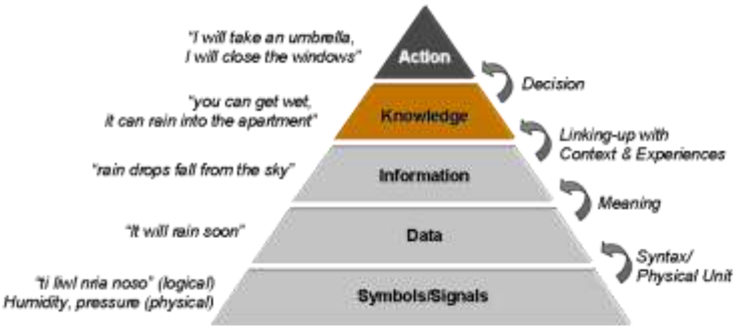

Figure 13: Knowledge evolutionary stages (adapted from Eppich et al. 2002)

Knowledge is a multifaceted concept having multilayered meanings (Nonaka 1994). Whereby, data and information are crucial within the knowledge evolution process.

[33]Based on the pyramid’s concept proposed by Aamodt/Nygard (1995). The knowledge pyramid is discussed in literature by a number of authors, e.g. Ackoff (1989) defines “Wisdom” as next higher stage of knowledge and classifies the pyramid temporal.
[34] Cf. Davenport (1997): “Data are simple observations of states of the world.”
[35] Cf. Pomerol/Brézillon (2001): “Data are the stimuli that enter an interpretation process”
[36] Cf. Geyer (2001): “Data can provide a basis a basis for understanding, but it is not the same as understanding.”
[37] Cf. Hildebrand (1995, cited in Faber 2007): “Information are defined through a subjective and qualitative dimension and can only be treated subjectively.”

Pomerol/Brézillon (2001) state that knowledge utilisation is threefold: to transform data into information, to elicit and elaborate new information from the existing stock, and lastly to acquire new knowledge.

However, knowledge is applicable and brings into context latest experiences and skills that will make at the end the distinction between “good” and “bad” decisions (Tiwana 2002). Likewise, Eppich et al. (2002) state “*knowledge enables us to act and is the core idea for knowledge management”*. Probst/Raub/Romhardt (1999) define knowledge as the entirety of experience, understanding and capabilities that persons utilise for solving problems. Nonaka (1994) conclude on Dretske’s (1981) distinction of information and knowledge as follows: *“Information is a flow of messages, while knowledge is created and organised by the very flow of information, anchored on the commitment and beliefs of its holder”*. Considering the relation between information and knowledge in a business context, knowledge can be treated as actionable information. Here, information provides facts only, whereby knowledge enables humans to act: make causal associations, predictions towards a final decision (Tiwana 2002)[38].

In conclusion, knowledge is utilised to stimulate and support decision-making processes, and to effectively act towards solving problems, which is also the key concept of collaboration. Organisations benefit from their knowledge in a manner that “decision-bearer” are enabled to conduct more accurate actions with less uncertainty in work-activities/tasks and improve their outcomes (e.g. deliverables) during the cause of organisation’s business processes (e.g. project)[39]. Baumard (1999) stresses that organisation’s individuals or a collective of individuals sometimes ‘territorialize’ their knowledge and cognitive capabilities for granting their right to exist within its authority and empowerment.

Based on the previous discussion, the following demarcation between data, information and knowledge is drawn below.

> ***Data.*** *Data is interpretable and is a result of a measurement, indication or observation based on symbols or signals.*
>
> ***Information.*** *Data endowed with relevance and purpose. This means that information in comparison to data has a subjective dimension and is an evaluation of its usefulness by individuals.*
>
> ***Knowledge*** *is actionable information comprising cognitive capabilities enabling to take actions and make situational (spatiotemporal) decisions.*
>
> *Own definitions*

The concept of collaboration comprises human’s interactions as an act of exchanging and processing objects (content) in terms of information but also knowledge (Kock

[38] Cf. Weick/Bougon (1986, cited in Kock 1998) says, “[…] knowledge is either predictive or associative, and can be seen as a collection of rules to process information. Predictive knowledge can be used to generate information about the future, based on information about the past, present, or future […]”

[39] cf. Mueller (2005): “In the knowledge pyramid, knowledge is exploited for decision making, and has thus direct and immediate value for a decision maker in an organization.”

1998). The concept of collaboration is in parallel a stimulating vehicle towards knowledge emergence (comparatively to emergence in the context of collaboration). The interrelationship between collaboration and knowledge is further discussed in the forthcoming section 2.5.

Delimitation to Artificial Intelligence

Since the 1970's companies have trialled out to manipulate captured knowledge with machine programmes but it has been notice that human knowledge is a complex construct. Experts systems, case-based reasoning systems, neural networks, and intelligent agents are utilisable approaches in artificial intelligence, but their application domain is rather thin (Tiwana 2002). The present work will delimitate knowledge capture and manipulation from artificial intelligence and focus on human intelligence only.

2.2.2 Essential Types of Organisational Knowledge

Knowledge is a dynamic and difficult to grasp concept which appears at different levels of an organisation. Franken (2002) argues that knowledge is stored in several different ways and causes different problems within its application. Driven by globalisation forces, organisations often employ strategies, ruses, and intelligence for organising their knowledge as well as maintain and deploy a memory, a capacity to learn, and a mode of knowing. Nevertheless, companies may be swamped with information and are incapable to express their knowledge and even if, it could be unaware (self- or collective unawareness) and have only a minor identity of the knowledge it owns (Baumard 1999).

Nonaka (1994) discusses knowledge creation twofold in *epistemological* and *ontological* dimensions (the ontological dimension of knowledge is discussed in section 2.3) and can be ascribed to Polany[40] (1966). The epistemological dimension is sub-divided into the prevalent form of explicit and tacit knowledge creation.
Explicit knowledge is articulated and codified, and can be characterised as being transmittable in a formal and systematic language (Tiwana 2002). Explicit knowledge refers to intellectual artefacts (Baker/Badamshina 2007) and can be discrete or digital and captured in records of the past such as libraries, archives, and databases and is assessed on a sequential basis (Nonaka (1994). Franken (2002) classifies codifiable knowledge as being available in forms of structured and unstructured information. Structured explicit knowledge is pre-defined in its usage through meta-knowledge and can be analysed with respect to defined criteria (e.g. database, etc.), whereas unstructured explicit knowledge is not pre-defined within its originating form (e.g. all documents, CAD-sketches, photos). However, human users of unstructured knowledge can add context, experience and structure.
In contrast, *tacit knowledge*[41] is that kind of individual's utilised knowledge of which they are occasionally unaware (Geyer 2001). Tacit knowledge is context-specific knowledge that has a personal quality constructed by and stored in individual's minds which is difficult to access and to formalise for communication/transmission issues

[40] Michael Polanyi was scientist and philosopher and invented the concept of tacit knowledge.
[41] Tacit knowledge is often mentioned in synonyms of implicit, subjective or cognitive knowledge.

(Nonaka 1994/Tiwana 2002), and cannot be objective[42, 43]. The articulation of tacit knowledge is an analogue process, a sort of "mobilisation process" focussing on mutual understanding ("parallel processing" of individuals interaction), which is a key factor in the creation of new knowledge (Nonaka 1994). Based on the fact that knowledge is inherently personal and preserved mostly tacit, Sanchez (2004) hypothesises that organisational learning appears once individuals interact and thus knowledgeable individuals may operate as 'knowledge-carriers' being transferred and disseminate knowledge from one part of the organisation to another for accomplishing specific tasks.
Nonaka (1994) and Baumard (1999) mention two forms of tacit knowledge:

- A cognitive dimension involving paradigms, mental models in which humans form working models of the world (personnel representation of reality) by creating and manipulating analogies in mind, representations/individual's images of reality and visions for the future
- A technical dimension involving concrete know-how, expertise and skills that apply to specific context

Baumard (1999) hypothesises that all organisation is founded on differing degrees of knowledge intensities. Organisation's individuals embody the instance for possessing organisational knowledge creation (Nonaka 1994) whereas epistemological (tacit and explicit) knowledge can embody individual knowledge as well as collective knowledge.

Individual knowledge is personnel knowledge, which is related to individual knowledge bearers and not visible/accessible for other individuals and can only be accessed through meta-knowledge[44] (Franken 2002/Faber 2006).

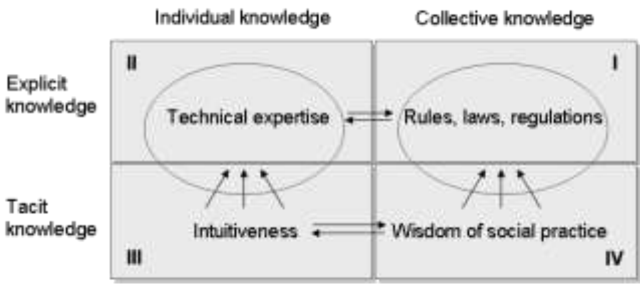

Figure 14: Four inseparable types of organisational knowledge (Baumard 1999)

Collective knowledge is organisational knowledge of an organisations unit, group, team or department (Faber 2006) and is composed of individual knowledge bearer. The collective as a whole could bear a shared (understood and accepted) understanding of facts (e.g. information) amongst its individual's of the collective. On the other hand, the collective knowledge is may be a knowledge-pool where each

[42] cf. Baker/Badamshina (2007): *"Tacit knowledge refers to cognition that resides in people's heads, such as cumulated wisdom and understanding, institutional knowledge, organizational lore, and basic orientations. It also includes personal knowledge embedded in individual experience in the form of rules of thumb, values, preferences, intuitions, and insights."*
[43] cf. Sanchez (2004): *"The salient characteristic of the tacit knowledge approach is the basic belief that knowledge is essentially personal in nature and is therefore difficult to extract from the heads of individuals."*
[44] Wikipedia defines meta-knowledge loosely as *"knowledge about knowledge"*, available from http://en.wikipedia.org/wiki/Meta-knowledge, Internet, accessed 21 December 2007

individual holds specific knowledge pieces (Franken 2002). Baumard (1999) conceptualises organisational knowledge creation within a model of four reflexive and inseparable quadrants from explicit or tacit to individual or collective knowledge (see Figure 14).

The first quadrant embodies explicit and collective knowledge that is the profound knowledge of a specific area or environment (e.g. rules and laws for product development processes). The second quadrant incorporates explicit/codifiable and individual knowledge techniques that technical expertise counteracting nets and traps (e.g. best in class technician). Tacit and individual knowledge comprises the third quadrant reflecting the non-codifiable individual's 'talent' that is complemented by hard technical expertise, a kind of unique technical skill. Lastly, the fourth quadrant that is the body of tacit and collective knowledge is characterised as the unspoken, a certain wisdom that is acquired through social practice and which drives organisations in their daily business. In addition, Geyer (2001) appends that collective tacit knowledge may generate the most valuable "comparative advantage".

Beside the prevalent distinction of knowledge as explicit or tacit knowledge and individual or collective knowledge, knowledge can be *viewed* differentiated (Faber 2006):

- Knowledge as *object*: static, outcome of a process or activity
- Knowledge as *process*: dynamic act or activity, evolving
- Knowledge as *product*: in forms of services or knowledge stored in products, frozen knowledge which can be materialised
- Knowledge as *steering-medium*: e.g. knowledge based organisations strategy

2.2.3 Organisational Knowledge Conversion

Previously, the epistemological dimension of knowledge has been discussed twofold in an explicit and tacit dimension within individual and collective knowledge. This paragraph shall highlight the aspect of organisational knowledge conversion (tacit or explicit and explicit or tacit) based on the Socialisation-Externalisation-Combination-Internalisation (SECI) model introduced by Nonaka (1994, see Figure 15).

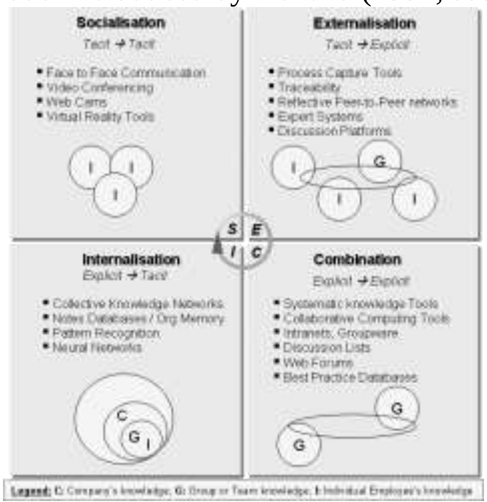

Figure 15: SECI model for organisational knowledge creation (Tiwana 2002)

This model identifies different patterns of interactions based on the assumption that organisational knowledge is created through a continuous dialogue between tacit and explicit knowledge. For Nokana (1994) the following four modes of knowledge conversion are feasible and meant to assure a consistent evolution of organisational knowledge.

- **Tacit to tacit—Socialisation[45].** The process of passing tacit knowledge of one individual to tacit knowledge in another individual is socialisation. Individuals can acquire tacit knowledge without utilising language but by observing, imitating, and practicing each other's behaviours and beliefs (e.g. apprentices work with their mentors). A key feature towards acquiring tacit knowledge is the individual's shared experience for having access to each other's mental models (thinking processes). For Baumard (1999) the principle characteristic of socialisation is its resistance against codification until it becomes part of the organisational culture.
- **Explicit to explicit—Combination.** This kind of knowledge conversion involves social processes to combine bodies of explicit knowledge to new explicit knowledge, e.g. reconfiguring of existing information through sorting, adding, re-categorising. Baumard (1999) adds that knowledge elements must organically[46] fit together: compatibility between characteristics (also mentioned as articulative logic), e.g. researchers combine empirical data from industry observation with theories and come out with new conceptual approaches.

According to Nonaka (1994), the next two sorts of knowledge conversion encompass tacit and explicit knowledge, which are complementary notions by its nature and evolve mutually based on the following two modes[47]:

- **Tacit to explicit—Externalisation[48].** The conversion of knowledge from a tacit to an explicit form is a routine in the day-to-day business in organisations. Externalisation is a sort of knowledge conversion which is commonly known and articulated into tacit knowledge, e.g. articulation of rumours get persistent and explicit organisational knowledge by their articulation become hard facts and turn into organisational policy over time (Baumard 1999).
- **Explicit to tacit—Internalisation.** The mode of internalisation could be associated to the traditional notion of "learning" and becomes routine or automatism (e.g. workers clock in and out without noticing). Nonaka (1994) talks about "action" as being acutely associated to the internalisation process.

[45] Baumard (1999) states that socialisation is intimately connected to theories of organisational culture, which is above all a 'tacit system' of knowledge conversion and regulation. He stresses thereby the importance of attitudes and beliefs as well as values of an organisation. However, within the frame of this work organisational culture will not be further highlighted

[46] cf. an organic organisation "is a fluid and flexible network of multi-talented individuals who perform a variety of tasks" (Wikipedia 2007), available from http://en.wikipedia.org/wiki/Organic_organisation, Internet, accessed 23 December 2007

[47] In contrary to Nonaka (1994), Baumard (1999) identifies both tacit to explicit and explicit to tacit knowledge conversions as engines for organisational learning.

[48] Nonaka (1994) note that the transformation of tacit into explicit knowledge is twofold: (i) by recognising contradictions through metaphor (free association, imaging) and (ii) by resolving them through analogies (commonness of different things towards unambiguity)

2.2.4 Synopsis and Conclusion

The depicted conversions are all exclusively important for articulating and advancing within the knowledge basis within an organisation. Tacit knowledge seems to play an extraordinary role and is the key feature in generating and boosting knowledge creation. The explicit form of knowledge can be (partially) utilised in a tacit knowledge context and has been discussed previously as a kind of learning procedure. In turn, evolving tacit knowledge remains for excellence and can enrich explicit knowledge container (e.g. databases, documents) while serving as multiplier and stimuli for other organisational 'brains' which are may not identified so far for socialisation acts (tacit to tacit knowledge conversions). Thus, the most important component is to let individuals mind and intelligence – the tacit component – evolves in a shared manner while maintaining knowledge inter-conversions. Nonaka (1994) highlights that each single knowledge conversion is capable to create knowledge as such, but the central theme of knowledge creation is the dynamic and interrelated aspect between the different modes of knowledge conversion.

2.3 The Concept of Ontology: *Organisation and Representation of Knowledge*

This section is devoted to highlight the concept of ontology and is organised as follows:

- *2.3.1 Introduction and Definition*
- *2.3.2 Levels of Ontology*
- *2.3.3 Interim Synopsis and Conclusion*

2.3.1 Introduction and Definition

Since the epistemological dimension of knowledge is illustrated previously, this section is devoted to highlight the ontological dimension of knowledge.

The concept of ontology[49] has been historically confined to the philosophy branch, which refers to ontology as the study of the world, the nature of reality[50]. In recent years, it gains an emerging role of interest in computer, knowledge and information science (Brank/Grobelnik/Mladenic 2005; Sure/Studer 2002; Guarino 1998). Hüttenegger (2006) generally describes the notion of ontology as a hierarchical order of terms in conjunction with its semantic meaning[51] and its relationships. Ontology can serve as an alternative organisation and representation of knowledge for some kind of domain of interest. Swartout et al. (1996) state, "*An ontology is a hierarchically structured set of terms for describing a domain that can be used as a skeletal foundation for a knowledge base*". Swartout et al. (1996) argue that knowledge can be more readily shared, once knowledge bases share a common

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[49] Merriam-Webster: Etymology: late Latin *onto logia*, from Latin *ont-* to be + *-logia* word, Date: circa 1721, a branch of metaphysics concerned with the nature and relations of being, available from http://www.merriam-webster.com/dictionary/ontology, Internet, accessed 6 December 2007

[50] Wikipedia (2007) states, *"In philosophy, ontology is the study of being or existence and forms the basic subject matter of metaphysics. It seeks to describe or posit the basic categories and relationships of being or existence to define entities and types of entities."*, Internet, available from http://www.en.wikipedia.org/wiki/Ontology, Internet, accessed 26 December 2007

[51] This is a missing element in taxonomies and differentiating feature in comparison to ontology.

fundamental structure, the common ontology. According to Guarino (1998), ontology in its *modern* form refers to an engineering artefact, constituted by a specific vocabulary used to describe a certain reality, plus a set of assumptions regarding the intended meaning of the vocabulary words. Ontology's role (from an "information system" perspective) is to provide a formal conceptualisation (potentially machine-readable) of some domain of interest and can be commonly used as data structure capturing 'background' (tacit) knowledge about a certain area via providing relevant concepts and relations between them. Also, much different ontology could conceptualise the same body of knowledge. (Brank/Grobelnik/Mladenic 2005).

The notion of ontology is frequently denoted (e.g. in information and knowledge science) in context of the *meaning* or *semiotic triangle* based on Ogden/Richards provided landmark (Ogden/Richards 1923). Ogden/Richards (1923) developed a dryadic structure to describe (entirely and correct) the dyadic relationship between a symbol (syntactic structures: term, sign) and an object (referent, thing). Hereby, the relationship between a symbol and an object is indirect (see Figure 16).

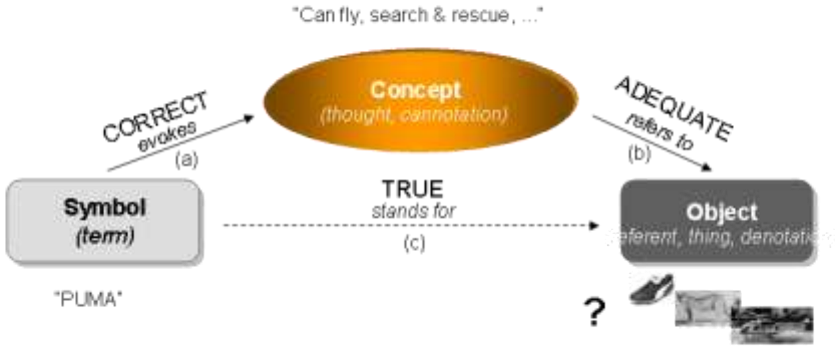

Figure 16: The semiotic triangle (adapted from Ogden/Richards (1923); Sure/Studer 2002)

In fact, the course of this imputed and causal relationship requires the reference to a corresponding notional level, a concept or thought providing semantic structures. In accordance to this model, the 'direct' identity relationship (edge 'c') can only be accomplished through a mutual interaction with the mediating concept (edge 'a' and 'b') establishing the proper linkage between his concept and the appropriate thing the world (=object) in someone's individual's mind (cf. Sure/Studer 2002). Finally, Jurisica/Mylopoulos/Yu (2004) add that ontology can be used as common and representative knowledge that facilitates communication among individuals.

Concluding on the semiotic (meaning) triangle, the notion of ontology holds relational characteristics describing symbols (syntactic structures) and associated concepts (semantic structures) employed while representing an area of knowledge. The construct of ontology is capable to enrich information semantically, improve reasoning and may constitute user-specific views. Thus, ontology potentially enable interpreter: artificial (machine readable) or humans intelligence; to better understand symbols and anticipate those with objects.

From the discussion above, some essential characteristics of ontology can be defined in a knowledge-context as follows:

> ***Ontology.*** *Ontology sustains a shared and common understanding and enables one to trace and find, exchange and discover organised knowledge and can be used to facilitate semantic interoperability between some domains of interest.*
>
> *Own definition*

2.3.2 Levels of Ontology

Knowledge creation[52] can occur at different organisational levels and evolves in cohesion of epistemological and ontological knowledge dimensions (see Figure 17). A generic approach characterizing levels of knowledge *"is to see at knowledge as progressing from identifying attributes of concepts, to establishing relationships between concepts, to specifying the conditions under which these relationships apply"* (Baker/Badamshina 2002). Kivijärvi (2004) stresses that personal knowledge is always tied to personal action and personal valuation while organisational knowledge is tied to organisational valuation. Tsoukas (2000) describes organisational knowledge is *"the set of collective understanding embedded in a firm and is the capability members of an organisation have developed to draw distinctions between in the process of carrying out their work, in particular concrete contexts, by enacting sets of generalisations (propositional statements) whose application depends on historically evolved collective understandings and experiences."*[53]

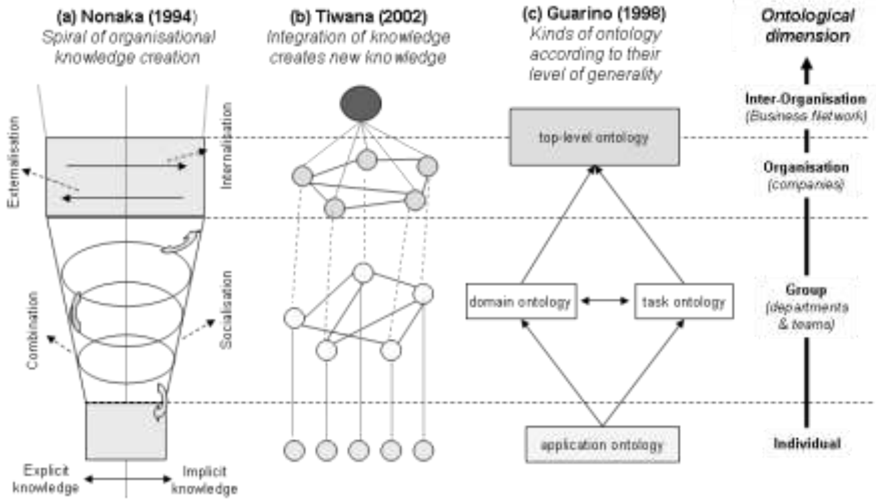

Figure 17: Overview of different ontological models associated to organisational knowledge creation (adapted from (a) Nonaka 1994, (b) Tiwana 2002, (c) Guarino 1998)

Figure 17 (a) visualises how these interactions of knowledge might be associated in an organisational environment. The *ontological* dimension of knowledge can be described as a sort of social interactions existing at intra- as well as inter-organisational level (including suppliers, customers, distributors and other stakeholder): from individuals to groups (practical levels: close to action), then to organisations and inter-organisation (theoretical levels: focused on high level understandings that, as yet, have little relation to practical action) domains (Nonaka (1994); Baker/Badamshina 2002). Once knowledge held at individual's level interact in a group context (e.g. team or department), new knowledge is created on group level. Equally, as once knowledge hold in groups incorporate with other group's knowledge in a company context, new knowledge is created in an organisational context. Tiwana (2002) refers to this process as knowledge integration across organisational hierarchies while progressively valuable knowledge is generated from lower (practical) towards the upper (theoretical) levels of the organisational hierarchy (see Figure 17 (b)).

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[52] Nonaka (1994) states, *"An organisation cannot create knowledge without individuals. The organisation supports creative individuals or provides context for such individuals to create knowledge."*

[53] cf. individual and collective knowledge discussed in section 2.2.2.

A more generalised classification of ontological levels provides Guarino (1998, see Figure 17 (c)) distinguishing four kinds of ontology as follows:

- **Top-level ontology.** Describe very generic concepts, e.g. space, time, matter, object, event, action, etc., which are independent of a problem domain: it seems therefore reasonable, at least in theory, to have unified top-level ontologies for large communities of users.

The next two generalised types of ontology: domain and task ontology; are characterised through its co-existence in specialising a related top-level ontology.

- **Domain ontology.** Describe the vocabulary related to a generic domain (e.g. medicine, automobiles) by specialising the concepts introduced in the top-level ontology.
- **Task ontology.** Describe the vocabulary related to a generic task or activity (e.g. diagnosing, selling) by specialising the concepts introduced in the top-level ontology.
- **Application ontology.** Describe concepts depending both on a particular domain and task, which are often specialisations of the former ontologies.

In the frame of this work ontology build a sort of reference of individual's and collective's knowledge bases organised in commonly shared structural 'frameworks' for better representing and employing knowledge artefacts at different organisational levels.

2.3.3 Synopsis and Conclusion

Having discussed essential types of knowledge and different dimensions of knowledge conversions, it seems that the concept ontology can play a fitful role and could serve as vehicle towards an organised and transparent mobilisation of knowledge conversions: During externalisation, knowledge bearer store and make tacit bodies of knowledge explicit and available for further exploitation by others while supporting implicitly the act of internalisation through visualising knowledge. The combination axis represents combinatory results of explicit knowledge conversion reflected in some ontology. Ontology as such does not directly support socialisation, the individuals tacit to tacit knowledge interaction (e.g. sharing experiences, best practices and beliefs). However, they can serve and stimulate socialisation by providing guidance to explicit made knowledge and provide a 'physical address' to some source/initiator (individual) of a specific (part of a) knowledge base. Based on the level and organisational area, ontology is associated to represent different kinds of viewpoints. The author centres the concept of ontology for this work as a strong and transparent foundation providing a shared skeletal and relational organisation for knowledge bases (e.g. documents and information units), including it's semantically reasoning for their existence (see also concept of context, section 2.4). Generally, ontology is twofold in a structural/skeletal part and a relational created content part representing various domain knowledge bases. The content part can organise and address generic parts (e.g. organisational standard procedures and guidelines) relevant for all domains and specific parts relevant for one domain (e.g. concrete instructions, tasks). Rules and constraints could legitimate the access to specific information of ontology's content part. Actionable ontology structures shall be customised and have a sort of template character representing a shared (accepted and understood by impacted individuals) view of an organisational domain or area enabling individuals to associate commonly but different knowledge bases. This requires also defined interfaces between the various different ontologies on the same level of organisational granularity (horizontal) as well as across different levels of organisations (vertical), which have also to be realised and maintained. Full traceability throughout ontology elements is mandatory maintaining knowledge bases evolutions in cohesion with ontology. Establishing a shared (understood and accepted) ontology across potentially impacted individuals is challenging within identifying the needs to support knowledge conversion processes in an adequate manner.

The author further envisions and follows the trend away from macro-viewing on documents, i.e. focussing on documents as a whole, to a microscopic consideration of documents based on knowledge or information units of documents for providing contextual orientation towards documents.

2.4 The Concept of Context: *Meaning of Knowledge*

"The skill of writing is to create a context in which other people can think."
—Edwin Schlossberg[54]

This section is devoted to highlight the concept of context and is organised as follows:

- *2.4.1 Introduction and Definition*
- *2.4.2 Context Classes*
- *2.4.3 Knowledge Conversion in Context*
- *2.4.4 Synopsis and Conclusion*

2.4.1 Introduction and Definition

The concept of *context*[55] is subject of discussions in several different fields, but in particular in artificial intelligence, knowledge representation, natural language processing, and intelligent information retrieval and is identified as vital for communication (Akman/Surav 1996). The notion of context is important when looking at the meaning of information (Klemke 1999) related to the importance in reasoning and cognition in humans (Kofod-Petersen/Cassens 2005). Kivijärvi (2004) argues that "knowledge always reflects its context" and the "individual capacity to exercise judgement and take actions is based on appreciation of context". The OED (2003) state that context is "*the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood*". Grasping this definition, context seems uttering a specific situation (spatiotemporal) and surrounds

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[54] Wikipedia: *"Edwin Arthur Schlossberg (b. July 19, 1945), founder and principal of ESI Design, is an internationally recognized designer, author and artist"*, Internet, available from http://www.en.wikipedia.org/wiki/Edwin_Arthur_Schlossberg, accessed 9 January 2008

[55] Merriam-Webster, Etymology: Middle English, weaving together of words, from Latin *contextus* connection of words, coherence, from *contextere* to weave together, from *com-* + *textere* to weave, Date: ~1568, available from http://www.merriam-webster.com/dictionary/context, Internet, accessed 8 December 2007

something, perhaps information/knowledge enabling someone (machine or human) to grasp its intended meaning (as meant by the initial owner) in a truthful manner. In fact, contexts are abstract objects (McCarthy 1993). Longueville/Gardoni (2003) define context in sense of language use (text or talk) saying, *"exchanged information is an abstracted entity, a theoretical object which consists of linguistic components and rhetoric or context components"*. Linguistic components characterises the significance of information starting from instructions, whereby rhetoric components provide contextual information and give a meaning to the information in a specific situation (see Figure 18).

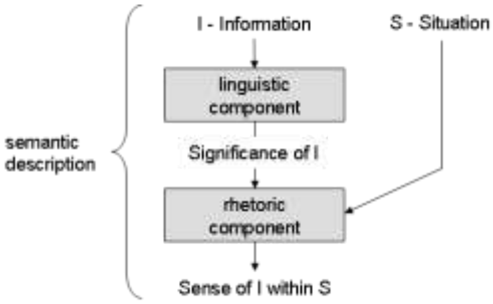

Figure 18: Significance of information (Longueville/Gardoni 2003)

The rhetoric or contextual component influences the way of understanding/interpreting the expression. Situation or circumstance (as mentioned by the OED) expands the concept of context within a spatiotemporal dimension and significance of information describes a degree of importance (e.g. weighting in terms of relevancy). Strictly speaking, models (mechanical design elements, or other figurative description) do not stringently fit to the idea of semantic description in language use. Edmonds (1999) claims that context in a modelling sense arises from a study of the pragmatics of learning and applying knowledge, and centre context on the transference of knowledge between learning and application saying that context *"is the abstraction of those elements of the circumstances in which a model, that are not used explicitly in the production of an interference or prediction when the model is later applied, that allow the recognition of new circumstances where the model be usefully applied."* Edmonds centres context as the emergence from model heuristics and requires the combined treatment of learning and applying knowledge (process of transference, see Figure 19) *"via fairly simple models from the circumstances where they are learnt to the circumstances where they are applied"*.

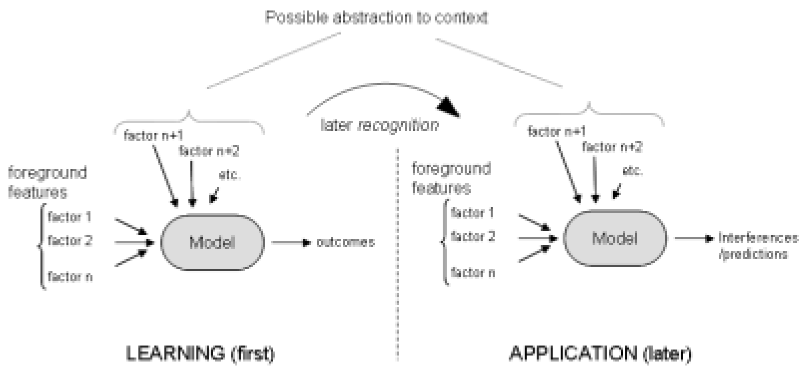

Figure 19: Context in the transference of knowledge between learning and application (Edmonds 1999)

Edmonds (2001) discusses further the opportunity that truth is by its nature context-dependent saying that *"truths only have meaning in a limited set of contexts and thus* *they are only applicable in those contexts"*. Contextually, McCarthy's (1993) work is devoted to formal theories of context and aims at formalising context in a viewpoint of artificial intelligence. McCarthy settles context as basic relation of *ist*[56] *(c, p)* and declares that proposition 'p' is true in the context 'c'. Edmonds highlights that for each proposition there is a context in which it does not hold.

In the frame of the present work context is defined as follows:

> ***Context.*** *Surrounds and gives a meaning to knowledge going to be transmitted or integrated at a particular situation and that is interpretable in its initial sense in a different situation by someone else.*
>
> *Own definition*

2.4.2 Context Classes

Penco (1999) provides a distinction of context as an *objective* or metaphysical (independently of our access to it) state of affaires (features of the world) and secondly context as a *subjective* or cognitive representation of features of the world (individual set of beliefs). These two classes are apparently linked. Subjective context offers beliefs on objective context, but the problem with this conception is that it is difficult to know what objective-context is. Penco (1999) mentions that individuals always illustrate reality in cognitive contexts from any point of view, but no point of view can be taken for representing the objective or metaphysical reality (not expressible by us).

With the present work, only subjective context is of importance.

2.4.3 Knowledge Conversion in Context

Previously the notion of knowledge has been illustrated as a process of interaction and conversion, a movement between the epistemological knowledge: explicit and tacit, followed by the introduction of the ontological dimension of knowledge. It has been shown that the notion of semantic plays an important role in providing sense to information for interpretation of its initial meaning at a certain situation by the interpreter (whether human or machine). In this sense Bunt's (1999) concept of dialogue management should be introduced briefly. Bunt classifies the general information exchange into two subclasses of *dialogue acts*, one constituted as information seeking (receiver or interpreter[57]) and one as information providing (transmitter). Context is important while performing knowledge transmission for reasons of learning and understanding (cf. Edmonds 2001).

Knowledge conversion or a sort of transmission involves a transmitter (owner/initiator of information) and a receiver (holder or interpreter of the information). Once an owner of tacit knowledge would like to make (pieces of) this knowledge explicit and codified, a transformation into information is needed (inverse step in the knowledge

[56] Modality that is pronounced *is true*.
[57] Receiver and interpreter are used in synonyms of each other's.

pyramid). Klemke 1999 argues that explicit context models enable – perhaps together with the information itself – to utilise produced contextual information over time.

Within the present work, information '*I*' can be characterised as a kind of *message* and is *absolute*. A message[58] is a component-based construct constituted of a *specific* information component '*i*' and the contextual information '*c (i)*' which is required to assure and support the correct interpretation of the transferred specific information by the receiver.

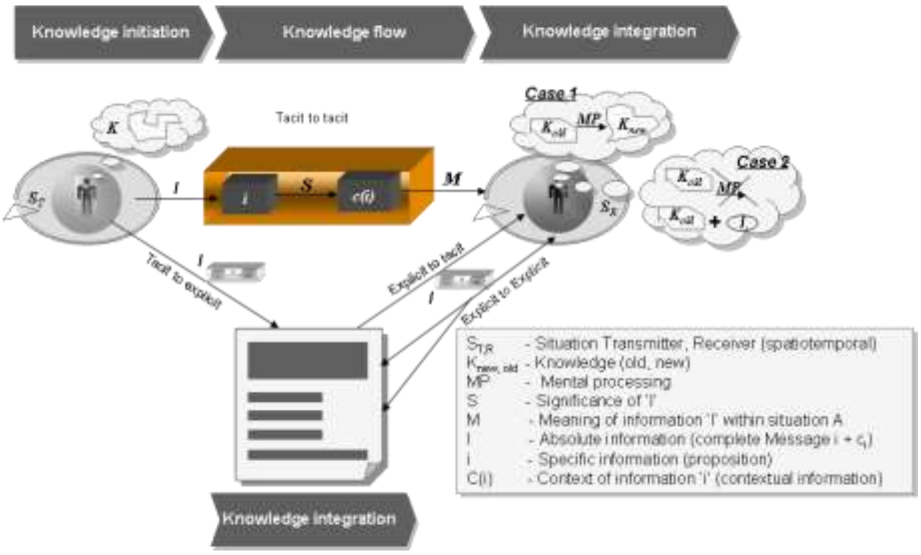

Figure 20: Samples of knowledge conversion in context

Moreover, the receiver himself recognises the message at a different situation *'S_R'* than the transmitter's situation 'S_T'. Depending on the medium used for transmitting/conversing knowledge (e.g. telephone call, electronic post or mail, face-to-face) and when it is recognised (transition time), the validity of transmitted knowledge can be still given or not. It depends on the transmitter's evolution in terms of knowledge and cognitive experiences. However, Faber (2006) argues that information (including its significance) obtained by the receiver is raw material to develop but also to change his knowledge (evolution of knowledge). The meaning *'M'* of information *'I'* is given through the contextual information component *'c (i)'* and should enable the receiver to completely understand the initial concern at the situation it was built by the information producer. However, from the receiver's perspective those are still information or data and only existing knowledge can generate value added (Faber 2006) as a matter of interactions in mind. This circumstance is pictorially differentiated twofold in Figure 20: In the first case the receiver processes mentally the information fragment, perhaps in a selective mode (subjective consideration of (pieces of) information), creates analogies and updates/evolves in his

[58] In management literature the *conduit model* inspired by Shannon/Weaver (1949) portrays communication as a message sending and receiving model, in which the symbolic or interpretative character of messages in languages in not considered (Boland/Tenkasi 1995). The conduit's model definition lacks an important attribute of human communication, rather it's emphasis is to control communication and communication channels. In contrast Wittgenstein's (1974) *language game model* considers the non-linear sharing of meanings, facilitating conversations and creating a common lexicon. In this work the concept of message (in the sense of the conduit model) is a sort of container for knowledge transmission and meant to establish collaboration channels across communities of knowing (consult section 2.5.2) stimulating human interaction (in the sense of Wittgenstein's language game model).

existing knowledge. Within the second case the receiver is mentally not capable to process the information and build knowledge analogies—the information is simply out of his sphere of knowledge and cannot be further applied to his mind.

Krogh/Koehne (1998) divide a knowledge transfer into the phases of knowledge initiation, knowledge flow, and knowledge integration. In conclusion knowledge is transmitted once all these phases are conducted.

2.4.4 Synopsis and Conclusion

The construct of context is essential for knowledge conversion in the sense of Nonaka's SECI model. Contextual information provides the individual, the transmitter and the receiver, with a specific semantic and experience endowment (see section 2.2.1) that enlarge them to process knowledge based on the given information. Only within the transmitted context, information has a meaning and is receiver-specific and -dependent. Considering once more the relation between information and knowledge, it has been shown now that context is the element that knowledge can be treated as actionable information. This is the basic feature of organisations and its members to take (more accurate) actions in a valuable way for the organisation.
Due to the fact that objective context – the reality – is too complex to be expressed as a whole and perhaps not efficient, it is rather vital to consider only subjective contexts. However, it is difficult to draw the line between objective and subjective context.

2.5 The Organisational Context: *Communities and Principles*

"An empowered organization is one in which individuals have the knowledge, skill, desire, and opportunity to personally succeed in a way that leads to collective organizational success."
—Steven Covey, available from Principle Centred Leadership

This section is devoted to highlight the concept of organisation and is organised as follows:

- *2.6.1 Introduction and Background*
- *2.6.2 Communities and Social Construction of Knowledge*
- *2.6.3 Organisation's Continuum*
- *2.6.3.1 Business Management*
- *2.6.3.2 Project Management*
- *2.6.3.3 Systems Engineering*
- *2.6.4 Organisational Environment*
- *2.6.5 Visualisation of Organisational Knowledge*
- *2.6.6 Synopsis and Conclusion*

2.5.1 Introduction and Background

A characteristic feature and formative element of modern industry and service economy are organisations. In social theory the term organisation can be differentiated in the *act of organising* or the association of individuals or groups of individuals to accomplish *common interests*, which have a minor chance to be reached through the single individuals. In general, organisations serve specific selected *purposes* (technical, economical, social, political, human oriented), are segmented in terms of *work share*, have *directive instance*, and got a '*constitution'* (rights and duties) (Bueschges/Abraham 1997).

Organisation and *enterprise* are prevalent terms and frequently used in synonyms, by bodies of practice or science as well as across different disciplines of science. While in social science an enterprise is considered as one kind of organisation, the PMI[59] considers an organisation as part of an enterprise that is larger than the organisation itself. However, both perspectives do not fit to the purpose of the present work. Within this work it is rather of interest to investigate an organisation constituted of multi-enterprises[60].

For example an organisation where individuals are associated to the same enterprise – but can relate to different *teams* and *communities* (consult section 2.6.2) – is referred to by the author as an *intra-organisation*. In contrast, an organisation that is composed of individuals related to dissimilar enterprises is defined in this work as *inter-organisation* (e.g. partnerships like in European projects). In particular, an inter-organisation is challenged towards reaching commonly shared (accepted and understood) working principles (processes, methods, tools) as well as establishing a foundation for collaboration (e.g. tasks and goals). Moreover; Westphal/Thoben/Seifert (2007) argue that inter-organisational formations provide a frame of which individual enterprises, in particular small and medium-sized enterprises, can take advantages and overcome its own limitations comprising competences, capacities and financial resources. Whether intra- or inter-organisations (see Figure 21) are temporal constructs and could occur as one-off or more lasting formations.

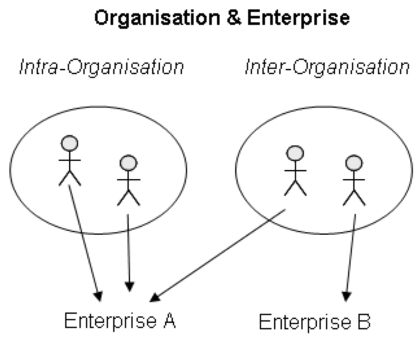

Figure 21: Intra- and Inter-Organisations

This introduced business-oriented organisation's model requires that each organisation and its members be related to at minimum one enterprise. But one enterprise can relate to one or more organisations (e.g. different projects).

[59] The PMI (2004) define an organisation as *"a group of persons organised for some purpose or to perform some type of work within an enterprise"* and an enterprise as *"a company, business, firm, partnership, corporation, or governmental agency"*.
[60] In this work an enterprise is defined as a company or firm (profit or non-profit).

2.5.2 Communities and Social Construction of Knowledge

Likewise an organisation, a community is characterised as a number of individuals that are in a social relationship and follow a common goal for a certain time (Bahrdt 2000). The notion of community and the social construction of knowledge (the act of learning) is founded on individual's information exchange and social interaction (Novak/Wurst 2004). Individual's social interaction drives common goal development and the individuals are acting together towards reaching these goals and solving arising problems. This social unit is characterised as a group. Bahrdt (2000) assumes that a community is a type of group and their existence and structure is characterised through its demarcation, rather than its isolation to its environment. The attitude of social acting is based upon subjective perceived togetherness of the involved individuals (Morel et al. 2001). The identity of each community's individual is based on the membership to this group (e.g. engagement, emotional relationship). Only in such (closed) groups and the related individuals, consensus about objectives, norms and rules is reachable (Bahrdt 2000).

Member's identity is a crucial aspect of the concept community, as it directs not only attention but also acting and thinking—it shapes the learning process (Lesser/Storck 2001). Communities are social factories creating knowledge and in accordance to Novak/Wurst (2004) develop commonality in sense making and language use. For example a stereotype of a community is the *community of practice*[61] (CoP). Lesser/Storck (2001) and Novak/Wurst (2004) introduce a CoP as groups whose members regularly engage in work related sharing of knowledge, learning and experience based on common interests. Boland/Tenkasi (1995) introduce a generalised term that is the "community of knowing" as a readiness for directed perception[62]. Lesser/Storck (2001) suggest thinking about community as an engine for the development of *social capital*[63] that results in greater knowledge sharing and in turn is key driving organisational performance. The knowledge transfer within a community tends to be good, because its members posses a common language and have the same background knowledge (Faber 2006).

The incoherent usage of the terms 'team' and 'community' within an organisational context could lead to confusion. For example Lesser/Storck (2001) provide the following distinction (see Table 1).

Feature	Team	Community
Relationship	When organisation assigns people to be team member	Are formed around practice
Authority relationship	Organisationally determined	In a CoP emerge through interaction around expertise
Responsibility	Teams have goals which are often established by people not on the team	Only responsible to their members
Processes	Rely on work and reporting processes that are organisationally defined	Develop their own processes

Table 1: Differences between communities and teams (Lesser/Storck 2001)

[61] In literature a number of different stereotypes of communities emerge. In the following sections the community of business management, project management, and systems engineering are discussed in detail.

[62] Boland/Tenkasi (1995) conclude that their concept of community of knowing echo other terms like "community of learning", "interpretive community", "context of learning" including "community of practice". The notion "community of knowing" is the most appropriate label for this work.

[63] Social capital describes the value of individual's relationships, in contrast to human capital (consult for example Coleman 1988; Becker 1996).

This comparison illustrates that two types of groups can be distinguished (consult Figure 22). Within an organisational context, teams emerge as *formal frame* ("functional" within individual's business profession) and in contrast communities as the *informal frame* ("voluntary" contribution of individuals). Team's members can relate to a number of similar or dissimilar communities. Moreover, communities can exist within an organisation (e.g. an informal meetings for modelling and simulation specialists from different business units) or outside of an organisation (e.g. news groups). Lesser/Storck (2001) conclude that in some organisations communities are becoming recognised as a valuable means to handle unstructured problems and to share knowledge outside of traditional structural boundaries.

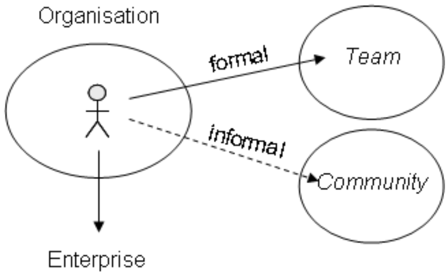

Figure 22: Example of teams and community in an organisational context

In turn organisations can internalise community's knowledge and construct new knowledge—they learn from communities and potentially capitalise from constructed knowledge. Organisations, teams, and communities they all fulfil the characteristics of collaboration and span representative conceptual frames in which 'human' collaboration could occur.

Lesser/Storck (2001) have shown a number of differentiating features of teams and communities, but those also have certain commonalities in *cultural aspects*, e.g. sense making, norms and values, beliefs and expectations. It is not subject of investigation to show that teams and communities are different types of groups. The perhaps more interesting challenge is the construct of cross-communities. Novak/Wurst (2004) mention, *"much research has been devoted to the development of tools and systems for supporting knowledge creation and sharing in teams and within communities, the problem of supporting cross-community has been relatively under-investigated".* Further, they highlight *"knowledge exchange between heterogeneous communities of practice as critical source of innovation and creation of new knowledge"*. To follow this route of investigation, it is sufficient enough to consider group's cultural aspects only, which allows us to use the terms teams and communities as synonyms[64].

[64] A further term that is employed in literature is the notion "domain". This notion shall not be further defined; rather it will be used as a synonym.

Novak/Wurst (2004) established some requirements for supporting cross-community sharing and creation of knowledge, which are synopsised in Table 2.

Short description	Description
Different "thought worlds"	Different communities inhabit different "thought worlds" (Dougherty 1992) which determine how their members interpret the meaning of information, artefacts, procedures, events, and experiences
Different knowledge perspectives	Knowledge artefacts produced by different communities (e.g. documents) are not neutral organisation of information, but reflect perspectives of those involved in the sense making process. Thus knowledge cannot be simply passed on by exchanging information between members of different communities (Novak/Wurst 2004).
Establish a shared Context of Knowing	To support the sharing of knowledge between different communities we need to provide a way for members of different communities to establish a "shared context of knowing" as way of "locating one form of knowledge in the context of another" (Boland/Tenkasi 1995, Swan 2001), which requires o Knowledge perspectives underlying individual communities be captured, represented and visualised o Knowledge perspectives need to be put in relation to each others, which could require extensive participation in community interaction and is a matter of value for money
Perspective Making and Perspective Taking	Describes the process of knowledge exchange between different "communities of knowing" (Boland/Tenkasi 1995) o PM refers to intra-community development and refinement of knowledge o PT refers to making the thought-worlds of different communities visible and accessible to each other Both are connected constructs: a community develops knowledge both through social exchanges and knowledge discourses between its members, as well as taking on perspectives of others. This cross-community involves two needs: o Need to share meanings among a community's members o The need to negotiate and coordinate meanings among different communities Communities share, convert, negotiate and cooperate only through negotiation of perspectives
Boundary Objects	Boundary objects (BO) refers to knowledge artefacts that embody different perspectives and can be interpreted in different ways, without the need for prior shared understanding to be established. BO are essential means for supporting cooperation between different communities in a way, which allows each community to retain local perspectives and yet these perspectives to become interconnected
Visualisation of cross-community knowledge perspectives	Supporting cross-community exchanges through visualising community knowledge perspectives and relating them to each other

Table 2: Requirements for supporting cross-community sharing and creation of knowledge (adapted from Novak/Wurst 2004)

In the following sections some prevalent types of organisational communities are discussed as prerequisite to investigate on cross-community aspects.

2.5.3 The Organisation's Continuum

The constructs of enterprise and organisation, community/team are introduced and delimitated. It is depicted that each organisation could be constituted of a number of differentiating communities and teams. The business context of an organisation was realised through the relation to one or more enterprises. This distinction enabled to have a better understanding of potential possibilities of how organisations are formed (intra- or inter-organisation).

This work focuses on project-based[65] organisations and utilises the ISO/IEC 15288[66] "Systems Life Cycle and Process Standards" for introducing organisation's prevalent communities. Generally, the standard provides a guideline of processes, activities and outcomes[67] that covers the systems life cycle. In accordance to ISO/IEC 15288 and Arnold/Lawson (2004), the author of the present work differentiates four kinds of organisation's groups[68]: *Business Management*, *Project Management*, *Systems Engineering*, *and Speciality Engineering* (consult Figure 23).

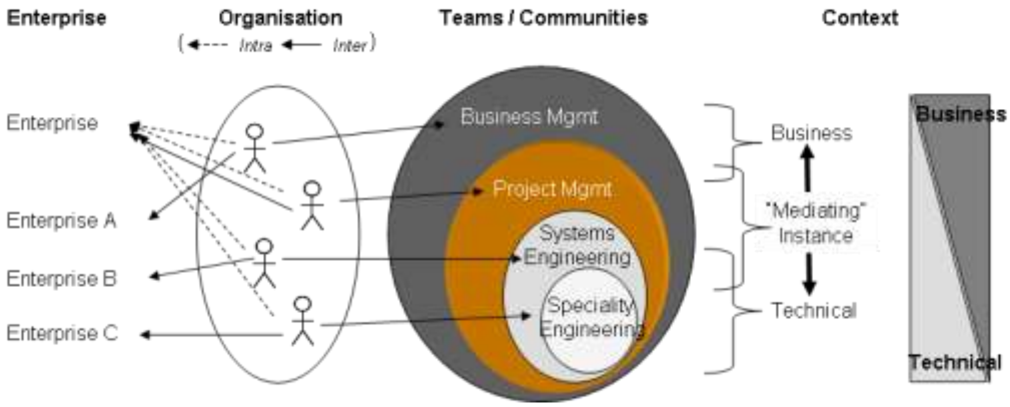

Figure 23: Organisational structures

For example Westphal/Thoben/Seifert (2007) argue that *"collaboration creates an organisational environment in which enterprises and human actors temporarily or permanently can merge their processes for performing joint business in hierarchic way"*. This in fact is an example and a loosely argumentation for composing inter-organisation formations.

The standard aims at establishing a systems-oriented thinking organisation. It continuously spans the different organisation's communities: from business management processes to project management processes over to systems engineering and finally provide interfaces with engineering specialism processes. For engineering specialisms the standard provides three generic implementation classes: hardware and software implementation, and human task implementation—more specific implementation guidelines for concepts of systems engineering into special system elements is a matter to other standards, e.g. software implementation in systems is referred to ISO/IEC 12207.

In the following sections the identified groups are introduced in more detail[69].

[65] The PMI (2004) differentiates between project-based and non project-based organisations. Project-based organisations fall into two categories: enterprises perform their work for others under contract, or enterprises that have adopted management by projects.
[66] The standard aims at providing - with a strong systems thinking attitude on all organisational levels - an interrelated process description for the communities of enterprise or business management, project management, systems and specialists engineering group.
[67] Outcomes are not further defined in terms of their contents and properties.
[68] Groups comprise whether communities or teams as defined in section 2.5.2.
[69] A number of different speciality engineering groups exist: electrical, aerodynamic, mechanical engineering, etc. The community of speciality engineering is not in the focus of this work and will not be further detailed.

2.5.3.1 Business Management

Business management (BM) is the directive and strategic instance of an organisation that is concerned with the organisation's business development. It includes updating and maintaining organisation's purpose, screen for new markets and customers and identify potential business opportunities and needs, and engage in conceiving, creating, utilizing and retiring products (see Figure 24).

This instance has the responsibility to elaborate and establish meaningful strategies and tactics in response to new business opportunities, and create a business framework[70] that reflects the optimum project investigation paths for the organisation to potentially meet the needs of its stakeholder whether inside and outside of the organisation (Arnold/Lawson 2004). The BM captures the future view of the business (business analysis) to provide context to project requirements (IIBA 2006).

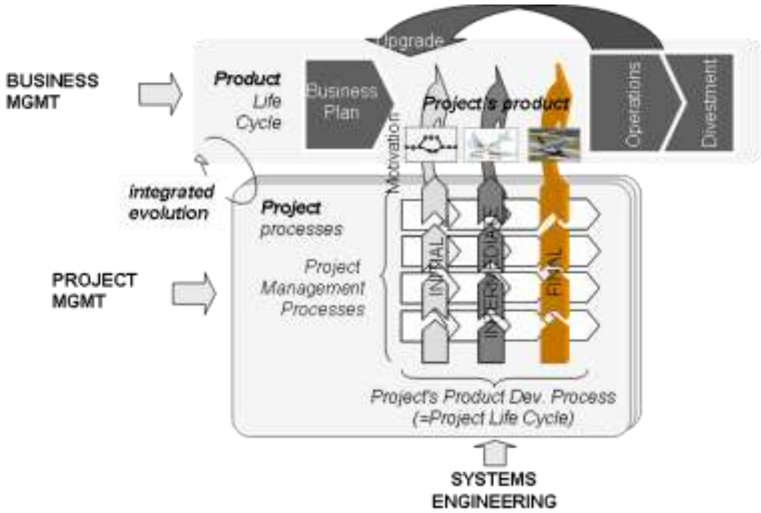

Figure 24: Relationship between business management, project management, and systems engineering (partially adapted from PMI 2004)

Strategic changes (e.g. political, financial changes) shape events in constructing and deconstructing the portfolio of projects quite likely including feasibility study, business case elaboration, risk rating, etc. and projects follow the organisational vision, goals, and governance (IIBA 2006; DeRosa et al. 2006). Generally, BM can establish two versions of projects which could contain a potential level of innovation[71], something *new* in a sense: a project that envisions at improving or optimising organisational business processes (i.e. process innovation), or projects that are delivering tradable objects[72] (i.e. product innovation). The responsibility for the creation of a process or product innovation is then assigned to a project within the framework of the organisational policy (contractual issues)[73] which confers the authority from the BM to employ organisational infrastructural capability

[70] DeRosa et al. (2006) state that business framework's components *"describe the roles and relationships in an organisation and can be further noticed as strategic information asset, which defines the business mission, the information necessary to perform the mission, the technologies necessary to perform the mission, and the transitional processes implementing new technologies in response".*

[71] Innovation is referred to by DeRosa et al. (2006) in the synonym of *differentiation*.

[72] Refers to something that can be traded with a quantity and a price in some markets.

[73] cf. Bueschges/Abraham (1997) "…each organisation got a '*constitution'* (rights and duties)", cited in section 2.6.1.

technologies and enabling resources as well as acquire externally provided assets and services (Arnold/Lawson 2004). Key aspects of this policy consider the creation, support and review (solution assessment and validation) of projects. DeRosa et al. (2006) point out that technical dimensions of the organisation are tied into business decisions and stand for a part of the learning and control dimension of an organisation.

2.5.3.2 Project Management

"Projects[74] play an essential role in the growth and survival of organisations today." (PMI 2004). Projects are potential vehicles towards achieving organisation's strategic business plan, which is not attainable during ongoing organisation's operation sustaining the business[75]. In turn, *project management* (PM) is established as a mediating instance, authorised and responsible for implementing addressed organisation's conceived business needs and expectations, and carrying out appropriate responses in terms of project's products[76].

In addition to PMI's product definition (see footnote 75), the author of this work considers the project's product as follows:

> ***Project's Product.*** *The project's product is constituted of engineered things/objects for which the product life cycle is tailored and delivers the expected results (quality and functional characteristics) to satisfy the organisation and the environment as it has been considered in the project.*
>
> *Own definition*

Figure 24 exemplarily illustrates the interrelations between the *product life cycle* and *project processes*. The product life cycle starts with a business plan and goes through idea, to product, ongoing operations and product retirement. Project processes are twofold in *project management processes*[77] and *project's product processes* (Project Life cycle). The PMI[78] (2004) identified that PM is accomplished through the

[74] In this work a project is defined in accordance to the PMI (2004) as *"a temporary endeavour undertaken to create a unique product, service or result"*.

[75] "Projects and operations differ primarily in that operations are ongoing and repetitive while projects are temporary and unique—the purpose of a project is to attain its objective and then terminate" (PMI 2004). The PMI notices a progressive tendency of organisations in adopting "management by project" approach—that means organisation's operations are organised and facilitated in projects.

[76] Cf. The PMI (2004) defines a product as *"an artefact that is produced, is quantifiable, and can be either an end item or a component item"*, a service as *"work performed that does not produce a tangible product or result, such as performing any of the business functions supporting production or distribution"*, and a result as *"an output from performing project management processes and activities"*. The service aspect is not considered in this work.

[77] cf. Milosevic (2003) underlines that the different projects vary in their technical activities and not in their management activities.

[78] PMBoK (2004) is the Project Management Body of Knowledge related to a joint work of the Project Management Institute (PMI) and is a collection of processes (5 process groups) of knowledge (9 areas) accepted as best practices generally applicable to all projects. The PMBoK (2004) is approved ANSI/PMI. 99-001-2004. ISO 10006:2003 titled 'Quality Management Systems – Guidelines for Quality Management in Project's treats definition of terms and processes. The ISO 10006 (2003) standard consists of 7 processes to produce the projects' product. The ISO standard gives guidance on

application and integration of *project management processes* of initiating, planning, executing, monitoring and controlling, and closing. These *process groups* and underlying processes as well as activities are guiding principles to apply appropriate knowledge and skills during the project. Once a project is divided into different phases[79] these process groups are probably repeated within each phase throughout the project. The PMI (2004) further stresses the matter of responsibility for deciding what processes from the process groups will be employed, by whom, and the degree of rigor that will be applied to the execution of the processes to achieve the desired project objectives. The applied and underlying concept for the interaction among the project management processes is the Deming Cycle[80] also known as the Plan-Do-Check-Act Cycle. This concept is a repetitive closed feedback loop, where results from one part of the cycle become the input to another—it is defined as a continuous process improvement cycle. Project life cycles processes are quite common (may vary in rigorousness) from project to project, whereas project life cycle models are predominately subject of customisation varying in relation to the project's products. There is no single best way to define an ideal project life cycle, rather it is science and art of the organisation shaping and customising the appropriate project processes and carrying out project's products ready to be operated. The project life cycle goes through a series of technical phases that are established to create the specified product (PMI 2004) that meets the business needs and expectations. Additional projects can include performance upgrades for an existing product. In some organisations project life cycles are considered as part of the product life cycle and many projects are linked to ongoing operations of the performing organisation (PMI 2004, e.g. new product released to manufacturing).

Figure 25: Project- and product-success

The prevalent triadic structure of a project, and that is to be managed by project management, is frequently denoted as *magic triangle*. The key interrelating indicators

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the application of quality management in projects and not intended to be used for certification/registration purposes. The PRINCE2 (2005) "Projects in controlled environment" is a project management methodology. It is a process driven project management method consisting of 8 process groups.

[79] A number of different lifecycle models exist, e.g. there are few prevalent generic models like Waterfall-, Spiral- or V-Model orienting on software and systems development.

[80] Deming's approach to total quality is a management led process that actively involves every labour in satisfying customer needs (internal and external) by continuously improving all aspects of work activity through structured control, improvement, and planning methods. The Deming wheel is a simple concept for continuous improvement adaptable on various problem-preventions and problem-solving aspects.

of the magic triangle are *quality, time* and *cost (QTC)*, which embody the constraints of a project and demarcate the indication for project success (see Figure 25). Cost (e.g. humans, machines, material, facilities and other efforts) and time are project resources. Quality is the more difficult to grasp concept. This work comprises a threefold distinction of project quality aspects:

- The availability and adequacy of individual's *cognitive capabilities* (craftsmanship) needed to conduct project work at the various levels. All organisation's individuals and their organisation's origination in underlying structures associating to their tasks to the project's product
- The appropriateness of *processes, methods* and *tools* to support a quasi-standardised and secured execution of the project work (project management processes, project's product processes see below)
- The features and functions of *the project's product*. The project's product herein is constituted of engineered things/objects for which the product life cycle is tailored delivering expected results (function and features) within the resources allocated to the project. All relevant assets, the underlying product breakdown structure and associated technical (engineering) work are allocated here.

PM's *task* is to evaluate project achievements and progress towards *technical (project's product), schedule* and *budget* requirements, as well as to demonstrate achievements and progress at decision gates established by the enterprise management (Arnold/Lawson 2004).
The project's processes are about seamless performance of orderly arranged project activities and phases, resulting in project deliverables (Milosevic 2003). Project deliverables indicate the various interim work results comprising one or more specific tasks assigned with associated resources, labours (cognitive capabilities) and applied means (methods, processes, tools), and are in a certain way addressed to the project's product.

2.5.3.3 Systems Engineering

"Project management in the absence of systems engineering is meaningless, and the ties between the two disciplines have not been well documented" (Stevens et al. 1998). *Systems engineering* (SE) is considered as the technical PM instance concerned with the development of *project's product* and processes. Stevens et al. (1998) assume that the primary link is established through project deliverables associated with the project's product (consult Figure 25). Both disciplines PM and SE are highly interdependent, which is reasonable due to each technical decision has a management consequence and vice versa. In contrast, the differentiating feature between these two disciplines is that SE is more concerned with creating, defining and improving the project's product, while PM is more concerned with the delivery of the project within the given resources.

System theory centres the notion of system as an essential part for describing or abstracting (parts) the reality, the real world in sorts of models (cf. Edmonds 1999). The concept of system appertains to the branch of information and computer science, engineering, and social science. More specific, engineering branches like concept of electrical engineering, software and systems engineering centres the notion of system in their perspective (INCOSE 2004).

Arnold/Lawson (2004) summarise that the branch of SE conduct technical processes and the associated activities, establishes a technical reference for unification of more specialised engineering disciplines, and guide engineering specialist's effort from a systems thinking perspective throughout the whole project life cycle. The DAU (2001) defines the SE process as a top-down solving process that is applied across all project life cycle stages and issued to:

- Transform needs and requirements into a set of system product and process descriptions (adding value and more detail with each level of development),
- Generate information for decision makers, and
- Provide input for the next level of development.

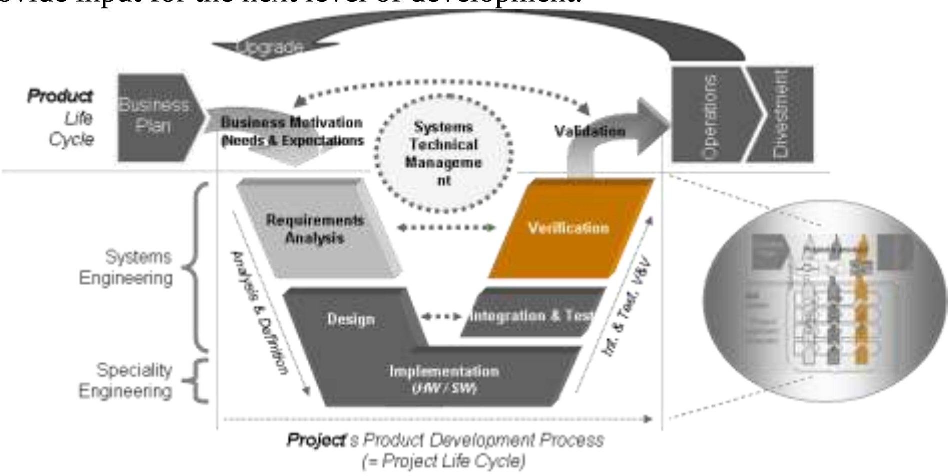

Figure 26: Systems engineering's role in the product development process[81]

Figure 26 illustrates a more detailed resolution of the core activities of SE. Each SE activity as such is a complex task and got its essential role in the project's product development process. A detailed review of each single process step would go too far in the frame of this study. However, a brief introduction is given as follows:

- **Requirements Analysis**: This activity includes the interpretation of the business stakeholders' motivation needs and expectations and the subsequent implementation into a requirements specification (from top-level to detailed requirements). Sometimes this phase starts with the elaboration of an operational concept, which describes the envisaged use of the system and the actors as well as their activities involved.
- **Design**[82]: Logical (functional) and physical system design (also called architecture) including interfaces is defined within this step. Elaboration of the design specification (from initial to detailed design) defining how the system is going to meet the requirements.

[81] The figure shows an idealised illustration of development activities. Development activities in practice are of concurrent and iterative nature.

[82] The term "architecture" or "design" are frequently used in various contexts in the general field of engineering. It is used as a general description of how the subsystems join together to form the system. It can also be a detailed description of an aspect of a system: for example, the Operational, System, and Technical Architectures used in Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR), and software intensive developments (DAU 2001).

- **Implementation**: This activity is executed by *speciality engineering groups* who are concerned whether with the building of hardware or software components.
- **Integration & Test**: Each of the hardware / software components are completed in this phase. Components are integrated into the overall systems architecture and tested ensuring that the design specification is met.
- **Verification**: In this phase the overall system's formal fit for purpose is proved through a reflection on the requirements specification.
- **Validation**: This stage comprises prove of the system within its expected business and operational behaviour and involves relevant (business and operational) stakeholder and actors.
- **Systems Technical Management**: This phase encompasses overall control, monitoring and evaluation activities of all previous mentioned SE activities. Trade-offs and adaptations within plans are taken throughout the development process resulting into decisions taken in cohesion with the business motivation and approved by project management[83].

All these activities are executed repetitively throughout the project life cycle and in correlation with applied project management processes. Moreover, the complete set of SE activities are applied to all decomposed levels of the system (sub-systems, sub-sub systems, etc.) and the relating interfaces that have to be managed in front of speciality engineering groups.

A particular focus of this work relies on organisation aspect, handling information that is determined in the early phase of requirements analysis. In contrast to the classical task model of requirements analysis, goal-oriented approaches in RE try to integrate the organisational context upstream in the PD process.

Early Requirements Analysis

Yu (1997) states *"Requirements are usually understood as stating what a system is supposed to do, as opposed to how it should do it. However, understanding the organizational context and rationales (the "Whys") that lead up to systems requirements can be just as important for the ongoing success of the system."* Prior research on RE optimised the traditional task model on requirements analysis starting from the concept of requirements statements[84]. The respective view on the requirements information model provided not only an un-rationalised, but also a "flat" representation on requirements specification documents; the former is sometimes considered in form of a requirements' statement attribute; the latter through cluster (i.e. chapter) within requirements specification documents. Further, vanLamsweerde (2004) states that *"a well structured document specifying adequate, complete, consistent, precise, and measurable requirements is critical prerequisite for software claiming to deliver "What you get is what you want."* The importance of the goal concept was identified in requirements engineering (RE) in early 1990s (Yamamoto et al. 2006). The introduction of goal-oriented requirements analysis enriches and

[83] Cf. DAU (2001) states that *"evaluate alternative approaches to satisfy technical requirements and program objectives, and provide a rigorous quantitative basis for selecting performance, functional, and design requirements."*

[84] Cf. Yu (1997) states *"Much of requirements engineering research has taken as starting point the initial requirements statements, which express customer's wishes about what the system should do. Initial requirements are often ambiguous, incomplete, inconsistent, and usually expressed informally."*

complements approaches of structured analysis[85] and object-oriented analysis[86] (Mylopoulos et al. 1999; Yamato et al. 2006; vanLamsweerde/Letier 2004) concerned with modelling the *relevant* part of the real world. In literature, goal-oriented requirements analysis is discussed in synonyms of conceptual, organisational and intentional modelling and analysis, and is concerned with identifying the process a system, human or existing system should perform.

This area of research has attracted much interest from the software engineering domain (Kavakli/Loucopoulos 2003), while less recognition is perceived within the systems engineering domain judging on the amount of publications available[87]. In software engineering goal-oriented approaches encourage the modelling of goals in order to understand or describe problems associated with business structures and processes, and their supporting systems (Kavakli/Loucopoulos 2003). Whereas *goals* is a concept that is driving force towards requirements elicitation, elaboration, organisation, analysis, negotiation, and evolution (vanLamsweerde 2001) as well as designing business processes and serve as criteria for requirements completeness (El Ghazi 2007).

In accordance to Pohl`s (1996) RE task model, Kavakli/Loucopoulos (2003) established an overview on contributing features of goal-oriented approaches (see Table 3). Those are mostly concerned with modelling (requirements elicitation and specification) and analysing (requirements negotiation) goals, but also to define stakeholders' criteria to assess fitness of system components (requirements validation).

RE Activity	Contributing features	Goal-Oriented Approach[88]
Requirements elicitation	1. Understanding the current organisational situation, 2. Understanding the need for change	GOMS, Goal-based Workflow, i*, EKD ISAC, F³
Requirements negotiation	3. Providing the deliberation context of the RE process	SIBYL, REMAP, The reasoning loop model
Requirements specification	4. Relating business goals to functional and non-functional system components	KAOS, GBRAM, the NFR framework, the goal-scenario coupling framework
Requirements validation	5. Validating system specifications against stakeholders' goals	GSN, GQM

Table 3: Goal-oriented approaches in RE and contributing features (adapted from Kavakli/Loucopoulos 2003)

A commonly shared definition of the notion of "goal" from a RE perspective does not exist.

- A goal is an objective that the future system must guarantee by a suitable cooperation of agents[89] with the system (Rolland (2003), cited in El Ghazi (2007)).

[85] A methodological approach that considers the definition of the system-as-is, define changes and build the system-model-to-be. DeMarco (1978) built basis of the concept of structured analysis (Pohl 2007).

[86] Wikipedia states *"Object-oriented analysis is a software engineering approach that models a system as a group of interacting objects. […] There are a number of different notations fro representing these models, such as Unified Modelling Language."*, Internet, available from http://www.en.wikipedia.org/wiki/Object-oriented_anaysis, Internet, accessed 25 July 2008

[87] Cf. vanLamsweerde/Letier (2004) state that *"recent surveys have confirmed that the growing recognition of RE as an area of primary concern in software engineering research and practice"*.

[88] For further information on the specifics of the methods see for instance Kavakli/Loucopoulos 2003.

- A goal is an objective under consideration should achieve and refers to intended properties to be achieved (Lamsweerde/Letier 2004).
- Goals represent objectives that the system ought to achieve, refer to properties intended to be ensured (Zave 1997) and thus are requirements at a higher level of abstraction (Yamato et al. 2006).

In principle, those definitions have all in common that the construct of goal aims at establishing intentional structures considered as contextual information for a system to be developed.

The concept of goals is applied on organisational level (e.g. i* approach (referred to the early requirements phase), see Yu 1997) as well as on system level (e.g. KAOS approach (referred to the late requirements phase), see vanLamsweerde 2001)[90].

The construct of goal *contributes* to RE through integrating business intents in engineering definition providing a contextual frame. Lamsweerde (2001) describes the general approach of GORE as a mix of bottom-up and top-down sub-processes as goal models are built asking "Why" and "How" questions about source material obtained from interviews and available documents. The *classification* of goals is differentiated in general and specialised forms. The majority of GORE approaches are formal or semi-formal. Moreover, *relational* characteristics are discussed in intrinsic and extrinsic types. Table 4 complements the overview on characteristics of goals in context of RE.

Characteristic	Description	Reference
Contribution	• Sufficient criteria for completeness of a requirements specification • Requirements pertinence and rationale • Provide roots for detecting conflicts among requirements • Refinements help to structure specification requirements • Goals are more stable structure than alternatively growing underlying requirements structures • Provide the roots for detecting conflicts among requirements	vanLamsweerde (2001)
Source	• Current system, existing documents, interviews, refinement & abstraction asking why and how questions about requirements / goals available, scenarios	vanLamsweerde (2001); El Ghazi (2007)
Classification	• Functional: lead to particular function for the new product/system expected to be delivered; sometimes used in synonyms of *hard* or *concrete* goal whose satisfaction can be established through verification techniques and can be directly measured. Functional goals are satisfied through a process to be carried out by the system, human, and/or other existing systems. • Non-functional: express (global) system qualities; sometimes used in synonyms of *soft-goal* or *abstract goal* (achievement not directly measurable) which have no clear-cut definition and are hard to express	vanLamsweerde (2001); Yamato et al. 2006, Mylopoulos et al. (1999)

[89] Agents are system components such as humans playing specific roles, devices, and software (vanLamsweerde/Letier 2004).

[90] i* is an early RE approach devoted to consider and model dependencies among actors as well as the reasons (goals, soft-goals, tasks, resources) associated with each actor and their dependencies. The KAOS approach considers modelling system goals and is state-oriented. In turn TROPOS (2008) *"proposes a software development methodology founded on concepts used to model early requirements. In particular, the proposal adopts Eric Yu's i* modelling framework, which offers the notions of actor, goal and (actor) dependency, and uses these as a foundation to model early and late requirements, architectural and detailed design".*

	• Temporal Behaviour: 1/ ***achieve*** goals generate system behaviour, in that they require target property to be eventually satisfied in every future state; 2/ ***maintain*** goals restrict behaviours, in that they require some target property to be permanently satisfied in every future state unless some other property holds. 3/ ***Optimise*** goals compare to behaviours to favour those which better ensure some soft target property	Dardenne et al. 1993
Formats	• Informal (natural language, text), semi-formal (box-arrow diagrams), formal (logical assertions in formal specification languages, aim at providing consistent, unambiguous, and precise representation of goals)	Kavakali/Loucoupolos (2003)
Attributes	• Name and specification, priority indication	VanLamsweerde (2001)

Link types	• Intra-relations - goals with each other:
	  • And (refinement links relate a goal to a set of sub goals)/Or (Or-refinements indicate alternative setoff refinements) refinements in a set of sub-goals; Conflict / Contribute link: negatively, positively
	• Inter-relations – goals with requirement model:
	  • Goals and scenarios have complementing nicely the elicitation and validation
	  • Relate goals to agents (responsibility links)
	  • actor owns which goal or some view of it
		VanLamsweerde (2001),
		
		El Ghazi (2007)

Specifying goals	• Textual, graphic syntax	VanLamsweerde (2001)

Table 4: Characteristics of goals in RE context

Exemplarily, Figure 27 provides an impression of a goal-model structure in accordance to the i* modelling framework for early requirements consideration.

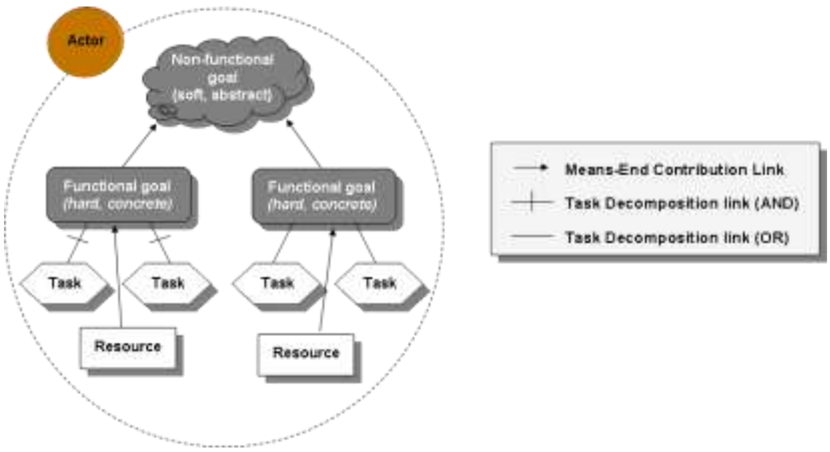

Figure 27: Simple illustration of a goal model using i* notation as an example

Goal-oriented analysis analyses functional requirements[91] as soft-goals and non-functional requirements[92] as goals (Mylopoulos et al. 1999). Goals are illustrated in forms of refinement patterns decomposition (i.e. decomposition). Non-functional goals at high (e.g. whole system) level typically lead to functions at lower (e.g. subsystem) levels (Alexander 2003). Functional goals satisfying non-functional goals,

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[91] Functional requirements are the things that the system must take, an action that the system must carry out to provide a service to the user (Robertson 1999).

[92] Non-functional requirements are characteristics, properties or qualities that the system must have. They are sometimes critical to the success of a system (Robertson 1999).

while specific tasks and resources can be assigned within a business process context through "and/or" relationships indicating alternative paths. Actors rationalize the existence of goal models.

El Ghazi (2007) points that the concepts of business goals (purposes that the business organisation desire to achieve) and their relationships to functional and non-functional requirements are not clear-cut[93]. While Kavakali/Loucoupolos (2003) argue that fewer approaches support stakeholder involvement in the goal modelling process. They further claim that a focus is on representation aspects of goal analysis, most widely used semi-formal and often approaches combine diagrammatic with formal techniques. Cyprus (2004) mentions conflicting concerns of formalism and usability and the need for compromising between both in RE practice. Lamsweerde (2004) states the need for effective tool support in context of industrial GORE projects that scale up to the size of project deliverables and can be used by non-experts is still at an optimising level. He experienced that in practice one third of the time is required for goal-model building; whereas the latter needs twice the time for interviewing people along the process of requirements analysis.

2.5.4 The Organisation's Environment

"Evolution of the organisation is done through the continual process of variation and selection in which the stronger innovative solutions are integrated into the organisation" (De Rosa et al. 2006) for innovating business processes or products attracting the environment, e.g. the market. With the rapidly changing competitive business environment, projects are viewed as a means to manage change and achieve strategic plans developed by business management. Competitive advantage is now linked to an organisation's ability to rapidly deploy business solutions and to effectively make those applicable in an operational context (PMI 2004).

An organisation's environment behaves like a fluid which continually deforms and to which an organisation has to adopt and react. In accordance to Baumard (1999), organisation's transition time to construct "cohesive, 'objective', interpretations" of this environment is limited. Daft/Weick (1984) provide four major assumptions of the nature of organisations and how they are designed and functioning:

- ***Organisations are open social systems that process information from the environment***—The environment contains a certain degree of uncertainty and requires actions, develop information processing mechanisms capable of detecting trends, events, competitors, markets, and technological developments relevant to organisation's survival.
- ***Individual versus organisational interpretations***—Individual human mutually send and receive information and carrying out interpretation processes involving individuals but also cognitive systems and memories (e.g. individuals come and go).
- ***Business managers at the strategic level formulate the organisation's interpretation***—Organisational interpretation is related to a relatively small group

[93] El Ghazi (2007) proposes a three step process of goal analysis towards requirements: 1/ capturing actors' goals (strategic actors, who are the future users), 2/ Analyse actors' goals (translate actors goals into system requirements, 3/ requirements elicitation (discovery of system requirements, elicitation of requirements from system goals).

at the top of the organisation's hierarchy that is then channelled into the organisation. Organisations can be seen as a series of nested systems and each subsystem may deal with a different external sector.

- ***Organisations differ systematically in the mode or process by which they interpret the environment***—Organisations develop specific ways, interpretation processes to anticipate the environment based on organisational and environmental characteristics and in turn influence organisational outcomes such as strategy, structure, and decision making.

In conclusion organisations can be seen as immense interpretation systems, reconciling their intrusions into the environment with the confidence they have in their capacity to interpret it (Baumard 1999). Whereby, interpretation is a process of translating emerging events of developing models for understanding, of bringing out meaning, and of assembling conceptual schemas among key managers (Daft/Weick 1984).

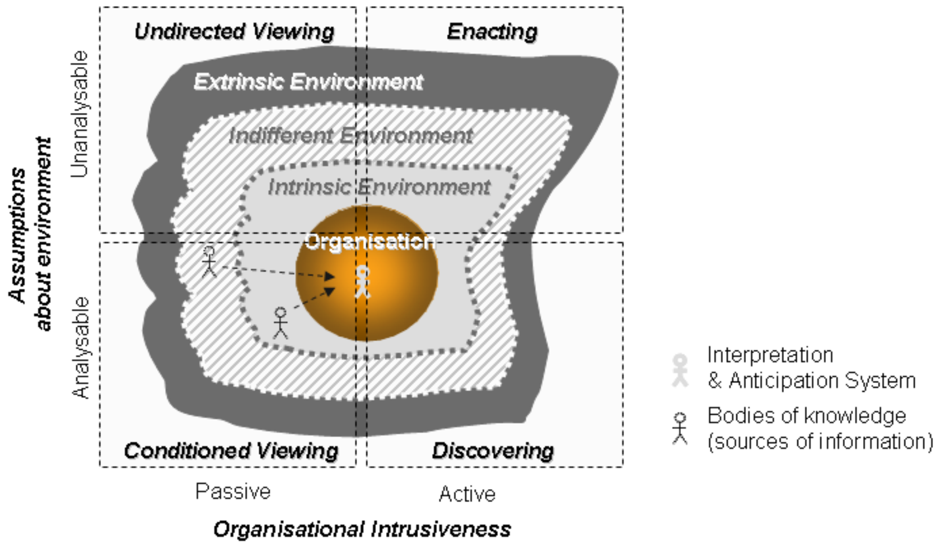

Figure 28: Organisations as interpretation and anticipation systems

In reflection to Penco's (1999) understanding of *objective context* (consult section 2.4.2) as the abstraction of the reality in models which is limited if not impossible, organisation's opportunities towards interpreting its environment as discussed above are limited also (e.g. limited access to bodies of knowledge and information, unknown in terms of their existence, causal chains are too abstract and thus too complex to be considered in models, etc.). Figure 28 illustrates the delimitation of the organisation's environment into an *extrinsic* and an *intrinsic* part. The intrinsic borderline distinguishes organisation's relevant business context[94] towards the extrinsic environment that is the part not going to be considered within the product life cycle as well as in project processes. The intrinsic environment defines the organisation's relevant business context that is basis for the high level definition of innovation processes or products. The distinguishing zone between the extrinsic and intrinsic environment contains indifferent bodies of knowledge, unclear to be consider whether or not within the organisation's business context. This in turn is a matter of the objective or metaphysical context's complexity that affects also a definite delimitation in form of a clear context boundary. However, during the temporal course,

[94] Can be referred to Penco (1999) generic definition of subjective context introduced in section

progressively more information is available and zones evolve more and more accurate.

Daft/Weick (1984) have used the concept of interpretation twofold in business management's belief about the *analysability of the organisation's environment* and the extent to which the organisation *intrudes into the environment to understand* it. This conditioned consideration of interpretation led to model of four modes (associated in Figure 28): *Enacting* (experimentation, testing, coercion, invent environment, learn by doing), *undirected viewing* (constrained interpretations, non-routine, informal data, hunch, rumour, chance, opportunities), *conditioned viewing* (interprets, within traditional boundaries, passive detection, routine, formal data) and *discovering* (formal search, questioning, surveys, data gathering, active detection).

2.5.5 Visualisation of Organisational Knowledge

The concept of knowledge visualisation is discussed by Eppler/Burkhard (2004) as being concerned with "the use of visual representations to improve the *creation* and *transfer* of knowledge between at least two people". For example a conceptual visualisation is given by Nonaka's (1994) SECI model. The availability and representation of knowledge is a crucial means for supporting knowledge conversion within homo- or heterogeneous communities. In accordance to Eppler/Burkhard (2004), Novak/Wurst (2004) scrutinize visualisation twofold *"information visualisation typically solves problems of complex information structures (i.e. explore, store or provide access to large amounts of data), while knowledge visualisation is intrinsically connected to the problem of knowledge transfer in social structures."* Knowledge visualisation is divided into *content* (descriptive factors, principles and relations) and an associated *format*, triggering sense making in the interpreter's mind and update/complement the knowledge picture.

Visualisation of knowledge in organisations can serve as a conceptual "viaduct" within the ontological dimension of knowledge, capable to establish interrelationships at different organisational levels, i.e. at individual's level (mind) but also at department or speciality group level. Eppler/Burkhard (2004) define three application motives of knowledge visualisation.

- *Transferring knowledge*: The communication between the many different organisations' participants and their specific professional backgrounds is a major problem in organisations. Visualisation could act as a sort of mediating instance towards inter-functional knowledge communication and helping to make differing assumptions visible and communicable while common contexts (visual frameworks) help to bridge different backgrounds.
- *Creating knowledge:* Knowledge visualisation potentially helps to create new knowledge and thus drive innovation forces.
- *Information overload* (prerequisite for the previous application motives): Knowledge visualisation could compress large amounts of information with the help of analytical frameworks, theories, and models that absorb complexity and render it accessible.

The effects during knowledge transmission, i.e. overcome knowledge asymmetries (Eppler/Burkhard 2004) and the capability of recipient's cognitive capacity to mentally process incoming knowledge has been discussion in correlation to the

concept of context in section 2.4. It is challenging for organisation's participants to reflect knowledge bases of a different organisational speciality group, related to a different community. For example, communities have differentiating professional languages and vocabulary while exchanging knowledge about the same *thing*, but having rather differentiating *thinks* (e.g. engineering and business manager have distinguishing perception of the same product at hand). Different organisation's communities think and speak differently about similar objects. Access to knowledge bases is the first step in knowledge conversion, but a customised inside into complex knowledge bases (e.g. a number of extensive documents) is key towards efficient and effective knowledge sharing and creation in particular in cross-communities (consult Table 2).
Eppler/Burkhard (2004) hypothesise a threefold perspective: *type*, *motive*, *and format*, of a knowledge visualisation framework.

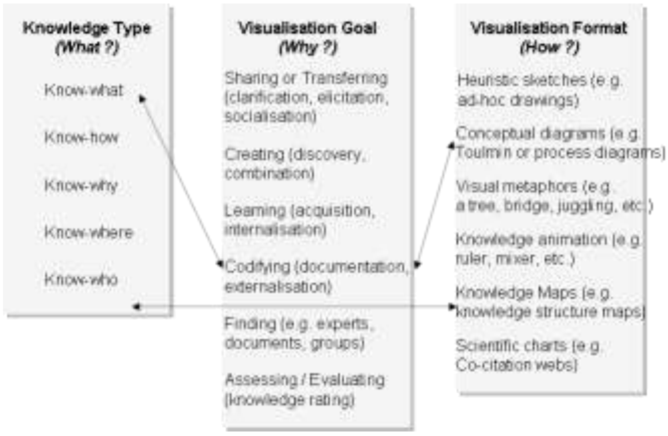

Figure 29: Three perspectives of the knowledge visualisation framework (Eppler/Burkhard 2004)

The *knowledge type perspective*, the *'What'* component, classifies five different types of knowledge going to be transferred (see Figure 29).

The *visualisation goal perspective*, the *'Why'* component, comprises the motive and provide justifications for the representation used.

The *visualisation format perspective*, the *'How'* component - provides six different sorts for implementing and realising an accurate knowledge representation mode within the framework.

In addition Boland/Tenkasi (1995) discuss a knowledge representation[95] within the following features.

- Overtly reflexive in that participants are trying to reflect upon their current state of understanding of some issue
- Capture community's cooperative efforts to reflect upon, interpret and depict, and understand their situation to themselves
- Sense-making forum in which the objects of discussion are visual representations of their understanding of a situation, a problem or an objective
- Open reflexive forum in which communities of knowing explicitly talk about their understandings

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[95] Beside knowledge representation forum, Boland/Tenkasi (1995) identified four additional forums: task narrative forums, interpretative reading forums, theory building forums, and intelligent agent forums.

- Means: storyboards, visual representations, cause maps or other diagrams, models

Boland/Tenkasi (1995) complement the knowledge visualisation framework and point particular features in correlation with notion of cross-communities.

2.5.6 Synopsis and Conclusion

An organisation has been introduced as a collective of individuals that are jointly acting together to accomplish common interests, while utilising synergising effects in terms of resources, knowledge and cognitive capabilities. Organisations and enterprises were delimitated, which enabled a differentiated view of organisations in inter- and intra-organisations. The differentiation is given through organisation's members affiliation to one (intra) or more than one (inter) enterprises.

Likewise an organisation, Bahrdt (2000) characterises a community as a number of individuals that are in a social relationship and follow a common goal for a certain time. Communities span a frame for its members with respect to common sense making, norms and values, beliefs and expectations. The emphasis of the present work regards the notion of cross-communities, its process of knowledge conversion between different thought-worlds and associated perspectives. The organisation's continuum was illustrated with a particular focus on project- and engineering-based organisations and is introduced in accordance to the ISO/IEC 15288 "Systems Life Cycle and Process Standards". Four organisational groups have been distinguished: *Business Management*, *Project Management*, *Systems Engineering*, *and Speciality Engineering*. In particular the early phase of requirements analysis has been pointed within its importance establishing integrated understandings on business and engineering level. The former three communities were focussed and have shown distinguishing features within Novak/Wurst (2004) aspects of cross-communities: different "thought worlds", different knowledge perspectives, establish a shared context of knowing, perspective making and perspective taking, boundary objects, and visualisation of cross-community knowledge perspectives. For the further investigation of cross-communities these highlighted aspects are essential.

Another essential characteristic within the analysis of cross-communities is the notion of *organisational environment*. An organisation can be seen as an interpretation system, screening and trying to understand the environment for potential business opportunities. The environment has been thereby differentiated in a triadic structure: intrinsic and extrinsic, and the indifferent environment. The intrinsic part encompasses all relevant assets for the organisation. In contrast, the extrinsic mirrors the irrelevant part that is not going to be channelled into the organisation. The borderline between these is not explicit, but rather a grey-zone. Contextually, to the extent of how the environment change and the organisation is adapting, equally the indifferent zone shifts and evolves towards concretisation and a different borderline. In order to evaluate the environment, an organisation has four possible interpretation modes (enacting undirected viewing, conditioned viewing, and discovering) characterised within two dimensions: *assuming* and *intruding* the organisational environment.

While performing interpretation about the environment on organisational level it is important to *visualise* this epistemic experience to the inside of the organisation. This requires establishing a commonly shared (accepted and understood) perspective before providing this for perspective taking of different/external communities of knowing (e.g. engineering). As a logical consequence the availability and representation of knowledge is a crucial means for supporting knowledge conversion within such cross-communities. Visualisation serves thereby as a medium for accessibility supporting the process of perspective making and taking, and bridges different organisational thought-worlds.

2.6 Synopsis and Conclusion

The theoretical foundation has been established within this chapter. Figure 30 illustrates introduced concepts of collaboration, knowledge, ontology and context in an organisational context, which comprises the aspect of cross-community collaboration and knowledge conversion. To sum up, the figure shows cross-community knowledge conversion between systems engineering, project and business management. This requires mutual update/maintenance of each other's communities' knowledge (conversion) evolution throughout the project life span – analysis of community cohesion.

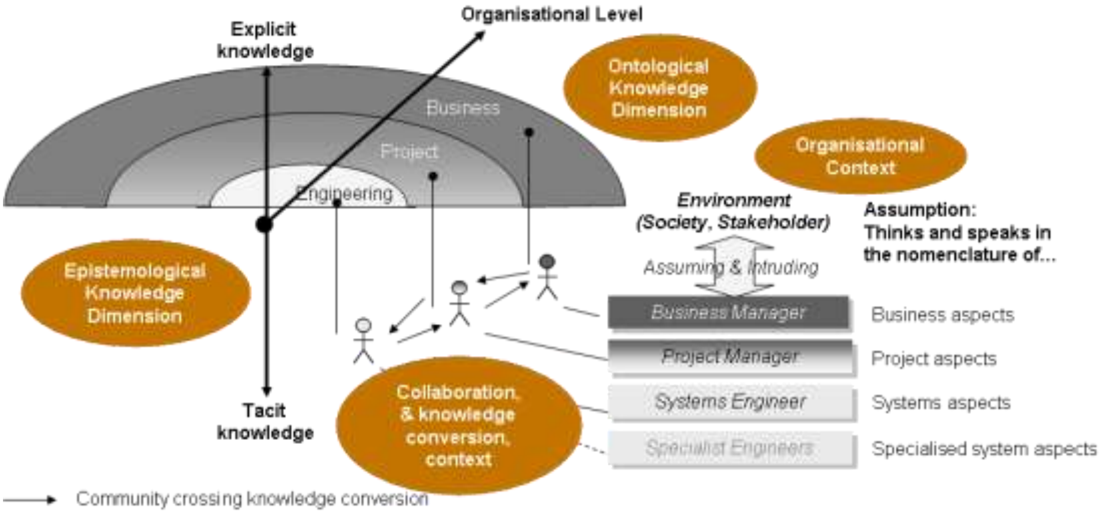

Figure 30: Cross-community collaboration and knowledge conversion in the organisation's continuum

Organisations were introduced as immense interpretation systems, whereby business management considers assuming and intruding the organisational environment and finally establishes the innovation path to develop new products or processes. The organisation provides the space in which communities of business and project management, systems and speciality engineering are acting.

It has been shown that an organisation and the smaller unit community provide the frame in which collaboration could occur between two individuals or larger collectives of individuals (communities). Collaboration appears in the modes of communication, cooperation and coordination towards the established objective for collaboration, which echo the aspect of group awareness (emergence). Along the ontological dimension of knowledge these communities share and create knowledge. This knowledge is exchanged within the objectives of collaboration and enables appropriate and valuable actions to be taken by the individuals. During the collaboration knowledge is transmitted or conversed in different modes along the epistemological axis of knowledge (a shifting mode between tacit and explicit knowledge – Nonaka's SECI model). It has been further shown that the notion of context takes an important role within assuring knowledge conversion.

In this context the aspect of cross-communities was discussed. Novak/Wurst (2004) have shown that a number of aspects in cross-communities have to be considered in order to reach a knowledge conversion. The essential point is finally the access, representation and visualisation of knowledge organised within a commonly shared perspective ready to be utilised by external communities.

Lastly, all relevant assets highlighted in the theoretical part of the thesis at hand are synthesised in Table 5.

Chapter	Concept	Features
2.1	**Collaboration**	
		General
		- 2+ individuals
		- Objective*: to solve a problem or improve a situation
		- Exchanging knowledge using cognitive capabilities
		Building Blocks
		- Cooperation, communication, coordination
		- Group awareness* (emergence), equal to objective above
		Direction
		- Horizontal & vertical collaboration
2.2	**Knowledge**	
		General
		- Is actionable information comprising cognitive capabilities enabling to take actions and make situational (spatiotemporal) decisions?
		- Data, information, knowledge
		Types of organisational knowledge
		- Explicit, tacit
		- Individual, collective
		- *Others*: knowledge as object, process, product, steering-medium
		Organisational Knowledge Conversion
		- Socialisation, Externalisation, Combination, and Internationalisation
2.3	**Ontology**	
		General
		- An ontology sustain a shared and common understanding and enable to trace and find, exchange and discover organised knowledge and can be used to facilitate semantic interoperability between some domains of interest.
		Levels of Ontologies
		- Individual, group, organisation, inter-organisation
		- Top-level, domain- and task-level, application-level ontology
2.4	**Context**	
		General
		- Surrounds information and give a meaning to information going to be transmitted or integrated at a particular situation and that is interpretable in its initial sense in a different situation by someone else.
		Context Classes
		- Objective and subjective context
		Knowledge conversion in context
		- Knowledge transfer: k-initiation, k-flow, and k-integration
2.5	**Organisation**	
		General
		- Intra- and inter organisation
		Communities and social construction of knowledge

- Teams and communities
- Cross-communities

Organisation's continuum

- Business Management, Project Management, and Systems Engineering

Organisation's Environment

- Extrinsic, intrinsic and indifferent environment
- Interpretation modes: Enacting, undirected viewing, conditioned viewing, and discovering

Knowledge Visualisation

- K-Visualisation Framework: type-, goal-, and format perspective
- Application motives: transferring K, creating K, information overload

Table 5: Framework theoretical foundation

The theoretical background pointed the *research context* as synopsised and concluded above. It has been further shown that all concepts fulfil a particular role within the organisational context. Those concepts are essential to understand and investigate knowledge collaboration and conversion. A particular interest has been outlined in the area of early requirements analysis.

The following chapter discusses the empirical study accomplished within an inter-organisational project- and engineering-based environment. The aim of this study was firstly to complement gained theoretical findings namely by experiencing and investigating an organisation within their structures, actors as well as behaviour in an operational context identifying real world problem situations.

3 Empirical Study: *VIVACE*

Within the introductorily chapter 1, the GLOBE Action Research Methodology was outlined as utilising three channels of cognitions. This chapter is devoted to the cognitive channel experts' interview (see Figure 31).

Figure 31: GLOBE Hybrid Action Research Methodology – Experts Interview

This chapter highlights the empirical study executed within a large integrated European research project namely "VIVACE" (Value Improvement through a Virtual Aeronautical Collaborative Enterprise). VIVACE provides a real case inter-organisational environment in order to understand and elaborate industrial requirements for justification of proposing solutions within the focus of the present work. This chapter is organised as follows: Section 3.1 describes the empirical context, section 3.2 comprises the preparation, execution and analysis of the qualitative expert's interviews, and section 3.3 finally synopsises and concludes on the empirical study.

3.1 The Empirical Context

The empirical context is given by an inter-organisational environment represented through a large integrated European aeronautical research and technology (R&T) project namely "VIVACE" (Value Improvement through an Aeronautical Collaborative Enterprise). The main product of the project comprises the development of an aeronautical collaborative design environment. This inter-organisation is composed of 62 partners reflecting different industrial branches originating from all over Europe: aero companies, IT technology vendors, research centres and universities. Some basic characteristics of this project are illustrated within the Figure 32 below.

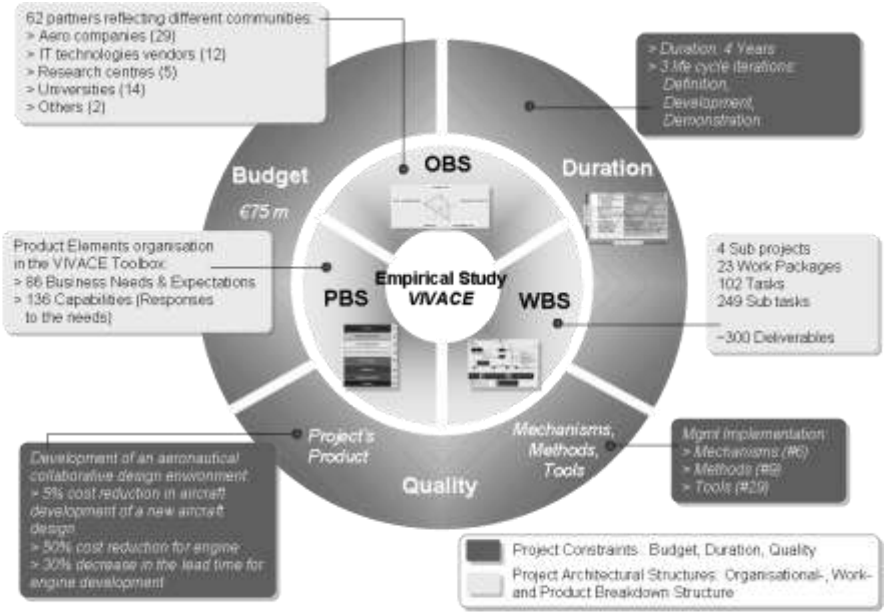

Figure 32: VIVACE Project Constraints and Architectural Structures

The project is assembled of three operational sub-projects (SP): *Aircraft (SP1), Engine (SP2)* and *Advanced Capabilities (SP3)* that will embrace all product related developments. A fourth sub project considers management issues as well as a dedicated work package dealing with third tier supplier's needs and viewpoints. SP1 'Aircraft' is devoted for developing different elements of the aircraft of both the airplanes and helicopters and thus major tasks of this sub project are designs, models and tests of the product. SP2 two 'Engine' is a global product work area that has the responsibility of developing different engine modules of the aircraft propulsion system. SP3 'Advanced Capabilities' is a key integrating work area that develops services, methods and guidelines, information standards and tools for the support of the development environments of sub project one and two. These 4 sub projects are further subdivided into 23 work packages (WP), 102 tasks (T) and 249 sub tasks (ST).

The project's products are organised within a common structure called 8-layer model (see Figure 33). The model has been developed as a means to organise partner's product needs and result elements developed within the operational sub projects (SP1-3).

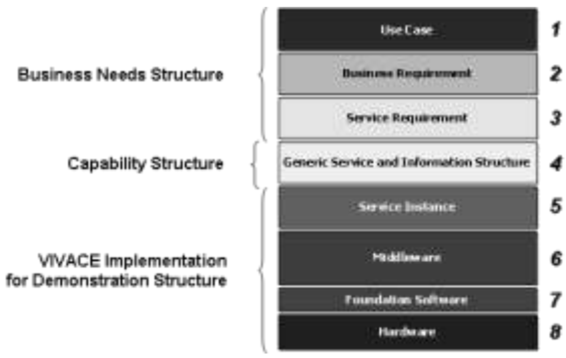

Figure 33: VIVACE 8-Layer Model (VIVACE 2006)

The 8-layer model itself is a construct consisting of three structures: *Business structure, Capability structure* and finally an *Implementation Structure*. It comprises partner's assigned business contexts and needs associated with concrete questions (a business problematic to be solved or situation going to be improved) and specific as well as generic developed solutions considered as responses (enabling results respective to the business needs).

The model is also a representation of the VIVACE product elements in coherence to the project activities. It reflects the generic technical process, starting from operational sub project one and two use cases' descriptions and requirements, and resulting into software installation on hardware to assess product results elements (VIVACE 2006).

Project Iterative Life Cycle

The project iterative life cycle organises the project duration in iterative and logical sequences (timely ordered) of activities and associated partners in roles to accomplish the project's objectives. The establishment and definition of the project iterative life cycle phases support management control within the following issues:

- *What* technical work is required to be conducted in each iteration?
- *Who* - in terms of partner - is involved in each iteration and with which responsibilities?
- *When* are deliverables going to be generated in regards to each iterative project phase (while ensuring each deliverable's quality through a commonly applied review process)?
- *How* to control and approve each iterative phase?

The VIVACE project is planned for 4 years, starting from the 1st January 2004. The project's duration of 4 years is divided into 48 monthly (M) periodic segments. The VIVACE project is divided into three Iterations: *1st Definition (M0-M18), 2nd Development (M18-M36) and 3rd Validation (M36-M48),* to support an effective management control with appropriate interrelationships to partners in roles (see Figure 34).

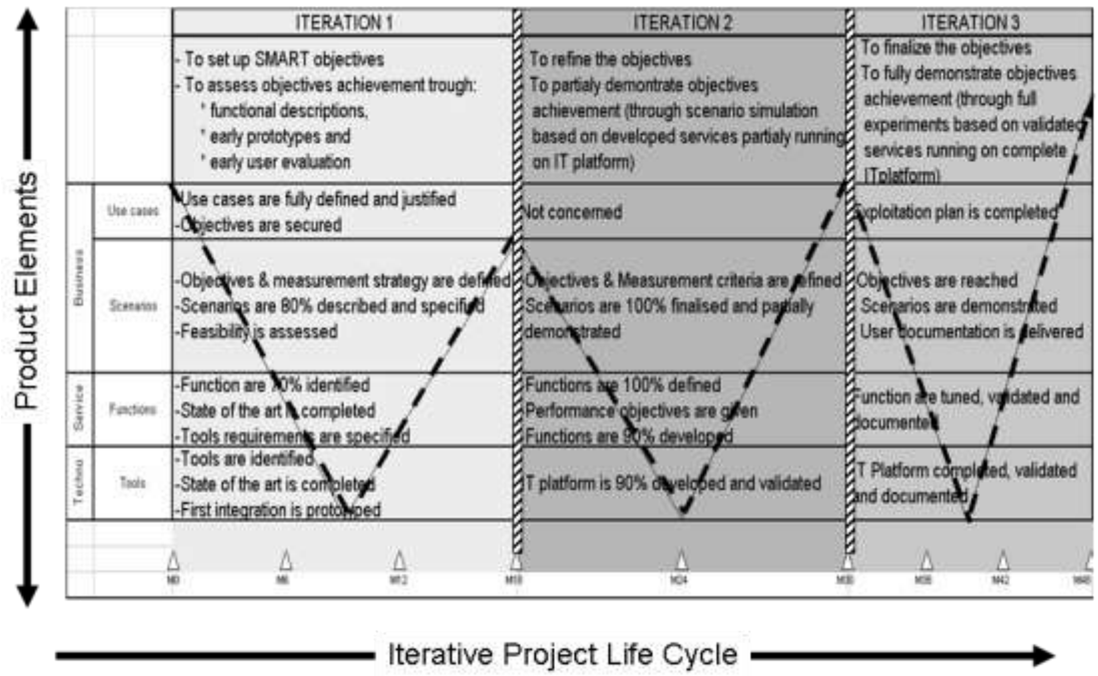

Figure 34: Project Iterative Life Cycle wit h a Product Perspective (adapted from VIVACE Material)

The iterative approach in defining the project life cycle orients on a continuous improvement in the development of the product elements introduced within the 8-layer model. Figure 34 illustrates the project iterative life cycle with a product perspective throughout the three iterations.

In the next section the preparation, execution and analysis of the empirical study in accordance to this 'complex' inter-organisational environment is highlighted.

3.2 The Empirical Study

3.2.1 Motivation

In general experts' interviews are one of the most frequently utilised qualitative research methodologies to construct a fundamental knowledge with respect to the object of investigation (Meuser/Nagel 2005). Thereby, the integrated European research project VIVACE and its members provide a real-case inter-organisational environment. The experts' interviews will be conducted with VIVACE members in order to gain a broad understanding of inter-organisations in practice. In the frame of this work the empirical study is devoted to:

- Disclose obstacles (difficulties and challenges) in executing and managing project activities within an inter-organisational environment,
- Observe qualitative correlations between the explored difficulties, challenges and the dimensions of an inter-organisational context and
- Select from the complete set of surveyed material the relevant subset of difficulties and challenges that correlate with the study context.

Figure 35 illustrates the different steps towards the execution of the empirical study.

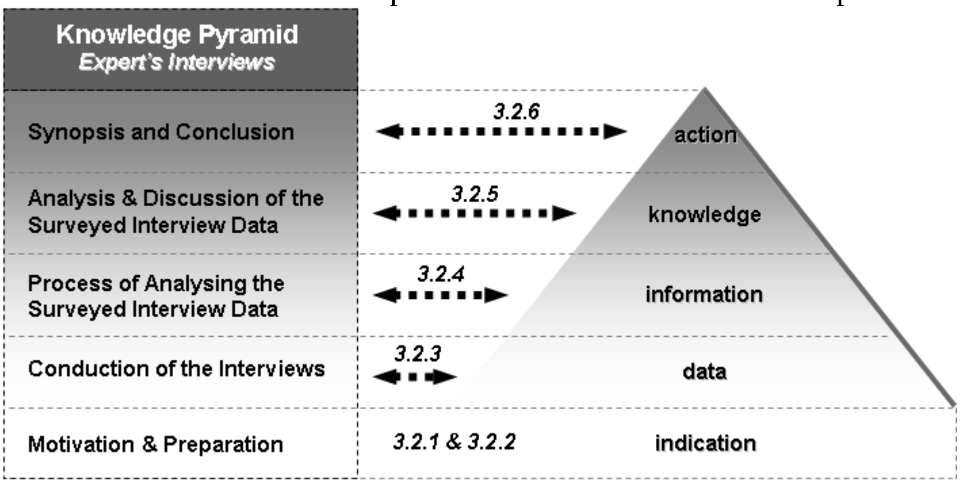

Figure 35: Knowledge Pyramid: Experts Interviews

3.2.2 Preparation of the Survey

3.2.2.1 Methodology Selection

The ways to generate cognitive knowledge are divided into *empiricism* and *theory*. Theory is dedicated to describe interrelations and consists of notional constructs or hypotheses. They are logical derivatives to be validated within the 'real world'.

Conversely, empiricism is that part of cognition which depends on experiencing. Empiricism can be subdivided into *quantitative* and *qualitative* approaches. Moreover *quantitative empirical methods* are for instance questionnaires, quantitative interviews etc. that 'measure' a defined content (closed question) in a structured way. This type of empiricism uses a large number of samples and statistical analysing methods. *Qualitative empirical methods* are for instance qualitative interviews, group discussions etc. that 'verbalises' unstructured content. This type of empiricism uses a small number of samples with a subsequent explicative data analysis (interpretation) in contrast to quantitative empirical methods.

A qualitative survey is an adequate means to get insights and perceptions in regards to a factual context that is going to be explored. Thereby, it is mandatory to ensure compatibility within the method applied to survey and to analysis data. In this context, some essential characteristics of qualitative methods are:

- **Qualitative methods require openness from the researcher.** The basic course of the interviews is given through guide-lining questions. But also specific questions arise differently within each interview, which makes the course of qualitative interviews inhomogeneous as well as the surveyed material gained throughout the several interviews.
- **Due to the application of non-standardised surveying methods and the low number of samples, the analysis could not be conducted with statistical methods.** In comparison to quantitative methods (e.g. questionnaires with closed questions), the score of one interview relative to the total of 17 interviews results into a percentage distance of 6%. Respective to the absolute quantity it seems to be apparently significant.
- **Qualitative methods encompass widening content-related understandings of the research context.** Thus, the aim is to generate hypothesis, rather than to proof hypothesis and establishing generalised statements.

The objectives of this empirical study (see section 3.2.1) led to a qualitative survey. In context of the empirical study not enough detailed knowledge is available. Due to the novelty of such large inter-organisational European projects, not enough research studies have been conducted. The aim of this empirical study is to generate profound arguments in the scope of the research context (i.e. determine industrial requirements pointing real-world problem situations), rather than proving already established hypothesis. In consequence, a field-observing and open facilitated research method is applied.

Experts' Interviews

The most adequate means to gain such understandings and arguments is the conduction of experts' interviews. These interviews characterise the first step towards a systematic data survey within a particular area of research.

> ***Expert*:** A person who is very knowledgeable about or skilful in a particular area.
>
> ***Interview:*** A meeting of people, physical or virtual, especially for consultation.
>
> *Source: OED 2003*

Herein, experts are humans who are part of the research topic and as knowledge bearer they are part or having responsibility of a problem-solving process, or they dispose information of groups or decision processes (Meuser/Nagel 2005). Expert's interviews allow authentic reconstruction of exclusive, detailed and encompassing knowledge. These interviews can vary between structured and non-structured associated with open or closed questions providing the necessity guidance (i.e. factual motives) during the course of the interviews. Not at least the subsequent analysis and interpretation of information could vary also due to the variety of different experts.

The access of the experts' knowledge allows to identify conflicts between the different answers given and to priorities the importance of the answers in terms of their "relevance" within the research context, and lastly to evaluate or structure the surveyed and analysed data based on categories. In fact, the surveyed and analysed data gathered through the experts' interviews, construct a valuable basis as input for establishing questionnaires. Quantitative means, e.g. questionnaires that are compiled based on closed questions, provide the required homogeneity for each interviewed person in order to apply statistical data analysis methods and finally to compose generally accepted statements.

3.2.2.2 Interview Guideline

Interview guidelines assist in conducting a structured approach within the execution of the interviews. Meuser and Nagel (2005) recommend using open guidelines while executing the experts' interviews. Open guidelines enable to have a wherewithal openness and flexibility during the interview. Those build the factual baseline to ensure a level of consistency within the execution of the interviews. Elaborating a guideline means also to oblige the interviewer to gain a certain level of domain understanding, which is important to execute the interview at eye height with the expert.

Within the scope of this study, the interview guideline (see Annex A.1.3) is composed of four guiding questions.

(1) What represents the problems and difficulties of the project VIVACE as a whole?

→ *This question is addressed to the expert's general perspective on the project as a whole with its problems and difficulties.*

(2) What are the problems and difficulties for you in terms of your position or role inside VIVACE?

→ *The second question focuses on the expert's position inside the project VIVACE and his problem and difficulties as management role.*

(3) What would you propose to face the problems stated in question one and two? What would you propose to do differently for a following European project? What needs to be improved?

→ *The third question focuses on the proposed approaches, ideas to face the problems and difficulties stated in question one and two.*

(4) What are your experiences from other projects? Did you have the same problems/ difficulties? What was different or similar?

→ *The fourth question aims at the experts' experience from other projects.*

Those questions are intending to explore the study context in practice and within a wider more general spectrum. Since new aspects were discovered from the several interviews, the interview guideline has been enriched with ad-hoc questions for further guidance during the execution of the interviews.

3.2.2.3 Selection of Interviewees

As initially mentioned the selected interview partners were all experts in the aeronautical engineering area, but different at several dimensions. They are representing different organisations, geographical dispersed in company locations with cultural and professional background. These interviewees have associated project roles and responsibilities at different levels of the project.

The interviewees were selected widespread being able to represent most appropriate the basic average of the project members. It is anticipated that the project individuals on sub project-, work package- and task level are experts having fundamental engineering and research expertise in a particular domain. In consequence expertise as a selective criterion by itself was not meaningful as such. Rather project roles (see section 3.1.1), nationalities, and the kind of organisation were criteria by which interviewed persons were selected. The interview profile is reflected within Table 6 below.

Parameter	Characteristics of the 17 interviewees	Distribution	
		Score	Total
Work entities	• Project office • Exploitation & dissemination manager • Sub-project leader • Operational work package leader • Task leader	1 1 2 8 5	3 3 3 17[96] 77[97]
Nationalities	• German • French • Italian • English • Swedish • Dutch	2 10 1 2 1 1	
Types of organisation	• Aero company • Industrial research centre • National research centre • Consulting (for administrative project mgmt support)	9 6 1 1	

Table 6: Interview Profile

[96] In total 23 work packages. 17 work packages are associated to the operational sub projects 1, 2 and the advanced capabilities sub project 3. 6 work packages are associated to administrative management activities, which for example led by the sub project leader, exploitation & dissemination manager (consider as interviewees already).

[97] In total 102 tasks, 77 responsible task leaders (some project participants lead more than one task).

3.2.2.4 Pre-Selected Categorisation System

The transliterated interview material is going to be organised independently from the order in which the interviews were conducted. Such an organisation system provides architecture for the surveyed interview material and thus can be logically categorised. In this work the categorisation system aims at:

- Structuring the surveyed material with respect to inter-organisational context dimensions
- Aiding qualitatively in scaling the research results and make those comparable to other projects having equivalent characteristics

A reflection on literature has shown different intentions and ways to categorise projects[98]. Parsons (2003) investigated a taxonomy that includes social and environmental components beside non-technical factors characterising project complexity. Parsons suggests a taxonomy (see Figure 36) that consists of four dimensions each with a number of variables: *Resources* (workforce, adequate budget, etc.), *technical* (technology maturity, interfaces, etc.), *socio* (interdependence, communication, etc.) and *environment* (top management support, competition, etc.). The taxonomy provides an appropriate separation of variables so that project controls can be tailored to the needs of individual projects based on their status in each category (Parsons 2003).

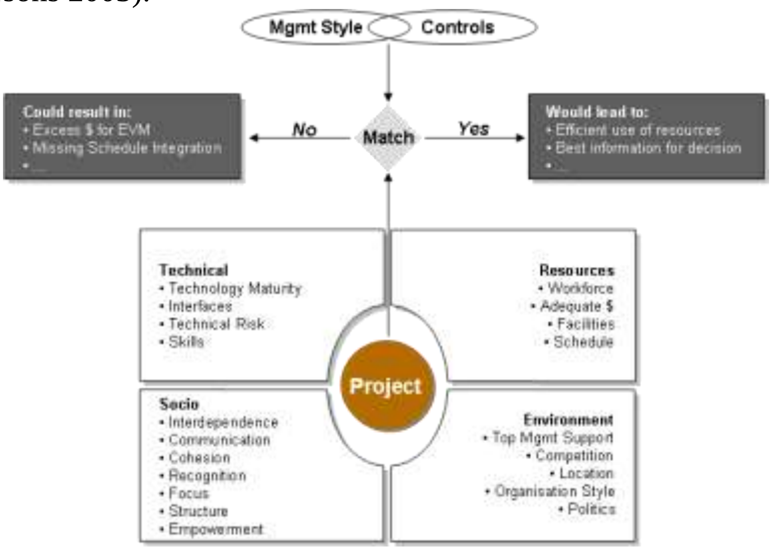

Figure 36: Categories Affecting Project Success (Parsons 2003)

Although those categories are not investigated until now and are mainly used within a context of project management, they provide an adequate framework for this work. They characterise organisations on a general level and illustrate essential features of an organisation, as Büschges/Abraham (1997, see section 2.5.1) define organisations. Thus, Parsons taxonomy covers aspects of an inter-organisational context, that is also relevant for the present empirical study VIVACE. In the following this taxonomy will be utilised to evaluate and structure the surveyed and analysed interview material.

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[98] For example see Baccarini (1996), Macheridis/Nilson (2004) and Turner/Cochrane (1993).

3.2.3 Conduction of the Interviews

The qualitative survey was executed with seventeen VIVACE project participants. The course of the interviews was in implicitly coherent. Explicitly, not at least their specific project-role and the company they were representing, the perception of problems, recommendations, and their experiences were perceived differently by the interviewer. Also, the thematic focus and specific questions varied and were differently within each interview.

The first three interviews were executed as pre-test interviews in order to prove the applicability and effectiveness (in terms of results = data surveyed) of the questions and to validate the pre-selected categories meant to evaluate and structure the surveyed data. Moreover, the pre-test interview served to elaborate ad-hoc questions for supporting the conduction of the remaining interviews. The duration of the interviews varied between 40 to 60 minutes. Due to the different geographical location of the interview partners, two of them have been interviewed during the VIVACE Forum 2[99] and two interviews have been accomplished via telephone. The remaining thirteen interviews have been executed at the experts' working places, i.e. in their offices. The conduction of the two telephone interviews as well as the two interviews executed during the VIVACE Forum 2, had no influence on the practical execution and the quality of the interview itself. Also, the fact that all interviews were executed in a foreign language (English) had no major impact on the execution and the quality (i.e. contently) of the interviews. The interview profile can be further characterised as follows (see also Table 6):

- Five different *project roles*: the majority were work package leader and task leader
- Five different *organisational types*: the majority was from aero companies and industrial research centre
- Six different *countries*: the majority was from France

The interviews started with a welcome and a short introduction of the survey. After this introductorily phase, the preliminary phrased open questions were stated each by each. Relating to the course of the interviews specific questions were taken in order to highlight and deepen particular aspects of the current topic under discussion. The interviewees were talkative and open in answering the stated questions. After each interview a short informal discussion followed, but there from no suitable material could be surveyed for further analysis.

The interviewer was at that time also a VIVACE project participant and responsible for a technical task on project level. Secondly, the project manager funds the thesis. Because of these circumstances, there was the threat to deal with a greater reservation of the interviewees while conducting audio-recorded interviews. Nevertheless, the interviewer's project involvement provided him with a certain background knowledge, which enabled both discussions on eye-height and to have the mental resources during the interviewees in order to make valuable notes legitimating non-recorded interviews. Thus **non-audio recorded** interviews were executed first. During the course of the first eight interviews, it has been shown that trust of the interviewees was appropriate enough having the opportunity to execute the remaining

[99] VIVACE Forum 2: A three days event where project achievements have been presented and demonstrated in a conference manner to the VIVACE project community, but also to invited or registered people not participating in VIVACE.

nine interviews **audio recorded**. The discontinuity in conducting expert's interviews has been accepted for utilising audio recording means. The course of the interviews didn't change in general. But the interviewer while conducting the interviews has perceived an increasing mental efficiency and reactivity following the interviews in content.

3.2.4 Process of Analysing the Surveyed Interview Data

In this section the process conducted to analysis the surveyed interview data will be illustrated.

The 17 expert's interviews: 8 interviews accomplished as non-audio recorded and 9 as audio recorded interviews with various VIVACE partners, yields to a total net interview time of 13 hours and 41minutes. The average interview time was about 45minutes. The thesis-oriented transliteration of the executed interviews - each compiled as individual interview protocols (see Annex A.1.4) - resulted into a preliminary set of data encompassing 67 computer-written pages (see Table 7).

#	Interview Ref.	VIVACE Role[100]	Nationality	Type of Organisation	Interview	Interview time	Audio recorded	Transliterated number of pages:
01	Pre-Test_01	SPL	French	Aero company	At the place	~ 40 min.	No	2 pp.
02	Pre-Test_02	TL	German	Research Centre	At the place	~ 30 min.	No	2 pp.
03	Pre-Test_03	WPL	German	Research Centre	At the place	~ 50 min.	No	3 pp.
04	Interview_01	TL	French	Research Centre	At the place	~ 45 min.	No	3 pp.
05	Interview_02	TL	French	Aero company	At the place	~ 57 min.	No	2 pp.
06	Interview_03	VPO	English	Consulting	At the place	~ 49 min.	No	2 pp.
07	Interview_04	WPL	French	Aero company	At the place	~ 41 min.	No	2 pp.
08	Interview_05	WPL	French	Aero company	At the place	~ 48 min.	No	2 pp.
09	Interview_06	EDI	French	Aero company	At the place	~ 53 min.	Yes	3 pp.
10	Interview_07	WPL	French	Aero company	At the place	~ 45 min.	Yes	10 pp.
11	Interview_08	TL	French	Research Centre	At the place	~ 47 min.	Yes	5 pp.
12	Interview_09	WPL	French	Research Centre	At the place	~ 51 min.	Yes	3 pp.
13	Interview_10	WPL	Italian	Aero company	At Forum 2	~ 60 min.	Yes	5 pp.
14	Interview_11	WPL	English	Aero company	At Forum 2	~ 47 min.	Yes	5 pp.
15	Interview_12	WPL	Swedish	Aero company	At the place	~ 60 min.	Yes	8 pp.
16	Interview_13	SPL	French	Research Centre	Telephone interview	~ 51 min.	Yes	5 pp.
17	Interview_14	WPL	Dutch	Research Centre	Telephone interview	~ 47 min.	Yes	5 pp.
Total						**13 hours 41min**		**67 pp.**

Table 7: Overview of the Expert's Interviews

During the **non-audio recorded interviews** the interviewer took notes. Subsequently, obscurities have been eliminated and a digitalised version has been provided to and validated by the respective interviewees. The **audio-recorded** interviews were transliterated, but in some cases remarkable passages have been transliterated word by word[101].

Within the present empirical study an inductive partly reconstructive approach in establishing the category system has been applied (see section 3.2.2.4).

[100] SPL – sub project leader, WPL – work package leader, TL – task leader, VPO, VIVACE project office, EDI – exploitation and dissemination manager

[101] The number of pages for the transliteration of the interviews differed in average between 2 for non-audio and 5 for audio-recorded interviews. Audio-recorded interviews enabled to save significant passages word by word in order to save the context.

Within two iterations the transliterated data material of each interview has been evaluated in pertinence to the categories (dimensions and variables) defined. During this analysis step, specific statements perceived as relevant were isolated and subsequently structured in the context of the dimension and variables defined within the pre-selected categorisation system.

3.2.5 Analysis and Discussion of the Surveyed Interview Data

This section paraphrases the results of the qualitative survey executed as experts' interviews. Finally, the introduced categorisation system (dimensions and variables) is utilised to evaluate and structure the surveyed interview data respectively.

Within this section surveyed data in accordance to obstacles (difficulties and challenges), suggested improvements and distinguishing features of the project are discussed along the 'Technical' dimension. The remaining dimensions Socio, Resources and Environment are discussed within the Annex A.1.5 (see Figure 37).

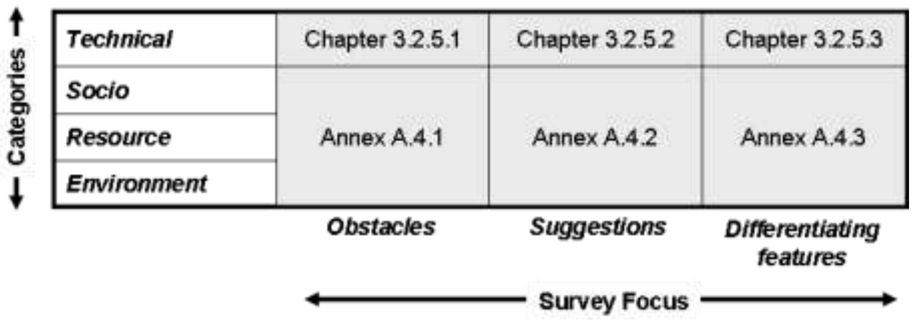

Figure 37: Survey results and chapter reference

All cited interviewee's statements are codified as follows:

"StatementStatementStatement"[Interview_#, Project Role, Type of Company]

3.2.5.1 Surveyed Difficulties and Challenges within Managing the European Project VIVACE

This sub section illustrates the evaluation and organisation of the data gathered in association to the first two questions as part of the interview guideline (see section 3.2.2.2).

<u>1 Technical</u>
1.1 Technical Maturity

VIVACE is an integrated European research project conducting research activities and developing research results, which are driven by and orienting at business (i.e. product development) operations improvements. Moreover, the project is based upon a consortium of 62 partners representing aeronautical companies, vendors, research centres and universities. In particular aero companies may demand project products of a higher technology readiness level and applicable closer to business operations. This in turn is probably prioritised differently by universities or research centres.

Interviewee_07 states that an emphasis only on research activities is insufficient in returning adequate business benefits with respect to the effort spent. The interviewee further argues that the project envisions a too large spectrum of aeronautical business and engineering topics. The non-topic's specificity may hinder the development of solutions, which are close enough to be applicable for engineering departments and their associated skills.

> *"The problem is - at least for our large company, what we expect from a research project is not improving scientific knowledge; we want to have ROI (Return on Investments)! That means if you just go at prototype level I would say we have an animated specification…so, that means that for large projects like this one we should think than differently. Trying to really set up the project with some clearer pragmatic objectives – I am talking for my organisation only – maybe with less ambitions, but with some more concrete or closer to industrial department results." [Interview_07, WPL, Aero Company]*

Conversely to the previous interviewee, Interviewee_08 is of the opinion that research activities should give orientation and highlight potentials to improve effectiveness and efficiency of aero company's business operations, rather than emphasising on the development of concrete solutions which are ready to support industry's business operations.

Thus, the challenge is to gain consensus and level research activities towards development or industrialisation activities.

> *"VIVACE is able to provide some point, some direction to investigate some selected solution and afterwards you have the industrialisation phase. Some partners take the opportunity to develop something concrete, but from my point of view this is not really research." [Interview_08, TL, Research Centre]*

In addition, the project is orienting on and driven by concrete aero company's introduced business needs (a business situation to be improved or business problems going to be solved). Likewise, Interviewee_09 highlights that the expectation of this project is to demonstrate potentials of future technologies and support in anticipating business improvement, but not to having applicable business solutions.

> *"What is important is to work together with different companies in order to think about concepts to see this way is a good way or not – that is the objective. Drivers – business driver: cost, time. The goal of this kind of projects is to show that the way is reachable/ possible not to have something industrial […] these demonstrators are to help making decision show what could be the future." [Interview_09, WPL, Research Centre]*

In general the intention of the European commission in funding aeronautical research and technology (R&T) programmes is to strengthen the competitive situation of the European aeronautical community towards the growing industrial globalisation. In addition, a well functioning and closed business network within the European aeronautical community (companies, universities, vendors, research centres, etc.) shall be strengthened. However, it is difficult to evaluate the benefit towards partner's investments in participating to the project VIVACE.

> *"The idea of European commission is to put money to help companies to improve their business. Some solution can be deployed very soon some others are more vision…It is also difficult to measure to the ROI (Return on Investments). How to measure new techniques? For instance reduction of time in design activities." [Interview_10, WPL, Aero Company]*

Another concern is related to the partner's mix and the relating different orientations achieving consensus within the respective technology readiness level of a commonly produced project product. Hereby, Interviewee_02 highlights the difficulty in building consensus between the various partners in levelling work activities; that is to focus on theoretical approaches and on the other hand experiencing on solutions applicable for industrial environments.

> *"Difficulty to convince people to reach a balanced level between theory and practice; means to make the solution applicable to business." [Interview_02, TL, Aero Company]*

1.2 Technical Risk

The operational work packages of sub project one and two are mostly designed streamlined and planned knowledge independent from each other. Accordingly, the partner's involvement and their related activities and contributions within work packages are planned independently also. The effectiveness of the individual partner's work activities have nearly no cross-functional impacts on other partners activities and thus can reduce the overall risk on work package level. On the other hand such a streamlined planning approach could lack in utilising potential synergies between the partners.

> *"We planned knowledge independent, by still having a common objective, so if one partner does not reach his objective it has no critical impact on the overall WP. It reduces the risk a lot – I would say this is a successful design." [Interview_11, WPL, Aero Company]*

The previously mentioned organisation of partners work packages involvement could ease the overall project management. In some cases it is difficult to understand each others partner's work performance that is characterised as a function of budget consumed and results developed. A necessary level of transparency is required in order to verify on which initial basis (e.g. knowledge, existing results, etc.) each partner started to develop further knowledge. It is nearly irreproducible, which partner is trying to mature on existing results within the environment of VIVACE and who is placing already existing results within the project 'only', while working on "innovations" in his dedicated company environment which is not visible for other partners in the VIVACE project (Interview_05).
However, an insight in the partner's real performance is not obviously given through the defined tasks itself.

> *"Difficult to understand who inside the project work - only separated island of work. Partner takes budget and they develop what they want. Not visible what will be really produced inside VIVACE." [Interview_05, WPL, Aero Company]*

Interviewee_10 notices that evolving towards a commonly shared orientation on project level is difficult, which is reasonable due to the multidimensional partnership. Also, the orientation on commonly shared objectives in association with some project products going to be developed counteracts with some partner's and their organisations business agenda.

> *"[...] It is not always true that the companies have the same objective. They have their own vision and maybe not so related to the high level objectives." [Interview_10, WPL, Aero Company]*

1.3 Skills

It is causal having a certain amount of financial, human, time; logistics etc. resources available for performing project activities and develop a number of project products and services. It may appear that the composition of partners and the associated individuals and their cognitive capabilities for performing project activities is not sufficiently managed. This means, that it is important not to consider the assignment of human resources to the project only, but rather to assure that people in partner have the required knowledge and cognitive capabilities, and that they make those available (spatiotemporal) within the project.

> *"Skills and capabilities of partner are not inline with the work that has to be done in a work package"[Interview_09, WPL, Research Centre]*

On the other hand, the project's end-results were not entirely tangible form the beginning and thus the selection of people in partner and accurate skills were difficult to anticipate.

However, the variety of people in partner may rather enrich the project in being capable of creating results with a higher robustness. This is due to the multiple partners and their facetted contributions in terms of their expertise, their professional background and their experiences involved in different topics. In this sense the diversity of partner can potentially create opportunities to benefit, rather than being negatively impacted in producing project outcomes. But again, this depends on what each partner initially was intended to gain as return on their investments.

> *"[…] Results of such a project are a multiform result, and the results also on the background and knowledge of the people involved in the project. If the result would be defined clearly from the beginning you were right, but I mean the result depend also on the knowledge what the people bring to the project and in this perspective it is better to have the rich experiences and several people coming form several types of activities involved in systems, structure, software development, involved methods, …thanks to this diversity we can improve and converge to a more robust result at the end. Thanks to the diversity of the people. And if we would have tried from the beginning to restrict the result to one view I think we would have lost robustness of the result, diversity and richness of diversity, …" [Interview_13, SPL, Research Centre]*

The partner's business relation within a European project is normally characterised as a
one off, i.e. timely limited, collaboration. Whereby each partner bring in their own business and engineering working standards and respective vocabulary.

> *"It is not possible to share methods entirely – because we have different structures and organisations - so the frameworks evolve are multiple, rather than having an integrated one. Because of different working standards, working language." [Interview_11]*

In accordance to the next interviewee (Pre-Trest_01), the number of partner and people in partner increases the difficulty attaining towards a common basis (standard) of understanding.

> *"Different way of working: 60 partner and different skills and experiences." [Pre-Test_01, SPL, Aero Company]*

Interviewee_04 complements the previous concern. The introduced project terminology or vocabulary has not been commonly shared and understood by each partner right from the beginning. The envisioned approach to gather and formalise the needs was based on the concept of use cases[102] refined into scenarios[103] and perhaps the meaning was not communicated and shared enough.

> *"Specific project terminology: use cases, scenarios… is not clear to communicate, no common understanding gathered." [Interview_04, WPL, Aero Company]*

In fact, the terms of use cases and scenarios are widely used and applied in different domains (e.g. in software engineering, systems engineering) and further the partners have developed also their own specific languages and understanding as mentioned previously Interviewee_07 convey that for his work package it took two years, that is half of the project duration, to develop a commonly shared working language being able to technically understand each others in the team.

> *"It takes about 2 years to build the skills to be able just to understand. But it is not the same (understanding). Even if they are working basically on the same things." [Interview_07, WPL, Aero Company]*

Interviewee_08 continues and mentions that a lot of effort has been spent in gathering a common agreement and build consensus between the partners considering the work plan and the project products going to be developed. There have been a few partners who took an active role in the work package and tried to progressively to develop results. Whereas others, are perceived as a sort of observer for new technologies, but did not contribute fully, or perhaps did not grasp their tasks.

> *"The problem was directly connected to the involvement of the different companies. From the beginning on a lot of time has been spent to discuss with a lot of people. Finally, the work has been just done with a small number of partners. The others are just there to listen." [Interview_08, TL, Research Centre]*

In consequence, since the partner's composition in project teams (e.g. work package) is sometimes inefficient, it becomes also a matter of lacking within the value addition in comparison to the budget invested. Interviewee_07 states that the selection of partners and their capabilities in terms of people was not at optimum, when considering the work activities needed to be performed.

> *"You have some tasks where you have 5 or 6 partner and some of the partners are not really the partner you would dream about and only 2-3 are really needed for the project and go do the work. That means for the other partner you just spending money." [Interview_07, WPL, Aero Company]*

Some of the effects of such a multi-partner environment have been discussed previously. However, in large scaled European projects, the partner's composition is not at least a political concern.
In consequence, Interviewee_14 stresses the issue that the acceptance of a European project proposal depends also on the geographical (i.e. inter- and national) dispersion in partners. However, this may leads also to the threat of having not always the best in class expertises available for the project. But such a multinational formed project could contain other, perhaps not expected but valuable opportunities for the partners;

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[102] Within VIVACE a use case describes the envisioned business intent

[103] Within VIVACE a scenario describes in association to a use case the future way of working in a process manner

that is the establishment of a lasting network with some partner from other countries, expanding their innovation capacity and exploit project products from those partners.

> *"You also have to have a reason of the geographical distribution of the participants that results in the fact that you often have to ask partners to do things which they can do, but they are not the best in. In order to get the reasonable…the vision of work between countries and companies, between corporate companies, universities and technical institutes…You have to allow partners to get in to the project, different partners have one or two things where they are excellent in and maybe five things what they can do, but where they are not best in. Because you have to have a certain amount of distribution of foreigners it might be that you have a partner doing one of his excellent things and not both of his excellent things, because too much participants from on country." [Interview_14, WPL, Research Centre]*

1.4 Interfaces and Integration

Initially the VIVACE project started with two different proposals – one from the Airframe and one from the Engine sector – whereby each claimed a large technical ambition with corresponding resources. The European Commission has recommended submitting a joint proposal.

> *"Due to the historically background of the project building of VIVACE, there is a problem of integration. Due to the fact, that in the beginning there has been a proposal for each Project: Aircraft and Engine. These emerging projects have been independently proposed and the EU commission asked to merge both. This fact raised the problem of integration." [Interview_06, EDI, Aero Company]*

It is obvious, that such a merging process is challenging. The preparation and organisation of a joint project proposal requires global consistency while not creating complementariness and overlapping of the various work packages and tasks, but also within the project products going to be developed. Further, Interviewee_10 highlights the difficulty of this merge due to the dissimilar business models from the Engine and Aircraft industry sector. As a result of this merge, each sector (engine and aircraft) has been organised within an individual sub project addressing their associated business problems and envisioned improvements.

> *"The different business models from aircraft and engines. The A/C area we have too big OEMs. Airbus has many suppliers. On the other side the engine manufacture you have more player working in several programmes we partners and competitors producing modules for MTU or Rolls Royce. Within engine area it is more a network." [Interview_10, WPL, Aero Company]*

However, these project inconsistencies are not only given through the merge of the two proposals as such, but perhaps also due to a missing global architecture integrating product elements at different levels (form business needs to results) and providing transparency on each others work packages developments. The work packages rather deliver project products based on individual partners induced business processes and needs in a bottom up manner. In this context, Interviewee_10 denotes that the bottom-up approach brought up individual work results, which in turn have shown some duplications and overlapping.

> *"A design of a new product with a vision in mind – a top down approach. In VIVACE we have a bottom up approach. It was a collection of work packages/ concepts and these were put together and aggregated bottom up. This may the reason why we have now some overlappings." [Interview_10, WPL, Aero Company]*

The VIVACE high-level objectives (committed objectives on project level) are business oriented towards individual partner's needs and results developments are orienting on. Moreover, Interviewee_13 points out that expectations and needs are present at different dimensions: at partner's company (strategic) level and or at individual level.

> *"We have stated high-level objectives, but in fact if you consider the several levels of the organisation, you will have expectation on company level and also on individual level. The product and the results…VIVACE is seen from different perspectives, we try to integrate all these visions in a common VIVACE Integration database. But it is not so easy." [Interview_13, WPL, Research Centre]*

In particular, it was difficult in the project to utilise and benefit from advantages of a transparent project picture in order to establish cross functional relationships between different work packages and their activities, i.e. sharing results, cognitive capabilities and sustain synergising effects. In addition, to get insights in the project from a steering perspective, e.g. project management or project committees is challenging. Thus, a global technical integration function and associated resources was established in the second half of the project. This initiative defined and fulfilled a global need and results architecture for conceptual technical integration on project level. Nevertheless, the activity was probably launched with a delay in order to provide project teams already during developments with such an integrative picture of the many product elements going to be developed. This could have been also a vehicle towards evaluating technical complementariness and synthesising development activities transversal within the project teams.

Interviewee_07 states that the budget for elaborating business needs comprising the specification and the budget foreseen for developing and implementing the results was levelled appropriately.

> *"Too much money in sub project 1 and 2 and not enough in sub project 3. So, you have a quite large working force to make specifications and after to put all together and provide a global demonstrator is really difficult." [Interview_07, WPL, Aero Company]*

Another aspect associated to budget issues in terms of integration is given by Interviewee_07, who is arguing that budget for implementing global integration requirements exceeded the work package scope and was even not foreseen within the planning.

> *"I don't have the money to do that, because initially I didn't plan to integrate everything. I have my own work and I just want to perform it." [Interview_07, WPL, Aero Company]*

A cause for having difficulties to establish an integrated view on the project is perhaps also given through the dimension of the project— the various partner and their (partial) different expectations and the technical challenges to be engineered. In accordance to variable *1.2 Technical Risks*, it has been mentioned that the independent planning of partner's knowledge and cognitive capabilities resulted into fewer interfaces to be managed and reduced the overall work streams risks. Nevertheless, from a technical integration point of view, it is required to have interactions (where relevant) between the single work packages and associated tasks and define the product interfaces to achieve an emergent product. Such an activity requires additional resources on project level—instantiating a technical management role providing guidance to achieve technical integration.

> *"The VIVACE project is too large to be able to present a consistent integration view and at the lower level the work between the different teams has not been guided by real technical coordinators more than management coordination [...] The work packages are too isolated and the integration has been made on management level. But this is not enough to make real technical achievement." [Interview_08, WPL, Aero Company]*

In correlation to the dimension of the project, Interview_06 mentions that a more or less integrative and closer to the participants acting technical management attendance should be applied for having better and common guidance on practical (task) level.

> *"The larger the project, the more the project has to be integrated and not to be left alone in terms of the project itself." [Interview_06]*

A means to stimulate developments has been established on work package level through the mediating concept of use cases and scenarios; that is to describe a partner's business intent, a business situation to be improved or problematic to be solved. To support the development of emergent product result (an overall and integrative product, *the* product) as discussed previously, business intents should have been elaborated on sub project level.

> *"Use cases should have been addressed on sub project level in order to assist in the integration part." [Interview_01, SPL, Aero Company]*

Likewise it has been preceded on work package level; industrial partner should address concrete business intent in such an emergent product and funds the associated activities. To reach integration and develop an emergent product, requires the introduction of associated industrial partner's business intents and funding work packages local use cases through a fewer "super use cases" on sub project level, could require also a partners intent justifying additional resources.
However, it could appear (especially) in research projects that the overall product context - an explicit top-down orientation for the product development - is not able being designed completely from the beginning before entering in to detailed product elements developments. Perhaps likewise in VIVACE, it requires the investigation on several different sub-product aspects first being able to evolve towards an emergent and integrative product definition—if this is envisioned.
Interviewee_14 perceived that the technical integration transversal to the work packages was not obviously intended when starting the project.

> *"[...] I think it is was not the intention or engineered from the beginning. Maybe it was intended, but I didn't grasp it." [Interview_14, WPL, Research Centre]*

Moreover, the VIVACE project is build upon a transversal architecture: two sub projects providing manly business and engineering needs, while a third sub project develops "responses" in terms of enabling products associated to the addressed needs. Lastly, a forth sub project deals with global management activities on project level. This kind of matrix organisation contains some challenges in terms interaction between the partners of sub project one, two and sub project three.

> *"[...] Complexity of the transversal project structure." [Interview_05, PL Aero Company]*

This kind of project architecture contains also opportunities towards synergies exploiting not only results but also experiences from a number of partners and accelerates individual work and designs it more robust (as mentioned earlier).
Sometimes partner remain for explicit inputs before continuing their work without trying to carry on and progress independently with other activities or trying to force contributions more pro-actively rather than resist in reactive mode.

> *"We not only conduct! We always have the opportunity to act and not to wait for someone else. There is always something you can do yourself."[Interview_12, WPL, Aero Company]*

The process of gaining peoples awareness and attention in terms integration takes time to evolve (Interview_03) since the integrative picture is not commonly shared between the different partners and is rather a matter of continuous and (hopefully) common evolvement in individuals mind.

> *"[…] Integration needs time to evolve." [Interview_03, VPO, Consulting]*

In the same sense Interviewee_07 states that people in partner are mentally not capable enough to anticipate a global integration picture right from the beginning.

> *"People are not smart enough, to just start from the concept to integrate everything." [Interview_07, WPL, Aero Company]*

Integration is even more challenging with such a sort of partnership like it exists in EU projects. It is characterised through different partners and people's ambitions as well as expectations that tried to follow, sometimes individually, throughout the project. Thus, it is mandatory create a certain awareness across the various partner (and people in partner) and evolve together towards a commonly shared (understood and accepted) integration approach right from the beginning. Integration rules and guidelines are potential means that are required to be monitored and steered throughout the projects.

> *"Disjoint objectives: set-up integration rules. What will be the technological environment? These rules have to be followed throughout the project." [Interview_02, TL, Aero Company]*

The difficulty is thereby, that technical topics are spread broad and not always close enough to approach towards a more intuitive recognition of integration aspects.

> *"Too many different complex subjects…not enough closed to technical subjects in order to influence technical ongoing of the subject." [Interview_04, TL, Research Centre]*

Likewise, it is hypothesised by Interviewee_14 that a technical agreement between the partners as well as closer complementary technological aspects are perhaps required to perform European programmes.

> *"If we want to do European programmes you need to have technical agreement or technical complementary between the partners." [Interview_14, WPL, Research Centre]*

3.2.5.2 Surveyed Suggestions for Improvements within Managing the European Project VIVACE

This sub section illustrates the evaluation and organisation of the data gathered in association to the third question as part of the interview guideline (see sub section 3.2.2.2).

<u>1 Technical</u>

1.1 Technology Maturity

The project VIVACE comprises a large scale of several different topics related to different disciplines and skills. The concentration of resources to a fewer but more common topics of investigation could lead to the development of more integrative and robust solutions. Interviewee_11 further argues that a partner consortium with generally fewer but stronger industrial partners might enable to reach higher strategic business targets towards producing project products which are closer to industrial business entities needs.

> *"VIVACE is an enormous project and it covers many of disciplines. But if more disciplines are involved it shrinks the budget, than having more budget for one discipline. From my part you should have fewer partners – bigger partners – to do strategic things. We cannot say we should have fewer small-budget partners, but we just need to have fewer partners. The industry partners should have more budget to go more in the development of the technical solutions when you look in detail." [Interview_11, WPL, Aero Company]*

1.2 Technical Risk

The success of project's products towards expected product characteristics (as an objective to be achieved) is also depending on project member's contributions. Further, partner in project teams that commonly share development objectives are likely going to perform and orient their activities in the shared direction.

> *"Identify the same goal for everybody; if there is no shared goal, no one will work." [Interview_02, TL, Aero Company]*

1.3 Skills

The selection of partners but also peoples in partners and their skills should be appropriate for conducting the required development activities. The required cognitive capabilities (experiences, skills and know how, etc.) are critical to reach a given technological readiness level within the project constraints of cost and time.

> *"But we need to have at least a core of partner that are really the right skills at the right place. […] If my team was in sub project three to implement structural parts, yes I can try to learn…It would take time, it is not our core activity and it is not my strategy." [Interview_07,, WPL, Aero Company]*

Interview_14 indicates that large dimensioned partnerships associated to developments of several different project outcomes, require an extraordinary project management. The interviewee further suggests thinking about opportunities that are capable to relax the interdependence between management cognitive capabilities and project results. Such a relaxation of this interdependence can secure the achievement of project results once people in management functions changes.

> *"If you spending this much money on so many companies, the results depend that much on the management skills. If the project management is leaving the project for one or another reason it should not depend on the results." [Interview_14, WPL, Research Centre]*

Contextually, the availability of a technical management or integrator role and assigned human resources could be key approaching to a consistent and integrative technical view on the project.

> *"One role having the technical overview to be able to report something consistent to the VIVACE committee is mandatory but not existing." [Interview_08, TL, Research Centre]*

Interview_08 associates this technical management role as an instance that could be capable to centralise communication as a consistent and transversal technical illustration of the project's product(s) and associated project member's contributions.

> *"Within VIVACE you have to discuss with different people from different companies to have the overview. It could be an improvement to have someone which role is to spend time in the work packages you centralise in fact communication." [Interview_08, TL, Research Centre]*

1.4 Interfaces and Integration

In accordance to the previous issue of a technical management role, Interviewee_14 underlines the significance to instantiate technical integration within the project's start up phase. However, the attention on integration requirements reinforced in the second half of the VIVACE project, whereby partner's local developments evolved in the meantime. The interviewee anticipates that creating earlier and perhaps more strongly partner's awareness in regard to integration requirements could increase the effectiveness of technical integration.

> *"The most important part is the integration which has to be start from day 1. With such a vehicle at least it is clearer what is being developed. I don't know if it is easier but you have longer time to think about of how integrating things, which basically where not integrated once they were being designed or written." [Interview_14, WPL, Research Centre]*

Also, results exploitation is a considerable aspect at the projects front-end already and corresponds with an early consideration of a respective concept of operations and the associated involvement of users and other stakeholder throughout the whole project's life. Interview_02 highlights that in particular the development of utilisable results for operational business activities is enabled through a seamless and effective end-user involvement.

> *Keep the link with end-user: The aim should be to provide something which will be operationally used." [Interview_02, TL, Aero Company]*

Interviewee_13 hooks into the already mentioned importance of early establishing technical integration, where interrelations between the individual partner's business needs are essential for establishing the basis for integration. The interviewee states further that the individual partner's viewpoints and their elaborated business needs within the project are required to serve and fulfil the common overall project's product objective.

> *"If you start from a set of heterogeneous use case without linkage between these use cases, it will be sure that we will not reach an integrated result. In fact the use cases shall be selected to fulfil a common target/ objective. And this should give an integration view. […] It is matter*

of balance between specific objectives and global objectives. In such a large project you cannot have only a large global objective you need also to have people involved and contributing with their own viewpoints and objectives." [Interview_13, SPL, Research Centre]

3.2.5.3 Surveyed Complementary and Distinguishing Project Characteristics

This sub section illustrates the evaluation and organisation of the data gathered in association to the fourth question as part of the interview guideline (see section 4.2.2.2).

<u>1. Technical</u>

1.1 Technology Maturity

Technical maturity describes the level of technologies operational applicability to business environments. In this context, projects can be seen as enabler or vehicles to accelerate and bring technologies closer to business operations. Interviewee_07 discusses the perimeter or scope of work in correlation with the level of result's applicability for business operations and concludes that company internal projects, in comparison to a European project, are capable to achieve equal results with less funding.

> *"You need to have internally 75 mio Euros with less ambition and concrete results, or if you want to get all the ambition… in this case I won't have concrete results! And I need to know that. […] I can show some more internal projects with 10% of the budget I have in the work package, I get some completely applicable results that can be useful for everybody." [Inerview_07, WPL, Aero Company]*

1.4 Interfaces and Integration

Individual work package related developments require some management and coordination effort. Additional coordination effort is necessitated once development activities in work packages are interrelated and cannot evolve in absence of each other. Interviewee_12 compares the VIVACE project with a former European project and mentions that in VIVACE the work packages developments were planned rather independently from each other's and enabled more parallel evolutions. This resulted in less temporal dependent integration and a decreased impact on each other's activities.

> *"And another thing that was a problem in ENHANCE. The tasks and the work packages must be as much as invariant, they could work in parallel, but they don't need to interact in order to function. In ENHANCE everybody was depending on everybody all the time. So there was always an excuse for everybody do not do anything. Nothing happened, that's the consequence. The number of relations was a complexity fact. That gives people always an excuse and defend themselves - I am waiting for this and so on." [Interview_12, WPL, Aero Company]*

3.2.5.4 Synthesis: Evaluation of Interview Data Corresponding to the Categorisation System

Within the previous sections the surveyed interview data has been illustrated and discussed along the aspects: *Obstacles*, *Improvements & Differences and Complementariness*, which were basically the originating questions addressed in the interviews. Table 8 synthesises these aspects have been evaluated and structured in correspondence to the categorisation system. In addition to the illustration of each aspect in a specific section, the table provides a transversal illustration across all surveying aspects.

Dimensions	***Variables***	***Empirical Study VIVACE***		
		Obstacles (Difficulties & Challenges)	***Suggested Improvements***	***Differences & Complementariness***
1 Technical	1.1 Technology Maturity	• Business objectives in a research project - Levelling the work focussing on theoretical approaches and on the other hand experiencing on solutions applicable business solutions - VIVACE project envisions a too large spectrum of aeronautical business and engineering topics • Measure ROI: difficult to evaluate the benefit towards partner's investments in participating to the project VIVACE • Difficult to establish consensus on the envisioned of the results TRL within the partner's	• The concentration of resources to a fewer but more common topics of investigation could lead to the development of more integrative and robust solutions • A partner consortium with generally fewer but stronger industrial partners might enable to reach higher strategic business targets towards producing project products which are closer to industrial business entities needs	• Company internal projects are able to achieve equal results with less funding
	1.2 Technical risk	• **Transparency of results and partner's real performance*** • **Commonly shared orientation and objectives on project level***	• **Success of project products towards expected product characteristics (as an objective to be achieved) is also depending on project member's contributions. And partner in project teams that commonly agree and share development objectives are likely going to perform and orient their activities in the agreed direction*.**	

	1.3 Skills	• Insufficient composition of team: ○ Some partner act as observer for new technologies only, don't contribute or don't know or understand the required tasks ○ Selection of partners associated to the required skills ○ European commissions political concern • Lack of common business and engineering working standards and languages • **Time to build a common technical understanding (project terminology)*** • No technical management role	• The selection of partners but also peoples in partner in terms of skills should be appropriate conducting the required development activities • Opportunities capable to relax the interdependence between management cognitive capabilities and project results. Such a relaxation of interdependence should secure the achievement of project results once people in management functions changes • **Availability of a technical management or integrator role and assigned human resources could be key approaching to a consistent and integrative technical view on the project. This technical management role could be an instance capable to centralise communication as a consistent and transversal technical illustration of the project's product(s) and associated project members contributions**	

	1.4 Interfaces and Integration	• History of the project (two proposals which have been merged): ensure appropriate global consistency and not creating too much complementariness and overlapping between the different work packages and tasks, but also within the project products going to be developed • **Missing top-down strategy: Bottom-up approach brought up individual work results, which in turn have shown some duplications and overlapping*** • **Commonly shared project vision and objectives: expectations and needs are present at different dimensions: at partner's company (strategic) level and or at individual level*** • Missing technical management role • Lack of a global technical integration guideline • Transversal project architecture • **Lack pro-active rather than being reactive partner's behaviour in terms of contributions*** • **Time to evolve until gaining people in partners awareness: partner are mentally not capable enough to anticipate a global integration picture right from the beginning*** • **Disjoint objectives (set integration rules)*** • Lack of technical complementary and closer technical subjects	• Significance to task technical integration within the project's start up phase to create earlier and perhaps more strongly partner's awareness about integration requirements which could increase the effectiveness of technical integration. • Results exploitation is a considerable aspect at the projects front-end already→ early involvement of users and other stakeholder throughout the whole project's life. In particular the development of utilisable results for operational businesses is enabled through a seamless and effective end-user involvement • **Interrelations between the individual partner's businesses needs are essential in establishing the basis for integration. The individual partner's viewpoints and their addressed business needs within the project are required to serve and fulfil a common overall objective***	• Comparing to a former European project, the architecture of work packages independently in their developments enabled parallel evolutions without having impacts on each other's activities.

2 Socio	2.1 Interdependence & Communication	• Difficult to make existing partner's knowledge and results available (state of the art and best practices) • **Weak transparency of knowledge and results*** **Distributed teams (means for communication)*** • Behaviour in people in partner's availability • **Strategic & political unwillingness: Collaboration had some of its challenges within partner's political or tactical behaviour*** • Commonly shared working language • Difficulties within reporting tools & activities: ○ Levelling and prioritising this additional work load beside the initial work activities ○ **Difficulties stated in regular reports are perceived to have not the sufficient recognition and attention on project level*** ○ Reporting tools are not at all considered by the project partners within the same level of responsibility ○ Reporting effort should be levelled appropriate with respect to what is required to control the project environment by its complexity ○ 6-weekly report is an interval which is defined too closed in correlation to the project duration ○ Challenge in understanding the individual work packages situation throughout the project from management perspective on project level ○ Risk management mechanisms requires not only resources in terms of budget but also the appropriate human cognitive capabilities	• Once document template formats have some evolutions a certain level of explanation in front of the project participants should be given • Explanation on why project documents or processes have changed should be effective and requiring not too much peoples effort in terms of understanding and adapting to these changes • Establishing a milestone oriented reporting mechanism, which enables to indicate partner's performance in project teams respective to its responsible tasks • Sustainability within a well balanced reporting effort which corresponds to the perimeter of work (tasks, partners involved, results, etc.) going to be performed • Adaptation of reporting templates established should be applicable due to the current level of criticality. The frequency and contents in reportings could be designed in correspondence to the characteristics of project life cycle within the different phases • **Establish mechanisms enabling which are capable to control the project's "fitness" in terms of progress achieved without decelerating development activities too much.** • Establish more objectives oriented reporting mechanisms, while suggesting more reactive feedback from management instances on operational work entities reporting on difficulties and problems	

	2.2 Cohesion	• Difficult to establish trust between people in partner, gaining their contributions and progress on a common solution development • Sometimes challenging to integrate people in partner and clarify their role and expectations in team • Balance of partner's motivation: Strategic and technical interest • Dominant partner to act more towards a balanced motivation on project level, but also obliquely on work package level • Changing people in partners: repetitive process of convincing and building trust within the team; timely critical to ongoing development activities	• **Establishing coherence within partner's individual and within the global project orientation (objectives) in terms of a common development direction is perceived as an improvement for collaboration on common results developments*** • **Creation of transparency within technical integration viewpoints: individual (single working entity) and global (project level), should support partner's identification as such, but also illustrating/stimulating interrelationships to other partner's addressed business needs and associated results***	
	2.3 Focus	• **Challenging to let the many of partners start to work all together*** • **People in partner underlie varying company's orientations and objectives, while having also a dimension which reflects their own personal interests*** • **Some partners are just intending to create there own networks or trying to benefit from partner's knowledge and results*** • People in partner take the European project within a different level of responsibility in comparison to internal company projects • Within the project's preparatory phase partners attitude was rather risk oriented and neither orienting on opportunities		• Common orientation within company internal projects is anticipated as being more commonly shared. People's common focus is rather effectively characterised towards developing a product which fulfils customer expectations at best • Also in company internal programmes partners could have at the same time also ongoing competing product developments • It could appear that company internal people assigned to a common project, develop at department level also competing structures, e.g. for political reasons, which in the end are counterproductive on project level within achieving the overall project objectives
	2.4 Structure	• **Multicultural formed project composed of individuals with different cultural backgrounds, which requires additional effort in establishing business relationships (difficult within a one-off corporation)*** • Some commercial companies utilise European project as an environment for education issues of company's newcomers		

	2.5 Empowerment	• Difficult to act in a partnership on the partner's performance and obligate insufficient partners at consortium level • Authority to make decisions: Missing responsibility and leadership capabilities on middle mgmt	• Opportunity to empower management is basically a matter of partner's attitude whether or not respecting other partner's conducting management functions in the project	• Company internal projects are mostly full funded project environments and in turn project activities bond full people's responsibilities. • Fewer differences within European & Internal projects in the preparation phase, where project activities facing equal difficulties in terms of collaboration and developing the strategic and technical project baseline • Internal company structures or management hierarchies respectively, are perceived as another means beside the different funding concept (European vs. Company internal projects) stimulating effectively contribution to projects
3 Resources	3.1 Workforce	• People in partners have additional commitments related to their business entities besides working in the European project VIVACE • Cognitive capabilities in partner's human resources: it could appear that such partners are not completely recognised and considered within work activities and in terms of management it is difficult to treat and guide such partners • Not enough IT competencies were considered • Misunderstanding in how work activities were shared between the sub projects • Insufficient involvement of partners and their cognitive capabilities towards the project life cycle	• A European project is a meeting place of people in partners coached and skilled differently in their business environments, it could be beneficial to have dedicated trainings on common management principles. This could be a vehicle for improving the axis of project quality in terms of common project management processes	• The VIVACE project environment requires management roles in spending effort to learn and apply the specific management principles, handling fewer acceptances in management authority and also treat less effective process of requesting resources • The management effort correlates also with the appropriateness of cognitive capabilities and project tasks going to be performed → European projects are differently organised within the selection process of partners • Management authority and developing a common project orientation depends on the contractual relationship: partner or sub-contractor, established between different companies. Importance of having the appropriate skills integrated in work packages who shares and believes in the project objectives (whether it is a partner or a subcontractor • In comparison to a former European project, where the correspondence of skills in terms of people in partner conducting the project tasks was not managed. The difficulty is given through the availability of people who should perform project tasks

	3.2 Adequate Budget	• Difficulty in allocating budget for human resources assigned to perform various activities in several tasks in different work packages and sub projects • Budget split between sub project one and two addressing essentially concrete business needs and sub project three basically leading the relating development activities is not effectively proportioned • Difficult to be reactive and secure the work performance while shifting budget from one partner to another, or subcontract external partner once the contribution of an initial partner is insufficient • Financing the IT infrastructure		
	3.3 Schedule	• The time needed to evolve towards industrialisation (1year to prepare the project, 4 years project duration, 2-3 years for industrialisation)		
4 Environment	4.1 Top Management Support	• **Challenging to get the support of the business seniors exploiting the project results*** • Corporate hierarchies and the strategic as well as technical orientations influences the conduction of the project within their personal work Company scope and objectives • **Problem of reconciling partner's different objectives and establish an overall commonly shared objective for orientation towards which people in partner can focus their work***		• Company internal projects are benefiting from more effectively established connections to companies operational business entities and are possibly delivering business benefits which are better perceived by management hierarchies. Nevertheless, a multicultural environment like VIVACE stimulates partners thinking towards more extended business solution • One sponsor who completely funds the project have more complete results expectations in front of developments and results going to be exploited. This in turn could be anticipated as being differently once a project has two or more sponsors and the degree of influence on developments and results is by half
	4.2 Competition	• IPR difficulties: challenging to gain insights in partner's work and its achievements, e.g. in terms of results • **Company environment influences and could also restrict the level of knowledge exchange between persons in partner***		

	4.3 Location	• Partner's geographical dispersion: attributes of nationalities and the related various cultures as well as languages is a challenge in gaining a shared understanding and start to work together • **Difficult to collaborate (communicate, cooperate and coordinate) within distributed project teams***		• The VIVACE project comprises a multinational consortium of partners, where partners are distributed all over Europe. However, partners and their relating companies could have similar multinational formation as being distributed in location and underlying several different environmental influences
	4.4 Organisational style	During the 17 interviews no data could be evaluated with respect to the variable Organisational Style. However, the author perceives parallels with the variable 4.1 Top Management Support and recommends to sees this section.		
	4.5 Politics	During the 17 interviews no data could be surveyed with respect to the variable Politics.		

Table 8: Overview of surveyed data[104]

[104] Thesis-relevant aspects are marked in bold and with a * and are finally discussed within section 3.2.6.2.

3.3 Synopsis and Conclusion

3.3.1 Methodological Review

Within the previous sub sections the empirical study conducted in VIVACE has been explained within the preparation-, execution- and analysis phase of qualitative experts' interviews.

Firstly, the motivation for conducting experts' interviews in the frame of the empirical study VIVACE has been denoted. Subsequently, the preparation of the interviews has been illustrated comprising the methodological choice, the interview guideline, the selection of interviewees and the pre-selected categorisation system to organise the surveyed and appraised interview data. Next, the process of conducting the interviews as well as the process of analysing the surveyed interview data towards the categorisation was described. Lastly, the surveyed interview data has been analysed and discussed, and were finally synthesised in a matrix comprising the categorisation system and the surveyed interviewed data within different aspects: *Challenges, Improvements, and Differences & Complementariness.*

Generally, the selected categorisation system to evaluate and organise the surveyed interview data was valid. Only minor modifications with respect to the initial categories had to be made. The 1st dimension *Technical* and the corresponding variable 1.4 has been extended from *Interfaces* to *Interfaces and Integration*. This extended variable should indicate stronger the aspect of integration, rather than emphasising on technical interfaces: e.g. boundaries and interconnections, only. Moreover, the variables *Interdependence and Communication* have been converged within the associated 2nd dimension *Socio*. The variable 2.1 *Interdependence & Communication* has been merged, because it was not effectively executable to evaluate the interview data whether corresponds to the matter of interdependence or communication. The two variables were perceived as being to close within their meaning to distinguish the evaluation of interview data within both interdependence and communication.

No interview data could be evaluated with respect to the variable 4.4 *Organisational Style* associated to the 4th dimension *Environment*. However, the author perceives parallels within the variable 4.1 *Top Management Support* and recommends to sees this variable and the appraised interview data. Likewise, no interview data could have been surveyed for the variable 4.5 *Politics*. Finally, the interview data surveyed has been evaluated and organised within 4 dimensions and 17 variables meant to provide taxonomy for project complexity. (See section 3.2.2.4). The complexity dimensions and variables have been associated and characterised within the surveyed aspects of VIVACE: *Challenges, Improvements, and Differences & Complementariness*, from a management perspective.

The selection of the interviewees represents an appropriate distribution of the experts in the project comprising their project role, nationality, and organisational type. A differentiated evaluation and organisation of the surveyed interview data based on the interviewees' project role in VIVACE was not reasonable compared to the assumption made in the beginning. Rather the different viewpoints and perceptions of the interviewees and their appraisal in accordance to the complexity dimensions and variables were valuable.

3.3.2 Overall Reflection of Surveyed and Thesis-Relevant Results

It has been shown that the empirical study delivered an extensive list of results in relation to the initial interest of collaboration features within an organisational context. In order to evaluate the surveyed material, the data was clustered and interpreted. At this point an overall reflection of the surveyed and thesis-relevant results (see section 3.2.5.4) is given as follows:

- **Different backgrounds.** One essential point that has been discovered through the interviews is the challenge of different backgrounds of the community members. The various different partners and members originate from different countries, speak different languages and belong to different cultures. The VIVACE project members have further shown different working experiences and cultures, nomenclatures (business language) and underlie varying companies' business orientations and objectives. These issues were perceived by interviewed experts as hampering collaboration within the execution of project tasks.
- **Missing common perspective.** The next challenging aspect is the missing top-down perspective, which is challenging in terms of letting the many partners start to work together and avoid duplications and overlapping in results development recognised later in the product development cycle. For collaboration within organisations it has been perceived as important to share the established project vision and objectives. It is mandatory that the business needs and expectations are shared (accepted and understood) throughout the organisation on all levels and communities, so that contributions can evolve in cohesion and throughout the project. Introduced concepts have shown that a perspective is essential for collaboration. This retrieves in the aspect of transparency, i.e. the transparency of results, knowledge and partners performance. Perspective making and taking has been only mentioned as a pre-requisite for collaboration and knowledge conversion between different communities. A perspective logically contains the feature of transparency, but was not explicitly mentioned within the reviewed concepts of the theoretical part. In terms of regular reporting, some experts mentioned having not the sufficient recognition and attention on project level in terms of reported difficulties. This point is hypothesised to correlate with the lack of being able to address reported difficulties towards an established business needs and expectation perspective and create community-conform awareness on project level.
- **Environmental influences.** A further aspect that the surveyed data delivered is dedicated to the influencing environment on the VIVACE project organisation. Each partner's company influences and could also restrict the degree of knowledge exchange between people in partner. It is further challenging to get the support of the business seniors within exploiting (research) project results through early addressing business customer and end-user.

Relation to the aspect of cross-community collaboration within the domain of business and engineering

The experts' interviews were conducted after the first year of this thesis, and at that stage the present research topic focussing on business and engineering collaboration within the top-level product definition was not established that clear. In this context, the empirical study served twofold. Firstly, the aim was to gain deepen insights and improved understandings of organisational structures and collaboration facets in a social contexts. Secondly, with the evolution of the thesis and the increasing clarification of the research purpose the empirical findings were condensed as outlined above in three challenging aspects.

Nonetheless, the topic of cross-community (i.e. business and engineering) interactions in VIVACE is matter of specific analysis within a dedicated application case (see section 5.1) and relates to the third cognitive channel “Experimentation” as it has been defined in the GLOBE action research methodology (see section 1.5.2).

4 Solution Proposition: *Conceptual Model Definition*

Previous chapter outlined the positioning and envisaged contributions of the present research work, introduced relevant theoretical requisites and addressed surveyed empirical world requirements.

Literature has shown that communication and coordination is challenging in conjunction with visualisation and representation of knowledge in a cross-community constellation of business and PD teams concerned with early requirements analysis[105]. Whereas, establishing, maintaining and visualising mental evolutions between those communities in the volatile phase of early requirements analysis is key towards establishing coherency-development within product/systems definitions. Current early requirements analysis approaches aim at increasing confidence and rationalisation of product/system definitions using the concept of goals, while business-engineering collaboration aspects and the feature of transparency is perceived as being underdeveloped.

The empirical study has shown that challenging aspects in cross-domain collaboration and knowledge conversion within establishing product definitions are different backgrounds, missing common perspectives and environmental influences. The concept of perspective making and taking is essential for collaboration. This retrieves in the aspect of transparency (results and knowledge) and is requisite for people share business intents throughout the (project) organisation on all levels and communities, so that contributions can evolve in cohesion along the project. Difficulties should be addressable towards an established business intent perspective which serves business seniors within exploiting (research) project results while early involving business customer and end-user acting in operational processes.

To sum-up, early phase requirements analysis is identified as requiring a collaborative and knowledge-driven, rather than process-oriented (i.e. stringent step-by-step) concept. Recent early requirements analysis approaches are challenged within balancing formalisms versus usability. To complement the chain of existing (semi-formal and formal) formalisms an informal knowledge-based approach is introduced. This approach is establishing a "synthetic meeting place", a knowledge representation forum to strengthen business-engineering collaboration and create reflexive transparency. Furthermore, it provides an instance for capturing and organising early requirements analysis information (informally) before entering into semi-formal and formal modelling and analysis approaches. Therewith it is rather preparatory vehicle for stronger formalisms (e.g. i). The proposed concept further emphasises the currently under-developed issue in RE of outlining a total value improvement baseline founded on the notion of business intent and in turn creating basis for an evolutionary control instance.*

This chapter is continuation within establishing the research framework as pointed in Figure 38 and is organised within the consecutively sections:

Section 4.1 *discusses concepts of knowledge, collaboration, context, and ontology that are essential to organise integrated cross-community knowledge evolutions.*

[105] In the present work early requirements analysis is concerned with both business intents and requirements elaboration in context of establishing a top-level product definition.

Those are consolidated in a conceptual model that is referred to as "Knowledge-CoCoOn".

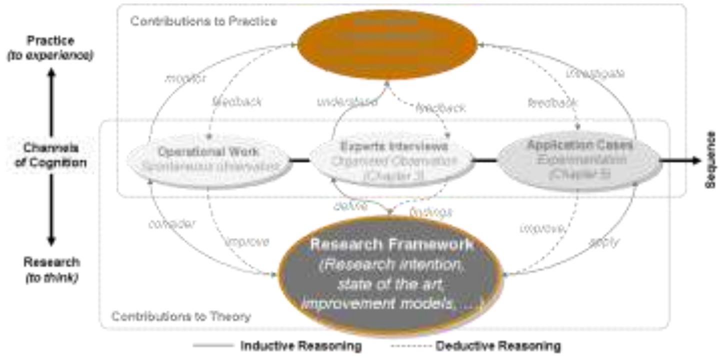

Figure 38: GLOBE Action Research Methodology – Research Framework

Sections 4.2 to 4.4 *describe the meaning and role of the Knowledge-CoCoOn within its single components and in an organisational context, i.e. outlining social structures and interaction scenarios between business and engineering. Adequate knowledge conversion modes are defined and characterised and finally result into an information model that uses an informal formalism to specify a business intent.*

Section 4.5 *synopsises and concludes on chapter 4.*

4.1 Confluence of Theoretical Concepts

This section comprises the confluence of the theoretical concepts: knowledge, collaboration, context, and ontology (see chapter 2); providing a conceptual frame for knowledge conversion between the community of business and engineering that is put forward in the construct of *Knowledge-CoCoOn* (Collaboration, Context, and Ontology). The main characteristics of these concepts are synopsised as follows:

- ***Concept of Collaboration (see section 2.1).*** The principles of collaboration have been defined as "*Two or more individuals act jointly trying to solve a problem or improve a situation, potentially in a new way, while exchanging knowledge in an organised way and using their cognitive capabilities*". Key elements of this concept are *individuals*, the *objective* for collaboration, and *knowledge*.
- ***Concept of Knowledge (see section 2.2).*** Knowledge beside data and information are delimitated in the knowledge pyramid. Knowledge was finally defined as "*actionable information comprising cognitive capabilities enabling to take actions and make situational (spatiotemporal) decisions*". Knowledge was differentiated, mainly based on Baumard (1999) and Nonaka (1994), in four inseparable types of knowledge: explicit and tacit, and individual and collective knowledge. In addition Nonaka's SECI-model is introduced to highlight different organisational knowledge conversion modes.
- ***Concept of Ontology (see section 2.3).*** The notion of ontology is introduced in a knowledge sharing and creation sense as "*sustain a shared and common understanding and enable to trace and find, exchange and discover organised knowledge and can be used to facilitate semantic interoperability between some domains of interest*". Ogden/Richards (1923) model of the semiotic triangle has been introduced as well as different levels of ontologies in an organisational

context were reflected. Here, key elements of an ontology are *structure*, *relationships*, *knowledge* and *semantic*.

- ***Concept of Context (consult section 2.4).*** Context is defined as *"Surrounds and give a meaning to knowledge going to be transmitted or integrated at a particular situation and that is interpretable in its initial sense in a different situation by someone else"*. Key elements of this concept are *knowledge* and *semantic*.

Within these concepts the notion of knowledge is integral component (see Figure 39).

Figure 39: Concept of Knowledge-CoCoOn

Whereby, collaboration provides the *objective* and therewith-common orientation in which knowledge conversion between two+ individuals or collectives should occur. The axis of context provides the *semantically* frame for knowledge conversion. The ontological component of the Knowledge-CoCoOn provides structure for organising and representing knowledge. It enables to associate semantic while establishing relationships within acts of knowledge conversion and between associated knowledge bases.

Figure 40 depicts the concluding thoughts of the theoretical chapter (see section 2.6). Furthermore, the illustration inhabits the consolidated construct introduced as a Knowledge-CoCoOn.

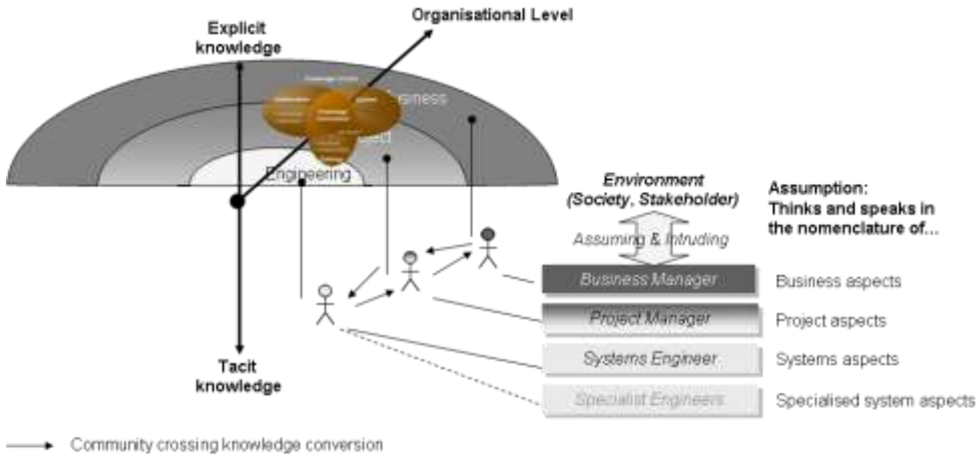

Figure 40: Association of the Knowledge-CoCoOn in the organisation's continuum

The proposition of the consolidated construct can be read and understood as follows.

> ***Knowledge-CoCoOn.*** *The Knowledge-CoCoOn is a formation consolidating different concepts to establish knowledge conversion within cross-community collaboration in the project's product context and the structural sense applied.*
>
> *Own Definition*

In the specific case of this work, it means to create a customised perspective by which business community shall be enabled to elaborate their thoughts and viewpoints that can be taken into community-specific consideration by engineering and assembled within their own "thought-world" and conversely.

The following sections discuss more deeply the components of the Knowledge-CoCoOn finally proposing a respective information model.

4.2 The Meaning of the Collaboration Component: Introduction to an Collaboration Scenario within an Organisational Context

One component of the Knowledge-CoCoOn is the concept of collaboration and characterises the social and cognitive component (individuals' interaction). In the following a generic collaboration scenario is outlined in an organisational context and within respective social structures.

Section 2.5.3 introduced ISO/IEC 15288 systems life cycle standard, which provided a generic composition of communities within a project- and engineering-based organisation. It has been shown that each community: business management, project management, systems engineering, and speciality engineering; has different tasks and thought-models, but also different perspectives on the product carried out along the PD process. It has been assumed that each community thinks and articulates the project's product differently while associating distinctive concepts (consult section 2.3). Figure 41 illustrates different organisation's communities interacting and converging knowledge in regards to the project's product[106].

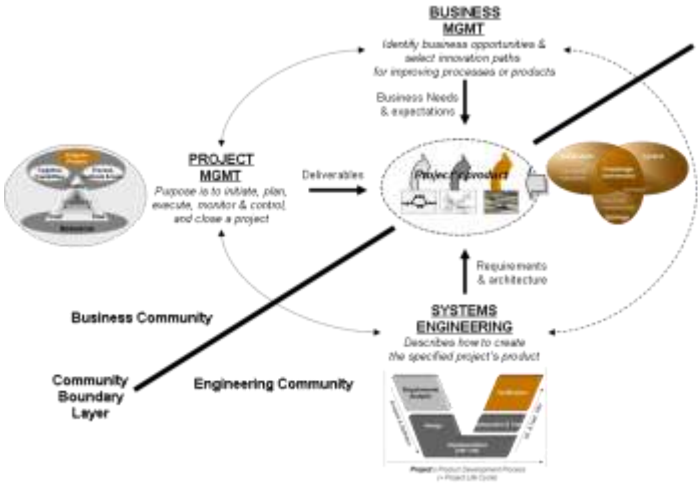

Figure 41: Collaboration between Business Mgmt, Project Management and Systems Engineering

Business management determines business opportunities and settles the path of innovation for improving organisation's business processes or products and addresses the related project requirements as inputs for project management. In this work both are defined for representing the community of business. Project management periodically reviews the projects in all its dimensions (e.g. through deliverable within its associated constraints of quality, cost and time (see section 2.5.3.2)) and stays in the continuous feedback loops with business management members. The

[106] Speciality Engineering is not considered in this illustration.

collaboration objective creates the level of emergence (group awareness, see section 2.1.2) for the community of business and engineering, and is given through business needs and expectations (BNE). Collaboration between the community of business and engineering towards the level of emergence appears within three collaboration-facets (consult section 2.1.2, definition in accordance to the OED 2003): *cooperation* (working together), *communication* (knowledge conversion in different modes) and *coordination* (guidance within the cooperation and overall collaboration). The collaboration-facets: communication and coordination are tackled within the Knowledge-CoCoOn through the notion of context and ontology (see Figure 42) and will be further described in section 4.3 and 4.4. Whereby it is postulated that the notion of cooperation could potentially supported indirectly, through synergising effects of both context and ontology.

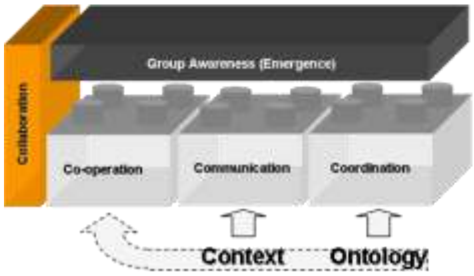

Figure 42: Association of context and ontology in the collaboration context

The community of business and engineering exchange knowledge on a regular basis,. They have interactions with members of their community and build commonly shared perspectives interacting with the organisation's environment. In this given collaboration thought-model it is anticipated that the organisation and its communities are interacting differently with the environment.

The construct of the organisation's environment (see section 2.5.4) has been introduced as the outside of the organisation differentiated threefold: intrinsic, extrinsic, indifferent, and was meant to distinguish the relevant from the irrelevant organisational environment while considering a grey-zone—demarcating the *environmental scope*. Both the organisation and its environment evolve in a mutual manner. This dynamism makes them behave like fluids. Thus organisations have been seen as interpretation systems considering four modes of conditioned interpretation business management's belief about environmental interactions. These modes were drawn by Daft/Weick (1984) on business management level reflecting that part of an environment that is classified in this work as the *business/organisational environment.* Two further environmental focuses are considered: *operational* and *development* environment. The operational environment reflects this part of the environment concerned with cooperating, competitive, and supporting systems (Stevens et al. 1998) and is considered by the community of systems engineering within the organisation. Lastly, the environmental focus considers the development environment in regard to hardware and software companies (Stevens et al. 1998). Communities' interaction with the environment means to interrelate with other (project-based) organisations whether related to a similar or a different enterprise (see section 2.5.1). Interactions of project management and the organisation's environment are not further detailed. However, it is further anticipated that project management is mediating instance between business management and engineering, functioning orthogonal in a project-based organisation (see Figure 43).

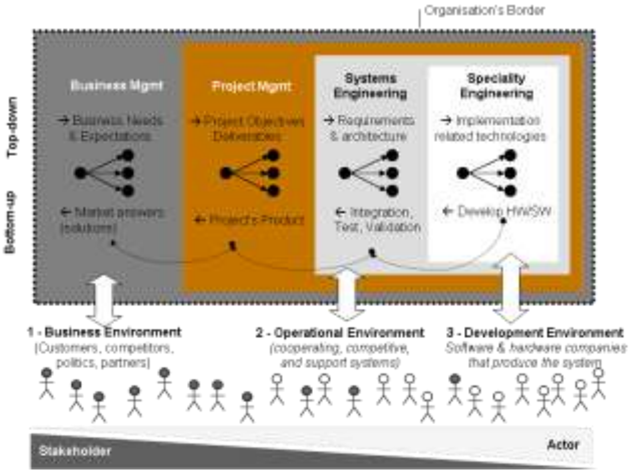

Figure 43: Threefold distinction of organisation's environmental focus

It has been drawn that each environmental focus is classified as treating different *objects* on different levels. But those focuses also provide orientation in terms of *stakeholders* to be considered on the three levels[107].

In literature, the nexus of actors and stakeholder is often given through the prevalent distinction that actors are stakeholder[108], but not all stakeholders are actors. Actors interact with systems and can appear in forms of system or human instances. It is anticipated that stakeholders appear merely within the business or operational environmental context and associated expectation about value generating characteristics. In contrast actors are concerned merely within operational and development aspects and are potential knowledge bearers also associated with expectations about value generating characteristics. The important point that has been shown is that each organisation and its communities interact with different parts of the environment. Communities (should) focus the environment differently. A clear delimitation of these environmental focuses is important for not mixing up logical levels of incoming stakeholders' information.

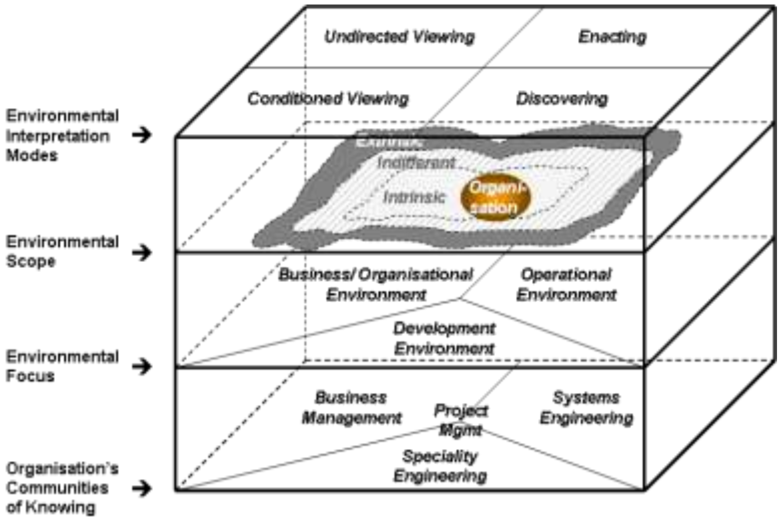

Figure 44: Cubic model of the organisational environment

[107] Nonetheless, a stakeholder identified can be associated with one or more environmental focuses.

[108] In accordance to the PMI (2004) a stakeholder as *"Persons and organisations such as customers, sponsors, performing organisation and the public, that are actively involved in the project, or whose interests may be positively or negatively affected by the execution or completion of the project. They may also exert influence over the project and its deliverables"*. This definition is valid for this work.

The different environmental aspects discussed above and aspects gained from the theoretical part are considered within a cubic model (see Figure 44) differentiating four facets in regards to the organisational environment: *environmental interpretation modes* (enacting, undirected viewing, conditioned viewing, discovering), *environmental scope* (extrinsic, intrinsic, indifferent), *environmental focus* (business/organisational environment, operational environment, development environment) and the related *organisational communities* (business management, systems engineering, speciality engineering).

The subsequent section highlights the ontological dimension of the Knowledge-CoCoOn. The ontological component is supportive element within the coordination of collaboration and knowledge conversion.

4.3 The Meaning of the On<u>to</u>logical Component: Coordination of Knowledge Conversion

Ontologies have been introduced as a vehicle serving towards an organised and transparent mobilisation of knowledge conversions (consult section 2.3). In this work the concept of ontology provide a shared skeletal and relational organisation for knowledge bases (e.g. documents and information units), including it's semantically reasoning for their existence. The ontological component of the Knowledge-CoCoOn goes further and aims at supporting *coordination* within cross-community collaboration and knowledge conversions from an organisational perspective.

Different organisational communities or domains inhabit different "thought worlds", a different vocabulary and diverging thinks about the same object (the project's product), affected by different processes and tasks as well as responsibilities taken in the organisational formation—so do the community of business and engineering. In previous sections the notion of perspective has been loosely mentioned. In this work the model of *"perspective making and perspective taking"* developed by Boland/Tenkasi (1995) is partially reused to describe the mutual exchange of knowledge between those two communities of knowing (see Figure 45). Herein perspective making refers to intra-community's development and refinement of knowledge including its structuring in community-related information spaces. In this work two classes of community perspectives are considered: *the business perspective making community (A)* and *engineering perspective making community (B)*; with an emphasis on the business perspective (including the transition to engineering concerning with early requirements development).

Both the organisation and the environment evolve. It requires the organisation (on all its level) to perform continuous interpretations (see section 4.2), take decisions (typically referred to go or no-go decision) and subsequently establish adaptation plans (e.g. corrective measures). This includes collaboration and knowledge conversion throughout the organisation and its social structures, and the project life cycle. In this context, *perspective taking* plays an important role considering the process reaching understandings of an external (not known or partially known) community. This includes mutual access and visualisation of the respective "thought-worlds". Perspective taking can be understood as a hermeneutic attitude, a sort of "interpretive competence" which means to be able to reflect upon non-familiar (external) community's knowledge and gain new insights and understandings (cf.

Boland/Tenkasi 1995) towards a shared understanding ready to be reflected onto the community’s homogeneous perspective. It is the attempt of “promoting” knowledge and makes it accessible for one or more targeted communities of knowing.

This work refers to the perspective taking area as a *synthetic meeting place*, a forum providing a customised information structure and space to support inter-community perspective making and taking. Knowledge artefacts produced by members of different communities requires a *community-related contextualisation*. This is a process of mutual evolution towards each others community-related information spaces. Figure 45 illustrates the mutual access of business and engineering related information spaces in a twofold manner.

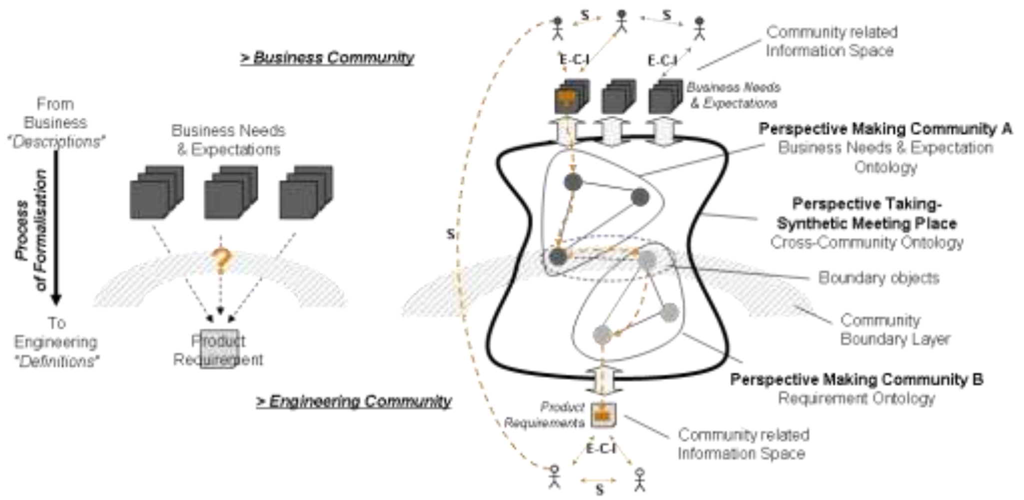

Figure 45: Conceptual illustration of cross-community collaboration and knowledge conversion, without (left) and with an intra- and cross-community ontology (right)[109]

On the left hand side a situation is outlined which indicates a flat and non-contextualised representation of business needs and expectations in front of engineering and is referred to as *macro viewing on information space* (see section 2.3.3). The structure of each of these codified knowledge containers is differently and thus difficult to mentally access in particular for engineering (as an external community). Codified knowledge is stored in different sorts of information spaces and physical IT access is not always given for the community of engineering. It is also a different situation once communities have to treat knowledge bases of an external community; so that unprepared and non-contextualised information could lead to uncontrolled interpretations within the community of engineering. Once business intents are managed exclusively in forms of requirements and architecture only, it could be difficult to prove its correct implementation in engineering processes and related information spaces.

In contrast, Figure 45 right points a situation which tries to capture the idea of perspective making and taking in association to the concept of a “shared” (accepted and understood) ontology. It conceptually illustrates a middle level between community-related information spaces of business and engineering. This middle level should enable previously discussed contextualisation as a synopsis of macroscopic knowledge bases handled separately within the relating communities itself. In comparison to focus community-related information spaces as a whole, the microscopic approach aims at the consideration of information spaces (e.g.

[109] S,E,C, and I indicate Nonaka’s knowledge conversion modes (see section 2.2.3).

documents) in forms of information elements for providing organised insights and orientations towards complex information spaces. The perspective taking area shows further that both communities develop perspectives in front of each other's information spaces. Those are meant to support firstly a community internal sharing and creation of knowledge and secondly identifying *boundary objects* for customised insights. In the frame of this work boundary objects are further defined as constituents for the objective of collaboration between the community of business and engineering. These two boundary objects provide a reflexive representation of each other's understandings towards the level of emergence (group awareness). The community boundary layer is a sort of transition area characterising the *critical pass*, a shift from one thought-world to another. It may requires a number of mutual iterations inside and throughout both perspectives in order to establish adequate BNEs in the thought-world of engineering and conversely. Hereby, the perspective taking area integrates both the business and engineering perspective including the identification of each other's boundary objects. The aspect of *reflexive associativity* between BNEs and the first level of requirements could enable to develop *adequate knowledge transmissions* (the aspect of adequacy is tackled in the following section) providing understandings in front of communities detailed and specialised knowledge spaces. This area is also meant to provide an improved transparency potentially stimulating and motivating each other's community member's awareness switching from a reluctant to a more pro-active mode, and avoiding a false perception of certainty. Even the establishment of perspective taking area does not convey unambiguousness, but it supports collaboration without imposing a cross-community commonly shared meaning (cf. Boland/Tenkasi 1995). Rather the approach is to boost the reconciliation process within each community's perspectives and associated boundary objects.

To sum-up, existing community-related perspectives evolve and might change as a result of changes from the inside or the outside of a community. New perspectives can emerge, which requires a proof of coherence amongst existing ones. Important feature is the ability to *trace* and *update* evolutions across relating communities. The idea and role of the ontological component is to coordinate collaboration and knowledge conversion in the perspective taking area. Thereby relationships between cross-community's members are developed. Business community members can trace consequences of their BNEs and create awareness towards the perspective of engineering (traces in terms of perspective), and help to identify the right persons in charge (traces in terms of responsibilities). Conversely, engineering members potentially gain confidence in their community related perspective and are enabled to mirror their perspective towards the business perspective.

All these aspects are important when thinking about cross-communities evolutions in the perspective taking area throughout the project life cycle and in context of the project's product. Before entering into a proposal for a shared perspective taking ontology within cross communities, it is required to firstly understand the contents of this area. Thus, in the following the aspect of contextualisation and communication within cross-communities will be described more deeply.

4.4 The Meaning of the Context Component: Contextualisation of Cross-Community Related Knowledge for Communication Issues

The context component of the Knowledge-CoCoOn is important for strengthening the dimension of communication of the concept of collaboration. The construct of a message has been utilised to express the matter of contextualisation in section 2.4.3. Herein a message represents a sort of organised and multilayered information-package acting further as a vehicle for contextualisation within cross-community knowledge conversion. The following sections discuss the contents of contextualisation, message adequacy and introduce an information model to organise business intents.

4.4.1 Introduction

A message is defined as being constituted of four components (see Figure 46): *Identity (ID)*, *Situation* (S_T), *Content (I)*, and *Significance (S)*. The four components of the construct *message in a box* (MIB) are organised in a twofold structure: *label* that comprises the component identity and the situation, while *object* encompasses the content and the significance of a message.

Figure 46: Message in a Box (MIB)

The single structural components are characterised as follows:

- **Identity (ID)—The *Who* component.** It provides information about the transmitter's and receiver's (business/personal) identity (name, business identification: department, function, etc.). The identity helps the receiver or interpreter to position transacting partner's origination within the intra-/inter-organisations network. The identity component could trigger rules, i.e. limited access, read/write/modify properties.
- **Situation (S_T)—The *Where & When* component.** The message component *situation* is a sort of snapshot that describes the transmitter's situational condition: spatiotemporal, in correlation with the label, content and its significance. It is a kind of implicit indication of message's validity. Inputs about transmitter's situational circumstances help the receiver to build/abstract environmental relations and get potential insights in circumstances under which the transmitter composed the message. Thus, situational inputs help to bridge the vital and evolving environment (dynamic) towards the transmitter's situation at which he transmitted the message (static).
- **Content (I)—The *What* component.** The content is central part of a message and represents the absolute information that is twofold into specific information 'i' and the related contextual information c (i). The content provides the reason for messaging and contains the actual knowledge elements associated to community related information spaces. The specific information builds the subject and

contains the core information (e.g. a product requirements document) and in association the contextual information provides a sort of source and justification (e.g. based on customer workshops, market survey, R&T and business strategy, etc.).

- **Significance (S)—The *Why* component.** The significance component stands for the degree of attention to be paid in regard to the content (e.g. an email indicated with a high priority in association to the email subject). The degree of significance could potentially have an influence on the recognition and response time (transition time).

4.4.2 Context Adequacy and Success in Knowledge Conversion

A certain degree of receiver's or interpreter's meta-knowledge is required to have a potential probability that the message fulfils its intended aim—to build analogies in the receiver's mind and let him potentially initiate further actions in accordance to the transmitter's message. However, *completeness* and *adequacy*[110] of a message are two critical characteristics towards reaching a *successful knowledge conversion*. *Completeness* constitutes the quantitative dimension of a message and indicates if all attributes in all components IDS_TIS are described. In cohesion, *adequacy* indicates the quality of a message (within each indicated component) having the ability to meet the expectations of the transmitter.

A successful knowledge conversion means that the receiver reacts in a corridor of possible 'acceptable' actions within the transmitter's mind. Receiver's taken actions on the message could vary from: initiating one or more actions inline with the transmitter's intent (including 'consultation' (knowledge conversion) the receiver), ignoring the message and 'do' nothing (mentally or physically) in accordance to the message, or the receiver reacts insufficient and differently as initially expected. Notification and transition time between transmitting and the act of mentally processing the message is not subject of investigation within the frame of this thesis. Rather to identify those components characterising the completeness of a message. A message 'M' is a function of the Identity 'ID', Transmitters-Situation 'S_T', Content 'I' and its Significance 'S'.

$$M = f\,(ID, S_T, I, S)$$

Whereby ID, S_T, and S build a sort of *outer context* respective to the absolute information 'I', that is not to be confused with the contextual information 'c (i)' building the *inner contextual frame* for the specific information 'i' (see Figure 47). Both are representatives of subjective context as introduced in section 2.4.2.

[110] cf. Boland/Tenkasi (1995) argue that *„the stronger and more developed a community's perspective is, the more useful a conduit model (portrays communication as a message sending and receiving model, in which the symbolic or interpretative character of messages in languages in not considered) of communication and feedback becomes"*.

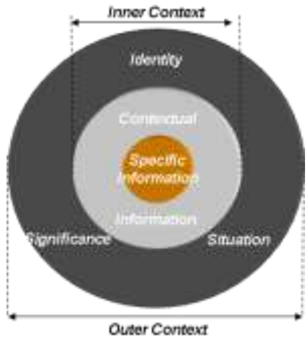

Figure 47: Message's inner and outer context

The completeness of messages is crucial feature for having success in conversing knowledge. This principle is illustrated in a model of message adequacy modes evaluating the potential success of a knowledge conversion. Figure 48 distinguishes four different modes of a message adequacy[111].

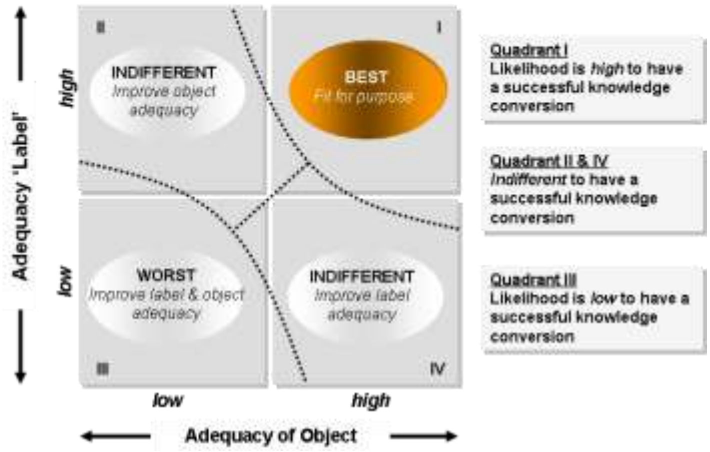

Figure 48: Model of message adequacy modes

1st Quadrant—Likelihood is *high* to have a successful knowledge conversion. The adequacy of both label and object is high and the message is fully and adequately described within all components and its attributes. The probability of a successful knowledge conversion is very high.

2nd Quadrant—*Indifferent* to have a successful knowledge conversion. Messages related to the 2nd quadrant are in an indifferent mode towards reaching a successful knowledge conversion. Here, the label is adequately and completely described, but the object component of the message is not satisfactorily described and needs to be improved. The content could be unstructured, stated in a different language or nomenclature, defects in grammar, spelling and syntax, or contains false or incomplete information and contextual information. Without having adequate specific information 'i' it is difficult to anticipate the subject of message. A defect in the contextual information 'c (i)' components is synonymous with no inputs to the source or justification of specific information existence. A deficiency in information significance impacts the point of realisation and efforts to be spent by the receiver.

[111] A characterisation of message adequacy in context of requirements engineering is the notion of *unambiguous*. Pohl (2007) distinguishes four sorts of unambiguity: lexical, syntactic, semantic and referential.

The extreme situation would be that the message has no content and only an empty 'envelop' with an adequate label was transmitted. In this case a successful knowledge conversion is quite unlikely.

3rd Quadrant—Likelihood is *low* to have a successful knowledge conversion. The message adequacy lacks within both components label and content, e.g. engineering design sketches captured during a meeting on a whiteboard. Without having information of the message-owner's identity there is a potential thread that the interpreter does not trust the message. A defect in the situational component makes it difficult to evaluate the validity of the message object. Potential defects in the object are similar to what has been stated in the 2nd quadrant.

4th Quadrant—*Indifferent* to have a successful knowledge conversion. Likewise in the 2nd quadrant, this quadrant is characterised as being indifferent towards reaching a successful knowledge conversion. But in this mode the label is insufficiently described (reflect 3rd quadrant), in opposite to the content component. The extreme would be that the message is transmitted without label-related information and a highly adequate content. It is a kind of anonymous message, which can potentially lacks in trustworthiness by the receiver. Nevertheless, if the intended receiver reflects the message content it could appear the receiver mentally processes the message and potentially reacts in the sense of the transmitter. However, the knowledge conversion success mode is indifferent.

In consequence of collaboration, the four quadrants described different knowledge conversion success modes in correlation to the message adequacy. Table 9 provides a detailed resolution of characteristics of these four modes within each single knowledge conversion of Nonaka's (1994) SECI model.

S-E-C-I	Low message adequacy (3rd quadrant)	Indifferent message adequacy (2nd & 4th quadrant)	High message adequacy (1st quadrant)
Socialisation (tacit to tacit) Share experiences, spend time together	- Weak personal introduction (label related information) - Hesitatingly tacit-to-tacit conversions with little mental processing by the knowledge recipient - No compatible or low language basis, differing nomenclature → Ineffective knowledge conversion in content and perhaps a poor success on a personal level	***2nd quadrant:*** - Well personal introduction (label related information) - Hesitatingly tacit-to-tacit conversions with little mental processing by the knowledge recipient - No compatible or low language basis, differing nomenclature → Weak knowledge conversion in content, but could be a success on a personal level, e.g. business relation between managers of different languages ***4th quadrant:*** - Weak personal introduction (label related information) - Shared language and nomenclature - Fluent mutual tacit-to-tacit conversions with effective mental processing acts by the recipient → Effective knowledge conversion, but perhaps a poor success on a personal level	- Complete personal introductions (label related information) - shared language and nomenclature - Fluent mutual tacit-to-tacit conversions with effective mental processing acts by the recipient → Effective knowledge conversion in content and perhaps successful also on a personal level
Externalisation (tacit to explicit) → Community based electronic discussions	- Empty or only partial completed record in a database system with only little label information (user name, date) - Empty or partial completely document (digital or hardcopy) - Unstructured and unclear expressions used, false syntax, different language, differing nomenclature → Weak foundation for combination and internalisation	***2nd quadrant:*** - Complete fulfilled label - Empty or only partial completed record in a database system with fully adequate label information (e.g. user name, date) - Empty or partial completely document (digital or hardcopy) - Unstructured and unclear expressions used, false syntax, different language, differing nomenclature → Weak foundation for combination and internalisation based on the codified content, but due to the complete label the owner can be contacted and message's codified content can be improved ***4th quadrant:*** - no or incomplete label information - Complete fulfilled records and associated attributes in a database system - Completely fulfilled document (digital or hardcopy) - Clear expressions used, syntax, language and nomenclature is adequate → Lacks in trustworthiness (no label info), but could induce some further conversions in combination, internalisation	- Completed fulfilled record and associated attributes in a database system, complete label information (e.g. user name, date) - Complete fulfilled document (digital or hardcopy) - Well structured expressions, correct syntax, compatible language and nomenclature used → Excellent foundation for combination and internalisation
Combination (explicit to explicit) → Acquisition, integration,	- poor codified knowledge (content, see above) - weak label information, difficult to establish contact the owner of	***2nd quadrant:*** - Completely fulfilled label - Poor codified knowledge (see above) in content → Combination as such is unlikely, but due to the complete label the owner can be	- Well codified knowledge base in content and label → High potential in associativity and gaining synergising effects based on

synthesis, processing, dissemination	the information → Low associativity and unlikely to gain synergising effects by the interpreter	contacted and message's codified content can be improved ***4th quadrant:*** - Well codified knowledge (see above) but with incomplete label information → Lacks in trustworthiness (no label info), but could induce some further conversions in combination, internalisation	the codified knowledge
Internalisation (explicit to tacit) → personal experience	→ Low learning effects, weak utilisation of guidelines or other instructions, etc.	***2nd quadrant:*** → Low learning effects, weak utilisation of guidelines or other instructions, etc. ***4th quadrant:*** → Effective learning and utilisation of guidelines, instructions, etc.	→ Effective learning and utilisation of guidelines, instructions, etc.

Table 9: Exemplified characteristics of messages adequacy modes for each type of knowledge conversion

The table above depicts some effects of message's success modes within the different modes of knowledge conversion in accordance to Nonaka's SECI-model (1994). Again, the concept of message has been introduced as a vehicle to establish a quasi-standardise organisation for collaboration within all sorts of knowledge conversion across organisational levels and its social structures.

4.4.3 Organisation of the Transition Area between Business and Engineering

The construct of MIB has been discussed within aspects of adequacy and success in context of cross-community collaboration and knowledge conversion. The present construct of MIB employs four components: *identity*, *situation*, *content*, and *significance* as introduced previously in section 4.4.1. This section complements previous elaborations of the MIB (see Figure 49) and focuses on employing a conceptual model capable to serve real-world business-engineering collaboration scenarios using in-formal formalisms (see chapter 5).

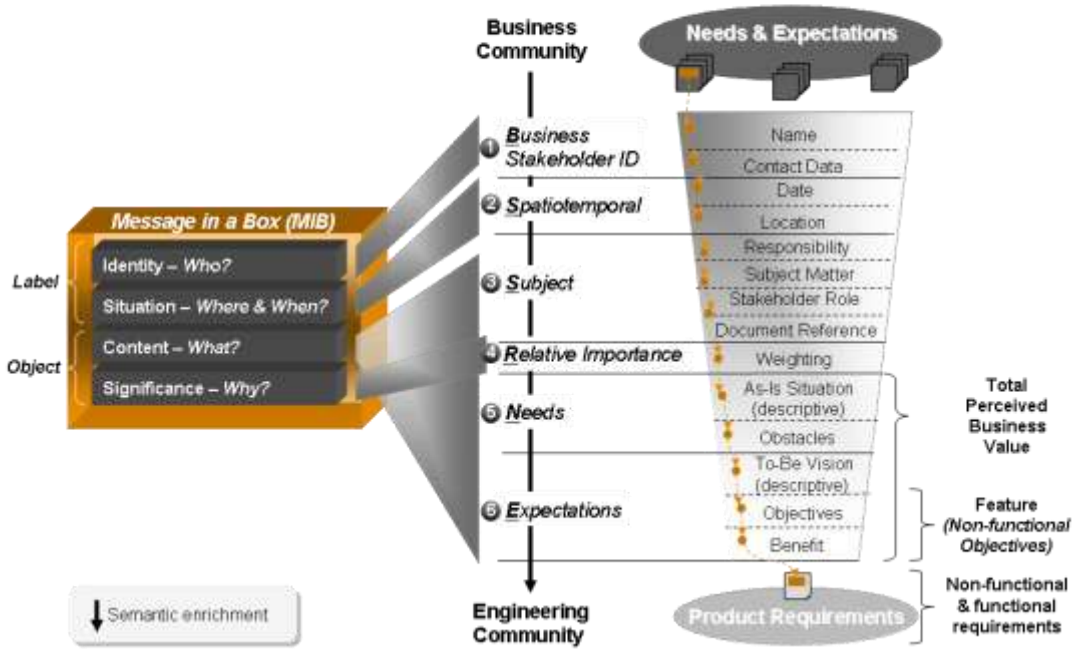

Figure 49: Precision of the Message Concept – A BNE-Perspective (BNE-P)

A business intent[112] that is specified within a BNE-Perspective (BNE-P) comprises the twofold structure of the concept MIB: *label* and *content*, associated to an inner- and outer-context, and is further detailed in six classes[113]: *1) Business Stakeholder Identification, 2) Spatiotemporal, 3) Subject, 4) Relative Importance, 5) Needs, and 6) Expectations*. The figure above illustrates that these six classes and relating attributes[114] are characterising a "funnelling" principle, a concretisation of a specified business intent towards the level of engineered product requirements[115] managed in a requirements specification document[116].

Hereafter, the BNE-P model within its classes and attributes is described in further details.

[112] A business intent is a sketch of BNEs. A business intent is associated with a Total Perceived Business Value (TPBV), which results from the comparison of current needs (at situation A) and future expectations (at situation B), and is characterised through two main features: Expectation Value Degree and Resources (see section 1.1.3.4).

[113] A grouping or collection of objects.

[114] An attribute has at minimum a name and a value (can be of various data type).

[115] Product requirements are defined as the first level of elaborated engineering definitions.

[116] In this work a requirements specification document outlines obligations in forms of conditions and constraints on which business stakeholder agreed upon. This document could also contain specified BNE-P models.

LABEL

(1) – Business Stakeholder Identification

Within the class *"Business Stakeholder Identification"* individuals within the business community are captured. Those are business customers and knowledge bearers in regards to intended business needs and expectations (changes, improvements), and relate to the class "*Subject* (3)" embodying the following sub-classes and attributes:

- *Name*: First name, last name
- *Contact data*: Email, telephone, department, function, etc.

(2) - Spatiotemporal

Situational aspects complete outer context information of a BNE-P. This class complements the previous one within the following attributes respective to when and where a *"Subject* (3)" was created.

- *Date*: month, day, year
- *Location*: company, country

CONTENT

(3) - Subject

The class *"Subject"* is classified as specific information 'i' that is refined into the following sub-classes and attributes:

- *Responsibility:* Provides the person (contact data[117]) in charge, the cognitive capability to control the evolution of fulfilling the addressed *subject matter*, and coordinates communications towards the business customers. Thereby *tasks* (defined project activities) and resources (budget and time) can be assigned towards a subject matter in regards to the overall project constraints, which are part of a structured project plan[118] needed to perform the intended level of change (see intentional analysis below). An issue indicates a problem within the process of business intent fulfilment and that may disturb the project continuation with its given constraints.
- *Subject matter*: Provides the BNE topic that indicates a business intent framed into a BNE-P.
- *Stakeholder role*: Business community members' identified within the class *"Business Stakeholder Identification (1)"* are associated with a stakeholder role.
- *Document Reference:* References to community-related information spaces and objects (justification dossiers, macroscopic document view) from which information is extracted for performing the intentional analysis in contents, i.e. class *"Need (5)"* and *"Expectation (6)"*.

(4) - Relative Importance

This aspect classifies the importance of a BNE-P amongst others. This aspect contains also a rationale for the given weighting.

- *Subject matter weighting:* e.g. percentage, short description (rationale)

[117] Indicates name, telephone, business function, site information, etc.

[118] In contrast to current goal model notations (e.g. i*), tasks and resources focus elements in context of a business process.

BNE elaboration – An intentional analysis

The intentional analysis[119] aims at finding essential features that are mandatory for reaching business intent satisfactoriness. The following two classes: current business *needs* and future *expectations*; are matter of a systematic approach establishing the business intent in form of a comparative analysis. It is an indication of a Total Perceived Business Value (TPBV) associated with a change in product *features* to be available at a future situation and capable to create the expected value, benefit for business community and its members within a given amount of resources[120].

The BNE-P model is orienting on developing intentional structures using informal formalisms towards establishing non-functional product characteristics in partial fulfilment of goal-oriented requirements analysis. For both need and expectation, information is determined from business community-related information spaces and knowledge bearers, i.e. through secondary analysis (i.e. analysis documents), primary analysis (i.e. interviewing business customer) and reviewing cycles. Respective information is considered as *features* on business intent level and as functional and non-functional requirements on engineering level (see Figure 49); the former characterises non-functional objectives, soft-goals indicating product/system qualities; the latter implement features expressing expected system capabilities (see section 2.5.3.3). This separation of features (but staying interrelated) sort from the product/system it is applied to. Established relations enable vertical traceability for both communities having integrated and mutual insights, i.e. follow product qualities to respective functionalities and conversely.

The intentional analysis fulfils a BNE-P within classes of *"Need (5)"* and *"Expectation (6)"* and finally concretises towards one soft-goal tree established within *objective* and *benefits*.

(5) - Need

Initially, a *need* has been defined as *"a lack of something requisite"*. It rationalises the need for change and improve a current business situation. This class considers the following sub-classes:

- *As-Is Situation*: This sub-class provides a descriptive and / or figurative outline of an existing business problematic to be solved or a situation to be improved. It contains information about present real-world circumstances. Here the "point of departure" within pre-conditions and -constraints is outlined including all relevant assets in present use towards the expected future situation stated under (6).
- *Obstacles*: Based on the outlined current business state a concretisation follows, i.e. *essential* (relevant and to be considered) problem statements are elaborated and associated towards objectives stated under (6). Problem statements indicate perceived challenges to overcome and consequently lead (implicitly) to future states of circumstances (see class expectation below).

(6) - Expectation

An *expectation* has been defined as *"a strong belief about something that will happen or be the case"*. Here, an expectation within the BNE-P provides the visionary outlook, and defines the horizon in a predicted mode of circumstances. The class of expectation is refined into three sub-classes:

[119] In principle the proposed approach shows analogies to system analysis approaches like DeMarco's approach of structure analysis (Pohl 2007).

[120] A business intent has been initially defined in section 1.1.4.4.

- *To-Be Vision*: This sub-class provides a descriptive and / or figurative outline of the envisaged future situation. It illustrates the targeted and improved business situation in conjunction with the outlined situation-as-is and obstacles to overcome. The To-Be Vision appears in the logical frame of the subject matter as stated under (3).

Objectives and benefits establish a soft-goal tree. The soft-goal tree is responding towards both obstacles to overcome and functional objectives elaboration.

- *Objectives*: are concrete features, soft-goals characterising projected business intents associated with a *Business Stakeholder* and derived from and representing an element of the sub-class To-Be Vision. Implicitly, those could be also driven through expressed information identified under the class of *"Need (5)"*.

- *Benefits*: Benefits are non-functional leaf-goals and express an objective in terms evaluation criteria providing targeted values and future states respectively (including its characterisation). Benefits are sorts of key performance indicator (KPI) and further constrain the possible solution space from a business stakeholders' value perspective. A benefit is most concretised intentional information unit, i.e. non-functional derivate of a business intent in context of a specific BNE-P. From benefits functional product requirements are developed by PD Teams as part of the requirements specification document. The requirements specification document embodies also engineered requirements statements in regards to elements of the soft-goal tree itself. Whereas, an element of the soft-goal tree results into one or more objects in the requirements specification document (i.e. requirements that outline respective conditions and constraints). Benefits and engineered requirements are classified as boundary objects.

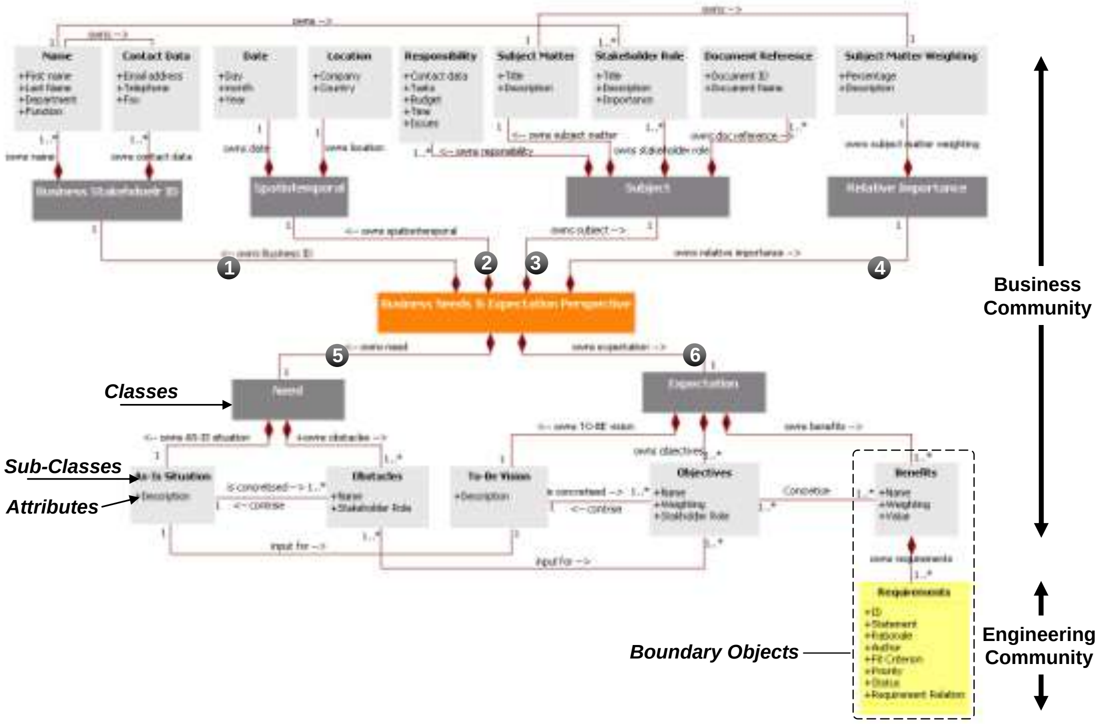

Figure 50: BNE-P – An Information Model[121]

[121] This illustration does not claim full compliance with UML notation.

Figure 50 illustrates the BNE-P model within its constituents of classes, sub-classes, attributes and its associations in form of an information model and the ontological model respectively[122].

4.5 Synopsis and Conclusion

This chapter outlined an informal approach that aims at organising the transition area between business and engineering within a *knowledge representation forum*. This area is characterised as being rather knowledge-driven and challenged by business-engineering collaboration and knowledge conversion. Theoretical concepts of knowledge, collaboration, context and ontology were consolidated and establish basis for a knowledge representation forum introduced as *Knowledge-CoCoOn*, whereas the notion of knowledge is integral component. The concept of *message* is central and vehicle for defining adequate communication and knowledge conversion modes. In context of business intent definition a comprising information model of 6 classes, 14 sub-classes and associated attributes has been developed within a *BNE-Perspective*. A BNE-P integrates structural and step-wise concretisation logic towards engineered requirements as part of the requirements specification document. Soft-goal trees are sorted and organised within informal intentional models specified within a BNE-P. The BNE-P model is based upon a value-oriented and non-functional definition of a business intent (need and expectation) addressed by business customers[123]. Relationships are created between soft-goal trees and elements of the requirements specification document (defined as boundary-objects). The refinement of soft-goal trees results into benefits (non-functional leaf-goals), which are evaluation criteria including their satisfying conditions and constraints (i.e. values). Such goal-metrics' refinement patterns are based upon "AND" relations (aggregated sub-goal structures towards the overall goal). However, alternative paths of goal-metrics ("OR" relations) may be considered and coupled with scenario techniques for preparation once soft-goal trees and functional structures respectively change. Soft-goal trees represent prioritised decompositions (i.e. weighted structures) of expected product qualities. Finally, satisfying conditions and constraints in regards to benefits are weighted, and in turn can provide underlying functional structures and respective PD Teams with prioritised orientations. Progressive states in regards to PD teams' activities and knowledge enables better anticipation of satisfactoriness towards expected value-situations indicated within BNE-Ps and associated soft-goal trees. Established relations enable vertical traceability that aid within mutual navigation from objects of a soft-goal tree to functional structures and conversely supporting business-engineering constellations with evolutionary and cohesive awareness.

In conclusion, a BNE-P is knowledge-based construct for collaborative business-engineering constellations, which centres a total perceived business value perspective of qualities (features) towards the PD process and functional structures. It presents an informal approach to organise intentional structures within BNE-Ps providing better usability for business customer towards stronger formalisms in intentional modelling. Further, the informal approach complements semi-formal and formal approaches in

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[122] Within forthcoming sections and in context of a BNE-P, the notion of "information model" and "ontological model" are used in synonyms of each other.

[123] However, a BNE-P may indicate functional elements that than appear in the requirements specification document within its full functional context associated to one or more soft-goal element.

early RE analysis providing business stakeholder information and prioritised soft-goal trees for modelling stakeholders' dependencies as well as relationships within and across non-functional as well functional structures in conjunction with the requirements specification document. Further information is provided with the BNE-P information model: Responsibility (including tasks, resources and issues), As-Is Situation and Obstacles, To-Be Vision, Relative Importance of a Subject Matter and so forth.

Conceptual Model Requirements

Theory and empiricism delivered a set of overall requirements. Table 10 comprises gained theoretical and empirical requirements in context of business-engineering collaboration and knowledge conversions.

Cognitive Source	Requirements for supporting cross-community collaboration	Rationale / Features
Theory *(see section 2.5.2)*	T.1 Different "thought worlds"	Determine how their members interpret the meaning of information, artefacts, procedures, events, and experiences
	T.2 Different knowledge perspectives	Knowledge cannot be simply passed on by exchanging information between members of different communities
	T.3 Establish a shared context of knowing	Knowledge perspectives underlying individual communities be captured, represented and visualised
		Knowledge perspectives need to be put in relation to each others, which could require extensive participation in community interaction
	T.4 Perspective making and perspective taking	Share meanings among a community's members
		to negotiate and coordinate meanings among different communities
	T.5 Boundary objects	Means for supporting cooperation between different communities in a way, which allows each community to retain local perspectives and yet these perspectives to become interconnected
	T.6 Visualisation of cross-community knowledge perspectives	Supporting cross-community exchanges through visualising community knowledge perspectives and relating them to each other
Empiricism *(section 3.2.6.2)*	E.1 Different Backgrounds	Organisation's members have different working experiences and cultures, nomenclatures (business language)
		Varying enterprise business orientations and objectives
	E.2 Missing common perspective	Missing top-down perspective
		Share the established project vision and objectives
		Transparency of results, knowledge and partners performance
		Ability to address reported difficulties towards an established business needs and expectation perspective on project level
	E.3 Environmental influences	Enterprises influences and could also restrict the degree of knowledge exchange between people in partner
		Support of the business seniors within exploiting the project results

Table 10: Conceptual Model Requirements

The comparison between theoretical and empirical findings shows further some relationships: For instance the requirement *"E.1 Different Backgrounds"* could be an enhancement of requirement *"T.1 Different Thought Worlds"*. In addition, *"T.2*

Different knowledge perspectives" and *"T.4 Perspective making and taking"* correlates with *"E.2 Missing common perspective"*.

5 Realisation: *Conceptual Model Implementation in Practice*

This chapter is devoted to discuss experiences mainly gained through the cognitive channel "Application Cases" of the GLOBE Hybrid Action Research Methodology (see Figure 51).

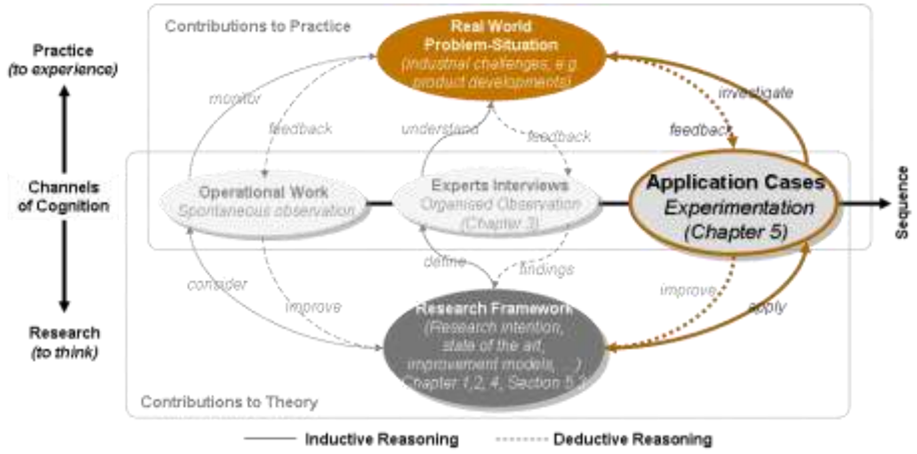

Figure 51: GLOBE Hybrid Action Research Methodology – Industrial Application Cases

The proposed solution of Knowledge-CoCoOn – established in form of the BNE-P model – is experimented (controlled investigation) within two industrial application cases associated with real-world problem situations. Both prove the applicability of BNE-P model classes and attributes based on a given set of business intents and are indicated as broad investigation. In addition, both application cases investigate specificities as follows.

Within the industrial application case of VIVACE principles of evaluating a BNE-P's total perceived business value of qualities (features) and vertical traceability towards functional structures, objects in the requirements specification document, are discussed. Gathered experiences result into the design and development of a knowledge representation forum that shall provide supportive capturing and organisation instance managing informal information in BNE-P models.

The industrial application case of Airbus provides prospective researches and discuses improvements models for engineered requirements as part of the requirements specification document and engineering-related means of verification towards addressed intentional structures specified within BNE-Ps.

The discussion of the industrial application cases (section 5.1 and 5.2) is followed by an overall synopsis and conclusion provided in section 5.3.

5.1 Industrial Application Case: VIVACE

The industrial application case VIVACE is providing an inter-organisational project- and engineering-based environment. It relates to customer-oriented product development of enabling engineering services implemented in software prototypes and is discussed in four sub-sections; the former three sub-sections characterise a respective referencing valuation process consisting of five consecutive activities for supporting the establishment of business-engineering structures; the latter synopsises and concludes on gained experiences (see Figure 53).

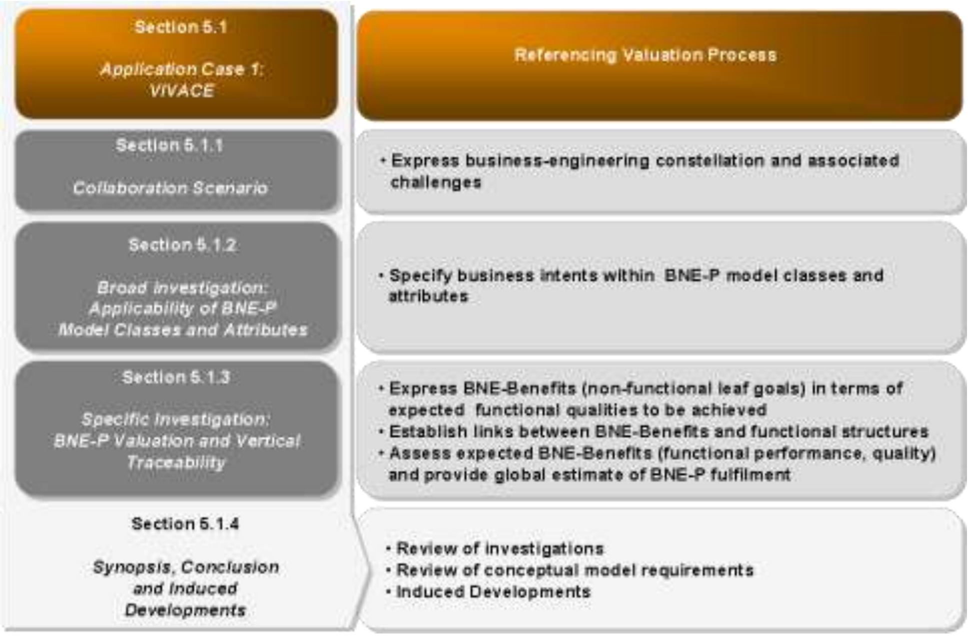

Figure 52: Discussion plan industrial application case: VIVACE

Section 5.1.1: The collaboration scenario is expressing the interaction in a business-engineering constellation within its principles and associated challenges requiring the application of the BNE-P model.

Section 5.1.2: Respectively, a process for capturing VIVACE partners' business intents is defined and conducted, and BNE-Ps were established. Cognitions within business-engineering behaviours (mutual evolutions, collaboration and knowledge conversion) using the BNE-P model are limited to the closure phase of the project. Rather the principle design and applicability of model classes is matter of proof.

Section 5.1.3: With a limited scope of only one BNE-P the transition between business and engineering is analysed more deeply. It complements the referencing valuation process outlining evolutionary control and awareness mechanisms using the construct of BNE-P and vertical traceability mechanisms to follow evaluated business intent and relating engineering structures.

Section 5.1.4: Within this section investigations are reflected, conceptual model requirements are reviewed and finally an aggregated result is proposed, "improving" the initial research framework.

5.1.1 Collaboration Scenario

This section expresses the business-engineering constellation and associated challenges existing in VIVACE.

The VIVACE organisation is grounded on a multi-partnership consisting of 62 partners originating from aero companies, research centres (national, industrial), universities and IT vendors. Figure 53 provides an idealised illustration of the organisational framework of VIVACE.

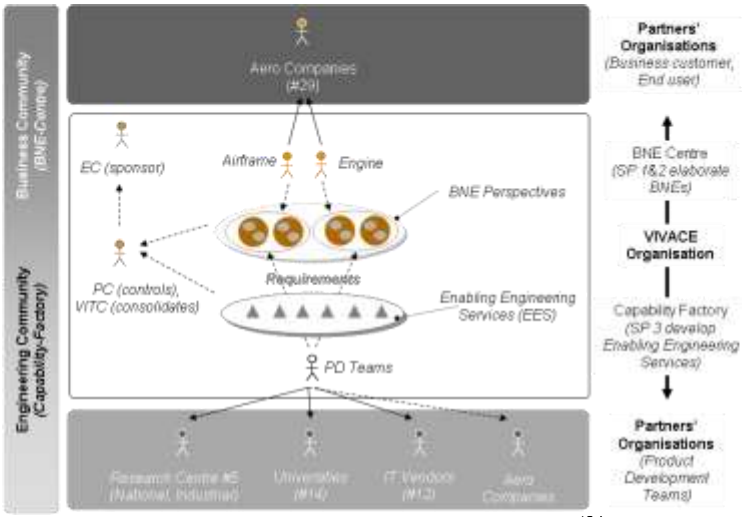

Figure 53: Application Case VIVACE[124]

Aero companies respective to airframe (sub-project 1) and engine (sub-project 2) industry sectors are associated here to a kind of *BNE-Centre*. This centre provided business intents describing current challenges and future expected business improvements respective to engineering work processes and expressed within business perspectives[125]. Conversely, research centres, universities, IT vendors are part of the *Capability-Factory* (sub-project 3[126]) embodying PD Teams responsible for developing *Enabling Engineering Services* (EES), engineering capabilities that are guidelines, information standards and services (modelling and simulation based engineering methods and tools) orienting on given business intents. In this organisational framework the project coordinator (PC) “controls” elaborated business intents in accordance to developments of respective EES. The VIVACE Integration Technical Committee (VITC) is responsible for organising aero companies’ addressed business intents and capabilities developed onto a common structure[127].

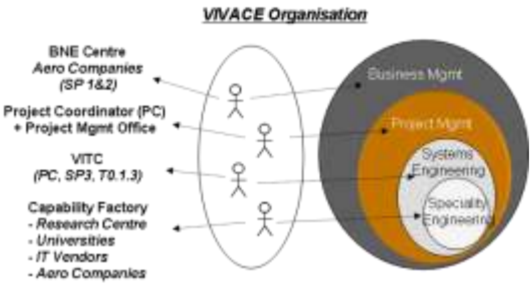

Figure 54: Allocation of Partners and roles respective to the VIVACE Organisation

[124] A detailed illustration of the project architecture, committees and lines of communications is outlined in Annex A.1.1. This illustration rather highlights the particular situation in regards to the elaboration of BNEs and relating developments of project’s products, i.e. EES.

[125] Not always these business intents were already linked to operational units of the respective partner’s company. That means that business-customer and end-user are sometimes not identified. Nonetheless, this aspect was part of exploitation plans aiming at the further evolution of EES in partners’ organisations towards operationalisation.

[126] Also aero companies contributed to developments performed in isolation of the capability centre (sub project 3). In those cases developments were conducted in the absence of other partners, which resulted conversely into more business specific EES, rather than being generic.

[127] The VITC is composed of the project coordinator, PD teams allocating in sub project 3 and task leader responsible for the operational conduction of integration tasks.

Respective to the previous discussions, the VIVACE organisation and associated roles can be depicted in accordance to the organisational structure introduced in section 2.5.3 and is illustrated in Figure 54.

In regards to this organisational framework, it has been noticed that the VIVACE project organisation did not assign a systems engineering layer right from the beginning. A global task for requirements and architecture definitions - consolidating business intents in association to developments of EES on speciality engineering group level - was not allocated in this organisation. Rather, each PD team (related to one or more business intents) performed this task itself. In the second half of the project this deficiency was counteracted through the launch of the VITC group[128].

Challenges

A number of problem-situations in the field of business-engineering collaboration and collective knowledge representation were surveyed by the author and are addressed in this work as follows:

- *Product concept*: Streamlined and sometimes independent organisation of addressed business intents, which contains a potential risk to deliver incoherency within the development of project's products (EES)[129].
- *Community-related information spaces*: BNEs as well as engineering definitions (ED) are elaborated in different documents within various formats (e.g. ppt, PDF, word), structured and elaborated differently (content and granularity), and sometimes only restricted access to those documents is available.
- *Business intent implementation*: Business domain knowledge (i.e. intentional structures) is loosely implemented in EES. PD teams had difficulties to start their work, due to a lack of this information provision from members of the BNE-Centre. In contrast, aero companies argued that outlining business intents in details is not mandatory for starting developments
- *BNE evaluation*: Further, it is difficult to create transparency on each aero company's business intent (in terms of what is intended to be improved partner's organisation) and create a related understanding of their potential contributions to project's high-level objectives.
- *Resources*: The integration activity was initiated in the second half of the project – end of the 2nd iteration and 3rd iteration of the project (see section 3.1). So that business intents and engineering definitions were already specified in deliverables, but rather individually.

Objectives

The BNE-P model is applied to create a collective and explicit representation of knowledge in regards to business intents and aligned with engineered requirements. Within the project the following situational circumstances shall be reached:

- To achieve consolidation in BNEs and EDs orienting onto a commonly shared (accepted and understood) structure

[128] The author of the present work was member of this group and responsible for a transversal task on project level called "T0.1.3_Technical Co-ordination Support". The aim of this transversal task was to consolidate business intents allocated in the BNE-Centre in coherence to EES developed in the Capability-Factory, and to organise those relationships within a commonly shared conceptual product model.

[129] To a certain degree this challenge is counteracted through the matrix organisation of BNE-Centre and the Capability Factory.

- To support not only the single use, but also the extended and lasting use of the project's products (after the VIVACE project), which goes beyond addressed partners business intentions in VIVACE
- To provide potential 'Explorers' (business customer and end-users) in partners' companies with a coherent (adequate, complete and consistent) BNE-ED Library, which is a key element of the deployment and exploitation strategy

The following section discusses the results experimented within the application of the conceptual model of BNE-P on the full scope of VIVACE business intents.

5.1.2 Broad Investigation: Applicability of BNE-P Model Classes and Attributes

The main objective within this section is a proof of BNE-P model classes and attributes based on various business intents addressed towards the VIVACE project organisation.

The approach of harmonising information and structuring information between BNE-Centre (~ business community) and Capability-Factory (~ engineering community) is established threefold (see Figure 55).

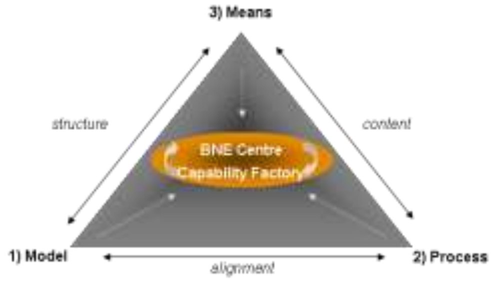

Figure 55: Threefold approach towards harmonisation of BNE-Centre and Capability-Factory

The approach starts with defining a conform version of the BNE-P model, which is aligned towards engineered requirements structures (see section 5.1.2.1). Next, a respective *process* (see section 5.1.2.2) is outlined that was conducted on the full scope of VIVACE business intents. Lastly, used *means* (see section 5.1.2.3) to handle and represent established business and engineering knowledge-structures are introduced.

5.1.2.1 Establishment of the BNE-P Model

Before establishing a BNE-P model that adapts to VIVACE, it was task to elaborate a complete sketch of the VIVACE product concept first. This product concept considers logical derivates respective to the whole PD process of conceptual integration, development, and technical integration and is expressed through three structures: *business structure, capability structure, and implementation for demonstration structure*.

Starting from the 8-layer product model (see section 3.1), a more detailed view of the business structure has been developed. Based on the overall project context and associated high-level objectives, a twofold viewpoint of business descriptions (BD) and engineering definitions (ED) is provided and cascaded as logical derivates throughout the PD process towards respective end-products (see Figure 56, left).

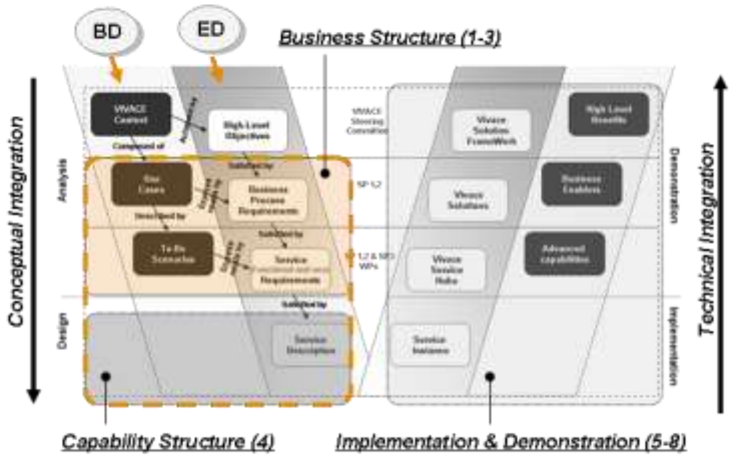

Figure 56: VIVACE Product Concept (adapted from VITC 2006)

The approach is illustrated in top-down logic. This is only valid when considering that business intents are developed streamlined (independently from each other) per aero company, which is reasonable due to the fact that a global and engineering life cycle transversal business intent was not addressed by one or more industrial business sponsors (including associated resources). In consequence, the project context and associated high-level objectives are founded on individual business intents addressed by aero companies.
An emphasis of the VITC group and the authors' work was devoted to conceptual integration encompassing the business and the capability structure.

Definition of the BNE-P Model

In the case of VIVACE a BNE-P is distinguished in BNE-Context (BNE-C) and BNE-Focus (BNE-F). The initial definition of a BNE-P model and the respective intentional analysis resulted into a soft-goal tree. Herein, a BNE-P provides a soft-goal tree that is considered within refined intentional structures of a BNE-C and BNE-F (see Figure 57).

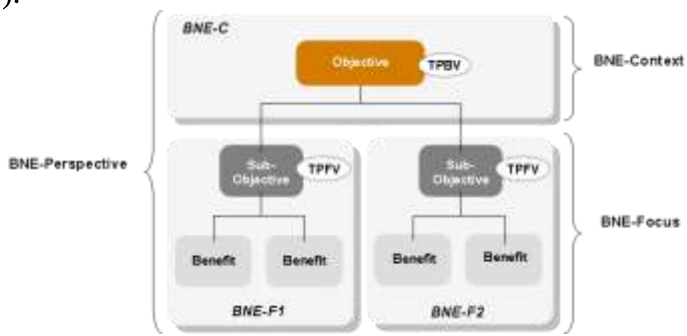

Figure 57: BNE-Perspective (BNE-P)

Inside a BNE-P the BNE-C[130] establishes the overall objective, whereas BNE-Fs establish sub-objectives and relating benefits. This demarcation has been made in order to precise the business intent - starting from its overall context - to be

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130 A BNE-C could consist of one or more BNE-F.

investigated in the scope of the project[131]. In consequence, this differentiated view on business intent results into a twofold distinction of a total perceived value: a *Total Perceived Business* and a *Functional Value* (TPBV, TPFV) and are also associated with an *Expectation Value Degree* (EVD) as well as required resources (see section 1.1.4.4). Table 11 summarises in context of VIVACE some characteristically features of both BNE-C and –F.

Characteristic	BNE-Context (BNE-C)	BNE-Focus (BNE-F)
Synonym used in VIVACE	Use case	Scenario
Stakeholder Class	Business customer	End-user
Value Creation	Total Perceived Business Value: Value creation in the overall business process towards expressed needs & expectations.	Total Perceived Functional Value: Value creation in regards to an element of a BNE-C towards needs & expectations expressed in a quasi-functional sense and the respective benefits.
Definition	A *BNE-C* describes a business context associated with a problematic to solve, or a situation to improve within the product development process. The improvement situation is described and concretised within objectives.	A *BNE-F* is a characterisation of a specific situational aspect of a BNE-C that conveys an improved future way of working using EES to achieve a specific business objective. The BNE-F provides the context and scope for demonstrating value within the BNE-C.

Table 11: Demarcation of BNE-Context and -Focus respective to VIVACE[132]

Elaboration of the BNE-P model respective for VIVACE

The constituents of BNE-C and BNE-F have principle similarities since it is precision of business intents, so that in first order all 6 six classes of a BNE-P: *1) Business ID, 2) Spatiotemporal, 3) Subject, 4) Relative Importance, 5) Needs, and 6) Expectations;* are identified as being applicable for both (see section 4.3.3 for detailed definitions). Nonetheless, the establishment of the VIVACE information model required some modifications as follows:

- *Business Stakeholder Identification (1):* For both BNE-C and BNE-F the business ID has been not utilised; the former would have indicated "physically" the business customer; the latter the end-user within the respective partner's organisation. Rather business customer and end-user are considered within their role in the sub-class *"Stakeholder Role"* related to the class *"Subject (3)"*.

[131] This is meaningful since the whole business improvement ambition encompasses too large a scope that cannot be investigated in the timeframe of the VIVACE project. Thus, the BNE-Context has been concentrated on specific aspects to be investigated in forms of BNE-Focuses.

[132] A BNE-C and BNE-F is associated with synonyms of use case and scenario. This given terminology created a diverging understanding within the VIVACE community, since those are employed by different disciplines and in different contexts. Sometimes these terms were confused with the notion of "system use case" outlining actor's interaction with the system, e.g. using modelling languages (e.g. Business Process Modelling Notation (BPMN), Unified Modelling Language (UML)). It is true that a BNE-C and BNE-F contains elements respective to a process point of view. Nonetheless, the aim of the conceptual integration performed by the author within the VITC group, was not to capture and formalise BNE-P in forms of process descriptions. Rather outlining the total value baselines that characterise the level of change and improvement in terms of features (product qualities interlinked with functional structures). Nonetheless, most work packages produced such descriptions of a concept of operations, but in various formats.

- *Spatiotemporal (2):* The attribute *"Location"* was not utilised in the project. It was not identified as being valuable to be managed in the way the BNE-P in VIVACE was captured.
- *Subject (3):* The sub-class *"Responsibility"* has been not used as such. Rather responsibility is indicated as one attribute of the sub-class *"Subject Matter"*. *"Partner"* is further attribute that indicates participating companies involved in dedicated developments. For a BNE-F two further attributes are defined: *"Inputs for demonstration"* that points all relevant assets (data, hardware, software, etc.) relevant to perform respectively the valuation towards a specific aspect of a BNE-C (i.e. indicated through BNE-F by itself), and secondly "Validation Method" stating how the improvement situation is going to be demonstrated (e.g. process comparison) and valuated.
- *Relative Importance (4)*: This class was not utilised since a weighting towards other BNE-P in regards to their contributions to the project objectives was managed in a different management task later in the process. Nonetheless, it will be part of discussion in section 5.1.3.

Those modifications are indicated in Figure 58, whereas not applied sub-classes are indicated in green. The figure further illustrates the previous twofold distinction of total perceived values as well as the soft-goal tree that is part of intentional structures managed in a BNE-C and one or more BNE-F.

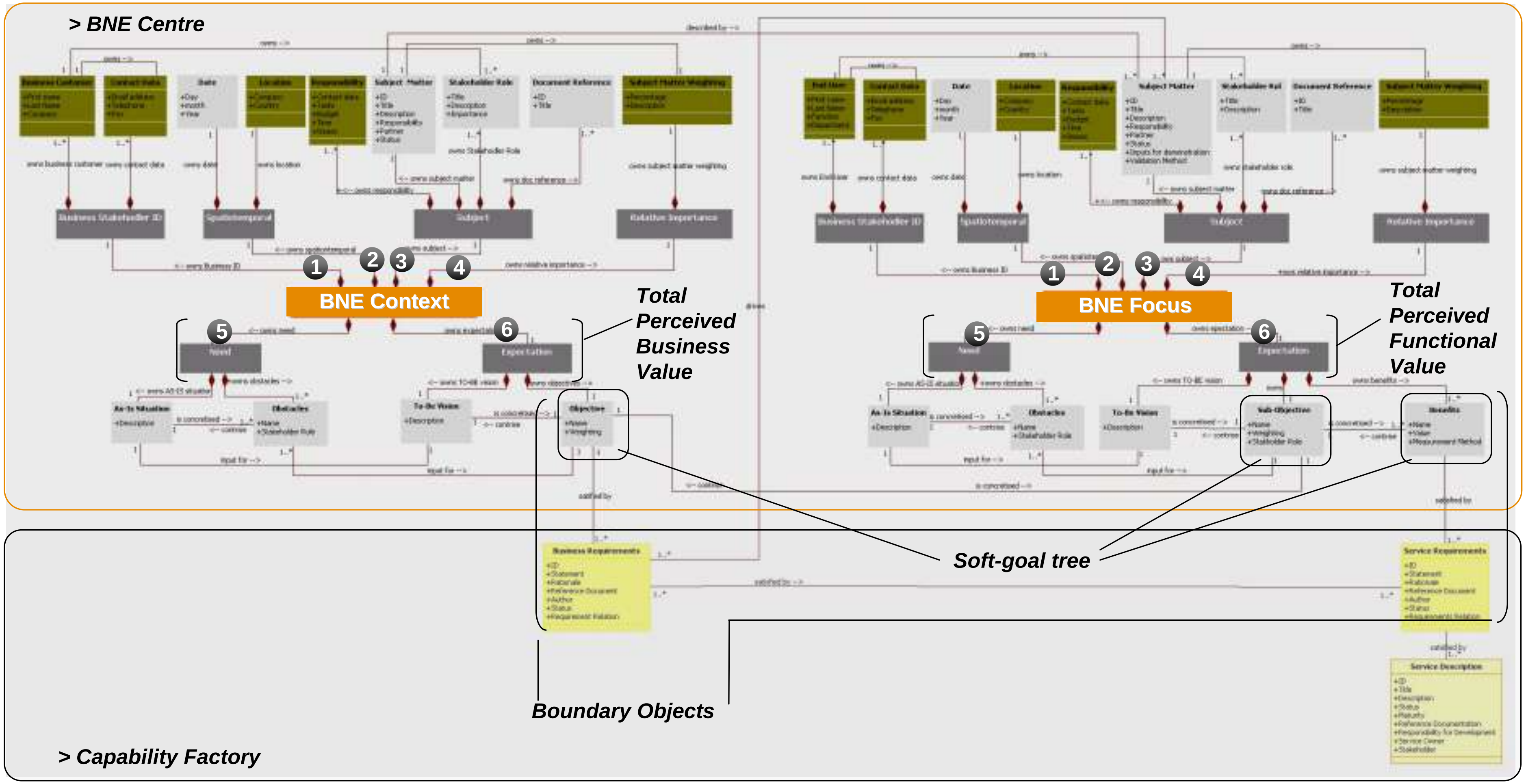

Figure 58: VIVACE related BNE-P model – An Information Model[133]

[133] This illustration does not claim full compliance with UML notation. The term BNE-P model includes related EDs.

5.1.2.2 Fulfilment of the BNE-P Model

This section copes with the *Information Integration Process (IIP)* established to perform the specification of business intents within BNE-Ps and it's relating implementation in forms of EDs. The conduction of the IIP is mixture of interviewing, document analysis, and reviewing cycles (see section 4.4.3) and involved the author of this work and BNE-P leaders, and was managed step by step (Figure 59)[134].

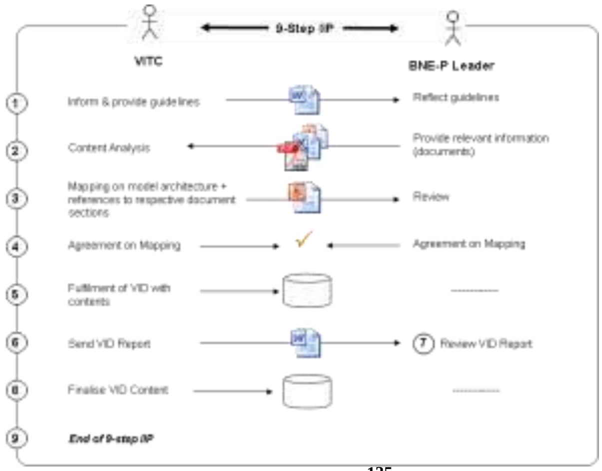

Figure 59: 9-Step Information Integration Process[135] (adapted from Laudan 2006, 2007a)

Firstly, the process has been applied to a limited set of business intents: two from the airframe sector (sub-project 1) and two from the engine sector (sub-project 2). These four pilots have shown that the IIP is feasible, effective and shared[136]. Subsequently, the process has been applied onto the complete scope of business intents addressed in VIVACE and delivered an extensive map of BNE-Ps and aligned with EDs. The following paragraphs point some characteristically features observed and challenges to overcome during the execution of the IIP.

Results Step 1-2

BDs and EDs were merely present in this progressive state of the project, but existing in different document formats and different versions, sometimes context was distributed over documents, and information varied in terms of granularity and formalisms applied. Also nomenclatures (wordings and use of professional language) varied from one business intent and associated EDs to another.

Results Step 3-4

During the analysis of community-related information spaces, contents were decoupled from provided documents and reorganised in association to the logic of the ontological BNE-P model. The mapping was realised in a document indicating

[134] A BNE-P leader was in most cases associated to the project-role work package leader. One premise for defining this process was to keep the level of workload for the BNE-leader as low as possible, so that most of the respective steps are orienting on being processed mainly by the author.

[135] The process was performed in collaboration the author of the present work and respective BNE-Leader using telephone, net-.meeting, and Email. The process has also an iterative character, not at least due to evolutions and updates in documents.

[136] The role of the pilots was not only to prove feasibility respective to different industry sectors, but also to convince remaining members of BNE-Centre of leanness and usefulness conducting this process.

elements of provided community-related information-sources (with an indication of document name, chapter, pages) in association to specific parts of the ontological model (see Figure 60, right). Also, the author captured (or established respectively) relationships between different BNE-P model attributes (see Figure 60).

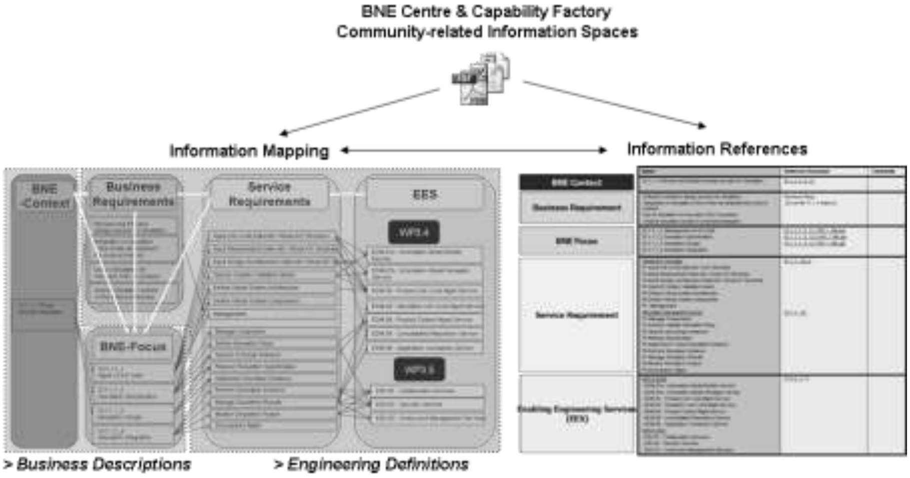

Figure 60: Mapping and referencing community-related information onto a BNE-P and related EDs

The result performed for a specific BNE-Ps and associated EDs was validated in collaboration with the respective BNE-P leader and the author of this work.

Results Step 5

After the validation of business intent related information mappings and references, the BNE-P model was fulfilled in contents. All respective model classes and attributes defined for BNE-C and-F as well as for requirements and EES were fulfilled[137]. Some attributes' values have been fulfilled by the author as derivates of existing information including the establishment of relations between information.

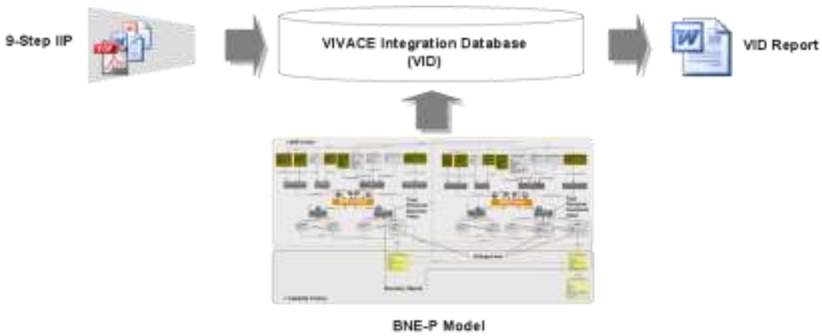

Figure 61: Instantiation of BNE-P Model

The conceptual establishment of the BNE-P model including contextual information structures is handled within a database (see section 5.1.2.3).

[137] The aim within this BNE model was not to manage whole community related information-spaces, rather a logical synthesis. The extent to which information was considered in the model was matter of decision to the author. No specific guidelines were established. Nevertheless, given classes and attributes defined in the ontological model provided some guiding principles.

Results Step 6-8
The BNE-P leader receives a respective specification report that includes specified intentional structures and EDs. The related report is extraction from the database that is finally validated and modified.

Results Step 9
The 9-Step IIP has been successfully processed.

5.1.2.3 Operationalisation of the BNE-P Model

The VIVACE Integration Database[138] (VID) is instance of the BNE-P information model. It supports the process of specifying business intents and EDs on project level and is utilised to organise and master the synthetic meeting place within structure and content, and includes all association. Besides the back-end solution three means for populating the collective knowledge representation forum in forms of front-end solutions for the VIVACE community were provided (see Figure 62).

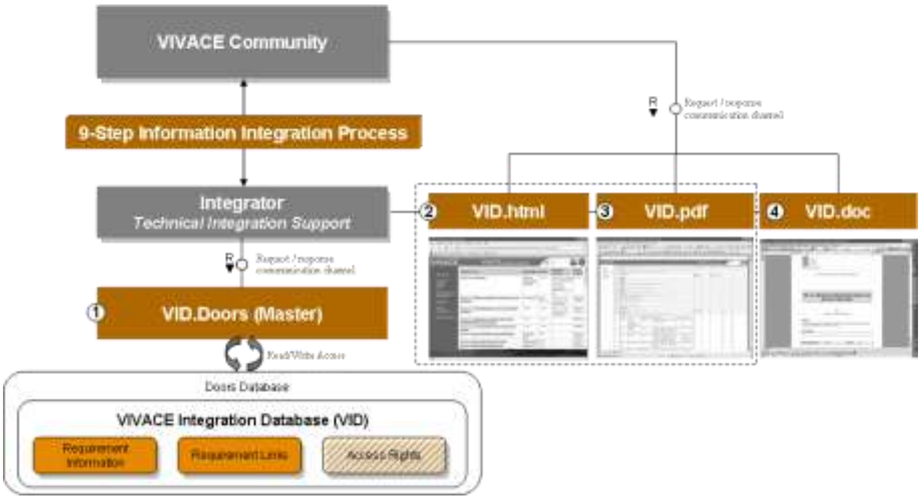

Figure 62: Means to populate the VID content (Laudan 2007a)

The three front-end means to exploit BNE-Ps and EDs are as follows:

- VID.html: A static website that is result of an export performed by the VID and provides full navigation and traceability mechanisms throughout business intentional structures and engineering definitions.
- VID.pdf: A report format that is based on the VID.html providing all links enabling to perform search and find elements in intentional and engineering structures.
- VID.doc: Respective project deliverable that contains all documents used and produced along the IIP and provides a complete collection of specified BNE-P and EDs.

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[138] The selected software tool to manage the VID is Telelogic DOORS® (Dynamic Object-Oriented Requirement System), a commercial requirement management tool from Telelogic (www.telelogic.com). This tool is a system designed to capture, link, trace, analyse and manage changes to information in order to ensure a project's compliance to specified requirements. In the field of requirements management and engineering a number software solutions exist. A complete overview of existing requirement traceability tools can be found on the International Council on Systems Engineering (INCOSE) website.

Following discussions emphasise the implementation of the BNE-.P model within the VID. The figure above shows that the VID consist of two elements: *requirements information* and *requirements links*.

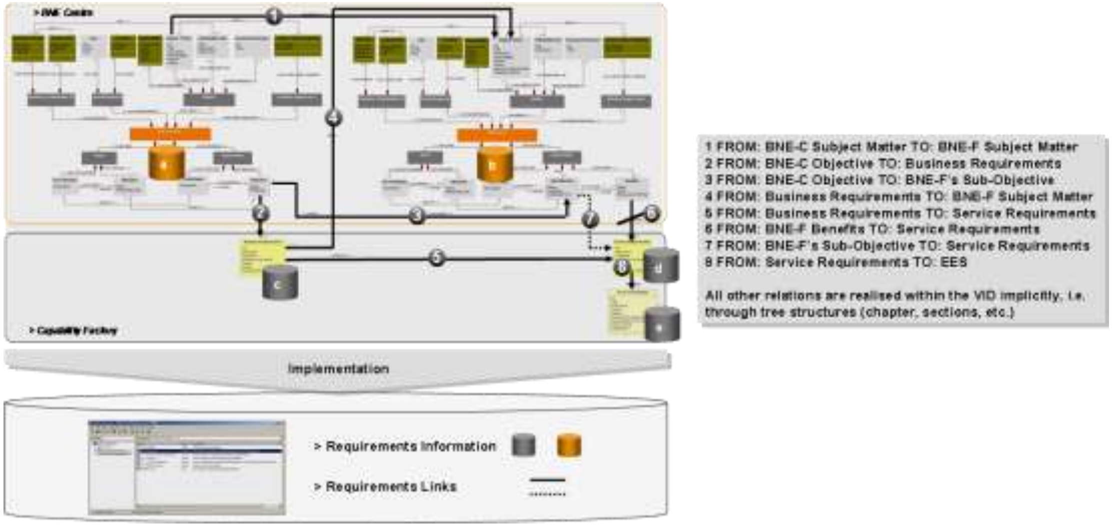

Figure 63: Implementation of BNE-P Model

The implementation of the conceptual model in DOORS is based on the following two elements[139]:

- **Requirements Information (see Figure 63, a-e).**

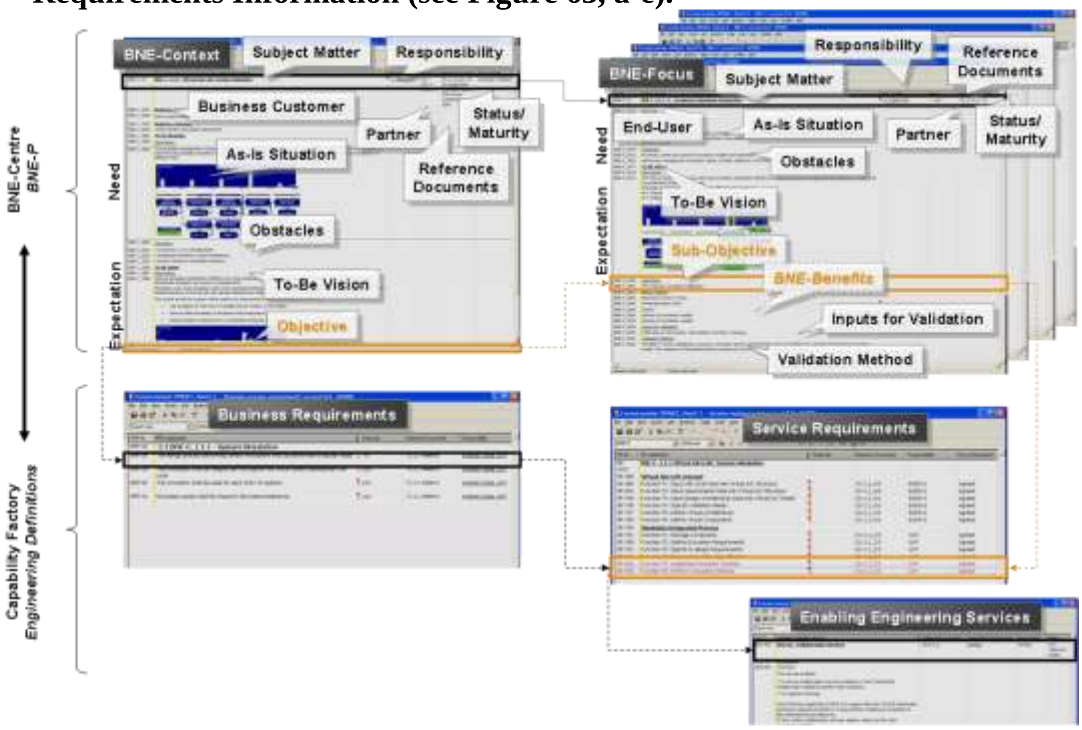

Figure 64: Implemented BNE-P model and related EDs

All relevant information in association to BNE-P model classes and attributes: BNE-C (a), BNE-F (b); and EDs: business requirements (c), service requirements

[139] User rights management and access to the doors database was not matter of discussions. The DOORS database was only used to support the management and administration of VIVACE requirements on project level; and secondly because of efforts for licenses and trainings.

(d), and EES (e); are organised in modules[140]. Figure 64 provides an example of implemented intentional and engineering structures and related information. It further illustrates the soft-goal tree establishment towards associated engineering structures.

- **Requirements Information Links (see Figure 63, 1-8).** The classifications of defined relations between requirements information managed across different modules are defined within Link-Modules (see Figure 65)[141].

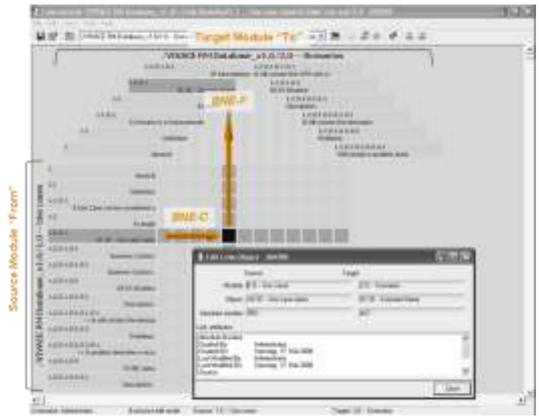

Figure 65: Example of a link module

The annotation of service requirements with BDs on the level of boundary objects, i.e. benefits indicated as non-functional leaf-goals (see Figure 58), was not achievable in the frame of the broad investigation (see Figure 63, requirement link (6)). Thus, as most practicable approach identified service requirements have been associated on the level on the level BNE-F's sub-class *"Sub-Objective"*.

Nonetheless, section 5.1.3 is devoted to perform a deepen analysis in the transition area between intentional and engineering structures in particular on the level of boundary objectives (i.e. decrease the "distance" of contextual relation).

5.1.2.4 Synopsis and Conclusion

Methodological Review

The previous three sections dealt with the establishment of a VIVACE BNE-P model originating from the concept of Knowledge-CoCoOn (see chapter 4), a process to fulfil the model with content and the means that were applied to operationalise the previous two.

The broad investigation of the conceptual model within the VIVACE organisation was a valid proof of classes and attributes defined for the extended consideration of a BNE-P differentiated in context and focus. The process was applicable and delivered a large set of business intents expressed within BNE-Ps and aligned with respective EDs (Laudan 2007b). This externalisation of collective (business and engineering) knowledge dealt with the conceptual product integration. Herein, business intents

[140] Modules are sorts of database tables.
[141] The direction of link types (see Figure 65) is performed through the selection of requirements information as Source Module ("From") and a Target Module ("To").

were specified in forms of BNE-C and –F annotating EDs and provide a respective contextual frame for rationalisation (see Figure 66).

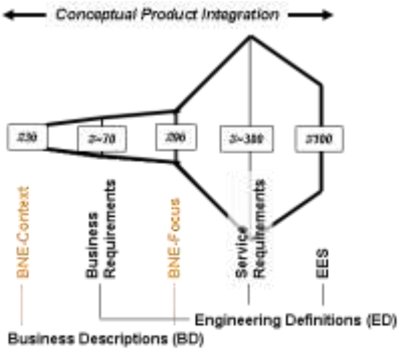

Figure 66: Annotation of engineering definitions with business descriptions[142]

Perceived challenges

The integration activity was performed at a progressive state of the project and PDs, so that business intents and engineering definitions were already established, but in individual structures (in contrast to defined BNE-P model classes and attributes). In consequence, it was not obviously beneficial for BNE-P leader to contribute within the conceptual integration activity.

Information coherency (adequacy, completeness and consistency) respective to the ontological model varied from case to case. But also the complexity, the number of documents and contently structure had an influence[143]. Even if the 9-Step IIP has been validated based on four pilots and explained as well as shared (accepted, understood) on project level, still efforts in performing "missionary" work was required - not only to explain, but also to convince BNE-P leader[144].

In coherence to the increasing specification of business intents in BNE-Ps (including associated EDs) a progressive transparency was created and led to a shift in behaviour: from reluctant to rather pro-active work package leaders' behaviour performing the integration task. Moreover, the notion of transparency and the establishment of a synthetic meeting place became to a certain degree operational and meaningful for collaboration in the project[145].

Achievements and Limitations – Review against objectives defined

- *To achieve consolidation in BNEs and EDs orienting onto a commonly shared (accepted and understood) structure*

  An organisation of BD in alignment with ED has been achieved in the logic of conceptual product integration, i.e. the BNE-P model. But, a transversal analysis of specified BNE-Ps in regards to aspects of coherency across on its most concrete

[142] Proportion of annotations within BDs and EDs: BNE-C to business requirements: ½, BNE-F to service requirements: ¼, SR to EES: 4/1.

[143] The average net time for conducting the 9-Step IPP differed from about 3 hours to 10 hours – considering that the gross time varied in between 1 to 4 weeks for performing the 9-step IIP per BNE-P due to peoples' availability.

[144] The continuously increasing level of transparency resulted in a shift of BNE-P leaders' mindset from in the beginning being more reluctant to a progressively encouraged behaviour being part of the VIVACE product concept.

[145] During project reviews increasingly BNE-P leader as well as PD Teams started to reference their reportings onto the ontological model defined.

constituents, i.e. across soft-goal trees (objectives, sub-objectives, and benefits) would have required additional iterations. It is anticipated, that such an analysis could have led to further optimisation of bundling and harmonising development resources - such synergising effects could be achieved if already performed in the project set-up phase. Nonetheless, the progressive state of the project did not justify attaining such a detailed analysis in terms of peoples' availability in the project.

- *To support not only the single use, but also the extended and lasting use of the project's products (after the VIVACE project), which goes beyond addressed partner's business intentions in VIVACE*

  This objective could have been not proved, but some of the partners contacted the author to get explanations on the usage and way to exploit VIVACE products with the means that have been put in place.

- *To provide potential 'Explorers' (business customer and end-user) of the VIVACE partners companies with a coherent (adequate, complete and consistent) BNE-ED Library which is a key element of the deployment and exploitation strategy*

  The ambition of establishing an organised BNE-ED Library has been achieved and is identified by the project partners as a key deliverable in the project which also supports partners' exploitation and deployment processes (as described before).

To sum-up, potentials of the model in the set-up and execution phase of the project were not experienced. Rather the closure phase of the project was experienced as being supported within exploitation task. It has been further not experienced in which way and to which degree this activity was timely able to influence or support demonstration and validation activities.

Contributions to Practice – Feedback gained through changed conditions and review against empirical findings

The integration activity that has been performed and the means that have been put in place changed VIVACE problem-situations as they were observed in the VIVACE organisation within the experts' interviews as follows (see Table 12).

Empirical Findings - Challenging aspects	Feedbacks
Different backgrounds	The circumstance of having to comprise different backgrounds cannot be changed, nevertheless it was mentioned that such an structured approach towards the illustration of BNE-Ps in conjunction with engineering definitions could have been potentially improved within reaching common and create value-oriented understandings more efficient (i.e. fast) and effective (i.e. coherent).
Missing common perspective	*"The mapping approach that has been trialled on the use cases/scenarios does work and helps to get a common understanding at global project level as well at work package level in regards to business intents addressed and functional components developed"* *"Effectively the approach helps to get a better understanding of the existing EES and open new opportunities to use these services through having created a business value perception baseline"* *"[…] Deliver at the end a fully consistent and organized set of results, linking the why? (Business intents, i.e. expected product qualities), the what? (Functional objectives) and*

	the how? (Enabling engineering services)"
Environmental influences	*"The model and process aids in gathering a common understanding within the project across other business intents and associated developments. It supports to have better organisation of the endeavour in form of synthesised description which aids as communication towards business seniors (business customer in partners' organisations) also"*

Table 12: Some Feedbacks in regards to changed condition in the real-world environment of VIVACE[146]

Winning people and convincing people in partners in order to gain their contributions was challenging aspects within the integration activity performed. The key aspect within such an inter-organisational environment is the creation of *transparency*, *trust* and mobilisation of collective (tacit and explicit, as well externalisation and internalisation of knowledge) *knowledge* through effective and efficient *collaboration*. Organised collaboration and knowledge conversions across business and engineering communities enabled an improved visibility and created shared understanding not only within the project organisation, but also outside (partners' organisations) for matters of exploitation and deployment.

5.1.3 Specific Investigation: BNE-P Valuation and Vertical Traceability

5.1.3.1 Introduction

Previous sections dealt with the outline of a business-engineering collaboration scenario and the specification of VIVACE business intents in forms of BNE-Ps including the alignment with EDs. But it has been shown that the application of BNE-Ps was limited in regards to detailed investigations in the transition area on the level of boundary objects (see Figure 67, black dotted line)[147]. In turn, the specific investigation copes with the explicit (i.e. more detailed) transition between business and engineering structures (see Figure 67, orange dotted line).

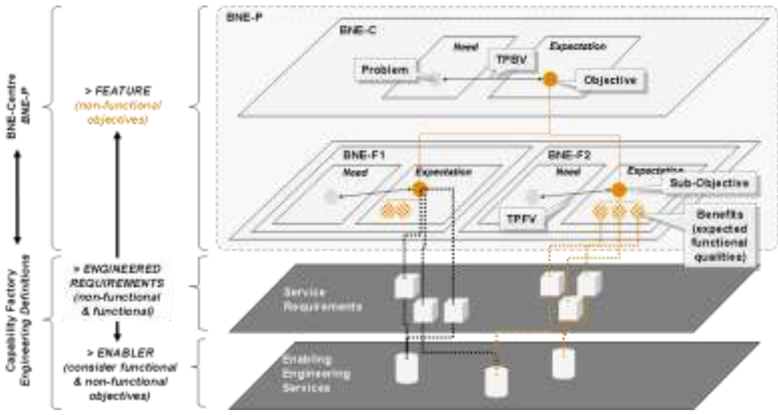

Figure 67: Scope of investigation Section 5.1.3[148]

[146] Those outlined feedbacks were captured during VIVACE review meetings (partially given by people who have been interviewed).

[147] As mentioned previously, relationships with service requirements have been established on the level of BNE-F, i.e. sub-objectives, but not on the most granular level of BNE-benefits (BNE-B), i.e. evaluation criteria.

[148] Business requirements are not matter detailed investigation. Rather the focus concentrates on benefits and service requirements transitions.

The overall purpose is to introduce mechanisms and techniques towards evolutionary control and awareness mechanisms using the concept of BNE-P and vertical traceability mechanisms. Herein, a soft-goal tree is established intent-driven, i.e. originating from intentional structures and described through context-providing information (i.e. based on fulfilled BNE-C and BNE-F model classes and attributes, e.g. stakeholder information, As-Is situation and To-Be Vision, obstacles, and so forth).

The proposed BNE-P model originates from a value-oriented definition of business intent and describes the level of change in product features (qualities) as a demarcation of the notion of *need* and *expectation*. As a result TPV can be defined for a BNE-C and BNE-F; the former is indicated as *Total Perceived Business Value (TPBV)*; the latter is indicated as *Total Perceived Functional Value (TPFV)*. Within the soft-goal tree a TPBV is aggregated result of underlying TPFV and can be described within the following equation.

$$TPV = \frac{Feature_{Expectations,SituationB} - Feature_{Need,SituationA}}{Resources}$$

The TPV increases once qualities (change in features) increases and requiring resources[149] decreases. In contrast, a TPV decreases once qualities decreases and requiring resources increases.

Moreover, forthcoming sections orient onto the introductorily outlined referencing valuation process (see section 5.1), which is outlined as follows:

- Express BNE-Benefits (non-functional leaf goals) in terms of expected functional qualities to be achieved
- Establish links between BNE-Benefits and functional structures, i.e. service requirements (functional objectives)
- Assess expected BNE-Benefits (functional qualities) and provide global estimate of BNE-P fulfilment

The process includes interviews, analysis of source material (documents), and reviewing cycles with the representative of one BNE-P.

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[149] In this context, resources were defined in section 1.1.4.4 as: Required human expertise (cognitive capabilities), hard- and software, facilities, machines, temporal assets, and so forth.

5.1.3.2 Approach

The establishment of a BNE-P evaluation approach requires a structured and organised process and activities. Previously it has been pointed that this section complements the introductorily outlined referencing valuation process. Moreover, Figure 68 describes the detailed evaluation process that is to be applied on one BNE-P.

Figure 68: A generic evaluation process (adapted from Breiing/Knosola 1997; Ehrlenspiel 2003)

Constraints

The evaluation model that is going to be established needs to serve the following demands:

- Low effort for conducting the evaluation process and method applied on a BNE-P
- Applicable throughout the whole project life cycle
- Ability to calculate a hierarchical constructed evaluation system based on targets (i.e. soft-goal trees)
- Possibility to calculate overall values for BNE-C and BNE-F
- Mechanisms to identify risk-areas in BNE-P structures
- Vertical traceability mechanisms to perform root cause analysis: enable to follow BNE- Benefits (BNE-B) identified as critical to be reached towards impacted engineering definitions
- Opportunities to consider uncertainties within the BNE-P evaluation model and outline the respective trajectory as today's business situation and the envisioned future business situation as well as continuous evaluations of a BNE-P during the execution of the project

Methodological Approach

This work introduces the *Utility Value Analysis*[150] (UVA), an evaluation method that will be applied along the evaluation process as outlined above (see Figure 68). Prevalently, the UVA is applied to evaluate product and project alternatives based on a step-wise weighted hierarchical objectives-system as well as a precision towards "measurable" evaluation criteria (see Laudan 2005; Laudan/Mauritz 2006). Overall

[150] This procedural method aims at an organisation of criteria within homogeneous and subordinate hierarchical levels in order to identify on lowest level logically dependent criteria for evaluations. Objectives are hierarchical structured and captured in a so-called objectives-system. This systematic approach aims at forcing the respective evaluator to reach completeness in surveying objectives on each hierarchical level. The importance of each individual objective is characterised through a corresponding weighting factor (Breiing/Knosala 1997).

utility values can be calculated and trade-offs between hierarchical systems can be performed accordingly[151].

Figure 69 points exemplarily the UVA applied onto the BNE-P model within three hierarchical levels: BNE-C (illustrating the overall objective and characterises business value), BNE-F (providing sub-objectives as a matter of detailing and characterises the functional value) and BNE-B (establishing baseline for evaluation criteria and values).

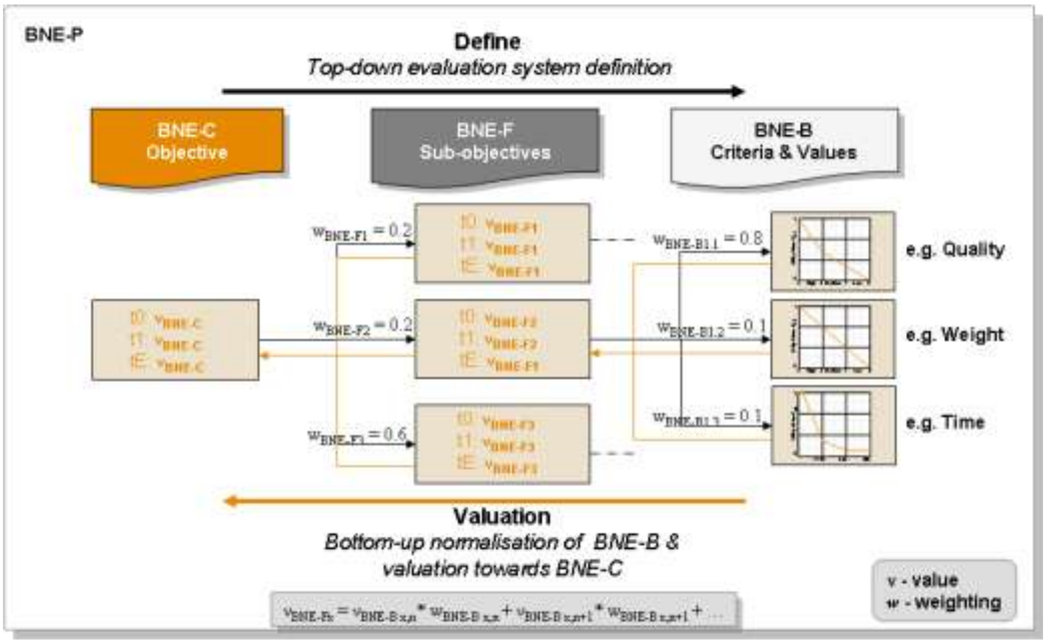

Figure 69: Utility Value Analysis applied on BNE-P

In complementation to previously defined constraints of a BNE-P evaluation model, the UVA will consider also the following:

- Allow assessments of a BNE-P (Figure 69), i.e. soft-goal trees encompassing intentional structures related to BNE-C, BNE-F, and to BNE-Benefits (criteria and values associated to the BNE-F)
- Characterisation of BNE-Bs through *Utility Value Functions* (UVF, see below)
- Express uncertainty of information related to BNE-B values into an uncertainty of assessment expressed within utility values (see Figure 70)
- Normalisation of BNE-B criteria so that overall utility values (on BNE-F and C level) can be calculated in a bottom-up manner

The evaluation system is characterised through a twofold organisation: the top-down definition and the bottom-up valuation process. Further, it is indicated that BNE-B criteria are described through UVF.

Utility Value Function

The level of BNE-Bs indicate the level were measurements are taken – the instance of detecting situational circumstances through end-users' evaluations (functional

[151] The method facilitates a normalisation of evaluation criteria so that qualitative as well as quantitative scales can be aggregated towards total values.

valuation[152]). End-users' provide associated weightings indicating different BNE-Bs contributions (i.e. weightings) respective to a BNE-F. In comparison, BNE-C and –F are dedicated valuations of business customer (business valuation[153]), who provide an indication of each single BNE-F contribution towards the BNE-C. The characterisation of evaluation criteria is facilitated within already mentioned UVFs[154], which means that incrementally BNE-Bs are expressed within utility values. Additionally, uncertain information respective to values of BNE-B criteria is required to be considered. This means that evaluation criteria shall not only be considered in forms of scalars, but also within different forms of random variables (RV) depending on the way BNE-B values were evaluated by the expert. Figure 70 exemplarily depicts BNE-B criteria 'time' as function of utility values.

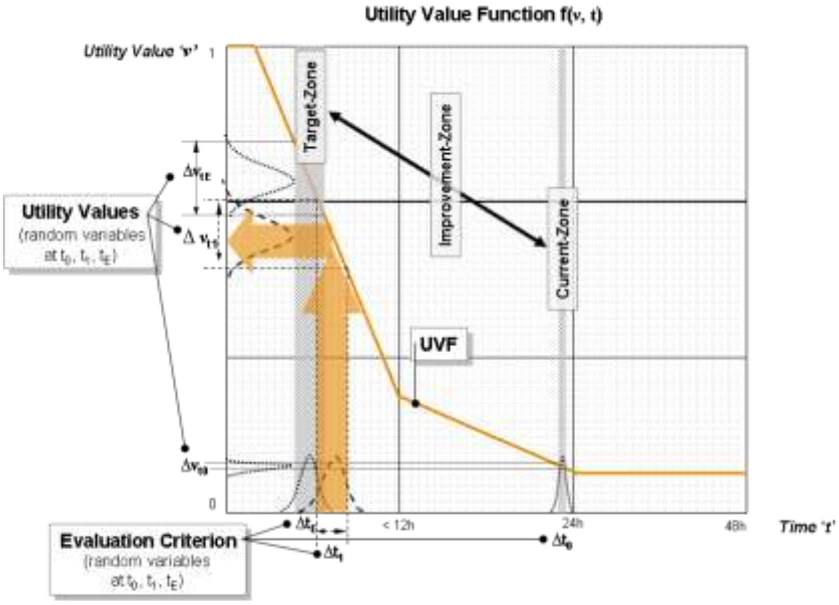

Figure 70: Example – Utility Value Function

Herein, three zones are indicated: *Current zone* (indicating the current business situation), the *target zone* (indicating targeted values to be reached at the end of the project) and *improvement zone* (indicating the continuum in between current and targeted zone). It is further illustrated that whether the current situation 't_0' as well as the targeted situation 't_E' is anticipated within ranges 'Δ'. Thereby, 't_1' indicates a measurement somewhere in the execution of the project towards probable target achievements[155].

The posterior discussed example is built upon this threefold zone- and temporal-distinction respectively.

[152] Effectiveness and performance of functional characteristics, i.e. improvements of engineering task models.
[153] Effectiveness and performance in business characteristics, i.e. improvements in the overall organisation's business process.
[154] A UVF expresses criteria characteristics and values. Its characteristic developing is determined either with the help of the known mathematical relationship between the value and the parameter, empirical surveyed data, or by use of estimates.
[155] In this work only one snapshot at 't+1'evaluating a BNE-P is exemplarily illustrated to denote the execution phase. Normally throughout the project's execution phase a number of measurements, probably in defined frequencies are performed.

Implementation approach

The computation of the utility value analysis including the consideration of uncertainties in BNE-B criteria is performed using an EADS in-house tool called CAPE (Computer Aided Probabilistic Evaluation)[156]. CAPE is a class library which implements required object libraries needed for modelling and simulating probabilistic systems based on Matlab's® core functions and Simulink's® graphical interface. The CAPE library provides functional modules divided into four areas as illustrated in Fig. 3.

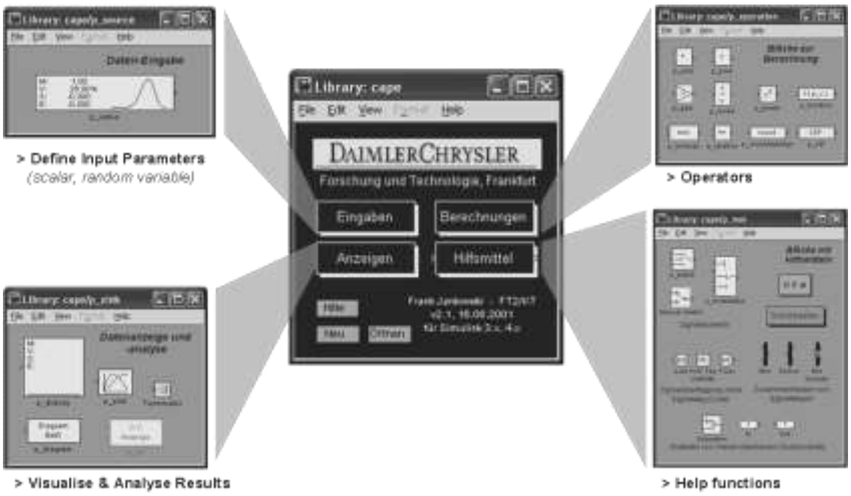

Figure 71: CAPE Library

Those consist of a full graphical user interface and support intuitively the application of those. Complex models can be organised in subsystems and are structured in several hierarchical levels.

5.1.3.3 Conduction and Analysis

In this section the introduced generic evaluation process (see Figure 68) is applied on one specific example surveyed within the broad investigation already.

Step 1 - Identify persons who evaluate

Exemplarily, the BNE-P indicated as "Virtual Aircraft (VAC)" with the overall objective *"To have a consistent vision of aircraft systems architecture using effective simulations shared in extended enterprise"* is selected as candidate to perform the evaluation process in contents. The conduction of the evaluation process is performed in collaboration with one BNE-P representative and the author of this work. In the

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[156] This tool is EADS IW in-house developed software that performs a mathematical-analytical approach. In comparison to other methods such as Monte Carlo Simulation (MCS) the mathematical-analytical approach is less a time-intensive computing method. It is based on moment transfer method considers the first four statistical moments; those are the expected value, variation coefficient, skewness, excess (see section 5.1.3.2, step 5). Apart from a rapid computation method, the implementation focus has been emphasised on an easy operation and management of probabilistic models from an engineering perspective. CAPE utilise Matlab®/Simulink® with its dedicated statistical toolbox. This software environment is frequently applied in simulation and analysis of linear and nonlinear systems in many branches. It offers the possibility for modelling mathematical-technical problems and their numerical solution, and provides graphical visualisation and analysis means.

frame of this study the BNE-P representative embodies also the business customer as well as the end-user.

Step2 – Derive evaluation criteria, Step3 – Characterise evaluation criteria

In context of the ontological BNE-P model, objectives and benefits were defined as representing constituents of the evaluation system. Within this system those are indicated as logical derivates and were subject of the survey devoted to the broad investigation. Herein, a threefold hierarchical consideration of the evaluation system is proposed as follows:

- BNE-C: The BNE-C provide the overall objective and associated challenges
- BNE-F: The BNE-F builds the next objective's level, i.e. sub-objectives including associated challenges

These first two levels will provide a indication of a Total Perceived Value[157] (TPV), an Expectation Value Degree as qualitative comparison of challenges and targeted improvements on business (BNE-C level) and functional level (BNE-F level).

- BNE-B: A BNE-B is non-functional leaf-goal and is level of measurable items (criteria and values). It indicates key performance indicators (KPI) including their characterisation and relate to a specific BNE-F. The principle characterisation of BNE-B criteria is given through so called utility value functions (UVF). Further, those criteria are weighted and indicate EES features (i.e. qualities) as being resources 'R' oriented (cost, time) or quality 'Q' oriented, including relations to stakeholders (i.e. end-users).

Based on the results gained through the broad investigation (see section 5.1.2), addressed objectives and benefits have been reviewed and were finally arranged in a specific evaluation system for the BNE-P "VAC" (see Table 13). Thereby, objectives surveyed for the BNE-C were synthesised to an overall objective including the indication of associated challenges. Each BNE-F was established as representing associated sub-objectives for the BNE-C. Four BNE-Fs were identified and characterised through a number of BNE-Bs, which were also indicated with challenging aspects.

Step 4 – Weight evaluation criteria

After having established the hierarchical evaluation system, each level of abstraction has been weighted providing a percentage distribution normalised to 100% (see Table 13)[158].

[157] A TPV is associated with an Expectation Value and resources in order to go from a current situation 'A' and challenges, to an improved future situation 'B' and objectives (see section 1.1.4.4). An economical / technical evaluation was not envisaged so that benefits (KPIs) were evaluated in the absence of resources and a TPV will be determined within its Expectation Value Degree herein only.

[158] A specific weighting methodology (e.g. pair-wise comparison, ranking order method, preference matrix) was not applied. To counteract this deficiency all weightings have been overloaded with a standard variation of 5% (which will be considered in the CAPE model), in order to consider the "insecurity" of given intuitive weightings and the absence of methodologies applied to survey weightings.

BNE-Context		BNE-Focus			BNE-Benefit					
Objective	***Challenges***	***Sub-Objectives***	***Challenges***	***Weighting***	***Criteria***	***Characterisation***	***Type***	***Stakeholder***	***Value***	***Weighting***
To have a consistent vision of aircraft systems architecture using effective simulations shared in extended enterprise **Stakeholder:** ***System Simulation Department leader***	- Consistency w A/C developments - Integrated Simulations - Reuse & Sharing in extended enterprise	**1. To provide access of elementary A/C data**	- to have a reference representation	0.2	**1.1 Better understanding of the overall architecture**	Contribute to a common understanding and transparency → Visualisation	Q	SD[159]	Degree of understanding : High, Medium, Low	0.6
					1.2 Cross-domain knowledge about system interdependencies	Integrated evolutions and informal prove of consistency	Q	SD	Degree of knowledge about system interdependencies: High, Medium, Low	0.2
					1.3 Provide up to date design information	Reduce time to identify A/C life cycle data	R	SD	From: days to: hours	0.2
		2. To Improve Simulation Specification Efficiency	- Ambiguous requirements towards simulation design - No formalised process, no standardised	0.2	**2.1 Reduced Simulation Specification Time**	Time required to execute the definition of the simulation specification, including: - specifying - failure & rework	R	SD, SA[160]	From: weeks to: days	0.5

[159] The System Designer (SD) is in charge of system architecture, defining validation needs and constraints, and management of simulation runs.
[160] The Simulation Architect (SA) is in charge of the design of the simulation facility.

			request for simulations - Document-based process - High effort to understand true requirements and to identify the relevant once		**2.2 Improved Specification Quality**	Process supported and formalised specification -unambiguous requirements -ensure right-sized simulation	Q	SD, SA	Completeness of simulation requirements (%)	0.5
		3. To Improve Simulation Design	- Simulation architecture design trade-offs & analysis - Interoperability check - Automated support of simulation architecture design - To benefit from existing models for the design - Build effectively simulation architecture	0.2	**3.1 Improved Design flexibility**	Architecture trade-off: Cost aligned, simulation available, fit to specification, selection of best solution from a set of architecture	Q	SA	Number architecture alternatives	0.3
					3.2 Right-sized simulation	Identification of most adequate simulation environment	Q	SA	Coverage Rate (%): prove of architecture coverage of functions, logical & physical components	0.7
		4. To Improve Simulation Integration	- Connect, share and reuse of simulation models and hardware - Resource management simulation assets	0.4	**4.1 Share of simulation models**	Rate of sharing (%): - Cost reduction by sharing the cost of ownership sharing of available simulation models	Q	SE[161]	Rate of sharing: High, Medium, low	0.4

[161] The Simulation Engineer (SE) is in charge of implementing the simulation design on a distributed infrastructure and performs the simulation.

			(models, platforms, h/w, s/w)		**4.2 Reuse of simulation models**	Rate of reusing (%) - Reducing cost of simulation by reusing available simulation models	Q	SE	Rate of reusing (%)	0.3
					4.3 Interoperability Check	Models can be integrated into simulation context	R	SE	Time to understand interoperability (hours)	0.3

Table 13: Surveyed Evaluation System

Step5 – Determine values for evaluation criteria

The evaluation process is designed and characterised in a twofold manner: top-down definition and bottom-up evaluation (see Figure 72). In terms of project roles and responsibilities a task leader (rather end-user oriented) has the responsibility to manage one or more respective BNE-Ps. In contrast the work package leader (WP, rather business customer oriented) is responsible to manage the total amount of BNE-Ps related to his work package.

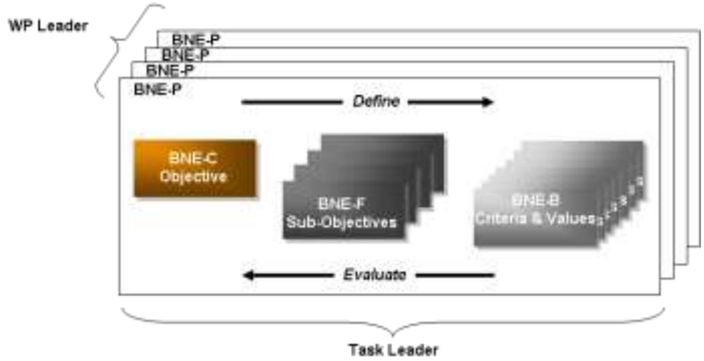


Figure 72: Evaluation Process and project roles

Step 1-4 dealt with that part of the evaluation process that is concerned with the definition of an objectives-oriented evaluation system, i.e. the establishment of the soft-goal tree for a respective BNE-P. The top-down approach encompasses the BNE-C in form of an overall objective, the BNE-Fs in forms of sub-objectives and finally BNE-Bs in forms of criteria and values.

Conversely, the present step is devoted to the bottom-up evaluation dealing with the determination of values for given BNE-B criteria at three *different points* of the project:

- t=0: Starting point of the project; best guess of BNE-B values in accordance to the current organisation's business situation (previously indicated as current zone)
- t+1: Somewhere during the project execution; best evaluation possible to reflect upon the possibilities to reach the targeted situation as indicated at t=End
- t=End: Targeted situation expressed in values and a range of uncertainty (previously indicated as targeted zone)

Determination of evaluation criteria values

Based on the principle determined evaluation system (see Table 13), the author anticipated and defined UVFs for BNE-B criteria and estimated values for those at t=0 and at t=End. The result of this work was reviewed together with the BNE-P leader as follows:

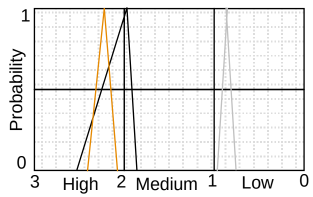
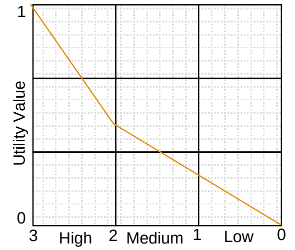
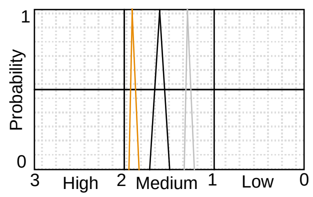
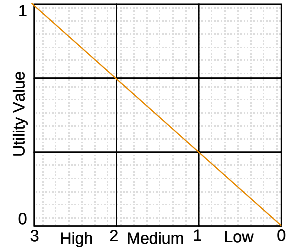
- The evaluation system was reflected within BNE-C, BNE-F and relating BNE-B criteria
- Introduction to the characterisation of the BNE-B criteria within UVFs[162] (see Table 14). During this activity one new BNE-B criteria *"BNE-B4.1: Share of simulation models"* has been identified and weightings were updated accordingly.

[162] Identified UVFs were not specifically characterised, e.g. different gradients or sections of a UVF. In order to ensure consistent understandings and evaluations in real case situations, this activity should be performed then.

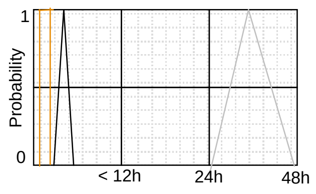
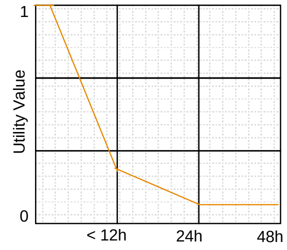
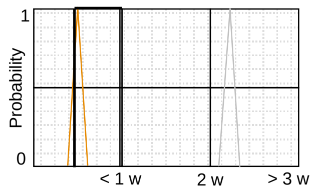
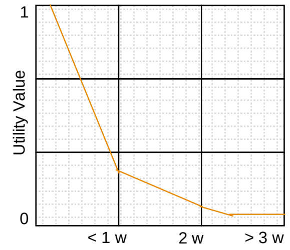
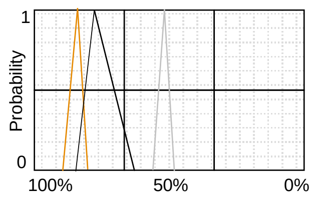
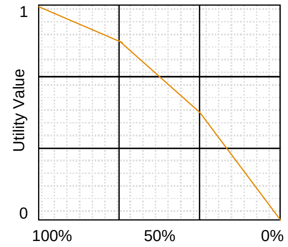
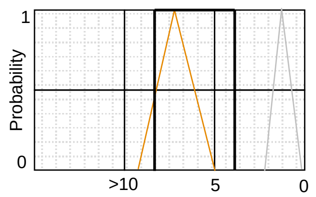
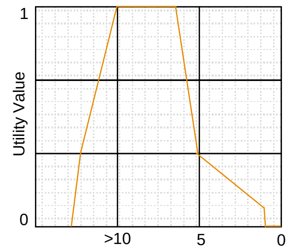
- Each BNE-B criteria was evaluated by the BNE-P representative within ranges of probable values for t=0, t+1 and t=End.

Critical Review

The concept of UVFs was well understood by the BNE-P representative and based on the preparations this review required about 1 hour. Also, the evaluation within ranges of uncertainties eased the process of providing values for BNE-B criteria. Nonetheless, it was mentioned that in a real case situation the characterisation of UVFs would require the inputs of a number of relevant BNE-P stakeholders (i.e. business customer and end-user), inducing also a number of iterations for reviewing. However, it was evaluated that such a representation format including the elaboration of BNE-Ps helps to converge towards a stronger focus on value adding PD activities.

BNE-C: To have a consistent vision of aircraft systems architecture using effective simulations shared in extended enterprise																	
BNE-F	***W***	***BNE-B Criteria***	***W***	***BNE-B Values at t=0***				***BNE-B Values at t+1***				***BNE-B Values at t=End***				***PDF***[163]	***Utility Value Function***
				l[164]	***e***[165]	***u***[166]	***DT***[167]	***l***	***e***	***u***	***DT***	***l***	***e***	***u***	***DT***		
1 To provide access of elementar y A/C data	0.2	1.1 Better understandi ng of the overall architecture	0.6	-5%	0.9	+5%	ND	1.8	2	2.5	G D	-5%	2.3	+5%	ND		
		1.2 Cross-domain knowledge about system interdepend encies	0.2	-5%	1.4	+5%	ND	1.5	1.6	1.7	N D	-5%	1.9	+5%	ND		

[163] Probability Density Function (PDF) is a function that represents a probability distribution in terms of integrals. Gathered values from BNE-P representative are illustrated as normalised PDF in forms of continuous triangles and uniform probability distributions.
[164] Lower limit estimate
[165] Expected value, mostly likely value estimate
[166] Upper limit estimate
[167] Distribution type (DT): UD – Uniform Distribution, ND – Normal Distribution, GD – Generic Distribution

		1.3 Provide up to date design information	0.2	24	36	48	ND	3	4	6	GD	2	-	3	UD		
2. To Improve Simulation Specification Efficiency	0.2	2.1 Reduced Simulation Specification Time	0.5	-5%	2.2	+5%	ND	0.4	-	1	UD	-5%	0.5	+5%	ND		
		2.2 Improved Specification Quality	0.5	-5%	50%	+5%	ND	60	75	80	GD	-5%	80%	+5%	ND		
3. To Improve Simulation Design	0.2	3.1 Improved Design flexibility	0.3	0	1	2	ND	4	-	8	ND	5	7	9	ND		

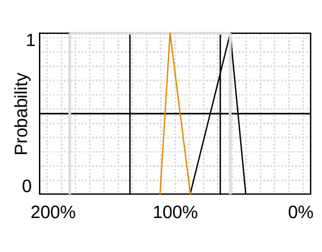
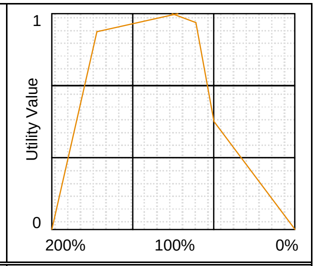
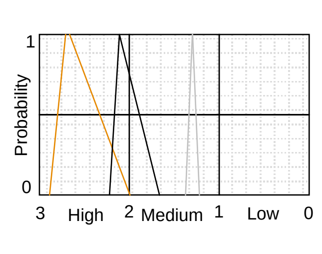
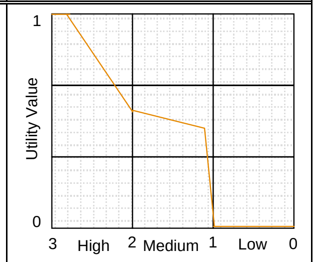
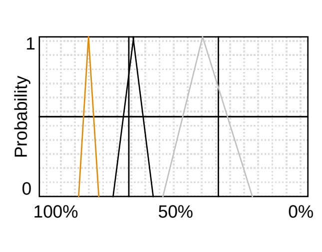
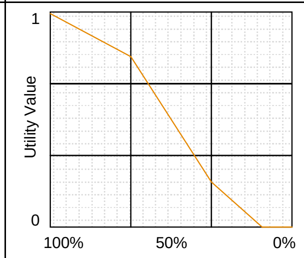
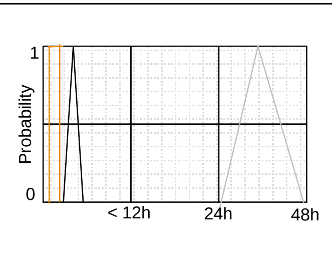
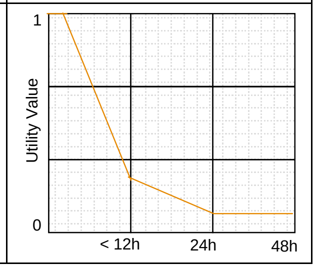
		3.2Right-sized simulation	0.7	60	-	180	UD	55	60	80	UD	80	100	120	ND		
4. To Improve Simulation Integration	0.4	4.1 Share of simulation models	0.4	-5%	1.3	+5%	ND	1.6	2.1	2.2	GD	2	2.6	2.8	GD		
		4.2 Reuse of simulation models	0.3	20%	40%	55%	GD	-15%	60	+15%	ND	-5%	70	+5%	ND		
		4.3 Interoperability Check	0.3	24	36	48	ND	5	7	8	GD	2	-	3	UD		

Table 14: Determined values for evaluation criteria, PDFs and UVFs

The author has indicated evaluated BNE-B values within ranges of uncertainties with a specific type of distribution depending on how BNE-B values were indicated by the BNE-P representative. The CAPE tool enables to define respective RVs (herein: BNE-B criteria overloaded with uncertainties) with appropriate distribution functions.

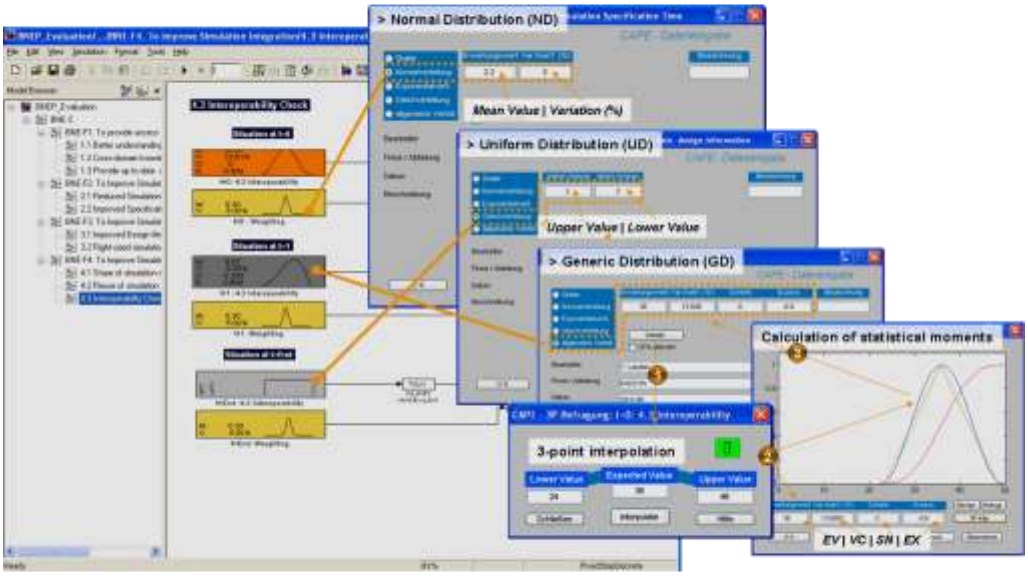


Figure 73: Definition of random variables within different distribution types for respective BNE-B values

In fact, three different types of distributions have been utilised in the following sense[168]:

- UD – Uniform distribution: A BNE-B value was indicated as UD once the BNE-P leader evaluated in a range of an upper and lower limit without providing an expected value.
- ND – Normal distribution: A BNE-B value was indicated as ND once the BNE-P leader evaluated with an expected value providing a symmetric variation within an upper and lower limit.
- GD – Generic distribution: A BNE-B value was indicated as ND once the BNE-P leader evaluated with an expected value providing asymmetric variations within an upper and lower limit.

The graphical-user-interface of CAPE enables to define these different types of distributions. Also, CAPE incorporates a 3-point[169] interpolation algorithm to compute the corresponding statistical moments. Thereby, a distribution function (random variable) can be effectively characterised through the first four statistical moments and can be expressed through a parameter-vector as follows (Neff 2002):

$$X = \begin{bmatrix} EV \\ VC \\ SN \\ EX \end{bmatrix}$$

[168] BNE-B values have been not evaluated within scalars, but could have been considered for computation within the CAPE tool besides RVs.

[169] The 3-point estimation is captured in a ‘triangle’ of expected value as well as an upper and lower limit estimates.

Within this vector the *variation coefficient (VC)* represents the degree of uncertainty of the *expected value (EV)*, the *skewness (SN)* a degree of the asymmetry of the distribution function and the *excess (EX)* characterizes the degree of its curvature compared to Gauß's normal distribution.

Phenomenology of continuous RV

It should be mentioned that modelling and calculating continuous RVs incorporates some mathematical phenomena leading to modifications of the significant vector's 2nd to 4th moment. Some stochastically phenomena's of continuous RVs are: expansion[170] and compression[171], as well as stochastically dependency[172].

In the frame of this work, those phenomena are not matter of a closer consideration and thus will not be further discussed. Rather it should be mentioned that for modelling and simulating stochastic systems a certain degree of (basic) understanding in this field is required in order to ensure accurate interpretations of the results. For further understandings on the principle approach, methodologies behind CAPE and its field of application consult for instance Neff (2002), Laudan (2004), Mauersberger/Laudan (2007).

	Business Requirements						Service Requirements											
	BPR-38	BPR-39	BPR-40	BPR-41			SR-486	SR-501	SR-706	SR-736	SR-747	SR-756	SR-761	SR-780	SR-791	SR-811	SR-816	SR-825
BNE-C	Efficient and Effective design process for simulation	Integration of simulation in the whole development life cycle of system	Use of Simulation for the early IV&V of systems	Shared Simulation assets in the extend enterprise	BNE-F	BNE-B	Function F1: Input Life Cycle Data into Virtual A/C Structure	Function F2: Input requirements Data into Virtual A/C Structure	Function F3: Input Design Architectures Data into Virtual A/C Model	Function F4: Specify Validation Needs	Function F5: Define Virtual Architectures	Function F6: Define Virtual Components	Function F1: Manage Component	Function F2: Define Simulation Requirements	Function F3: Specify & design Requirements	Function F4: Release Simulation Specification	Function F5: Implement Simulator Instance	Function F6: Perform Simulator Instance
To have a consistent vision of aircraft systems architecture using effective simulations shared in extended enterprise	x	x	x	x	1 To provide access of elementary A/C data	1.1 Better understanding of the overall architecture	x		x		x	x						
						1.2 Cross-domain knowledge about system interdependencies			x		x	x						
						1.3 Provide up to date design information			x		x	x						
			x		2. To Improve Simulation Specification Efficiency	2.1 Reduced Simulation Specification Time	x	x			x	x		x	x			
						2.2 Improved Specification Quality	x				x	x		x	x	x		
			x		3. To Improve Simulation Design	3.1 Improved Design flexibility											x	
						3.2Right-sized simulation											x	x
	x	x	x	x	4. To Improve Simulation Integration	4.1 Share of simulation models												x
						4.2 Reuse of simulation models							x				x	
						4.3 Interoperability Check											x	x
Enabling Engineering Service					GS-19	EDM-01a: Information Model Builder	x			x								
					GS-592	EDM-01b: Information Model Navigator Service	x			x								
					GS-524	EDM-02: Product Life Cycle Mgmt Service	x	x	x	x	x							
					GS-182	EDM-03: Simulation life Cycle Mgmt Service						x	x			x		
					GS-16	EDM-04: Product Context Mgmt Service								x	x			
					GS-28	EDM-06: Consolidated Repository Service	x											
					GS-21	EDM-08: Application Connectors Service											x	
					GS-562	DISI-01: Collaboration Services											x	
					GS-580	DISI-02: Security Services								x				x
					GS-583	DISI-03: Control and Mgmt Services												x

Table 15: Alignment of BDs and EDs within the defined boundary objects

Establishing cross-community relationships between boundary objects

The broad investigation delivered BNE-Ps and EDs. As mentioned earlier, resource constraints permitted to reach alignments of BDs and EDs within the defined

170 The multiplication of two continuous RVs X1 and X2 increases the variation coefficient (2nd moment) and changes shape (3rd and 4th moment) of the resulting distribution.

171 The addition of two continuous RVs X1 and X2 decreases the variation coefficient (2nd moment) in the aggregated result.

172 Correlation between RVs can be treated in a threefold manner: through stochastic co variances or approximations like detailing the probabilistic model towards independent RV, correction-factor and the assumption of stochastic independent RVs (Neff 2002). In the present example stochastic independent RVs are assumed.

granularity respective to the BNE-P model. In consequence, objectives and relating benefits were matter of a systematic approach (i.e. UVA). For reaching cross community associativity, a cross table has been prepared opposing soft-goal structures (i.e. BNE-C, BNE-Fs and BNE-Bs) and EDs (i.e. requirements and EES) based on information already being surveyed and prepared (see Table 15). Associativity between intentional and engineering-related information structures was established on their semantics and in collaboration with the author and the BNE-P representative. The associativity approach was characterised through both bottom-up and top-down alignments having used *what* and *why* questions for establishing alignments between intentional and engineering structures.

Changes/Improvements

The business-engineering transition area is established between non-functional leaf goals, i.e. benefits and service requirements. Herein the related soft-goal tree provides the instance for BNE-P situational analysis and TPV evaluation respectively in front of service requirements.

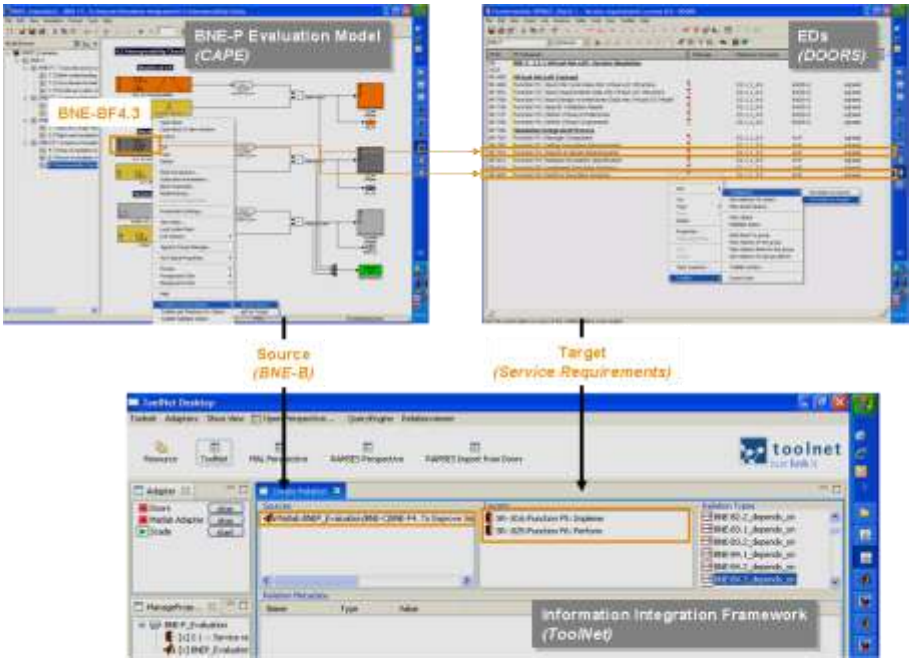


Figure 74: Relationship establishment between BNE-Model and EDs

Descriptions for a BNE-P and associated EDs are implemented in DOORS including relationships, as they are pointed in Table 15. Herein, BNE-C objectives, BNE-Fs sub-objectives and relating BNE-Bs criteria have been brought into alignment with EDs (i.e. business and service requirements). Despite this organisation handled within the VID, the objectives-system has been implemented in CAPE for illustrating evaluation principles applied on the soft-goal tree related to a respective BNE-P. Figure 74 illustrates the relationship establishment in a coherent manner, showing associations between the BNE-P model (on the level of BNE-Bs) and EDs (on the level of service requirements) using an information integration framework[173].

[173] The illustrated information integration framework is operationalised using EADS Innovation Works developed in-house prototype software called ToolNet.

Step6 – *Determine a Total Value*, Step7 – *Compare alternatives or estimate progress*, Step8 – *Illustrate and discuss results*

These steps illustrate the principle procedure towards the analysis of a BNE-P in the execution phase of the project. The evaluation logic is established as being a situational comparison of intermediate evaluations of the expected business situation providing utility values as a bottom-up aggregation starting from BNE-Bs to BNE-Fs towards the BNE-C (see Figure 75).

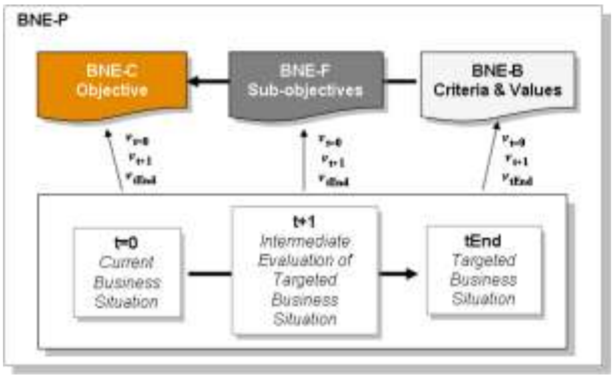


Figure 75: Evaluation Principle - A situational comparison

Equally, this hierarchical organised model is implemented in CAPE as illustrated in Figure 76.

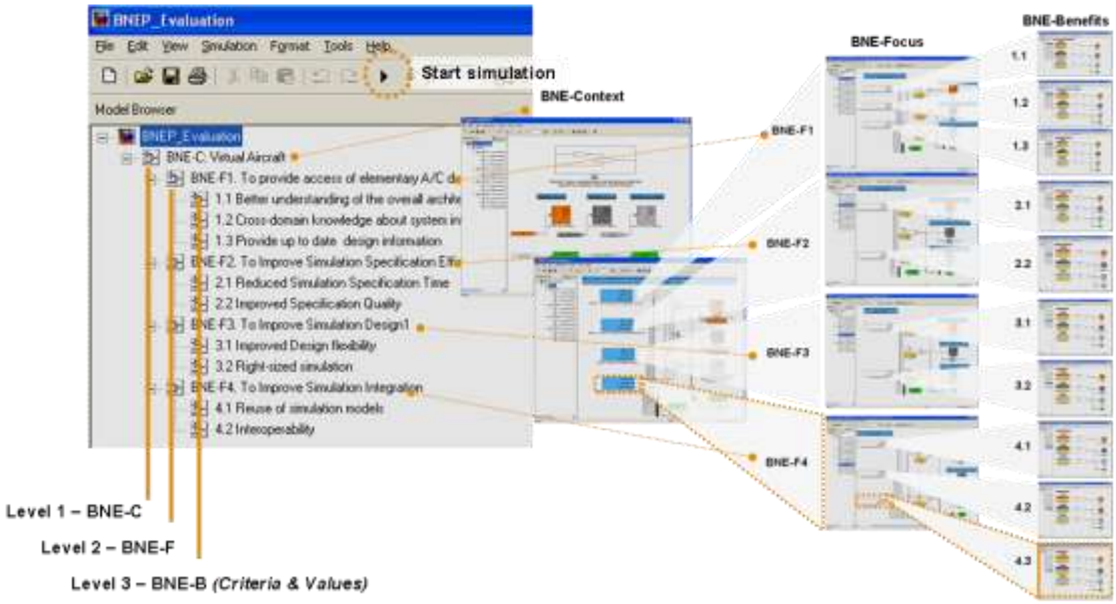


Figure 76: Implementation of BNE-P's soft-goal tree in CAPE

Path of calculation

On the level of BNE-Bs associated criteria and values are modelled as input signals. Also respective weightings and UVFs were implemented in order to calculate utility values as result of evaluations given within BNE-B criteria and values (see Figure 77).

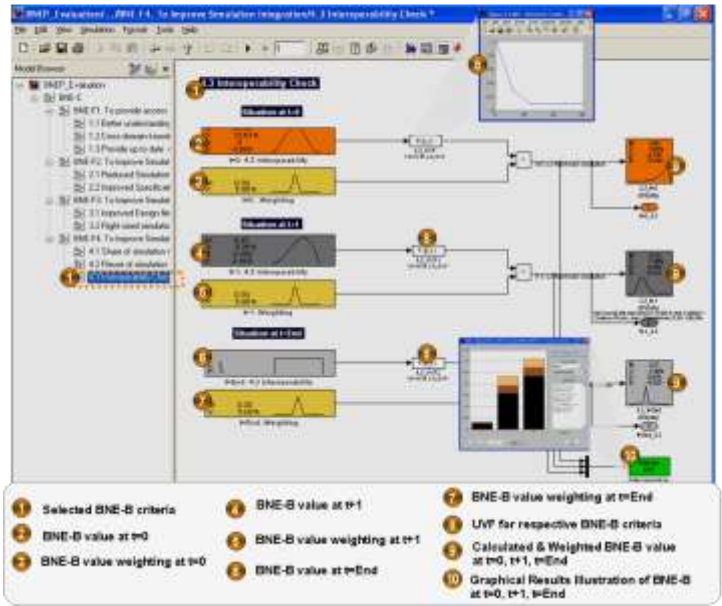


Figure 77: Example of BNE-B modelled in CAPE

Figure 78 illustrates BNE-Fs as next higher level in the evaluation system. Herein, BNE-B criteria and its utility values are aggregated within BNE-Fs.

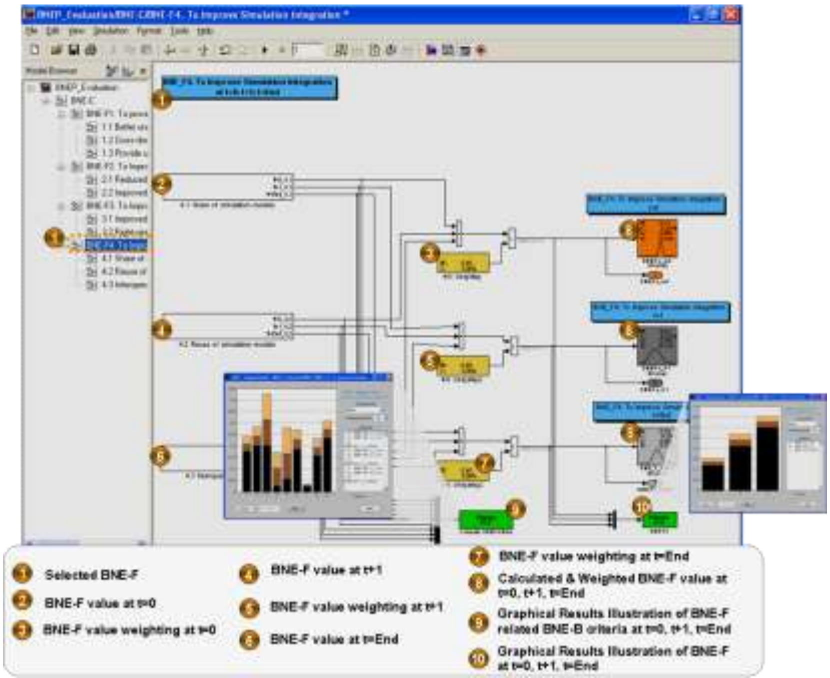


Figure 78: Implementation of a BNE-F in CAPE

Lastly, the BNE-C level complements the evaluation system while representing the overall evaluation object in association to a subject matter characterised as BNE-P. In accordance to a situational distinction (i.e. at t=0, t+1 and at t=End) in BNE-Bs, aggregated results on the next levels of abstraction, i.e. BNE-Fs and BNE-C are built equally (see Figure 79).

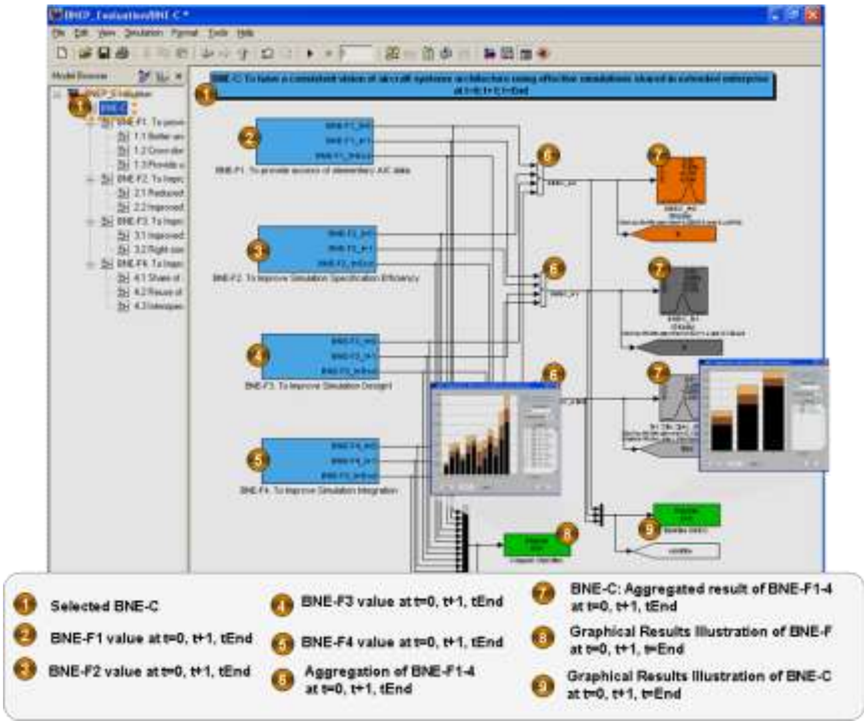


Figure 79: Implementation of BNE-C in CAPE

The above given illustrations pointed also graphical means assisting in analysing calculated results on each level of abstraction.

Having performed the simulation of the BNE-P model and underlying structures in a bottom-up fashion, subsequent paragraphs are devoted to discuss the analysis of simulated results in a top-down manner.

Critical Path Analysis

The modelled and simulated BNE-P evaluation model is supported in CAPE within a “dashboard” manner (see Figure 80).

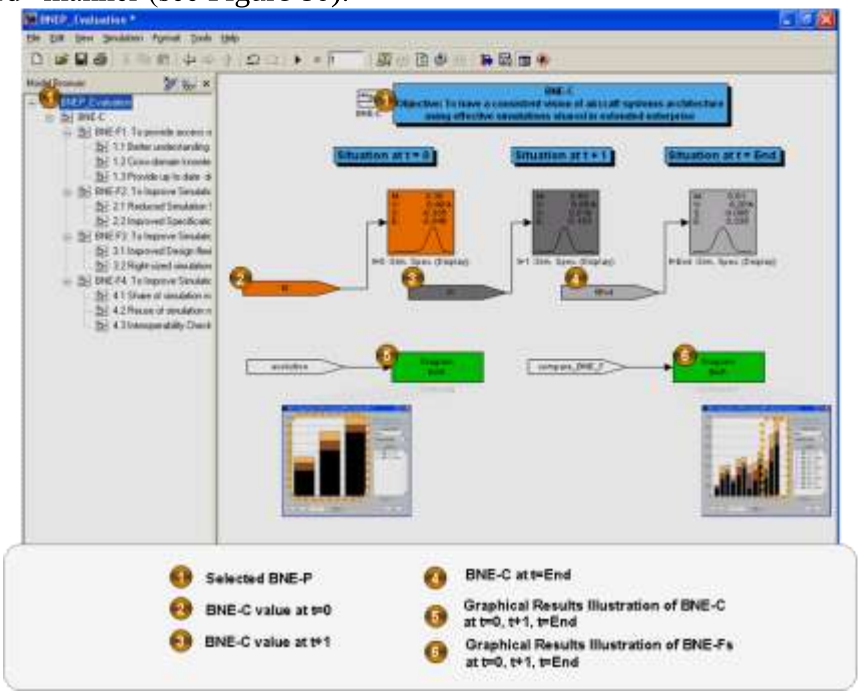


Figure 80: BNE-P evaluation dashboard

An overview is given in regards to calculated utility values facilitating the situational demarcation of current business (indicated as t=0), targeted business (indicated as t=End) and intermediate evaluation of targeted business (indicated as t+1).

In contrast to the bottom-up evaluation process, the process of analysis is established as being a top-down oriented. Thereby, the TPV (business and functional), characterised also through an Expectation Value Degree, is going to be analysed. Secondly, based on an intermediate evaluation of reaching the targeted business situation is discussed. Herein, the identification of unsatisfactory areas in a BNE-P – illustrating the most critical path – is going to be explained.

BNE-C Analysis

The BNE-C is illustrated in accordance to a threefold situational distinction as it has been already discussed previously (see Figure 81).

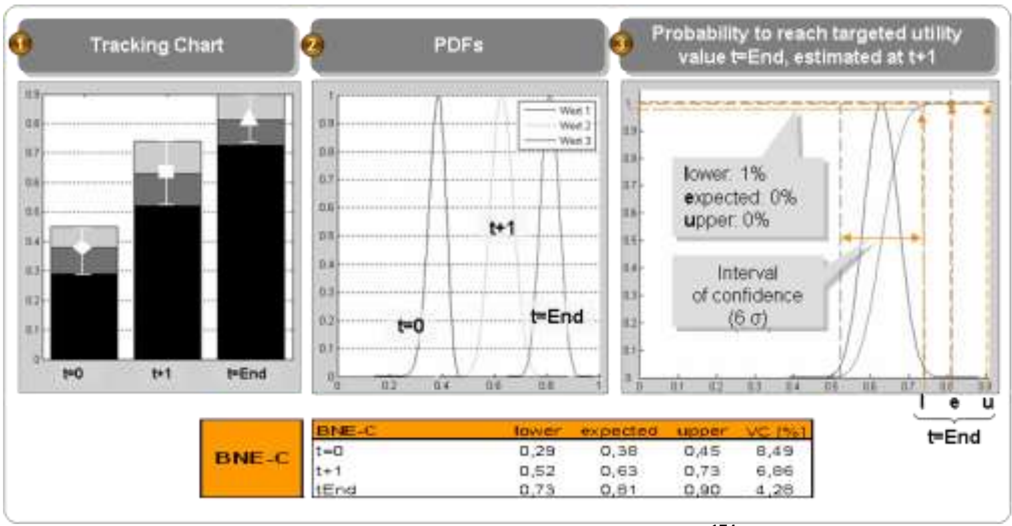


Figure 81: BNE-C situational analysis[174]

From the tracking chart it gets obvious that the intermediate evaluation (indicated as t+1) is estimated as an improvement towards the current operating business (indicated as t=0). But the intermediate evaluation shows further that the targeted situation is estimated below its expectation (indicated as t=End). This circumstance is also shown within the respective comparison of probability density functions (PDFs). The estimate of the intermediate utility value for BNE-C at t+1 is calculated within an expected value of 0,63 and a variation from 0.52 to 0.66. In comparison, the expected situation at t+1 has been defined within an expected value of 0.81, within a lower limit of 0.73 and an upper limit of 0.90. The third illustration depicted in Figure 81 (right) shows the projection of the expected situation, i.e. estimated utility values at t=End; within the *Cumulated Density Function*[175] (CDF) calculated for BNE-C at t+1. It is shown that reaching a utility value within the range of expectations to be reached at t=End is quite unlikely: to reach the lower limit of 0.73 is 1%, and to reach whether the expected as well as upper limit is 0%.

---

[174] All illustrated values are based on calculations performed within CAPE. For matters of illustration and discussion those have been prepared as pointed.

[175] The Cumulative Probability Density Function (CDF) describes the probability distribution of a real-valued random variable X.

In accordance to the BNE-C analysis and given illustrations, subsequent discussions will dwell on the principles of the *Expectation Value Degree*[176] (EVD).

Expectation Value Degree

The previous exemplification of BNE-C valuation along the project's life through three utility value zones: *current-zone*, *target-zone*, and *improvement-zone*; was mentioned.

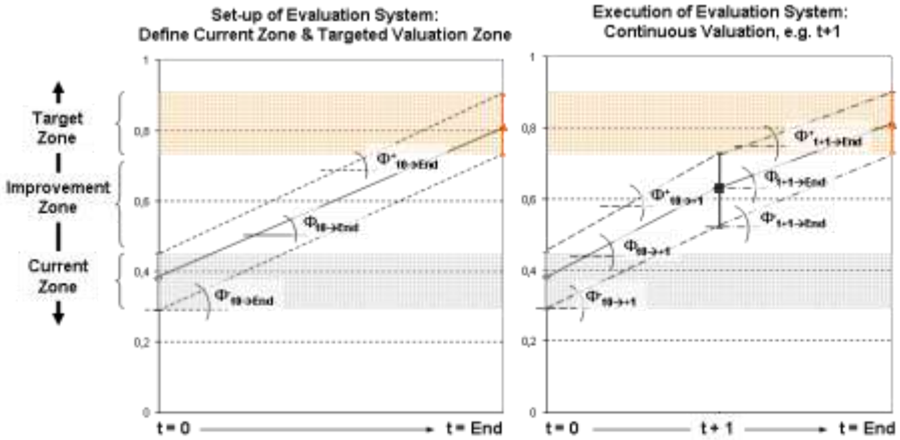


Figure 82: Trajectory of Expectation Value Degrees on BNE-C level - Set-up (left) and execution of evaluation system (right)

The value-oriented trajectory to move from an evaluated current business situation (indicated as current-zone, i.e. the business situation at t=0 respective to the project timeline and associated *needs*) to an improved future expected situation (indicated as target-zone, i.e. targeted business situation at t=End respective to the project timeline and associated with *expectations*) could be characterised through EVDs.

The BNE-C's related EVD describe the level of change in EES features to be available at a certain future situation and capable to create the expected business value for business customer. Figure 82 points basically two differentiating sorts of EVDs: those associated to set-up the evaluation system and those that are associated with the execution of the evaluation system.

Set-up of evaluation system (see Figure 82, left)

$t_0 \rightarrow t_{End}$: Definition of current-zone and the target-zone

- $\Phi^{-}_{t0\rightarrow tEnd}$: This degree is determined upon *lower* value limits of the current situational estimate and the targeted estimate.
- $\Phi_{t0\rightarrow tEnd}$: This degree is determined upon *expected* value limits in regards to the current situational estimate and the targeted estimate.
- $\Phi^{+}_{t0\rightarrow tEnd}$: This degree is determined upon *upper* value limits of the current situational estimate and the targeted estimate

Execution of evaluation system (see Figure 82, right)

Once the evaluation system has been set-up within a current- and targeted zone continuously the possibility to reach the targeted zone is estimated. This also depends

[176] The EVD is aligned with the principle definition of a business intent as initially defined in section 1.1.4.4.

on the frequency of the evaluation in the project trajectory, i.e. incrementally timely measurement points selected throughout the execution of the evaluation system in the project. Such an execution is illustrated within the right part of Figure 82 pointing an arbitrary situation indicated as t+1.

t0 → t+1: Current zone towards intermediate valuation of targeted situation

- $\Phi^{-}_{t0 \rightarrow t+1}$: This degree is determined upon *lower* value limits of the current situational estimate and the targeted estimate.
- $\Phi_{t0 \rightarrow t+1}$: This degree is determined upon *expected* value limits of the current situational estimate and the targeted estimate.
- $\Phi^{+}_{t0 \rightarrow t+1}$: This degree is determined upon *upper* value limits of the current situational estimate and the targeted estimate.

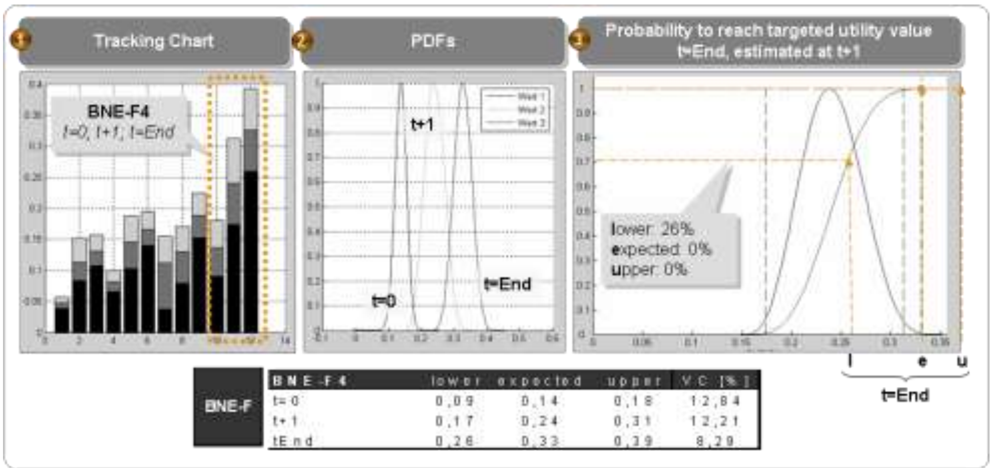
t+1 → tEnd: Intermediate valuation of targeted situation

- $\Phi^{-}_{t+1 \rightarrow tEnd}$: This degree is determined upon *lower* value limits of the current situational estimate and the targeted estimate.
- $\Phi_{t+1 \rightarrow tEnd}$: This degree is determined upon *expected* value limits of the current situational estimate and the targeted estimate.
- $\Phi^{+}_{t+1 \rightarrow tEnd}$: This degree is determined upon *upper* value limits of the current situational estimate and the targeted estimate

EVDs can be equally characterised for BNE-F and associating BNE-Bs for illustrating situational evolutions of respective utility values along the project's life.

BNE-F Analysis

The valuation of the intermediate situation for the BNE-C "Virtual Aircraft" has shown that the targeted utility value is unlikely to be reached. For a better understanding of uncertainty (risk) and most effective value driver the BNE-C is analysed not anymore as block-box. In contrast, Figure 83 depicts the situational comparison of underlying BNE-F structures.



BNE-F4	lower	expected	upper	V.C. [%]
t=0	0,09	0,14	0,18	12,84
t+1	0,17	0,24	0,31	12,21
tEnd	0,26	0,33	0,39	8,29

Figure 83: BNE-F Situational Analysis

The BNE-F analysis shows a number of deflections with regards to the targeted situation and utility value achievement as illustrated within the bar chart (see Figure 83, left side). Typically the top-down analysis and step-wise detailing principle is guided through a critical path. Herein BNE-F4 *"To Improve Simulation Integration"* is one of the most critical (risk and value driver) evaluated. The intermediate evaluated BNE-F4 distribution is calculated within an expected utility value of 0.24, an upper limit of 0.31 and lower limit of 0.26. The projection of the targeted utility value at t=End within the CDF of BNE-F4 at t+1, shows a probability of 26% lower limit utility value achievement. Neither expected nor upper utility value limits will most likely not be achievable in regards to the current situational estimate.

BNE-B Analysis

The level of BNE-B has been indicated as being the entities where measurements are taken. Therefore, BNE-B criteria were characterised within UVFs and since being defined as boundary-objects, those are established as entities towards EDs (i.e. requirements).
Equally, to the previous two analysis steps, the bar chart is utilised providing a situational distinction across all impacting BNE-Bs within BNE-F4. Herein BNE-B4.3 *"Interoperability Check"* is identified as one critical risk and value driver. Figure 84 illustrates further that reaching the targeted situation within the given utility value range is quite unlikely.

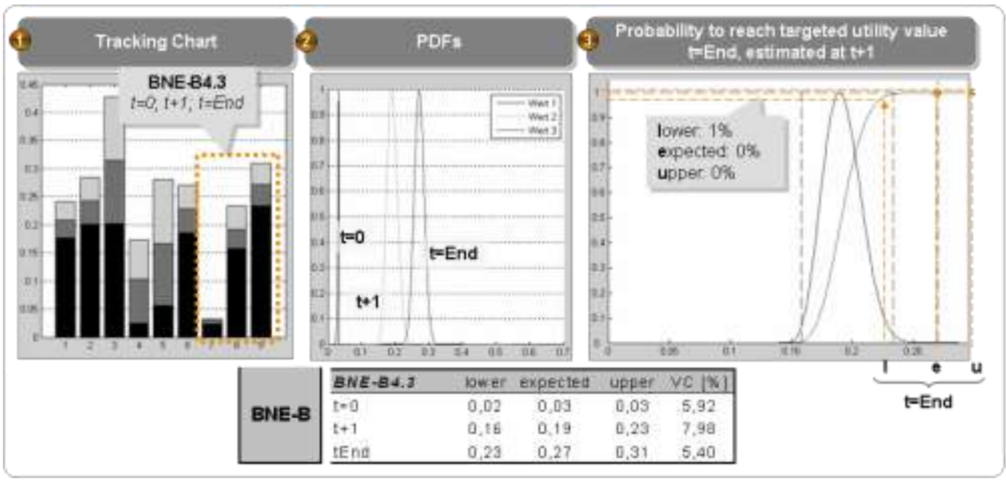


Figure 84: BNE-B Situational Analysis

Having exemplarily performed the critical path analysis throughout hierarchical structures of the objectives-system associated to one BNE-P, it is up to trace to areas identified as unsatisfying, i.e. BNE-B4.3 *"Interoperability Check"*. Thus, the following part is devoted to illustrate traceability mechanisms to EDs (based on defined boundary objects).

Vertical traceability

The realisation of interrelationships between boundary objects defined in a cross-domain sense: business and engineering provide informational basis to perform some sort of root-cause analysis. Thereby, the information integration framework enables to trace established relations between information managed by different technologies (as shown previously in Figure 74). Figure 85 illustrates a possibility to operationalise further traceability from unsatisfying BNE-P areas to ED structures.

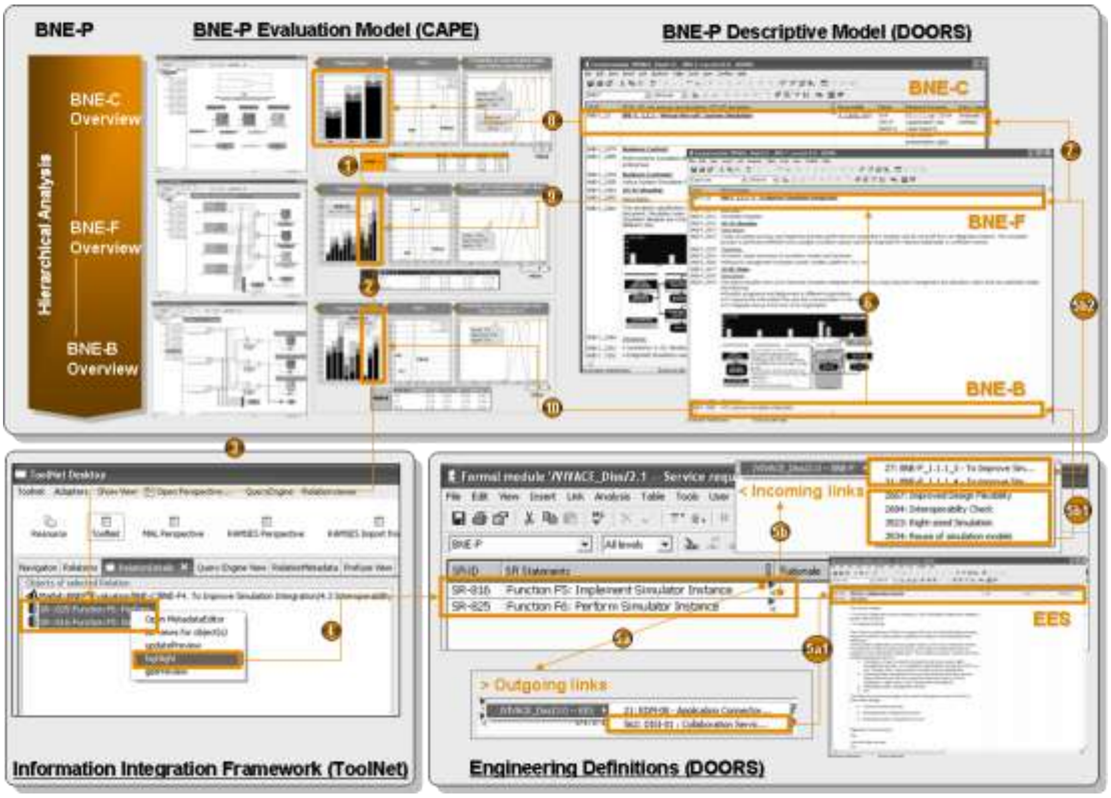


Figure 85: Critical Path Analysis – Tracing Scenarios

The following paragraphs are devoted to discuss the above shown relational framework.

BNE-P Evaluation Model (Figure 85, top left)

Within the present example an intermediate evaluation of a BNE-P has been previously analysed towards one unsatisfying BNE-B criteria, i.e. *BNE-B4.3 "Interoperability Check"* (indicated as step 1 and 2). The tracing process can be continued identifying relating requirement profiles (step 3). Requirements are potential indicators towards causing defects identified within the situational analysis of the BNE-P evaluation model.

Information Integration Framework (Figure 85, bottom left)

The information integration framework enables to follow established logical relations between technologies and software tools respectively. The illustration shows established relations to potentially driving requirements structures: *"SR-816 Implement Simulator Instance"* and *"SR-825 Perform Simulator Instance"*. Subsequently, these functional requirements are highlighted and can be further understood within the specific environment where EDs are managed (Step 4). Those potentially indicate a further rationalisation analysing defect in the respective BNE-P evaluation model. The information integration framework supports also the visualisation of relational frameworks. This visualisation is depicted in Figure 86, showing relations between BNE-B4.3 and the relating two service requirements and is classified through a specific relation type.

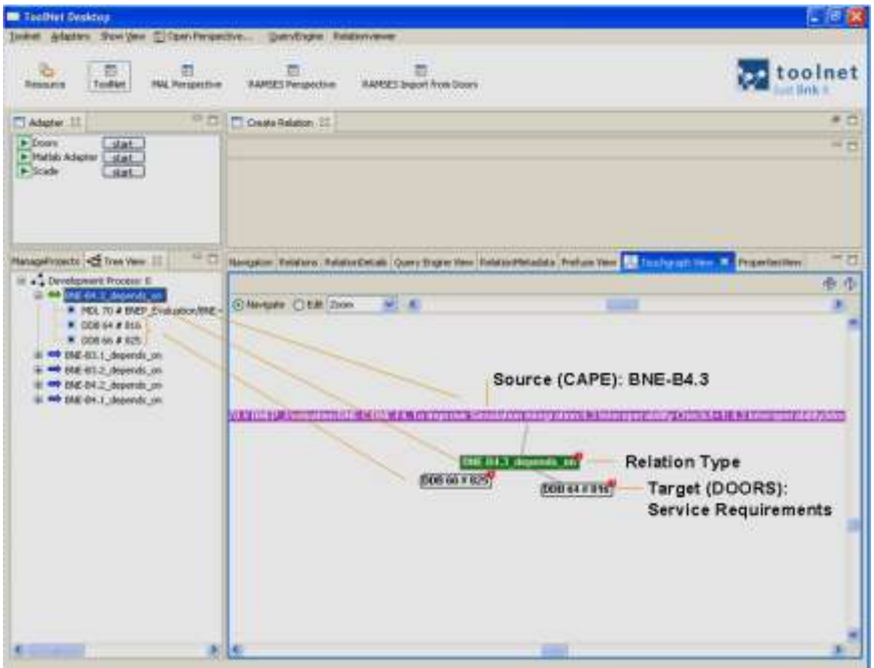


Figure 86: Visualisation of relations between BNE-B4.3 and related service requirements

Potentially the implementation of *BNE-B4.3 "Interoperability Check"* in forms of the relating requirements and further EDs indicate potential challenges within the engineering domain, which have been detected within the BNE-P evaluation model as unsatisfying.

Engineering Definitions (Figure 85, bottom right)

Within a subsequent step, BNE-B4.3 associated service requirements are filtered in the ED environment and further relations can be traced twofold:

1) Outgoing links

For quantification of next level related EDs (i.e. EES), the following tracing mechanism can be performed:

- Step 5a) Starting from the selected service requirement *"SR-816 Implement Simulation Instance" outgoing links* highlight relating EES: *"EDM-08 Application Connectors", "DISI-01 Collaboration Service".*
- Step 5a1) those outgoing links can be traced towards EES for gaining detailed understandings (e.g. descriptions, responsibilities).

2) Incoming links

After having quantified related EDs profiles on different levels, it is also possible to follow back to business and intentional level relations respectively, i.e. to the descriptive part of the BNE-P model:

- Step 5b) Starting from a selected requirement, *incoming links* can be highlighted and selected.
- Step 5b1) Service requirement *"SR-816 Implement Simulator Instance"* shows also associations to BNE-Bs: *BNE-B4.2 "Reuse of simulation models"*, *BNE-B3.1 "Improved Design flexibility"* and *BNE-B3.2 "Right-sized simulation"*. Potentially the intermediate estimate (evaluation at t+1) of those BNE-Bs is also

affected to a certain degree like it has been anticipated for BNE-B4.3. Figure 87 illustrates the relation viewer (a service of the information integration framework) providing the above-mentioned relational picture of next level interdependencies.

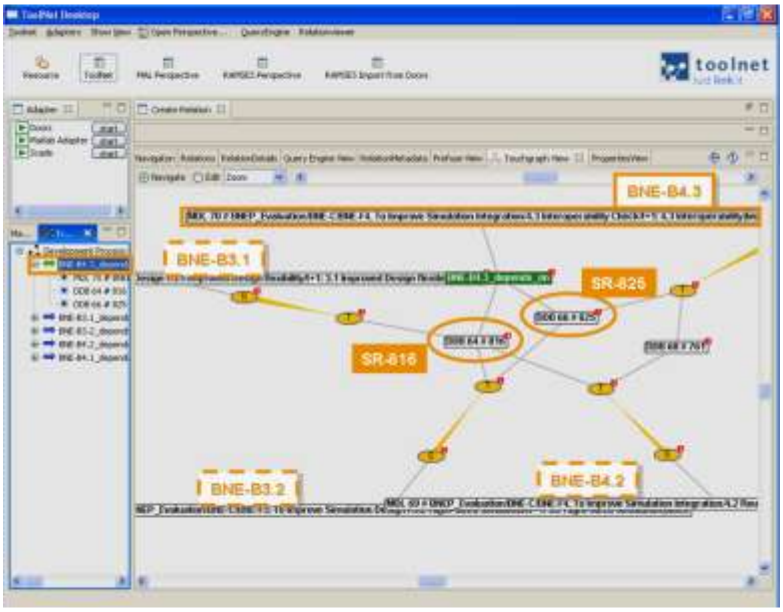


Figure 87: Relational Framework in association to BNE-B4.3

- Step 5b2) in accordance service requirements *"SR-816 Implement Simulator Instance"* shows associations – not only to the initially BNE-F4, but also on implicit impacted BNE-F3 – which can be followed and highlighted respectively.

BNE-P Ontological Model (Figure 85, top right)

Within the BNE-P descriptive model it is possible to continue the BNE-P situational analyses by whether trace to initially (BNE-B4.3) or implicitly identified critical BNE-Bs (BNE-B4.2, BNE-B3.1 and 3.2).

- Step 6) Trace from a highlighted BNE-B evaluation criteria to the related BNE-F (sub-objective)[177]
- Step 7) Trace from highlighted BNE-F (sub-objective) to related BNE-C (objective)
- Step 8) Trace from BNE-C associated objective to the respective evaluated utility-value
- Step 9) Trace from BNE-F associated sub-objective to the respective evaluated utility-value
- Step 10) trace from BNE-B associated criteria to the respective evaluated utility-value

5.1.3.4 Synopsis and Conclusion

Previous sections coped with complementing steps in regards to the referencing valuation process of intentional structures and vertical traceability mechanisms crossing business and engineering structures.

[177] In this case the relation is implicitly realised through the hierarchical structure.

BNE-P Model Evaluation

The evaluation principle applied dealt with the determination of BNE-P total perceived business and functional values of quality (TPBV, TPFV), i.e. soft-goal tree establishment and vertical traceability scenarios towards functional structures identified as objects within the requirements specification document. It has been demonstrated that soft-goal trees as part of the BNE-P model can be operationalised for serving a situational analysis in terms of controlling intentional structures and towards engineering definitions and conversely.

Utility Value Analysis is a concept that has been utilised for performing the BNE-P evaluation model having exemplified potential determination of business and functional qualities. In this context the following advantages of this methodology have been identified establishing an evaluative concept of a soft-goal tree related to a BNE-P:

- Usage of qualitative and quantitative BNE-B criteria, i.e. flexible in regards to the design of the evaluation model, i.e. the soft-goal tree
- Establishing weighted hierarchical structures and enable related calculations of utility values (including results-aggregation)
- Possibility for direct comparison of situational behaviour and the ability to create respective awareness within a specific decision situation
- Consideration of uncertain and risk information respectively in soft-goal tree structures
- Support a stepwise analysis of uncertainty and value driver in context of a BNE-P

In contrast, some disadvantages within the methodological approach have been observed:

- Due to the normalisation of BNE-B criteria's values absolute measurable values (e.g. cost, time, weight) cannot be calculated. Rather bottom-up evaluations deliver utility values as aggregated results starting from the measurable instance of BNE-B criteria
- Weightings of soft-goal structures lack a certain objectivity during its determination
- Soft-goal tree evaluation process related to a BNE-P could be time-consuming

More structured and systematic approaches like Delphi Method, or Conjoint Analysis, etc. could be applied to determine in particular more accurate soft-goal structures (e.g. BNE-B criteria and characterising UVFs and respective weightings). A lighter methodological approach could be the Goal-Question-Metric approach[178]. To counteract deficiencies respective to weightings the following methodologies like Pair-Wise Comparison, Ranking Order Method, Preference Matrix, or Analytical Hierarchy Process could be applied[179].

Vertical Traceability - Crossing business and engineering information structures

Within the exemplified case of a BNE-P evaluation and their analysis, possibilities to *prepare* a situational relevant decision base across business and engineering structures have been shown. Soft-goal tree structures were evaluated exemplarily and analysed

[178] For further information in regards to this methodological approach please consult Basili et al. (1994) which presents an approach for finding organisation's metric need towards software developments.
[179] For further information on those methodologies see for instance Breiing/Knosola (1997).

accordingly. The critical path that has been analysed is related to intentional structures and provided a situational picture in context of current situational estimates of soft-goal tree structures (see Figure 88).

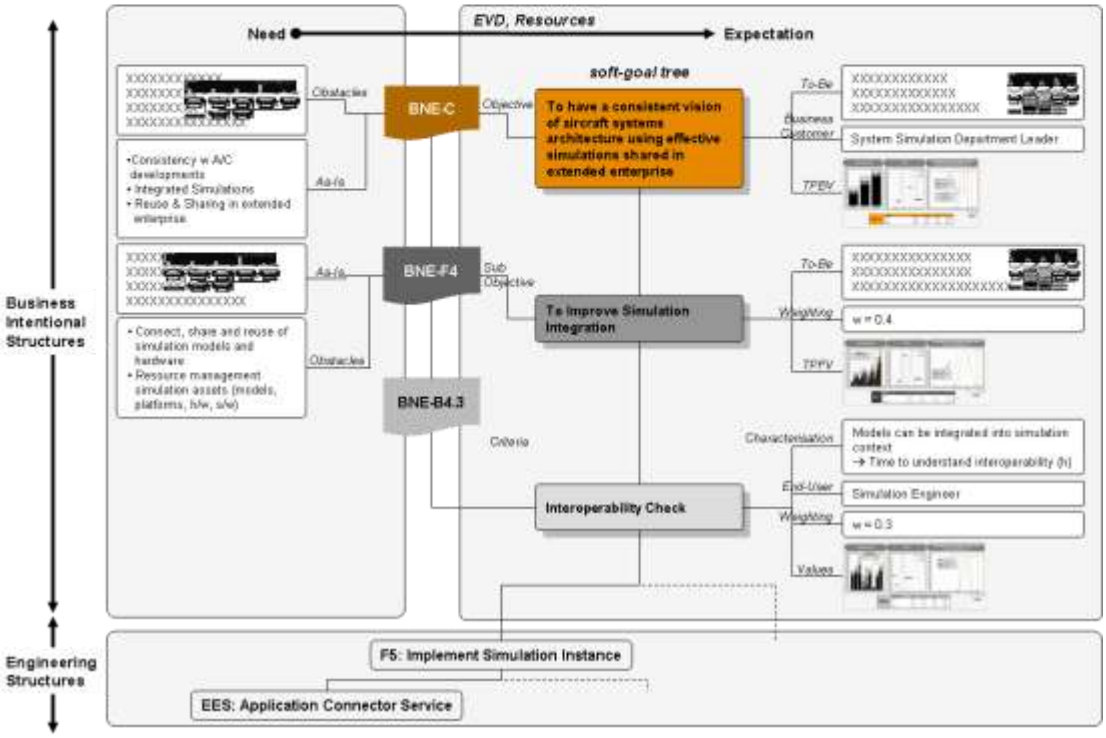


Figure 88: Vertical traceability - Exemplified critical path and partial illustration of BNE-P model classes and attributes

Some possible tracing scenarios across the domain of business and engineering have been discussed, but those tracing scenarios were fictive and anticipated, and not matter to a real case situation. Thus, it was not possible to prove cause-effect correlations between evaluated intentional structures and EDs and conversely. Rather, it resists being anticipation only. In principle tracing scenarios can be distinguished twofold within its direction, i.e. from business to engineering domain (i.e. top-down) and conversely (i.e. bottom-up) with the aim to ensure coherency in cross-domain evolutions in context of the project's product.

1) Top-Down Traceability

Intermediate and continuous evaluation of BNE-P indicating unsatisfying business related intentional structures that can be traced towards potential causing EDs. Motivating aspects may be moving targets and changes within the prioritisation of intentional structures (i.e. BNEs) relate to the organisational environment impacting the project organisation and respective product developments[180]. It induces changes in the initially defined BNE-P and requires associated coherency loops within EDs and potentially across intentional structures, i.e. other BNE-Ps.

2) Bottom-up Traceability

Motivating aspects may be difficulties within implementing BNE-Bs in forms of requirements and other relating EDs identified, which should be traceable towards

[180] In section 4.2 a cubic model of the organisational environment has been introduced proving associated mechanisms for conditioned viewing.

intentional structures within the business community. Bottom-up tracings are consequences of engineering's perceived obstacles within the implementation of requirements.

5.1.4 Synopsis, Conclusion and Induced Developments

5.1.4.1 Synopsis

The application case of VIVACE and the related BNE-P model were discussed alongside a referencing valuation process. The introductory section outlined the VIVACE respective collaboration scenario between the domain of business and engineering, which was followed by a differentiated discussion investigating the BNE-P model as follows.

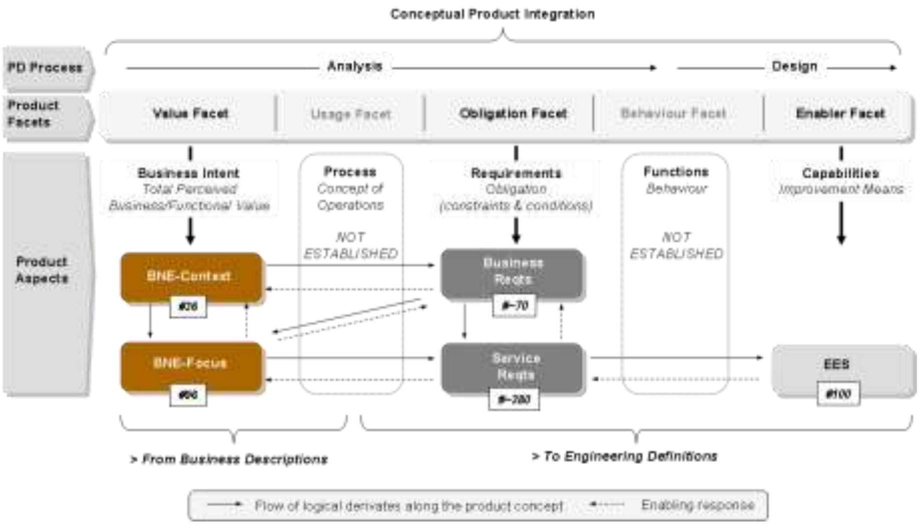


Figure 89: Application Case VIVACE – Results Broad Investigation

The broad investigation dealt with the establishment of the BNE-P *ontological* model distinguished within a BNE-Context and one or more associated Focuses applied on given VIVACE business intents. This concretisation of a business intent was not only associated to a Total Perceived Business Value, but also with a Total Perceived Functional Value. Feedbacks gained from the VIVACE organisation and their members have (partially) shown that a value-oriented representation (value facet, see Figure 89) of the business-engineering transition area increased transparency, trust and shared understandings. Figure 89 synthesises the results of the conceptual product integration providing differentiated *product facets*: Value, usage, obligation, behaviour, and enabler; and *product aspects*.

The second part of the investigation was devoted to discuss specificities within the business-engineering transition area, while complementing the referencing valuation process. Herein applied evaluation principles and vertical traceability mechanisms were explained. Thereby, it has been illustrated that prioritisations in regards of requirement structures (i.e. elements of the requirements specification document) can be given on intentional levels and in particular through the BNE-P *evaluative* model (i.e. weighted and evaluated soft-goal tree structures), which in turn also assists in prioritising PD Teams' activities. The consideration of BNE-P soft-goal structures as random variables enables them to consider uncertainties and estimate business needs and expectations under specific situational circumstances.

In conclusion, within the application case of VIVACE an improved associativity and established cause-effect relationships between intentional and engineering structures could have been partially established. It is anticipated that such an environment aids within increasing reactivity and potentially create a more pro-active behaviour in terms of negotiating commonly the direction of product developments. In addition, it has been shown that a *visual framework* (see Figure 86 and Figure 87) can be supporting vehicle towards traceability and beside the BNE-P ontological model key aspect towards transparency in cross-domain collaboration (i.e. business and engineering). Transparency is important feature and supports analysis across business and engineering information frameworks towards coherency and interconnected business-engineering evolutions.

5.1.4.2 Review of BNE-P Model Requirements

This section provides a brief review of the concept of Knowledge-CoCoOn in form of the BNE-P model establishing a coherent top-level product definition in a cross-community context towards requirements gained from theory and empiricism (see Figure 90).

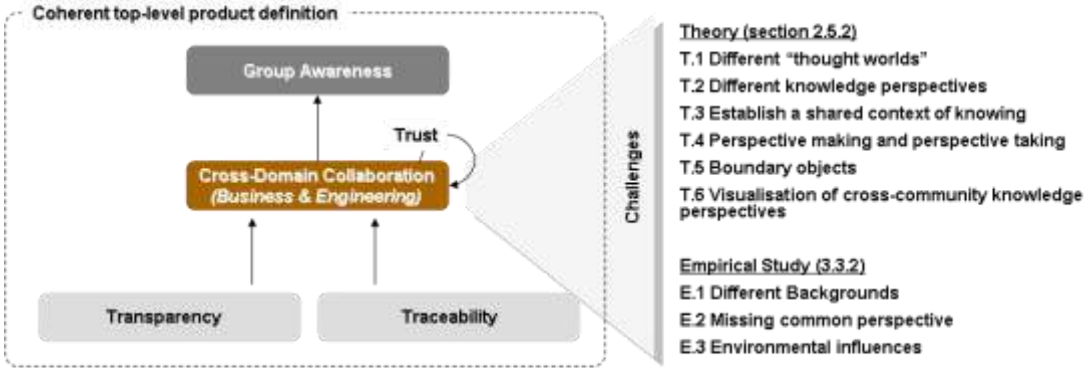


Figure 90: Cross-domain collaboration and coherent top-level product definition

Establishment of Collaboration Scenario

As discussed hereafter, the role of establishing the collaboration scenario is to provide a response towards below listed conceptual model requirements[181].

T.1 Different thought worlds
T.2 Different knowledge perspectives
E.1 Different Backgrounds

The collaboration scenario performs an analysis in particular of cross-domain interactions. The respective aim and perceived challenges of collaboration in the business-engineering transition area is identified and establishes the level of emergence, i.e. basis to converge towards a certain level of group-awareness. It deals with the identification of involved stakeholder including a definition on their role and

[181] 'T' indicates a requirement gained from Theory (see section 2.5.2) and 'E' indicates requirements gained from Empiricisms (see 3.2.6.2).

associated tasks. It is outline how collaboration is expressed in terms of knowledge conversion and expected information including perceived challenges. Finally, the collaboration scenario endows and prepares the establishment of the BNE-P model. In addition, it is balancing means for operationalising the model and in turn it helps to better anticipate respective method and tool set-ups.

Establishment of BNE-P ontological and evaluative model

As discussed hereafter, the establishment of the BNE-P model within its ontological and evaluative component providing response towards below listed model requirements.

T.3 Establish a shared context of knowing
T.4 Perspective making and perspective taking
T.5 Boundary objects
T.6 Visualisation of cross-community knowledge perspectives
E.2 Missing common perspective
E.3 Environmental influences

The BNE-P model has shown that it contributes establishing coherent top-level product definition through both components the ontological and evaluative. The BNE-P ontological model provides structure and logic towards the organisation of business-related community spaces (perspective making). Herein, the concept of boundary object supports perspective taking collaboration towards community external information spaces and provides controlled insights based on common or closed to common contextual information. The BNE-P evaluative model helps to perform cause-effect analysis crossing business intentional and engineering information structures. Thereby transparency development (including visualisation) and (vertical) traceability analysis were identified as two key enabling features. Another success factor in cross-domain collaboration that has been surveyed within the empirical study is trust.

5.1.4.3 Induced Developments: The BNE-P Tool – A Knowledge Representation Forum

As a last step within the GLOBE Action Research Methodology the research framework is updated (see Figure 91).

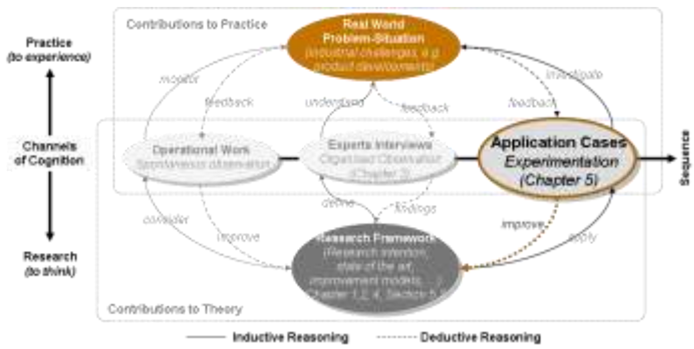


Figure 91: GLOBE Hybrid Action Research Methodology – Improve Research Framework

This section emphasises the role of the BNE-P model in context of organising and representing knowledge and is indicated in the following as knowledge representation forum. A first prototypical environment that relates to the threefold distinction of a knowledge visualisation framework: *type*, *motive*, *format* (see section 2.5.5); is represented. Whereas, the current state of developments considers mainly the phase of capturing and establishing BNE-P and EDs, rather than providing specific views on respective established information structures.

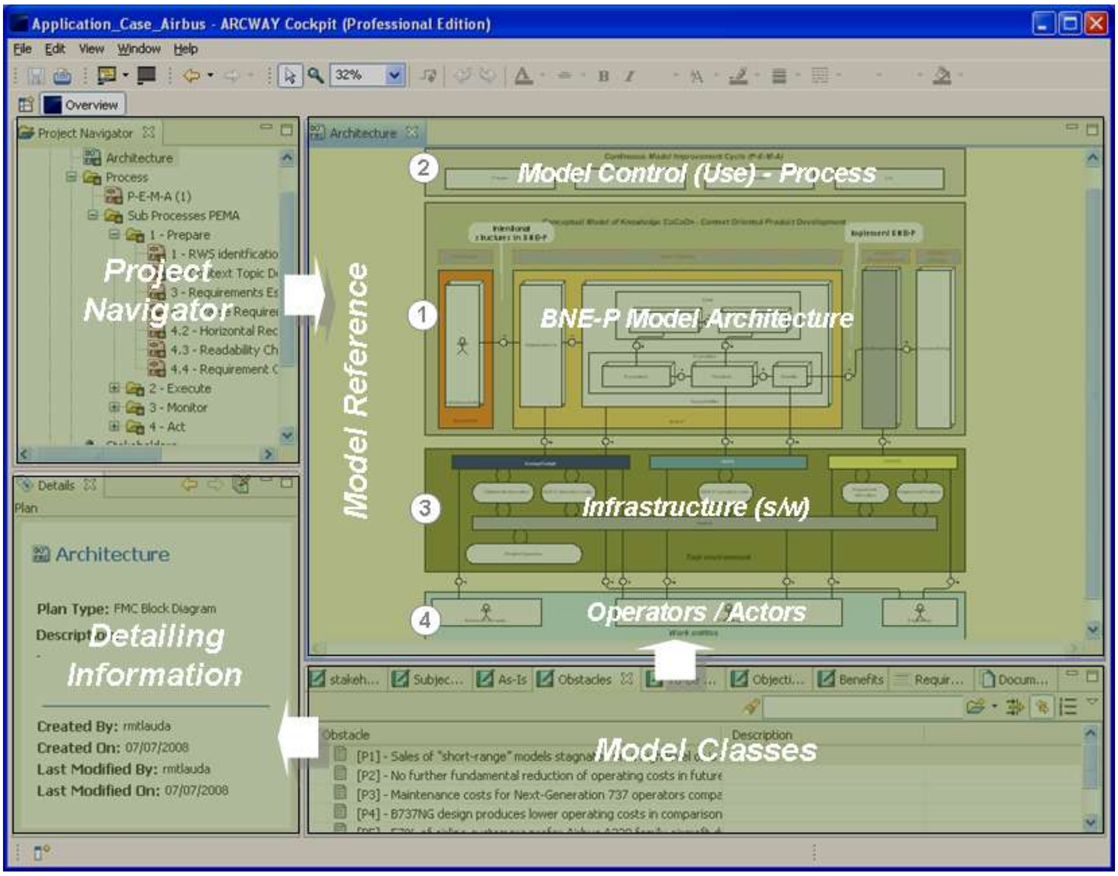


Figure 92: Implementation of Knowledge-Forum within Arcway-Cockpit

The software solution that has been utilised in order to operationalise the conceptual model of Knowledge-CoCoOn in forms of BNE-Ps aligned with requirements is Arcway Cockpit®[182]. This software utilises the fundamental modelling language[183] approach that is a consistent and coherent approach to think and talk about systems. It enables people to communicate the concepts and structures of complex informational systems in an efficient way among the different stakeholders. Within the software life cycle the FMC is devoted to architecture definition.

The knowledge representation forum has been set-up within four main frames (see Figure 92):

- *Project Navigator*: The project navigator displays a tree of projects and relating information in association to the *model reference**
- *Model Reference*: The model reference is main frame and illustrates the referencing system as the respective knowledge representation that has been

[182] For further information consult www.arcway.com.

[183] All information about the *Fundamental Modelling Concept* is available on http://www.fmc-modeling.org

specified in terms of

- *(1) Model Architecture*: Indicates the BNE-P model within its logic and towards which *model classes** can be associated.
- *(2) Model Control Process*: Guide-lining principles, i.e. activities to be performed including the indication of actors (human, tool)
- *(3) Infrastructure*: Indicates the defined tool set-up[184] and interfaces to parts of the *model architecture** for which those provide respective contents
- *(4) Operators/Actors*: Definition of actors and a respective indication of responsibilities in regards to the model architecture

• *Model Classes*[185]: All defined BNE-P model classes and attributes are available. By means of a drag & drop functionality fulfilled classes can be associated and relationships amongst them can be established accordingly.

• *Detailing Information*: Displays contents in regards to selected model classes.

In the following the different parts of the *model reference* are discussed more deeply.

(1) Model Architecture

The BNE-P model – as it has been defined including its logic – is implemented within Arcway Cockpit accordingly (see Figure 93).

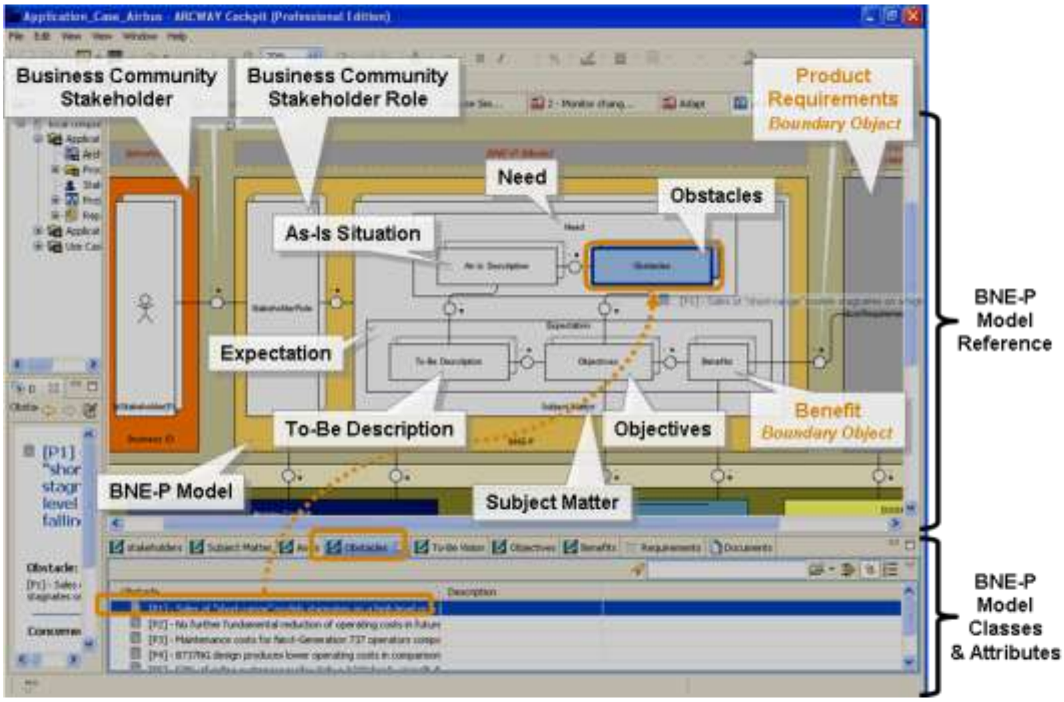


Figure 93: Implementation of BNE-P model in Arcway Cockpit

The central part, the "big picture", provides the BNE-P model in form of an architectural organisation towards which respective classes and attributes within its contents can be associated. Association of contents can be performed via drag & drop functionalities, which is exemplarily illustrated for the class *obstacles*. In an equal manner, community-related information spaces in forms of hyperlinked *documents* can be associated as well as elaborated *requirements* as part of the requirements

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[184] The infrastructure could be build upon any tool set-up that serves most appropriate towards the present collaboration scenario within respective aims and perceived challenges to overcome.

[185] The definition of the model classes was matter of specific customisation, i.e. coding.

specification document. Relationship establishment across the different model classes in context of one *subject matter* is considered hereby towards which related *responsibilities* and *issues* can be assigned.

The illustration further points business and engineering related boundary objects (indicated in orange) as a vehicle for supporting collaboration between those communities and enable to interconnect each other's perspectives besides retaining intra-community perspective making.

(2) Model Control Process

Arcway Cockpit has been used in order to describe guide-lining processes in regards to usage and control principles of a BNE-P model. The process is designed as a closed feedback loop and is built upon the principles of continuous improvement and grounded on the Deming Cycle respectively (see section 2.5.3.2). Accordingly, the process describes how the BNE-P model can be performed towards continuous improvements based on the conceptual BNE-P model and including investigations related to boundary objects. In this context the process has been defined within four phases: *Prepare, Execute, Monitor, and Act* (see Figure 94); and is based on learning outcomes that relates to the two industrial application cases (so far not validated).

1. Prepare
   - *Real World Stakeholder and related Stakeholder Role identification:* This process step concerns the identification of relevant business community members within their business identification and their associated stakeholder role.
   - *Context Topic Definition:* This process step is devoted to identify and elaborate the BNE-P model within all its classes, attributes and its logic (relationship establishments).
   - *Requirements Establishment:* This process step encompasses activities to be performed within the application of investigated approaches dedicated to the boundary object requirements. This includes HRI analysis, parsing requirements and reviewing requirements quality quadrants.

2. Execute
   - *Status Report Request:* This process step concerns the continuous evaluation of BNE-Ps based on intermediate evaluations of BNE-B values, which are in fact matter of the request as such.
   - *Change Request:* Changes are requested both top-down (from business to engineering, e.g. moving targets) and bottom-up (from engineering to business, e.g. difficulties in implementing BNE-B in forms of EDs).

3. Monitor
   - *Monitor status report:* The BNE-P evaluation model is updated with requested BNE-B criteria's values and in turn TPV values are determined and analysed.
   - *Monitor change request:* Change request is analysed and the type of change is identified. Traceability analysis is conducted and possible adaptations are performed.

4. Act
   - *Steering the operational use of the model:* An adaptation plan is available (output of monitoring phase) containing synthesised decision alternatives and relating consequences. A respective decision is taken and adaptations to initial planning are communicated.

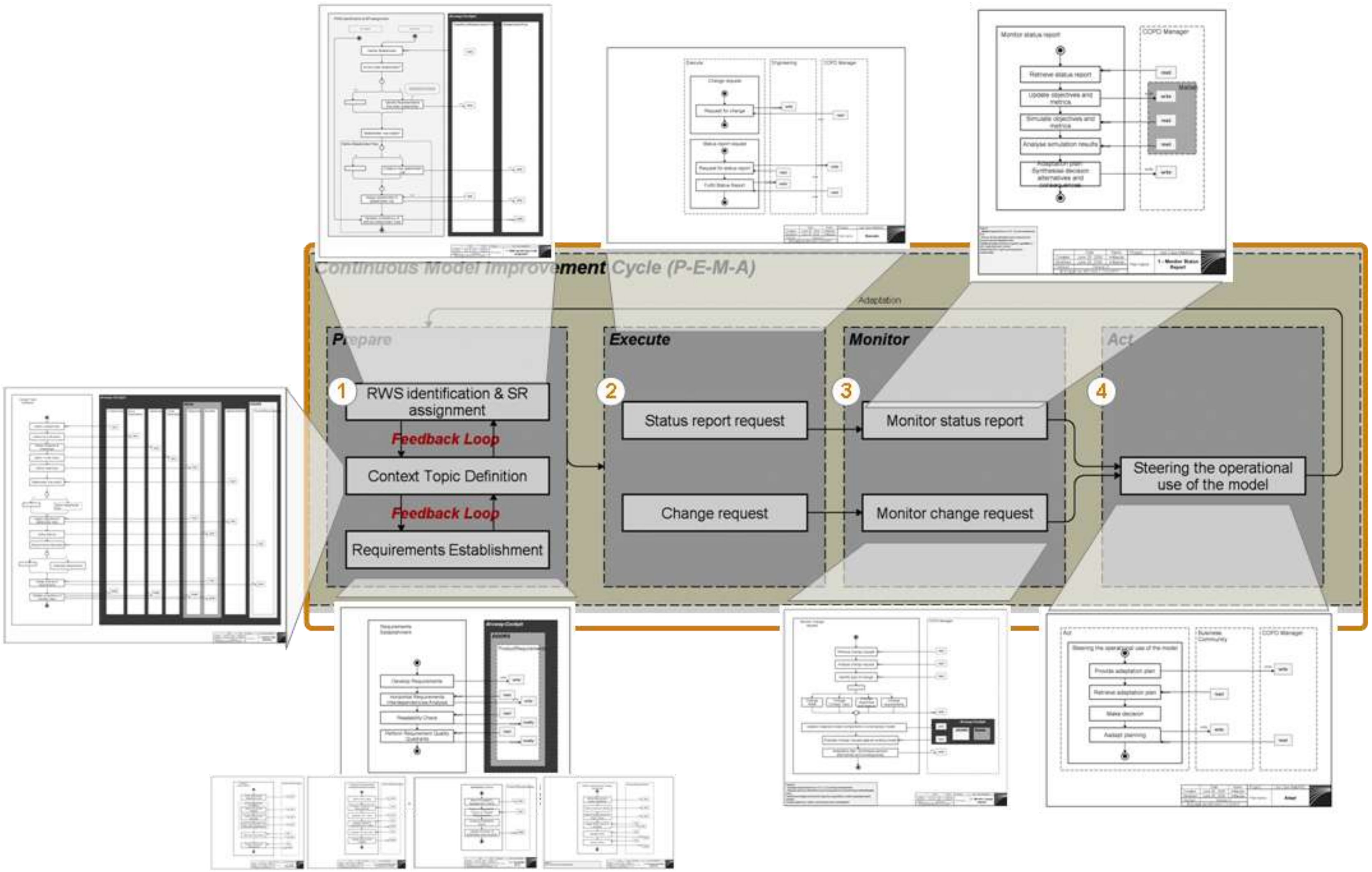

Figure 94: BNE-P Model Control Process

(3) Infrastructure (4) Operators/Actors

Customer of the BNE-P model

The BNE-model has been established to organise cross community collaboration and knowledge conversion for perspective-making (intra-community) within the *Business Community* and secondly enable perspective-taking (inter-community) within the community of *Engineering* (see Figure 95), while both can retain to their local perspectives.

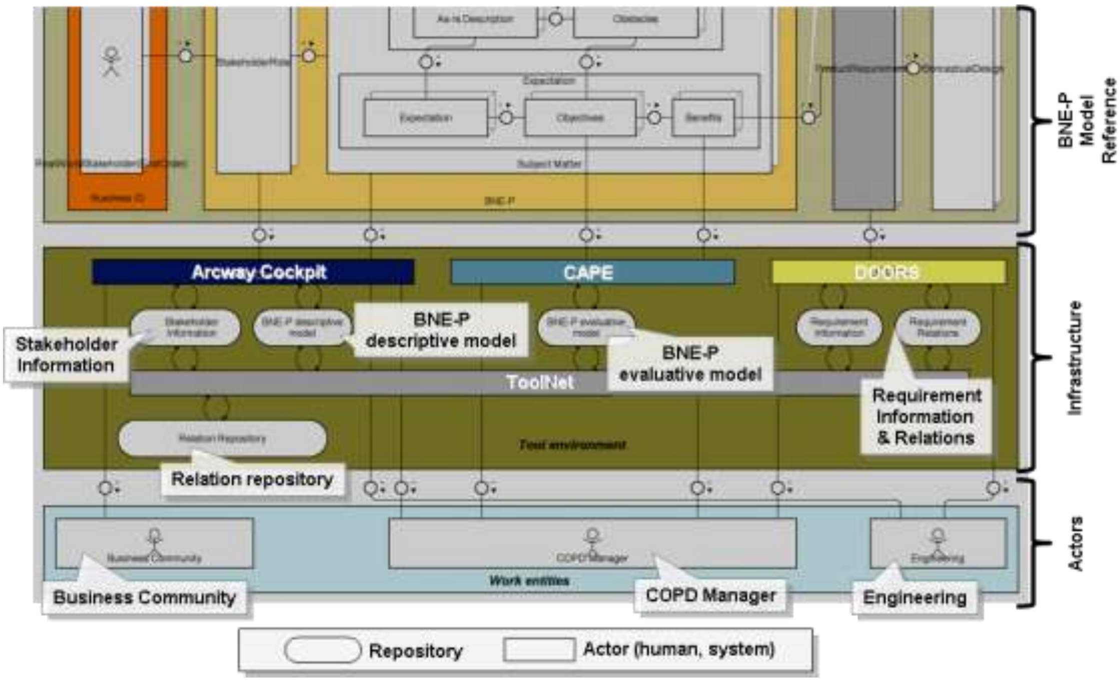

Figure 95: BNE-P Model infrastructure and performing actors

Nonetheless, from experiences gained through the application cases it is proposed that the core organisation (preparation, set-up and maintenance) of the synthetic meeting place is managed under the control of an integrator or sort of architect role (referenced as *COPD*[186] *Manager*, see Figure 95) as the author of this work performed it. This role should be capable to understand both the domain of business and engineering bringing BDs and EDs on informational level into alignments and who ensures the overall coherency as well as harmonised understandings. This role should be skilled to explain and fulfil the BNE-P model within its contents including associated management of boundary objects as interfacing entity to EDs.

[186] Context-oriented Product Development.

Infrastructure Capabilities

From a more conceptual view, Figure 96 pictorially illustrates the infrastructure layer and respective technologies.

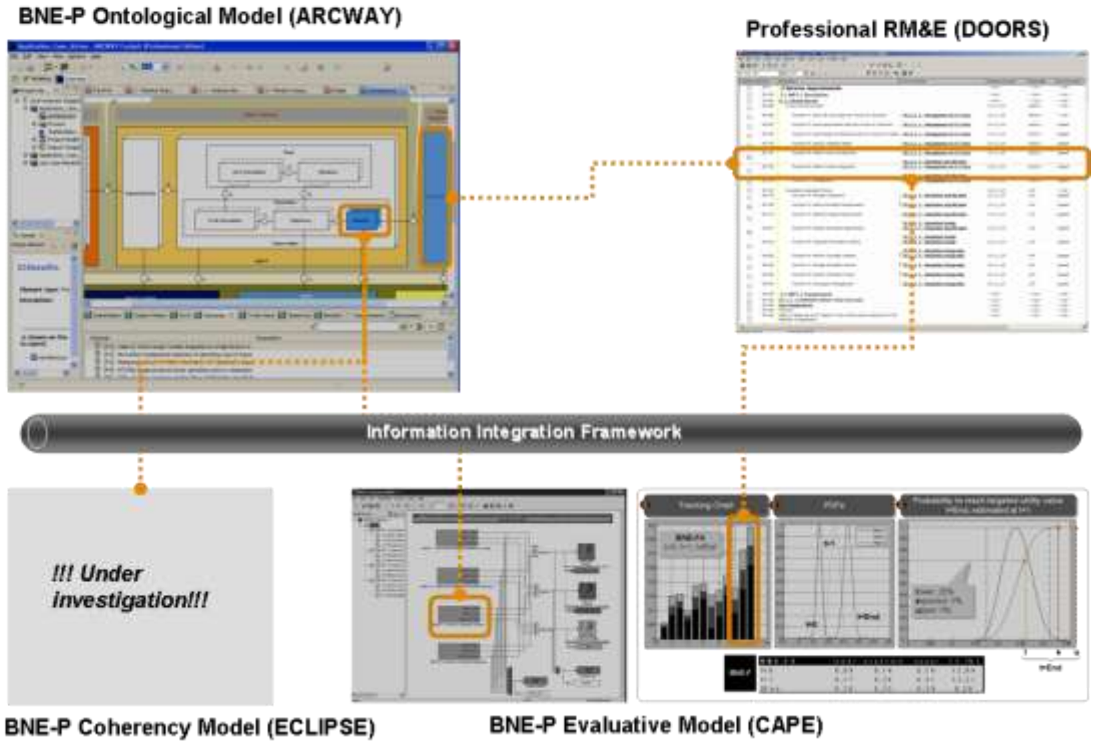

Figure 96: Illustration of the operationalised BNE-P infrastructure

The BNE-P environment consists of the following technologies, which have been prototypically implemented as follows:

- *BNE-P Ontological Model:* It contains information about the BNE-P ontological model, which includes the referencing architecture, classes and attributes, and the logic to perform the model. The model control and use process respectively is also defined so far (but not validated) in a static manner serving as guiding instance for the actors involved.

- *BNE-P Evaluative Model:* Here, enhanced evaluations (including probabilistic evaluations) of identified business intents can be performed for a subject matter and BNE-Ps respectively. Total perceived values (TPV) and expectation value degrees are simulated and illustrated for further analysis. Cause-effect analysis can be performed towards established requirements structures, which in turn can result into further and deepen analysis of consequences within EDs.

- *BNE-P Coherency Model:* As coherency has been identified as one important aspect on the level of requirements and is tackled in the second industrial application case in regards to topics like horizontal requirements interdependencies and requirements parsing (see section 5.3). A mandatory contribution supporting coherency establishment on the level of requirements is given through intentional instance where BNE-Ps are established. Herein, a valid proof within classes and attributes has been achieved on basis of the application cases. Nonetheless, it has been not achieved to reach coherency analysis across a number of BNE-Ps. In particular on basis of the objectives system, soft-goal trees as central part of the coherency analysis using contextual information like TPVs, requirements, obstacles, stakeholder, As-Is and To-Be descriptions, associated relations to community related information spaces and so forth. In this context, integration with semi-formal approaches related to intentional modelling is core of next step investigations (see section 6.3.6). First results have been achieved in terms of developments as data access and export related to all information handled in Arcway Cockpit. Since this software is based on Eclipse technology, respective implementations will utilise this technology also.

- *Professional Requirements Management & Engineering (RM&E):* Here agreed and under given requirements quality characteristics fulfilled product requirements are managed and controlled. Unless some requirement quality characteristic are not fulfilled and agreed by the actors, these requirements resists being managed within BNE-P ontological model. In contrast to process-oriented RE - as many engineering-based organisations behave - here the proposed BNE-P model contributes to a knowledge-driven evolution of product requirements and inducing follow-up engineering activities in particular in the volatile front-end phase of a project. Nonetheless, throughout the progressive knowledge-driven evolution, associations retains in both technologies, which requires some rules (e.g. read-only) to handle those duplicated data in a coherent manner.
- *Information Integration Framework:* Relation repository respective to the integrated data model (dotted lines indicated in orange) and supports traceability of information across different technologies. The utilised technology performing prototypical the information integration framework is also based on eclipse.

5.2 Prospective Industrial Application Case: Airbus

The industrial application case of Airbus provides prospective researches and discuses improvements models for engineered requirements as part of the requirements specification document and engineering-related means of verification towards addressed intentional structures specified within BNE-Ps.

5.2.1 Introduction and Approach

The present industrial application case was performed with an Airbus department concerned with engineering methods, processes and tools. One major task of this kind of department is to support transversally operational teams (engineering concerned with product developments at different phases and levels) with the mission of improving current situations and solve existing problems within the PD process.

For matters of confidentiality, respective contents are generalised and not subject to any actual product development within Airbus.

Aim

The aim of Airbus within this study was to investigate the question "*How to establish a complete and consistent set of top-level aircraft (product) requirements before entering into concept phase?"* A RE process is defined for the phase after the establishment of top-level requirements. An approach should be investigated in the front-end part of the PD process and should consider its volatility, situated through cross-domain collaborations between business and engineering.

Approach

The approach to this study is organised in a coherent manner as the application case of VIVACE. Firstly, the interactivity among business and engineering structures in context of the top-level product definition and related challenges are highlighted (see section 5.2.2). Next, exemplarily the BNE-P model is investigated in regards to the applicability of model classes and attributes (see section 5.2.3) and is followed by detailed investigations of engineering's related boundary-object (see section 5.2.4).

5.2.2 Collaboration Scenario

Airbus is a project- and engineering-based organisation concerned with highly complex and long-time product developments. The development of a new aircraft or aircraft-family respectively is concerned as being a market-oriented product development. Whereby airlines' specific cabin layout demands (e.g. seating, galleys, lavatories, etc.) are to a certain degree matter to customer-oriented development and explicitly concerned with airline respective business models.

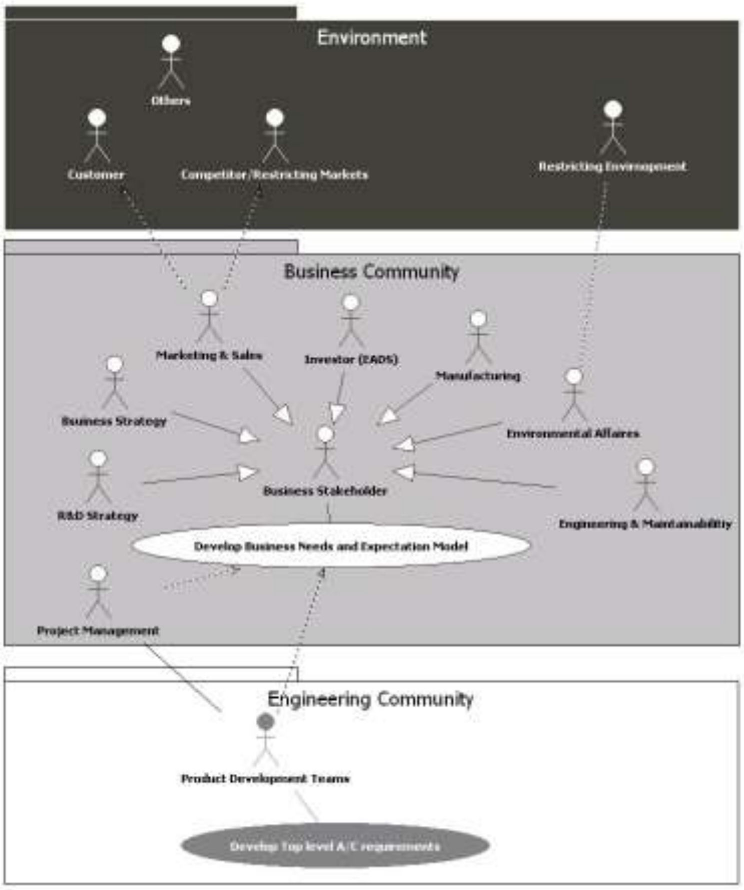

Figure 97: Exemplified collaboration scenario within Airbus[187]

[187] The figure does not claim to be completely conforming to respective UML notation.

For establishing an Airbus dedicated collaboration scenario a number of companies, quasi-standardised internal guidelines were reviewed[188]. Thereby stakeholder roles were associated to the organisational *environment*, *business* and *engineering community*. As a result, a principle (and not claiming to be complete) Airbus dedicated collaboration scenario across business (including indications to organisation's environment) and engineering domain establishing a top-level product definition is depicted in Figure 97[189].

Exemplarily organisational relationships with the environment are illustrated for "Marketing & Sales" and "Environmental Affaires"[190]. Interaction (i.e. consistency and completeness loops) with the environment is not in scope of investigation.

Perceived challenges

Within the above sketch of business and engineering collaboration, business community members are knowledge bearers that implicitly form "together" business needs and expectation perspectives. In return, product development teams are concerned with establishing respective EDs (herein top-level product requirements).

The current situation within establishing top-level product requirements is challenging:

- Lack of methods and tools to support the collection and management of BNEs and in turn gain greater responsiveness from PD teams and better traceability to EDs in regards to BNEs
  → *Disconnected evolutions and too late and uncontrolled reconciliations*
- Long process and numerous iterations on requirements development with business community members.
  → *Lack of a sufficient representation against which product requirements can be mirrored, negotiated and validated.*
- BNEs are managed and negotiated in the form of product requirements. Working with requirements on the level of business community is insufficient since it is a business community untypical and non-contextual illustration.
  → *Difficult to give sufficient feedbacks on problems and difficulties*
- Balance the level of product requirements specification and overcome challenges of "over-specification", "under-specification" and "mis-specification"
  → *Difficult to gain confidence in what has been specified in terms of top-level requirements*

The following sections outline observed possibilities and discuss potential opportunities to tackle above stated challenges.

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188 Those documents encompass project plans, project management and project establishment guidelines.

189 For a better understanding each stakeholder role has been indicated with associated intentions and roles (see annex A.2.1).

190 Formal relationships could be either *explicit or implicit*. Explicit means that an entity in the environment exists which is physically known and "maintained" by one or more business community members. In contrast implicit means that access to relevant environmental entities for business members is given through secondary information, e.g. market survey, regulations.

5.2.3 Broad Investigation: Applicability of BNE-P Model Classes and Attributes

The collaboration scenario is established and perceived challenges were outlined. Starting point to fulfil the conceptual model Knowledge-CoCoOn in contents is the identification of *"Subject Matters"* (see section 4.4.3), which indicates a specific BNE-P.

A preliminary defined set of 40 Cabin & Cargo Top Level Aircraft Requirements and the previously introduced collaboration scenario served for anticipating and building respective BNE-Ps. Access to business community members and related information spaces could have been not established. In consequence some information available on the Internet is utilised in order to exemplarily illustrate respective business community related information spaces and further stimulate the establishment of a respective BNE-P model.

Systematically available information were analysed and discussed with the customer of the study. As a result common information structures and properties were categorised in BNE-Ps "subject-matters" (see Table 16).

Notation Subject Matter	Name • Short description
Competition	
• Essential product features to stay competitive • Strategic decisions with respect to the product portfolio	
Configuration	
• Capability to adapt to different configurations, i.e. airline business scenario and transport mission	
Flexibility	
• Capability to change position of cabin & cargo elements	
Layout	
• Required space inline with principle concepts of operations in regards to cabin & cargo	
Efficiency, Ergonomics	
• Efficient and ergonomic workplace for the crew in terms of accessibility and usability	
Ambience	
• Defining parameters of perception, e.g. temperature, humidity, noise, light, etc.	
Interfaces	
• Connectivity of passenger equipment within cabin seating	

Table 16: Subject Matters

These identified subject matters are representations of BNE-Ps in regards to Cabin & Cargo on Aircraft level. In practice, the identification of subject matters would require a number reviews by business community members. Nonetheless, in the frame of the study it was decided as sufficient enough.

BNE-P Model Establishment

From the identified BNE-Ps exemplarily one subject matter namely *"Competition"* has been established within the relating model classes (*see* Figure 98).

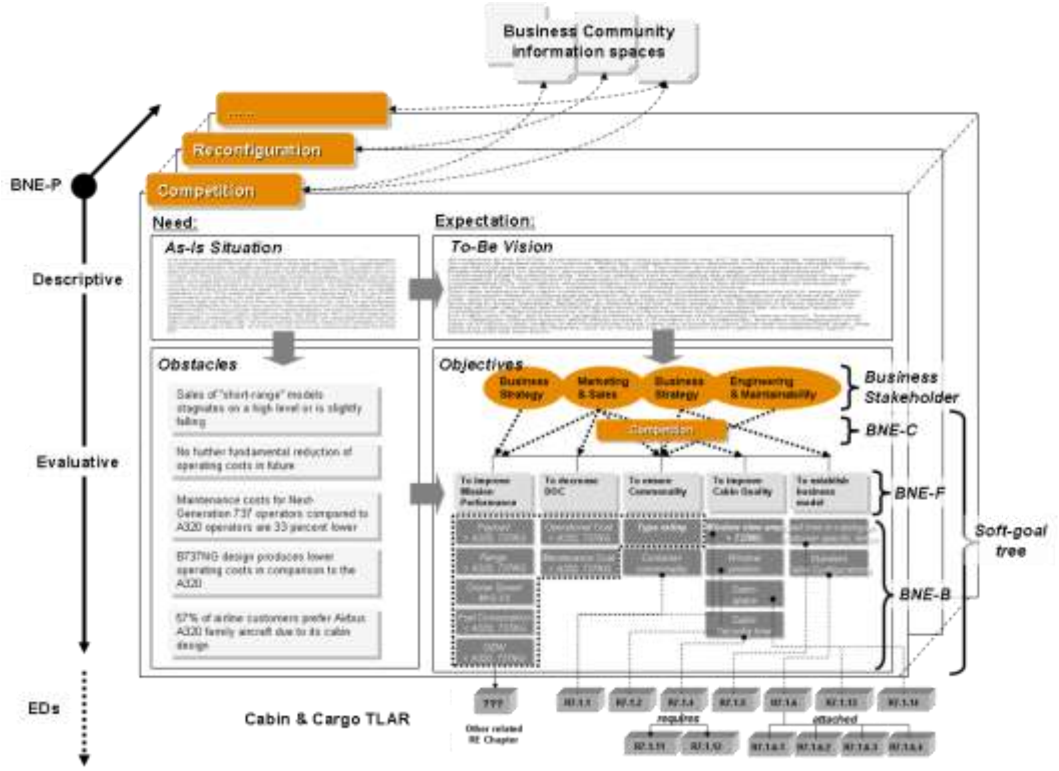

Figure 98: BNE-P Competition (simplified illustration)

To sum-up, the principle application of the BNE-P model in context of aircraft developments and top-level product definitions respectively could have been illustrated. However, a detailed proof of BNE-P model classes and attributes would have required a certain availability of business community members and / or appropriate documents. In contrast to the application case of VIVACE, the present BNE-P's related soft-goal structures were not elaborated in such detailed contextualised structures. Further it has shown that the soft-goal tree was not completely implemented in forms of TLARs. So that, in a real case environment this circumstance would potentially drive PD Teams establishing respective requirements structures. It is perceived by the customer of the study that the concept of BNE-P could provide a value proposition baseline which might help not only engineering but also both business and engineering together within articulating and prioritising in coherent manner an agreed route for product developments (including resource (re-) allocations). In turn, it is anticipated that the proposed model supports business and engineering evolving within an interconnected mode and that both can have transversal insights and synchronisations if needed.

5.2.4 Specific investigation: Verification of Intentional Structures implemented in forms of Requirements

A BNE-P rationalises the existence of requirements as part of the requirements specification document developed by respective PD Teams. Within this section some prospective researches are discussed that aids engineering within proving continuous coherency of interpreted business intentional structures, i.e. among requirements. Herein the following topics are discussed: *Requirements Quality Characteristics* (see section 5.2.4.1), *Horizontal Requirements Interdependency* (see section 5.2.4.2), and *Requirements Statement Pattern* (see section 5.2.4.3).

5.2.4.1 Requirements Quality Characteristics

To make requirements embody *quality* several properties have to be fulfilled. A respective task within the study dealt with the evaluation of requirements based on a set of developed quality characteristics. Following the literature those are denoted as *requirement quality characteristics* generally presented in a *checklist* format (see Annex A2.2.2). Requirement quality characteristics are subject to both individual and a set of requirements. Insufficient requirement quality can result into (AIRBUS-RBE 2006):

- *Over-specification:* leading to an increased non-recurring and recurring cost (also potentially decreased reliability due to increase in complexity)
- *Under-specification*: leading to customer dissatisfaction
- *Mis-specification*: leading to re-design, modifications

Those also have potentially negative effects on restricted resources in terms of time, cost and cognitive capabilities. For a better understanding of insufficient requirements quality a respective framework has been developed which embodies a two-dimensional organisation of *perception*:

- Subjective: Individual requirements, i.e. envision a single requirement statement
- Collective: Set of requirements, i.e. envision the overall set of requirements, e.g. a whole document and chapters respectively

And *quality aspect*:

- Documentation quality: Natural language processing, i.e. formalise and document natural language in terms of requirements statements, either individual as well as a set of requirements
- Validation quality: Negotiation and agreement, i.e. valid and agreed requirements (either individual as well as a set of requirements) amongst stakeholder or representatives respectively

Based on this twofold distinction of requirements quality a resulting matrix consisting of four quadrants and associated attributes has been elaborated (see Table 17).

Requirements Quality Quadrants		Perception	
		Subjective (individual requirements)	**Collective** (set of requirements = RE document or a cluster of requirements)
Quality Aspect	**Documentation Quality** (Formalise and document natural language)	**Quadrant II** • Singular • Necessary • Attainable • Clear/Unambiguous • Verifiable • Not premature design • Traceable	**Quadrant I** • Complete • Consistent • Non-redundant • Structured/organised

	Validation Quality (Negotiation and agreement)	**Quadrant III** • Understandable • Correct • Complete • Desired • Pertinent traceability	**Quadrant IV** • Correct • Complete

Table 17: Requirement Quality Quadrants (Laudan/Hornecker 2007)

The Requirements Quality Quadrants provide an organisation of guiding principles towards requirements quality in a checklist manner. A short explanation on each of these different checklist items can be found in the Annex A.2.2.2.

The meaningful operationalisation of the single quadrants and attributes would have required a certain domain knowledge, so that a valid proof of the respective framework based on the given set of preliminary defined Cabin & Cargo TLAR could have been not reached.

5.2.4.2 Horizontal Requirements Interdependency

Besides the logical requirements breakdown and associated synchronisations, equally requirements on the same level of granularity embody interdependencies between each other's also. Following the literature the topic of requirements interdependency is discussed as follows:

- Most requirements cannot be treated independently, since they are related to and affect each other in a complex manner (Carlshamre et al. 2001)
- Actions performed based on a single requirement change/affect other requirements not intended or even anticipated (Dahlstedt/Persson 2003)
- Dependencies between requirements may also affect decisions and activities during the development process, e.g. requirement change management (Kotonya/Sommerville 1998; Pohl 1996)
- The notion of requirement interdependency is one of the most important aspects of traceability from a change management perspective (Kotonya/Sommerville 1998)
- The area of requirement interdependency is quite unexplored judging by the amount of literature discussing it (Dahlstedt/Persson 2003)

In consequence it seems that there is a need to take *horizontal requirements interdependencies* (HRI) into consideration beside the classical breakdown of and tracings between requirements[191] on different levels of granularity. Dahlstedt/Persson (2003) argue that for making sound decisions throughout the product development process requirements cannot be treated as standalone artefacts. In this context a classification of HRI was carried out within a twofold distinction of *formal* and *informal* requirement interdependency classes (see Figure 99).

[191] The classical requirements breakdown encompasses from the continuous association from problem- to solution-oriented requirements.

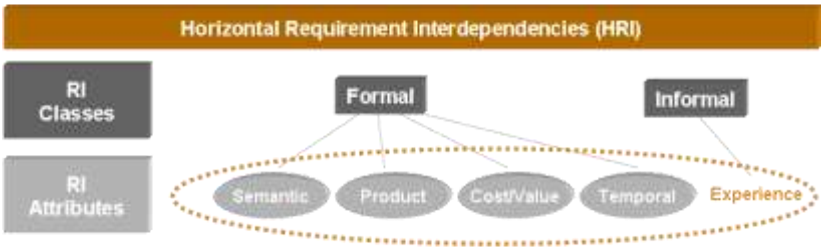

Figure 99: Horizontal requirement interdependencies – Classes and attributes (Laudan/Hornecker 2007)

Formal HRIs have been further detailed into four distinguishing types: *semantic*, *product*, *cost/value* and *temporal*; whereby informal HRIs are characterised as *experience*.

Formal HRI Attributes

- *Semantic*: Interdependency between requirements as originating from the semantics of the requirements statements itself.
- *Product*: Indicates physical, product-related interdependencies between two requirements.
- *Cost/value*: This type of interdependency is concerned with the costs involved implementing a requirement in relation to the value that the fulfilment of that requirement provide (Dahlstedt/Persson 2003). Increasing and decreasing relationships between two requirements.
- *Temporal*: Temporal interdependencies are concerned with the time required for implementing a requirement in an increasing and decreasing relationship with another requirement.

Informal HRI Attributes

- Experience: Interdependencies as originating from experts' cognitions, which could embody any of the formal HRI attributes as pointed above.

In the frame of the study only semantic HRI were investigated on the set of 40 requirements. Contextually, having a global view on a set of requirements and its semantic, requirement interdependencies might occur within the following characteristics: *Conflicting*, *Attached*, *Influencing*, *Required*, *And Overlapping.*

Example	ID	Requirement Statement	Sorts of Interdependencies
1	R1	The car shall be reconfigured in 5 minutes.	Requires
	R2	The back-seats shall be removable.	
2	R1	The system shall provide ergonomic access.	Attached
	R1.1	The user shall be able to access equipments.	
	R1.2	Signs and labels shall be self explanatory.	
3	R1	The system shall be offered in 8 standardized versions.	Influencing
	R2	The lead-time of a system shall not exceed one day.	
4	R1	The system shall be blue.	Conflicting
	R2	The system shall be black.	
5	R1	The user shall be able to open the door.	Overlapping
	R2	The user shall have a possibility to open the door.	

Figure 100: Semantic HRIs (adapted from Laudan/Hornecker 2007)

These developed characteristics were named *CAIRO*. Those are shortly described below and are exemplarily depicted in Figure 100.

- **"<u>C</u>onflicting"**: dysfunctional relationship – requirement R1 and R2 cannot exist at the same time or increasing satisfactory of R1 decreases satisfactory of R2
- **"<u>A</u>ttached"**: A general R1 is explained by a number of specific R1.1 and R1.2
- **"<u>I</u>nfluencing"**: General dependency type which is not 'conflicting', 'required', 'attached'
- **"<u>R</u>equired"**: R1 is a directed edge between two requirements and to satisfy requirement R1 it is needed to satisfy R2.
- **"<u>O</u>verlapping"**: R1 and R2 have a similar meaning

Identification of requirement interdependencies with CAIRO

A potential means to capture and handle identified semantic HRIs are cross tables, which provide an organisational frame for pair-wise comparisons between two requirements (see Figure 101).

	R1	R2	R3
R1		R	O
R2	C		I
R3	A		

C – *conflicting*
A – *attached*
I – *influencing*
R – *required*
O – *overlapping*

Figure 101: Pair-wise comparison with CAIRO (Laudan/Hornecker 2007)

Accordingly, the concept of CAIRO has been applied on the given set of requirements. Figure 102 depicts the results of identified semantic HRIs. Orange and black dotted boxes indicate pair-wise comparisons having *symmetric* and *asymmetric* characteristics. Hereby, semantic HRIs that occur inside one requirement cluster (i.e. a chapter in the originating RE document) were indicated as *closed requirement interdependencies* (see Figure 102, orange dotted boxes*)*. In contrast, interdependencies across two requirement clusters are called *cross-functional semantic HRIs* (see Figure 102, black dotted box). A cross-functional interdependency could be indicator for requirements that are of different departments' or teams' responsibility.

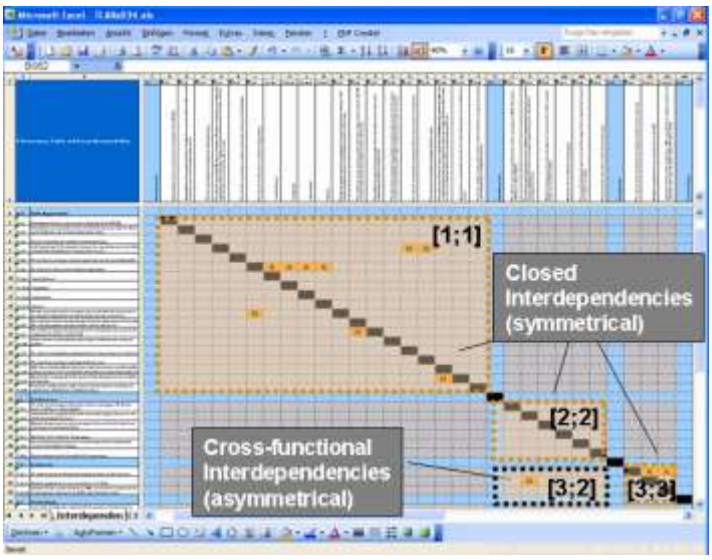

Figure 102: Example of semantic HRI based on CAIRO (Laudan/Hornecker 2007)

As a result, 26 semantic HRIs have been identified on the basis of the CAIRO concept that has been applied on the set of 40 requirements. The distribution of the HRIs is as follows:

C	: Conflicting:	none
A	: Attached:	18
I	: Influencing:	2
R	: Required:	6
O	: Overlapping:	none

Nonetheless, requirement interdependencies having conflicting and overlapping characteristics could have been not identified. But it has to be mentioned also, that respective domain experts relating to Cabin & Cargo have not validated the analysis.

5.2.4.3 Requirements Statement Pattern

Prevalently, requirements statements are compiled individually and mostly limited to indicate the degree of obligation using shall, should, must, etc. For supporting a matured entry into concept phase, while establishing a coherent set of TLAR, it has been identified as beneficial to exercise the idea of template structures for requirement statements. Hereby, the composition of a requirement statement is quasi-standardised using a commonly. The approach which is going to be introduced here and which has been applied on the given set of requirements, aims at providing a logical building block concept for PD teams concerned with the definition of requirements (see Table 18).

Original Requirement:

In the Combat zone, an HQ Switch, which is identical to a trunk node switch, shall be given two (2) independent links to at least two (2) other nodes in the network.

Component	Example
Actor	An HQ Switch
Condition(s) for action	i the Combat Zone
Action	Shall be given
Constraint(s) of action	
Object of action	Two (2) independent links
Refinement → Source of Object	
Refinement → Destination of Action	To at least two (2) other nodes in the network
Other	Which is identical to a trunk node switch.

Table 18: Requirements Statement Template (Halligan 1993)

The requirements statement pattern illustrated above is built upon a six element building-block organisation and is characterised in regards to Halligan (1993) as follows:

- **"Actor"**: Initiator of the action, the thing being specified "The aircraft", "The cabin", etc., subject of the sentence
- **"Action"**:
  - *Condition(s) for Action*, i.e. prerequisite for the action stated and defines the condition under which the action takes place
  - *Action*, i.e. obligation and action
  - *Constraint of Action*: restriction of the action
- **"Object of Action"**: This is a thing acted upon an actor, is the noun

- **“Refinement → Source Of Object”**: Qualifies the object
- **“Refinement → Destination Of Action”**: Qualifies the destination of action
- **“Other”**: Collect non-requirements material.

In contrast, some other approaches in the field of requirements parsing aim at applying specific algorithms on informal requirements expressions (i.e. continuous text) compiling grammatically correct sentences. The present application case considers rather engineering-based organisations where PD Teams are employed to specify requirements, so that applying a non-standardised approach in requirements expression first and improving requirements quality after in not envisioned.

Results

The introduced requirement statements pattern has been applied on the given set of requirements, which allows having investigation on the requirement statements by its contents (see Figure 103). A colour-coded representation of parsed requirements statements enables an improved mental access to the interpreter detecting its single properties. It is perceived that such an approach provide better consistent understandings and validations respectively across a number of interpreters as well as collectives of the requirements statements. Moreover, on basis of the commonly applied pattern, it could be easier to prove the overall context of a single requirement’s statement.

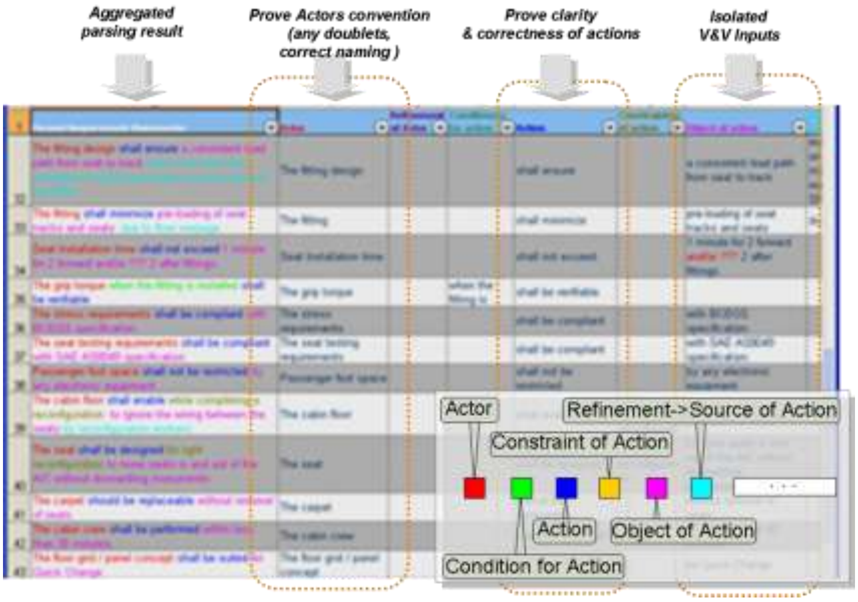

Figure 103: Results of Requirement Parsing (Laudan/Hornecker 2007)

“Actor”, *“Action”* and *“Object of Action”* could be interpreted as being core components of a requirement statement and hence shall exist for each requirement statement. The component *“condition”* defines the requirement’s validity in terms of circumstance respective to the action. The component *“Source of Object”* refines the “object” and possibly contains measurable parameters providing reasonable input for verification and validation activities (see Table 18). Furthermore, since contents of requirements statements are structured, a coherent (adequate, complete, consistent) domain and discipline specific vocabulary can evolve, and the vocabulary of future requirements can be meaningful limited.

Readability Score

Subsequently, it has been analysed if readability of requirement statements could have been increased or not. Therefore, a readability check has been performed within MS Word® (see Figure 104).

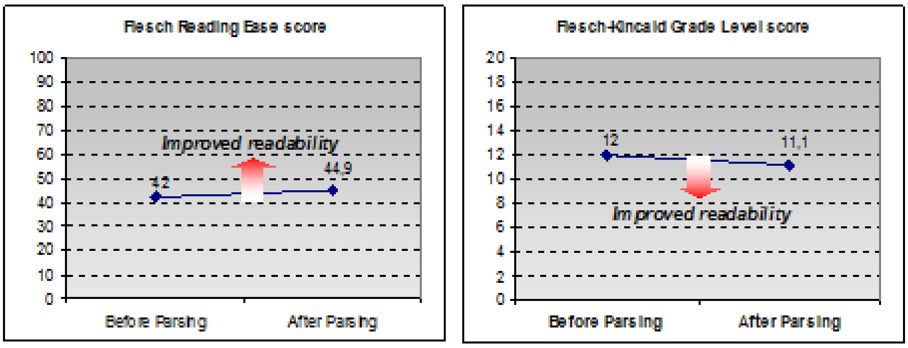

Figure 104: Results of the readability check before and after parsing requirements (Laudan/Hornecker 2007)

Readability scores bases its rating on the average number of *syllables per word* and *words per sentence* (see Annex A.2.2.4). It has been shown that both scores: *Flesch Reading Base Score* and *Flesch-Kincaid Grade Level Score*; could have been improved for both. But improvements were only marginal and might result from grammatically, orthographic improvements, rather than the component based requirements development. However, readability correlates with understandability and the level of interpretation quality towards which the component-based requirements statement development aids. In addition, further improvements can be achieved by:

- Shorter statements
- Less syllables within the words
- Common and uniform wording

Anticipated benefits

The author of this work synopsises benefits and feedbacks gained from experiencing the introduced parsing technique as follows:

- Requirement Parsing Technique = Template structure for requirement statements/sentences
  → *To reduce ambiguity and strengthen belief*
- Systematic analysis of available or composition of new requirements in a component based manner which is quasi-standardised
  → *To establish a think-when-write mentally*
- Establish an evolving and shared (=accepted and understood) domain vocabulary / dictionary
  → *To develop a consolidated and consistent requirement domain language*
- Requirement statements can be further analysed within its isolated components (e.g. check actor's appearance in chapters (complete?), early identification of V&V inputs)
  → *To work with and utilise requirement statement's content*

The experienced concept of requirements parsing seems to create “boring” to read requirement statements, but it is a perceived as being a mentally easier to grasp requirement statement concept.

5.2.4.4 Synopsis and Conclusion

The previously discussed application case of Airbus was concerned with a collaboration scenario among business and engineering that dealt with establishing a complete and consistent set of top-level aircraft requirements before entering into concept phase.

A simplified BNE-P model could have been established and principle applicability could have been shown. However, an appropriate model within classes and attributes was not feasible to be investigated within the frame of this study. Subsequently, a specific investigation dealt with the analysis of engineering’s related boundary object requirement in regards to quality characteristics, horizontal requirement interdependencies and requirements statement pattern. Those topics were discussed in context of supporting PD teams within proving continuous coherency of interpreted business intentional structures, i.e. among requirements.

Figure 105 pictorially depicts the results of the broad and the specific investigation. It illustrates the framework of requirements quality quadrants with some correlation indicating what is expected in terms of characteristics and what are aiding requisites to achieve those in turn[192].

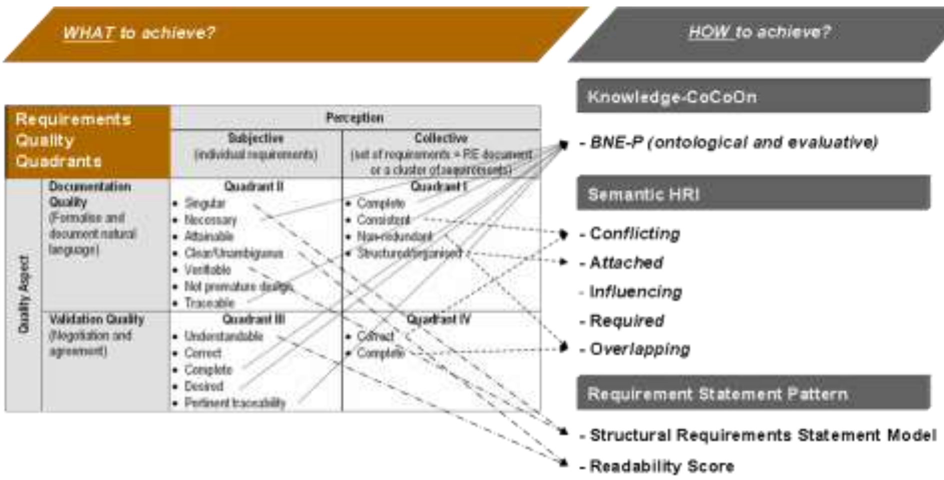

Figure 105: Airbus Use Case – Results overview (adapted from Laudan/Hornecker 2007)

In this context, it has been concluded together with the customer of the study that numerous requirements quality characteristics require the intentional model of BNE-Ps. In fact, this is an indication of cross-domain information and knowledge dependence (i.e. cross-domain knowledge conversions are required), which cannot be achieved by any engineering community related optimisation itself (i.e. on the level of requirements only). Whereas, the semantic *HRI model* as well as *requirements statement pattern* are approaches which assist in achieving coherent structures on the level of requirements. Respectively, the *requirements quality quadrant* framework

[192] Illustrated associations between requirement quality characteristics and investigated means to achieve those do not claim to be complete.

could serve to measure the fulfilment of its characteristics before entering into heavy specifications. In regards to the topic of HRI only semantic interdependencies have been investigated, which should be further extended to other classes (see 5.2.4.2) potentially applying the notion of CAIRO. Next, the introduced requirements statement pattern enabled to work within requirements contents. Amongst others, actor's appearance is highlighted across individual as well as set of requirements. It potentially provides a meaningful entity for both upper level and lower level of abstraction. For example, on the level of intentions it could be proved if business community members have been completely considered and BNE-Ps were appropriately considered in forms of EDs (i.e. requirements) respectively. Also, PD Teams concerned with functional and physical architecture definition on aircraft level have the opportunity to consider requirements statements not only as whole and complex information unit, but rather through its component actor serving also as a more concrete boundary object.

Even though Airbus methods and tools people validated results gained within application case, it lacks a real case proof by operational people (both business and engineering community members) and an operational environment.

5.3 Synopsis and Conclusion

This chapter discussed two industrial application cases investigating the conceptual model of Knowledge-CoCoOn in form of the BNE-P *ontological model* within classes and attributes (see Figure 106).

Figure 106: Industrial Application Cases – Properties and scope of investigations

The informal outline of collaboration scenarios aimed at defining business and engineering actors, and provided understandings in terms of interactivities amongst them including related challenges. Addressed business intents were determined by means of interviews with domain experts, document analysis and review cycles and subsequently specified within BNE-Ps (see Figure 107). Intentional structures specified in a BNE-P are grounded on a value-oriented concept. Respectively, the specific analysis of the VIVACE application case provided an approach towards reaching situational awareness and provided mechanisms to analysis cause-effect relationships between intentional and engineering information structures in context of a BNE-P (indicated as BNE-P *evaluative model*). Previously gained experiences induced developments of a prototypical environment that tackles the notion of knowledge representation forum and synthetic meeting place respectively, which are devoted to organise business-engineering collaborations and knowledge conversions.

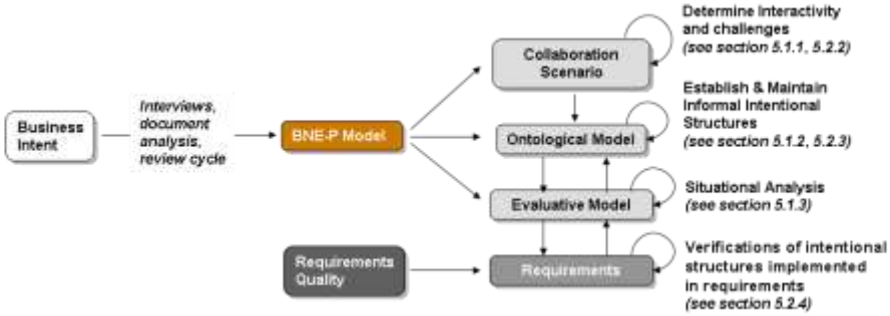

Figure 107: Synthesis – Investigations of industrial application cases

Specific investigations within the industrial application case of Airbus dealt with prospective researches among analysing features of requirements quality and a respective proof of continuous coherency of implemented intentional structures in forms of requirements information.

The investigation of business-engineering transition area and the respective proof of the concept of BNE-P was limited in regards to a lack of business and engineering involvement and feedback utilising the model along the various different project phases.

6 Synopsis, Concluding Thoughts and Outlook

The presented work has been concerned with the investigation of the business-engineering transition area in the field of early requirements analysis and the related development of a knowledge-driven concept for organising collaboration and knowledge conversions. This chapter briefly reminds initially stated thesis propositions and in turn learning outcomes are evaluated. Moreover, a synthesis of these contributions in early RE analysis theory and practice is provided and potential future works are outlined.

6.1 Re-establishment of the Research Question: Contributions to the attracted Area of Research and Validation in Practice

The presented research work received its stimulation by the fact of current research streams in the area of early requirements analysis. Contextually, this thesis has been built among the following research question.

Research Question

How to organise collaboration and knowledge conversion between business management and Product Development (PD) Teams concerned with the elaboration of top-level product requirements?

Sub-Research Questions

(i) *How to find coherence (adequacy, completeness and consistency) within the evolution of the project's product on the level of business and engineering?*

(ii) *How to maintain and trace knowledge evolutions in context of the project's product between business and engineering?*

In context of the *"research question"* the introductorily chapter highlighted that communication and coordination is challenging in conjunction with the visualisation and representation of knowledge in a cross-community constellation of business and PD teams concerned with early requirements analysis[193]. Most recently debated early requirements analysis approaches establish semi-formal and formal concepts that aim at increasing confidence and rationalisation of (information) product/system definitions and developments using the concept of goals. Herein, the construct of goal-oriented requirements analysis and applied formalisms falls short in establishing usable intentional structures that are able to provide the respective transparency for supporting continuously business-engineering evolutions within collaboration and knowledge conversions along a PD process. In addition, the present work introduced an empirical study that has been performed in an inter-organisational environment. It was shown that the notion of perspective making and taking retrieves in transparency in terms of cross-domain collaboration and that knowledge conversion in early product definitions are challenged by different backgrounds, missing common perspectives and environmental influences.

[193] Organisational structures were outlined in accordance to the systems life cycle standard ISO/IEC 15288 (see section 2.5.3).

In this context, organising the business-engineering transition area was identified as requiring a knowledge-driven approach that uses informal formalisms. This approach acknowledges the fact that business domain related intentional structures provide *knowledge* about *business needs* and *expectations* (BNE) that rationalises non-functional structures (i.e. soft-goal trees) towards which PD Teams can evolve within most promising value creating functional activities (i.e. functional definitions, specified through engineered requirements). The notion of knowledge, collaboration, context and ontology (whereas the notion of knowledge is integral component) were presented as constituents to organise knowledge conversions of BNE and engineering definitions. Moreover, the ISO/IEC 15288 Systems Life Cycle Standard was used as reference discussing organisation groups, their characteristics and relationships. The confluence of previously mentioned knowledge concepts in an organisational context resulted into the concept of Knowledge-CoCoOn (**Co**llaboration, **Co**ntext, **On**tology). Herein, collaboration constitutes the level of emergence, the circumstance and objective of knowledge conversions between business and engineering groups and related challenges. In this sense, context provides semantic and was put forward in terms of the construct of message that is central and vehicle for defining adequate communication and knowledge conversion modes. In this context the notion of ontology was introduced as providing structure for organising and representing knowledge that enables to associate semantic while establishing relationships along knowledge conversions and respective domain related knowledge bases. In addition, the Knowledge-CoCoOn was put forward in a construct of BNE-Perspective (BNE-P) that is a proposition for organising collaborative business-engineering constellations in operations. It was defined in form of an information model and ontological model respectively that centralises the concept of a total perceived business value perspective of qualities (features) related to the PD process and functional information and structures. It is an informal approach for organising intentional structures that relate to business community's information spaces and inputs from interviews. In this sense, the informal approach complements the chain of semi-formal and formal approaches in early RE analysis. It is furthermore an extension of existing intentional models with attributes that relate to project management information (e.g. responsibility, tasks, resources, issues that relates to a BNE-P).

In addition the BNE-P is potential asset improving *productivity* (performance of work, resource efficiency) for business stakeholder as well as for PD Teams by:

- Having an implicit proof of coherency amongst addressed business intents that are organised within BNE-Ps and relate to different business stakeholders (process of perspective making);
- Providing a manageable instance for capturing and organising early requirements analysis information (informally) before entering into semi-formal and formal modelling and analysis approaches;
- Operationalising a view which is communicable expertise-independent and can serve for stronger formalisms and proofs of coherency in terms of intentional modelling by experts;
- Providing opportunities for fast pace and reflexive updates of intentional and engineering information structures and avoid too late recognition of defects;
- Increasing transparency that is capable to progressively activate cohesive inter-domain group-awareness and negotiation forces along the PD process;
- Improving the evaluation of a high-level product definition enabling a confident entry into detailed engineering definitions; and

- Reaching a commonly shared (accepted and understood) high-level product orientation and communication baseline towards which business members and PD teams can activate all their efforts.

Validation of Contributions in Practice

The proposed solution of Knowledge-CoCoOn in form of the BNE-P ontological model was experimented within two industrial application cases. The application case of VIVACE was related to a European integrated research project that provided an inter-organisational project- and engineering-based environment and relates to customer-oriented product development of enabling engineering services implemented in software prototypes. The prospective application case of Airbus is considered as intra-organisational project- and engineering-based environment that is concerned with market-oriented product development of aircrafts and aircraft families[194].

For both respective collaboration scenarios were established that served for highlighting business-engineering constellations and associated real-world challenges to overcome by means of the BNE-P model. In this context-relating model classes and attributes were examined within its applicability in terms of specifying a given set of business intents. Within both industrial application cases respective BNE-P were build on existing documents, interviews with experts, and reviewing cycles.

Within the application case of VIVACE intentional structures were completely specified in forms of BNE-P ontological model in the closure phase of project. In this phase contributions to practice were given by an improved performance in exploitation and deployment activities towards partners' organisations. Even in this phase of the project, project members perceived it that transparency and common understandings on intentional structures and related developments were strengthened. The BNE-P ontological model was subject of partial investigation within the application case of Airbus. It was a study that was performed under laboratory conditions and only a principle application could have been illustrated. Nevertheless, the BNE-P model was well adapted being capable to provide partial answer to organise the volatile and rather knowledge-driven phase establishing high-level aircraft definitions.

Nonetheless experiences and feedbacks from applying the BNE-P ontological model did not allow investigating distinguishing features in relation of the two application cases. In addition, detailed analysis of business and engineering collaboration behaviour and better understandings of used knowledge conversion modes along the different phases of a PD process was also not feasible to investigate.

The *sub-research questions (i) and (ii)* were matter of specific investigations related to both industrial application cases. In this sense, explicitly the business-engineering area, i.e. business and engineering related boundary objects (transition points) were analysed. In the case of VIVACE cause-effect relationships were analysed among intentional and engineering information structures. In this sense, it was demonstrated that BNE-Ps and relating soft-goal structures could serve for situational analysis (including the notion of uncertainty and risk respectively) of intentional structures. In addition, vertical traceability enabled to follow consequences among unsatisfying structures in soft-goal trees and engineering information structures. In conclusion, it

[194] In this context, airlines' specific cabin layout demands are not considered.

was shown that the BNE-P evaluative model could provide situational decision basis that can be employed by (project) management instances to make sound decisions that can be addressed appropriately towards intentional and engineering structures (information and responsibilities). The VIVACE application case provided a continuous illustration of a respective valuation process applied on the concept of BNE-P.

Experiences gained from the empirical world of VIVACE and partially of Airbus were put forward in the development of the BNE-P Tool. It is first prototypical environment that establishes the construct of BNE-P emphasising the notion of knowledge representation forum. Currently it considers mainly the phase of capturing and establishing BNE-P and engineering definitions as well as performing features of situational analysis of intentional structures, rather than providing specific views on respective established information structures already.

The specific analysis performed within the application case of Airbus offered prospective researches in terms of verifications of intentional structures and information implemented in requirements as part of the requirements specification document. In this context, the concept of requirement quality quadrants provides decisive features that aim at establishing coherent requirements specifications in conjunction with relating BNE-Ps. Early investigations and feedbacks gained have shown that the BNE-P model can provide mandatory support in rationalising and increasing confidence in engineering definitions before entering the process of heavy specifications. In addition, the phase of establishing top-level aircraft requirements was perceived as requiring a knowledge-driven requirements analysis approach, rather than a process-driven process as characteristically for the phase of detailed engineering definition phases.

6.2 Evaluation of Contributions to Theory and Practice

The approach of this work was grounded on principles of the action research methodology. In this context the GLOBE Hybrid Action Research methodology was elaborated and is grounded on three cognitive channels (operational work, experts' interviews, and application cases) used to research and act, and in turn mutually contribute to theory and practice. This research methodology was guiding vehicle throughout the thesis and provided structured approach towards acting as an Industrial Ph.D. student.

Most significant contributions gained through the conduction of the research approach are summarised in Table 19 and evaluated in terms of contributions to practice or theory.

Proposition	Rationale	Contribution type: Theory (Research), Practice	Chapter reference
GLOBE Hybrid Action Research Methodology	Provide an action research approach that utilises three cognitive channels: Operational work, experts' interviews, and application cases in order to mutually contribute to both theory and practice.	Theory	1.5.2, p.19
Vertical & horizontal	Provide a distinction of collaboration direction in	Theory	2.1.2, p. 24

collaboration	complex decomposed collaboration cases in association to organisational levels.		
Empirical Map of Inter-Organisational Challenges	Provide an updated empirical map of challenges potentially stimulating further research ambitions in inter-organisational environments like European projects.	Theory	3.2.5.4, pp. 84 ff.
Knowledge-CoCoOn	A knowledge-driven concept for organising collaboration and knowledge conversions consolidating concepts of knowledge, collaboration, context, and ontology.	Theory	4.1, p. 96 ff.
Cubic model of the organisational environment	Provide a four facetted-differentiated perception of the organisational environment: Environmental Interpretation modes, environmental scope, environmental focus, and Organisation's communities of knowing.	Theory	4.2, p. 101
Message model for supporting knowledge conversion across organisational levels	Added the message model serving as a vehicle-providing context in Nonaka's (1994) spiral model within knowledge conversion across organisational levels.	Theory	4.4.1, p. 104
Model of Message Adequacy Modes	Placement of message's adequacy evaluating the potential success of a knowledge conversion.	Theory	4.4.2, p. 105 ff.
BNE-P Ontological Model	Based on the concept of Knowledge-CoCoOn an information model is proposed which offers a structural logic for knowledge representation towards organising BNE perspectives and its given semantics in cohesion with engineering definitions.	Theory	4.4.3, p. 113
BNE-P Ontological Model VIVACE	VIVACE: Inter-organisation, customer-oriented product development of enabling engineering services (implemented in software). Differentiated organisation of BNE-P in form of a BNE-C and BNE-F has been applied on a number of BNE-P.	Practice	5.1.2.1, p. 125
BNE-P Evaluative Model	Provide an approach for evaluating a BNE-P in terms of Total Perceived Values and mechanisms of vertical traceability providing situational awareness amongst business and engineering information structures.	Practice, theory	5.1.3.2, p. 135 ff.
Expectation Value Degree	Indicates the distance towards intentional structures (i.e. soft-goal trees) achievements appearing in three zones indicated situational analysis: current zone, improvement zone, and target zone.	Practice, theory	5.1.3.3, p. 155
BNE-P Tool	Prototypical environment establishing that put forward the concept of BNE-P in association with engineered requirements in terms of the notion of knowledge representation forum.	Practice	5.1.4.3, p. 165 ff.
BNE-P Ontological Model AIRBUS	Airbus: Intra-organisation, Market-oriented PD of aircrafts. Exemplarily the BNE-P was proved.	Practice	5.2.3, p. 175 ff.
Requirement Quality Quadrants	Provide an organisation of requirements quality characteristics in a matrix comprising documentation and validation quality towards individual and a set of requirements.	Theory, practice	5.2.4.1, p. 177ff.
C-A-I-R-O	Provide a notation for indicating semantic Horizontal Requirement Interdependencies, including the differentiation of closed (symmetric) and cross-functional interdependencies (asymmetric).	Theory, practice	5.2.4.2, p. 178 ff.
Requirements Statement Pattern	Experienced benefits towards coherency establishment within individual but also a set of	Practice	5.2.4.3, p. 181 ff.

	requirements.

Table 19: Thesis contributions

6.3 Criticisms of debated Contributions: Benefits, Open Issues and Stimuli for Future Researches

Strong formalisms exist for modelling intentional structures based on the concept of goals that rationalise engineering definitions with the difficulty to provide usable representations for non-experts (cf. vanLamsweerde 2004).

In this sense, the thesis provides a new informal approach that emphasises on business and engineering collaboration and knowledge conversions in the phase of early requirements analysis establishing the top-level product definition. It demonstrates a knowledge-driven approach that anchors a value-oriented organisation of intentional structures and is proposed in an organisational context to overcome perceived challenge of communication and coordination as well as the representation of knowledge.

Remaining sections discuss areas of contributions in detail; highlight some benefits, limitations and open issues respectively of the conducted work in context of project- and engineering-based organisations.

6.3.1 The Collaboration Scenario

The collaboration scenario was means within both application cases to outline business-engineering constellations and related collaboration contexts. In this sense surveyed challenges and related future circumstances to be reached utilising the BNE-P model were outlined.

Benefits

- Provide context to the BNE-P model: Initially it was not perceived as being a fundamental component, but finally it is concluded that it might be means justifying and balancing certain efforts establishing the BNE-P model within classes and attributes and methods and tools set-up to be applied.

Limitations & open issues

- Scalability: Develop a process and guide-lining principles that investigate business-engineering challenging scenarios and assist in balancing the BNE-P ontological model within establishing classes and attributes and the BNE-P evaluative model within establishing fit for purpose situational awareness mechanisms.
- Formalisms: Adaptation of semi-formal approaches that are concerned with modelling stakeholder and their interrelationships including an appropriate capability to associate challenging aspects within currently perceived collaborations and knowledge conversions.

6.3.2 The BNE-P Ontological Model

The BNE-P ontological model is central contribution of the thesis and grounded on the confluence of different knowledge concepts as well as the notion of perspective making and taking in context of organisation's business and engineering constellations. It is vehicle to organise the business-engineering transition area within communication and cooperation facets of cross-community collaborations as well as related knowledge conversions along a PD process.

Benefits

- Business community perspective making: Intentional structures relating to business community knowledge bases can be systematically abstracted and specified in BNE-Ps by members of the business community and an integrator role respectively.
- Reflexive perspective taking: PD Teams concerned with the requirements specifications document can evolve in alignment with business intents specified in a BNE-P and entry into heavier specification within an increased level of confidence. Also, business community members receive customised insights through BNE-Ps in engineering definitions and subsequent developments.

Limitations & open issues

- Integration with stronger formalisms in intentional modelling: The deployment of the BNE-P model, in particular organised soft-goal structures and stakeholders captured, can serve stronger formalisms that integrate strategies to perform a transversal proof of coherency amongst a number soft-goal trees organised in various different BNE-Ps. In addition, BNE-P information model classes and attributes extent existing semi-formal information models with project management related information.
- Interdependency types and impact analysis: In addition to coherency proofs as mentioned previously, different interdependency types (e.g. semantic, cost/value, time) could be applied across different BNE-Ps and soft-goal trees respectively (as defined for see section 5.2.4.2). In this context, appropriate change impact analysis mechanisms among the various interdependency types could be investigated also (see section 6.3.4).

6.3.3 The BNE-P Evaluative Model

The BNE-P evaluative model has shown a potential approach how to perform valuation. It provided mechanisms to analysis cause-effect relationships between intentional and engineering information structures in context of a BNE-P.

Benefits

- Orientation on value adding activities: PD Teams have an improved decision base through weighted total perceived values related to soft-goal trees that provides improved indication of expected functional qualities and orientation on prioritised business communities' intentional structures.
- Reflexive Traceability: The BNE-P evaluative model provides channels for cross-domain associativity (introduced as boundary objects). It offers logic to follow and trace in bottom-up or top-down fashions throughout intentional (BNE-P) and

engineering information structures; it also establishes the relevant situational picture in context of a BNE-P.

Limitations & open issues

- Integration with stakeholder analysis approaches: The establishment of soft-goal trees can be integrated with respective surveying approaches that establish respective stakeholder related soft-goal structures and values. Those approaches highlight consistency and completeness loops of business community members assuming and intruding the organisation's environment.
- Integration with higher level metrics: Establish connection of BNE-Ps and related soft goal trees on project level with higher level evaluation systems on organisational level.
- Scalability: A methodological approach that provides balancing means to select an appropriate method and tool assembly operationalising the BNE-P evaluative model in context of the collaboration scenario.

6.3.4 The Requirements Quality Model

The prospective Airbus application case highlighted some potential means to proof the implementation of intentional structures (specified in BNE-Ps) in forms of requirements and quality amongst requirements.

Benefits

- Establish fit for purpose requirements specifications: The proposed concept of requirements quality quadrants provides indication of what is required in terms of a fit for purpose requirements specification. It provides features towards requirements quality in a checklist manner.
- Indication of transversal requirement statements relationships: Semantically relationships between requirements statements on the same level of granularity can be characterised using the concept of CAIRO and support evaluating change impacts and gain better understandings of horizontal interrelationships.
- Improved adequacy in knowledge conversion: The concept of requirements statement pattern provides a means towards better common understandings and internalisation of knowledge amongst PD teams. It enables to work with requirements statement contents, rather than treating those as complex information units.

Limitations & open issues

- Interdependency Types: Investigate remaining horizontal requirements interdependency types (cost/value, time, and product) and proof its applicability.
- Methodological support towards requirements quality characteristics: Establish methodological support providing an appropriate method and tool assembly towards the different requirements quality attributes defined within the requirement quality quadrants.
- Integration with functional architecture definitions: Since requirements statements are not treated only as a whole and complex information units, so that it could be investigated if and how requirements statement components (e.g. actor) can be reused in context of functional architecture definitions.

6.3.5 The BNE-P Tool

The BNE-P tool is first a prototypical environment that is learning outcome gained through the industrial application cases. It provides opportunities to organise and represent knowledge and has been indicated as knowledge representation forum. This prototypical environment has implemented the BNE-P ontological model, the BNE-P evaluative model and an environment to manage requirements based on a tool integration framework that allows relationship establishment between the different information models. Whereas, the central module is the BNE-P ontological model that provides architecture for business intents association and requirements specification, and a static process framework that is built upon the concept of continuous improvement cycles. It further defines the technological and tool set-up respectively including respective operating roles association. This module is mainly business intent capturing service.

Benefits

- Service-oriented technology: The tool set-up that has been exemplarily illustrated is based on the concept of a tool integration framework that is based on eclipse technology. This integration framework allows establishing associations (relations) between different technologies (presented through different model discussed previously) and establishes a respective an integrated information model.
- User-friendly: Users have possibility to establish a BNE-P and associate fulfilled model classes and attributes in an intuitive way towards the BNE-P model and its logic behind.
- Static process framework: Establishes a continuous improvement cycle that offers a set of guide-lining processes in regards to the usage and control principles of a BNE-P model and the relating requirements specification document.
- Visual framework: Provides visual guidance while performing cause-effect relationships that relates to interrelationships between BNE-P and engineering information structures.

Limitations & open issues

- Flexible views: To develop features that allows users to create and define respective views that relate to information of the BNE-P ontological and evaluative as well as requirements specification document. This issue relates to further developments that have been indicated as visual framework.
- Report generation: To provide functionality that enables the creation of reports on basis of a selected customised view that provides a situation-dependent synthesis of BNE-P and underlying information structures.
- Coherency model: To implement functionalities that allows to classify interdependency models in different contexts
- Proof of process framework: To validate guide-lining processes within further applications and along the different characteristically phases of a PD process.

6.3.6 Complementary Issues and Way Forward

This work is a step towards better understandings of top-level product definition in context of business and engineering collaboration and knowledge conversion. It provided the idea of an instance that can perform the continuous evolving and changing influences within intentional and engineering structures and create a level of group-awareness among business and engineering domain.

It could be further preparatory vehicle organising intentional and engineering towards stronger formalisms.

Further developments are planned in regards to the BNE-P models and tool. Those will encompass also partial integration with the relevant methodological periphery and relating demonstrator developments. In this context the main next three steps will be concerned with:

- **Exploiting Projects:** Firstly to ensure continuation of this work in the environment of EADS it is required to get connected and be part of projects. In this sense, a forthcoming integrated European project - that is follow-up project of VIVACE – is already identified as one potential candidate. In this context an EADS internal exploitation programme is identified that will play a double role:

    1. to have continuous results exploitation from the European project towards respective EADS business units, and
    2. to perform customised developments for the exploiting customer in EADS.

    This synergising project-framework should provide cognitive channels that transfer learning outcomes and act towards continuous and iterative exploiting cycle, without negatively impacting each others development targets.

- **Investigate BNE-P Application**: In context of this project-framework empirical studies could be performed in both inter- and intra-organisational contexts: the former would be related to the European project, the latter relates to any exploiting EADS business unit. In this sense, the inter-organisational environment will provide the opportunity to investigate the BNE-P model along the PD process and include phase-specific surveys: interview cycles, questionnaires, etc.; to have validation of capabilities, limitations and open issues in regard to the usage of the BNE-P model and the related static process framework. In addition, it offers the opportunity to investigate business and engineering domain members' behaviours during collaborations and knowledge conversions along the PD process and what role the BNE-P model plays. The BNE-P model indicates each partner's organisation business intent specified within BNE-Ps that could be also implemented more stringently with indications of exploitation attributes (which programme/product, operational business customer and end-users, delivery milestones, valuation of contributing, etc.). In the case of Airbus it could be investigated how to integrate the BNE-P knowledge driven with the process driven RE approach which exists already and is initiated after the top-level product definition.

- **Methodological and Tool development:** In context of the first axis: exploiting projects; this axis is devoted to further methodological and tool demonstrator developments. Emphasis relies on a detailed review of semi-formal approach and potential strategies for methodological integration in context of BNE-P model. Such integration with stronger formalisms enables an explicit proof of coherency among BNE-Ps and soft-goal trees. In this context different interdependency types across BNE-Ps will be investigated. Another emphasised issue relates to visual frameworks that provide customised views on structures and information provided by the intentional (i.e. BNE-P) and requirements models. Respective demonstrator developments will be concerned with the implementation of the defined methodological approaches. Lastly, it could be part of investigations to better understand method and tool assemblies that shape appropriate environments for operationalising business-engineering collaboration scenarios within given constraints and associated challenges to overcome.

6.4 Concluding Remarks

This research found its origination from observations in the field of early requirements analysis and was put forward in context of project-and engineering-based organisations dealing with the establishment of the top-level project's product definition. Intentional modelling provides semi-formal and formal approaches that use the concept goals developing coherent (adequate, consistent and complete) requirement models and guaranteeing requirements quality. In addition, those debated formalisms produce coherent intentional models that aim at increasing rationalisation and confidence in engineering definitions using the concept of goals. Whereas, communication and coordination is challenging in conjunction with visualisation and representation of knowledge in a cross-community constellation of business and PD teams concerned with early requirements analysis and top-level product definition. In this context progressive product complexity is confronted with a changing business environment, which means that new requirements might emerge and existing requirements might change every week or even day (Sommerville 2005).

The presented work advocates the point that if current intentional models fall short in establishing usable intentional structures that are able to provide the transparency for supporting continuously business-engineering evolutions within collaboration and knowledge conversions along a PD process, then it could be valuable to have a mediating instance that organises collaboration and knowledge conversions. It can act in front of stronger formalisms in terms of coherency development in requirements. In addition, it could strengthen negotiation forces and group-awareness among business and engineering community. It provides organisation of knowledge bases, i.e. community-related information spaces and anchors a value-oriented definition of business intent. Thus, it supports not only front-end negotiations, but also establishes continuous interactivity structures and strengthens product development performance in terms of increasing reactivity and group-awareness between business and engineering. In this sense initially established objectives for this work have been reached.

The main contribution of this work is related to the organisation of the business-engineering transition area, while establishing the top-level product definition in terms of collaboration and knowledge conversions based on a value-oriented organisation of intentional structures (i.e. business needs and expectations) and tracing mechanisms to engineering definitions along a PD process.

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Annex

A.1 Chapter 3: Complementary Information

A1.1 Project Organisational and Product Architecture

The hierarchical, horizontal and vertical organisation of the project in sub projects, work packages, task and sub tasks has been depicted previously. This work breakdown is associated with responsible working entities as follows (VIVACE 2004):

- *VIVACE Project Office (VPO):* The VPO supports the project coordinator and the consortium to handle the daily management, administrative and logistics tasks. The VPO is composed of an experienced project manager, of a project administrator and of an assistant. They will be completed with experts in charge of more specific tasks related to legal, technical (e.g. web publishing), administrative or logistics aspects.
- *Exploitation, Dissemination and IPR (EDI) manager:* Is in charge of the implementation and monitoring of *Exploitation*, *Dissemination* and *Intellectual Property Rights* (IPR) issues including IPR management, exploitation planning and information dissemination strategy.
- *Sub Project Leader (SPL):* Each sub-project is divided into work packages (WP) and led by one sub-project leader. Responsible for administration, transmission of documents, coordinating technical work, monitor deliverables and making decisions related to SP matters.
- *Work Package Leader (WPL)*: Each WPL is cascaded into separated tasks. Each work package is one partner’s responsibility, who appoints a WPL accordingly. A WPL is responsible for coordinating the work carried out by the partners and the achievement of the objectives for a given work package.
- *Task Leader (TL)*: A TL manages the work performed at task level. Each task is led by a TL, and therefore a task leader may lead several tasks. The TL manages the operational work performed at task level and is responsible for providing reports as requested.

In addition, three committees: Sub Project Technical Committee, Management Committee and a Steering Committee, are established for supporting decision making processes within the project (see Figure 108).

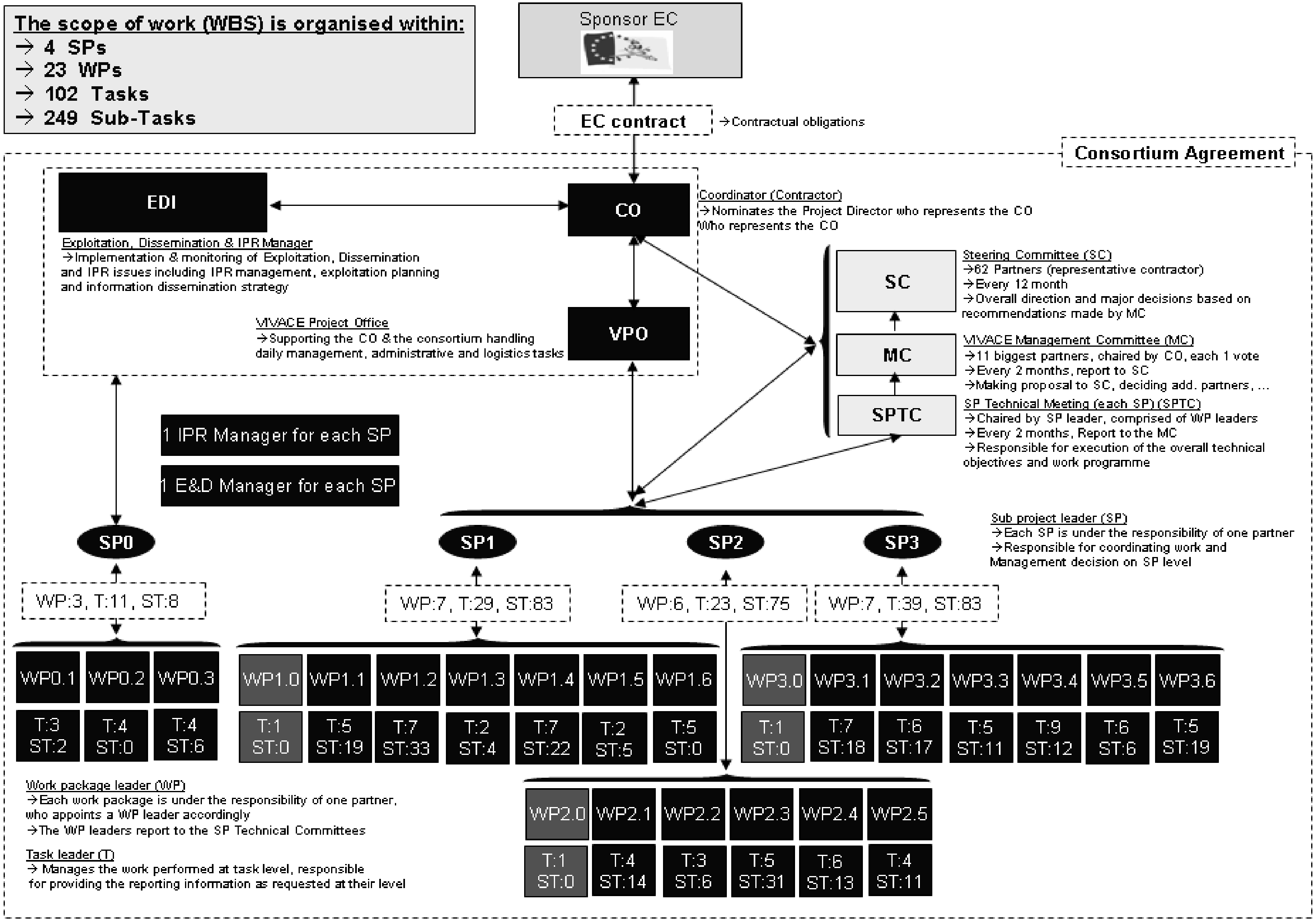

Figure 108: VIVACE Project Architecture and Lines of Communication

A1.2 Management Implementation

The coordination of the project throughout the iterative project life requires *management mechanisms* to control, organise, anticipate, facilitate, collaborate and decide within the project the established project objectives and the defined context.

The management mechanisms become operative through *management methods* and *tools*, where management methods, for example, correspond to the previously explained iterative cycle progress - and management tools correspond to project milestones.

The author conducted a group interview together with one representative from the VPO and one SP leader with respect to management mechanisms, methods and tools. The results are synthesised within Table 20 and illustrate the VIVACE management framework organised within three layers: *Management mechanisms*, *methods and tools.*

Mechanisms	*Methods*	*Tools*	*Frequency*	*Objective*	*Performed by*	*Performed to*
Control, Organise, Anticipate, Facilitate, Colloborate, Decide	**Reporting**	6 weekly report	6 weeks	To capture the general status, next steps and difficulties	WP leader	SP leader, VPO, PC
		SP leader telephone conference	2 weeks	To control the progress	SP leader, VPO, PC	WP leader
		Activity report	12 month	To control technical work performed (aggregation of 6 weekly reports)	WP leader	EC
		Management Report	12 month	To control financial aspects per partner.	Each Partner	EC
		Resource reporting	3 month	To control budget consumptions counted in person months	Each Partner	Ever
		Project Dashboard	3 month	To control the overall project's progress in terms of 3 iterations cycle progress, budget consumption and deliverable status	WP leader	SP leader, VPO, PC
	Decision Making	Steering Committee	12 month	To decide on the status of work (vote in) To validate External publications (by vote) and everything labelled "public material"	All partners	EC, PC
		VIVACE Management Committee (VMC)	2 month	To prepare decisions for the steering committee.	11 biggest partners	All Partners
		Sub project Technical Committee	2 month	To control deliverables, difficulties, resources, etc. and support technical exchange between WPs	SP leader, WP leader	PC
		Consortium Agreement	Once	To ensure contractual obligations for each partner	Each Partner	EC
		PC and EC Meeting	12 month	To evaluate the overall technical progress	PC, EC	n/a
	Requirement Engineering	Specification Reports	Ongoing (Installed at M36)	To capture in an organised way business needs and capabilities	WP Leader	VITC
		VIVACE Integration Database (Business Needs structure and Capability Structure of the 8-layer model)	Ongoing	To develop a consistent technical baseline conforming to the VIVACE mission objectives, inline with the VIVACE 8-layer toolbox architecture and managed on project level within a database	VITC	All partners
	Cycle Progress	Project Milestones	Ongoing	To establish decision gates for controlling the conduction of the 3 project iterations	VPO, PC	All partners

	Scenario Measurement	3 month	To control engineering activities with respect to the 3 project iterations	WP leader	VPO, PC
Intellectual Property Rights (IPR)	EC contract	Once	To ensure contractual obligations between the commission and the coordinator and other contractors	EC, PC	All partners
	Consortium Agreement	Once	To ensure contractual obligations for each partner	Each Partner	EC
	Knowledge Portfolio	Ongoing	To control the knowledge evolution and respective IPR	Each Partner	All
Communication & Dissemination	Internal Project Website	Ongoing	To provide an IT supported platform for the project community to share documents, important dates, etc.	VPO	All partners
	Public Forums	M21, M 34, M46	To share and communicate results to aeronautical community.	All partners, including EDI, PC	All
	Public Project Website	Ongoing	To present and promote the project externally	EDI	All
Risk Management	Risk Register	Ongoing	To identify risks and indicate mitigation actions	All Partner	VPO
	Risk Management	Ongoing	To establish methodology for application of Risk Management and use of the Risk Register by all members of the VIVACE	VPO, PC	All partners
Exploitation	Company Internal Forums	Ongoing	To strengthen the exploitation of results	All partner	Partner's company internal customer
	Direct use of results (programs & projects)	Ongoing	To promote already exploited VIVACE results for further exploitation/development	All partner	Partner's company internal customer
	Plan for Exploitation & dissemination of results	Ongoing	To ensure exploitation and dissemination activities in a controlled way	All partner	PC, VPO
Quality	Deliverable Approval Process (DAP)	Ongoing	To ensure a consistent level of quality transversal to all deliverables	All Partner	VPO
	Deliverable Status Table	Ongoing	To control deliverable statuses towards the project life cycle	WP leader	VPO
	Project Management Plan	Once	To define methods, means, tools and practical guidelines regarding the management of the VIVACE project	VPO, PC	All partners

Table 20: Overview of VIVACE management mechanisms, methods and tools

A.1.3 Interview Guideline

Interview Guideline

Theme

Cross-Community Collaboration and Knowledge Conversion within the Project's Product Context from an Organisation's Perspective

University directors

- Prof. Dr. Michel TOLLENAERE : INPG/ GILCO, Director of the doctorial thesis
- Prof. Dr. Mikael GARDONI : INSA/ LGeCo, Co-director of the doctorial thesis

Industrial directors

- Philippe HOMSI : AIRBUS SAS/ EDMR, Research and Technology Manager
- Rolf FELTRUP : AIRBUS-G/ EDDOG, Head of Value Engineering Germany
- Dr. Michel DUREIGNE : EADS-F/ DCR/IT, Research and Scientific Advisor of the Engineering and Information Technologies department
- Dr. Christian FRANK : EADS-F/ SC/IRT/R, EADS R&T Network Coordination
- Axel MAURITZ : EADS-G/ SC/IRT/LG-AS, Manager Systems Engineering

General rules

- The interview represents the empirical part of the dissertation and delivers a particular contribution for the results of the thesis
- The information of the interviews is confidential and not available for third parties. No information will be given to other interview partners. The interviews are treated in an anonymous manner.
- The content of the interviews will be summarised thesis-oriented.

Introduction

Objective

The objective is to collect data based on half-structure open experts interviews to generate knowledge in the domain of European projects as an example of inter-organisations and:

- To understand organisation's member within their problems and difficulties in managing tasks and state their relevancy in terms of complexity (dimensions)
- To scale the PhD concept validated in the frame of the VIVACE project on to other projects with respect to the project complexity.

Guideline questions for the interviews

- What represents the problems and difficulties of the project VIVACE as a whole?
  → This question is addressed to the experts' general perspective on the project as a whole with its problems and difficulties.

- What are the problems and difficulties for you in terms of your position or role inside VIVACE?
  → The second question focuses on the experts' position inside the project VIVACE and his problem and difficulties in a management role.

- How would you propose to solve the problems stated in question one and two? What would you propose to do different for a following European project? What needs to be improved?
  → The third question focuses on the proposed approaches, ideas in facing the problems and difficulties stated in question 1. + 2

- What are your experiences from other projects? Did you have the same problems/ difficulties? What was different or similar?
  → The fourth question targets on the experts experience from other projects

Ad-hoc questions for the interviews

The pre-test interviews were executed to prove the correctness of the question, to pre-categorise the identified problems, and to use those as input for ad-hoc questions supporting the execution of the interviews (see table below).

Problem Field	Problem statements
Technical project integration	❑ Lack of early defined global integration requirements ❑ Clear definition of methods, tools and environment
People & company environment	❑ Networking and strengthen business relations ❑ Hidden company objectives ❑ Different personal interests ❑ Sharing the project vision and contributing to the overall objectives ❑ Different roles represented in one person ❑ Different competitors integrated in the same project ❑ Industrial strategies ❑ Own company environment influences ❑ IPR difficulties
Skills & experiences	❑ Different skills and experiences of project partners ❑ Lack of PM skills on SP, WP level
Remote Team Management	❑ No hierarchical management structures ❑ Distributed Teams: different location, nationalities and

	cultures
Communication	❑ Lack and barriers of communication between management and executives
Task content Responsibility	❑ Task result responsibility ❑ Content Level ❑ Common results creation ❑ Discipline and sense for responsibility ❑ Responsibilities on content level of work ❑ Deliverables: precise assignment of partner contribution
Structure & Organization	❑ Overlapping WP planning: Conflicting targets of work packages working inside similar themes ❑ Difficult project structure and organisation ❑ Changing PM Tool (e.g. Annual Report)
Information circulation	❑ Dissemination and communication process is time consuming ❑ High reporting effort

A.1.4 Example - Interview Protocol

Interview Protocol
Interview 08

Case Study – VIVACE
Qualitative half structured expert interviews

Information of the Interview partner

VIVACE Role	: Task leader
Type of organisation	: Industrial Research Centre
Place of the interview	: Toulouse, France
Nationality	: French
Type of the interview	: At the place interview
Date	: 18th October 2006
Duration	: ca. 47min

Thesis-oriented summary

Question 1

- The main difficulty is the lack of integration between the different work packages and between the three sub projects.
- The integration difficulty of the project is given by the size of the project. VIVACE is too big to be able to present a consistent integration view and at a lower level the work between the different teams has not been guided by real technical coordinators more than management coordination.
- It took one year to get the connection between the partners. The key point is that we have missed the technical integration from the beginning on. Now it seems to be too late. People were nominated to follow the technical problematic of sub project 1 and 2. The work packages are too isolated and the integration has been made on a management level. But this is not enough to make real technical achievement. We need real experts with a fundamental background to do this kind of integration. But from the beginning there was no one who was able to do that kind of work.
- No clear policy at the beginning for e.g. software license, no clear definition of development resources (partners are not skilled enough - to take some supplier with “right” background could be easier)
- Some companies do not have the research aspects to provide the core of the project. It is difficult to have a guideline for the project. Because industrial partners are able to provide the business point but not the technical aspects. The first two years a lot of people did not understand all the workload and

technical issues. Again full time technical manager is missing who takes care of the technical overview.

- Improvement: Having an SP project starting before the operational sub projects and implementing the process (picturing the big picture, vision) in the beginning and implementing / starting a requirement engineering and management process. Next, to start with the operational sub projects in a common way for all work packages: Functional & operational requirements, concepts and systems to be developed. Everyone should start at the same time and should be able to contribute at the time.
  This can also act as a feasibility study for go or no go decision of the project itself.
- Business objectives in a research project? Is there a contradiction? VIVACE is able to provide some point, some direction to investigate some selected solution and afterwards comes the industrialisation phase. Some partners take the opportunity to develop something concrete, but from my point of view this is not really research. It is difficult to compare at the end of VIVACE between the people who have tried to develop something innovative and others, who are more pragmatic, who know the solution already. The first is more in line with research projects. With 60 partners you increase this difficulty immensely (problem to take a common opportunity). I think for a rather small research project with only 10 partners involved it is possible to find a guideline for programme / projects. The VIVACE project is too huge. Some people choose their own way from the beginning and are not able to carry out research.

Question 2

- The problem was directly connected to the involvement of the different companies. From the beginning onwards a lot of time has been spent discussing with a lot of people. Finally, the work has just been done with a small number of partners. The others are just there to listen. Partners having no experience in European projects are lost. A European project is something special.
- Internal reporting is linked to the research activity and the management report is used to control the consumption and smooth the conflicts. There is no core connection between these two kinds of reporting. But there is no problem of double reporting. What is missing is an integrating level: operative level and steering. How to make cohesion between the vision on lowest level and the highest level - to link technical indicator with top-level indicator.

Question 3

- The management of VIVACE is practiced in the same way as programme management. But it is not the same, because it is not the same business. The project coordinator is the "boss", but he has no real power because the partners are not working for the same company. The partners are in a collaboration environment. The question is how to find a way to manage collaborative projects more than managing the hierarchical structures of the collaborative project itself.
- From the real beginning of the project numerous people are in charge of following not only management aspects, but also fundamentally the technical aspects, the overview, etc. in order that the different partners have the competences to fulfil the tasks announced. One role, having the technical overview to be able to report something consistent to the VIVACE committee, is mandatory but not existing.

- For each new environment you need a unique / neutral format and therefore you have an infinite number of links. This is more or less what is happing in VIVACE. Within VIVACE you have to discuss with different people from different companies in order to have an overview. It could be an improvement to have someone whose role is to spend time in the work packages you centralise in your fact communication.

Question 4:

- The management methods in an internal organisation are different. The authority and resources can be easier requested. In VIVACE you always have to adapt. If we want to capitalise and write the lessons learnt, we need to apply different management methods for this kind of project.
- VIVACE is too big. The HLO are the same. The business in which you have to progress, to achieve this objective, is different. Different needs. From a sub project 3 AC point of view it is really difficult to provide something innovative that fulfils a large number of partners' requirements. It is easier when you are in a small project with 2 or 3 representatives, one integrator, and two from IT businesses to make a first check on the different needs.
- Reverse engineering in terms of integration: centralising the documentation, the needs (requirements).
- Do we learn from VIVACE? I have heard a lot from ENHANCE, there is no real refuse on lessons learnt in terms of centralised document, collaborative way working, etc.
- The amounts of resources more clearly define the kind of resources that will be provided by a partner. Balancing what is really wanted in the end in terms of results/objectives of achievement, small demonstrations show a lot of work is based on specification and design to produce: if the objective is to have a real prototype running, 80% of resources must be developers and testers. In VIVACE a lot of budget is foreseen for the specification part and small budget for development.

A.1.5 Analysis and Discussion of the Surveyed Interview Material: Complementary Information

A.1.5.1 Surveyed Difficulties and Challenges within Managing the European Project VIVACE

2nd Dimension: *Socio*

2.1 Interdependence & Communication

The main focus in the project's start-up phase relates to organising existing partner's knowledge and results (best practices) and making the relevant (which are the addressed business problems or situations going to be improved) available for the project or the cooperating partners respectively. Secondly, it was mandatory to make the partners aware of the work plan, their responsibility in their role, and associated activities. Month 18 and 30 were integration points, whereby in the meantime experiences were gathered and knowledge was developed and documented (cf. Interviewee_12).

> *"For the first 6 month it was of no importance to integrate with anybody except with your self. To make sure we do document what we knew, making sure that everything was equity with the DoW (Description of Work). […] M18 and M30 are integration points. So what we do is to document knowledge we have developed meanwhile and sure the knowledge is available for others. So actually the knowledge from the other we expected to be available at the have year review. And in between we have to be not invariant, but we need to be able to act invariant. And see all the opportunities of integration. They are opportunities rather than requirements. […] So bring the knowledge that somebody have and resolved it into something new. That is really the first product, to define what you have. That is the start-up." [Interview_12, WPL, Aero Company]*

Also, in the first phase of the project the current state-of-the-art in the perimeter of aero companies addressed business needs were subject for all work packages related to sub project one and two (besides reviewing partner's best practices).

However, to initiate partner interactions within sharing knowledge and results, a level of transparency and insight in such is mandatory (cf. Interview_02 below).

> *"Lack of view inside other tasks of other work packages in order to share results and ideas." [Interview_02, TL, Aero Company]*

The different partners are originating from different companies and not unusually committed to other company internal business activities, while being also committed to the European project VIVACE. The behaviour in people's availability to meet internal company colleagues and VIVACE project partners not originating from the same company is often different (cf. Interview_10).

> *"Availability of people: The pace of the project is low: telephone, email. If you compare a similar project to internal, the planning is shortening to reach the same result." [Interview_10, WPL, Aero Company]*

This could also be reasonable due to travelling effort and expenses.

The collaborations between partners from sub project one, two and sub project three as well as initiated actions were not always successful, depicting a statement from Interviewee_12. The Interviewee highlights that the aspect of collaboration had some challenges within the partner's political or tactical behaviour.

"We have a specific task relating to SP1&2. We tried to get connect with SP1 and we waited and also proactive trying to connect. There has been political unwillingness. From the SP2 site it has been never been a problem its been obvious." [Interview_12, WPL, Aero Company]

Collaboration means to work (effectively and efficiently) together, which further means to share activities while working on the same concept. That requires a degree of common industrial language shared amongst the partners, having a common understanding, and assuring an integrative technical process. There is one possibility to rely either on standards or define a project glossary (cf. Interviewee_13).

"In terms of understanding, matter of having a common vocabulary (working language, working standards). It could be improved by better applying the standards, but there is chance to reinvent for each project a new vocabulary. But it is a fact that it's requires a long time for the partner to reach a common understanding, common vocabulary, e.g. the term use cases, scenarios, ... and after 4 years I am quite sure that not everyone will have the same understanding." [Interview_13, SPL, Research Centre]

However, establishing a project glossary is a quite usual means - not only within European projects – in order to develop a common understanding.

Interviewee_11 states that the project has evolved with adaptations in its structure as well as new management activities have been launched to which management attention has to adapt and contribute to. The difficulty is perceived within levelling and prioritising this additional workload beside the initial work activities.

"Throughout the project new things arise within the projects which were not planned from the beginnings. Difficulty to rank the priority. […] VIVACE is a significant amount additional structuring after the project was lunched. Maybe necessarily but not planned in the beginning." [Interview_11, WPL, Aero Company]

During the course of the project these adaptations were maybe expected to work package leaderships. Changing reporting template formats is sometimes required on the one hand, but leads also to a level of adaptation for both the instance fulfilling these templates (e.g. work package leader) and the instance synthesising the fulfilled templates (e.g. the project office).

Nevertheless, Interviewee Pre-Test_03 mentions that sometimes difficulties stated in regular reports are perceived to not have the sufficient recognition and attention on project level.

"Feedback loops in regard to reported problems, risks, etc. are not working sufficiently. There is a feeling that on management level these difficulties are sometimes ignored." [Pre-Test_03, WPL, Research Centre]

Interviewee_09 shares the sentiment given previously, but also reveals that reporting tools as such are reflecting a kind of a problem-history on which it could be referred.

"The reporting tools are not completely working in terms of closed feedback loops. But it is means to refer to already stated difficulties." [Interview_09, WPL, Aero Company]

The difficulty in fact is also to get the partners' active involvement and gain feedback on the reporting mechanisms installed (cf. Interview_05). The project partners within the same level of responsibility do not consider the reporting tools at all.

"Nobody takes care of the reports and nobody reacts/ give feedback on 6 weekly reports." [Interview_05, WPL, Aero Company]

Interviewee_02 perceives the reporting level and the associated effort differently. The reporting effort should be levelled appropriate with respect to what is required to control the project environment by its complexity (e.g. the number of partners and interfaces).

"Reporting effort must be inline with what will be developed" [Interview_02, TL, Aero Company]

Further, the preliminary fixing of reporting intervals is also a matter of appropriateness. Interviewee_14 believes that the 6-weekly report is an interval that is defined too closed in correlation to the project duration.

"I think the 6-weekly is a sequence, maybe a bit too frequent. I do a lot a 6-weekly reporting but I don't see any visible response. But if you do it for three years, you start to think that maybe 3 or 6 monthly report." [Interview_14, WPL, Research Centre]

On the other hand, Interviewee_12 considers the level of reporting as meaningful.

"The level I see it, it is necessary. I don't see anything that is not necessary to be honest." [Interview_12, WPL, Aero Company]

It is easy to be affected by reporting efforts at the right level, but in fact it is difficult to adapt reporting mechanisms individually with respect to the size or scope of the several work packages.

In this context the dimension of the project as such forms further difficulties. The instance of collecting and aggregating the single reports (i.e. project management, VPO) has to face many different issues, whilst synopsising and concluding these to an overall situational picture (cf. Interviewee_10 below). Interviewee_10 highlights in general the challenge in understanding the individual work packages situation throughout the project from management perspective on project level.

"Document driven management in a sense that this process of aggregating from the low level to higher level is inefficient. The amount of information is so huge it is difficult to understand from the top level the low level and also to know what is going on in other work packages. Maybe it is, again, a problem of dimension." [Interview_10, WPL, Aero Company]

Risk management mechanisms have been installed and risks are interfering with envisioned objectives. Contextually, Interviewee_03 discusses the challenge in conducting risk management with respect to the several different partners' objectives. The execution of risk management mechanisms requires not only resources in terms of budget but also the appropriate human cognitive capabilities.

"Difficulty to monitor risks due to diverging company objectives [...] Difficult to execute valuable risk management due to a lack of human resources [...] the partners have difficulties to state clear risks." [Interview_03, VPO, Consulting]

2.2 Cohesion

A European project like VIVACE is built upon a partners' consortium, which is a multiform environment in terms of partners. On the other hand, such a partnership in projects could also limit the degree of management strength towards utilising hierarchies, while emphasising more of a management style of consensus building (as mentioned before). Moreover, it is rather important to establish trust between people in partnership, gaining their contributions and progress on a common solution development (cf. Interview_11 below).

> *"The challenge is to gain trust and start to get contributions. That means also to allow people to go on with the work, rather than monitoring and controlling them and to find a way of winning the trust and providing the direction." [Interview_11, WPL, Aero Company]*

In addition Interviewee_12 highlights the importance to integrate people in the team right from the beginning, clarify their role and the expected activities as well as the achievements to be gained.

> *"[…] That is the only way to create a team, because that knowledge is build on peoples' brains not on paper! To get a team up and running, have a good kick-off in the beginning and really before who have and execute what role with what expectations?!" [Interview_12, WPL Aero Company]*

Nevertheless, Interviewee_05 denotes the challenge of collaborative agreements between the various partners due to their individual strategic and technical orientations. It requires also a proactive participation, which could mean firstly to create transparency and secondly to have collaborative agreements on commonly shared strategic and technical objectives (cf. Interviewee_05).

> *"Problem of motivation, common technical and strategically interest, which requires a proactive participation." [Interview_05, WPL, Aero Company]*

Thus, the balance of the single motivations in a partners' consortium contains the opportunity of being inhomogeneous.

Interviewee_14 points out that in the case of VIVACE a dominant partner (Airbus) - having a specific business position in Europe - is leading the project. And to some extent it empowers such a dominant partner to act more towards a balanced motivation on project level, but also obliquely on work package level.

> *"In the specific case of VIVACE, due to the authority of AIRBUS as a dominant partner, it is possible to reduce some of these impacts. Officially it is only VIVACE, but unofficially the dominant partner notices this partner. Next time you choose another one. The balance of interest is different (partners have their own agenda, personal interest)" [Interview_14, WPL, Research Centre]*

However, there is also a risk of misusing such a position towards individual partner's interests.

Building a project team is about winning trust and reaching consensus on envisaged achievements. Conversely, the matter of changing people in partners is critical, which leads to a repetitive process of convincing and building trust within the team (cf. Interviewee_10).

> *"To reach a real consensus a real understanding of the objectives – if you change people/ partner frequently it means to start again. At least one physical meeting is needed to build trust-ship. And this is quite common in a 4 year project." [Interview_10, WPL, Aero Company]*

Interviewee_04 states that the impact of changing people and in particular within its expertise has to be recognised as being timely critical to ongoing development activities.

> *"[...] Changing people along the project and arising timely critical development." [Interview_04, WPL, Aero Company]*

In consequence, additional training activities are required for gaining the equal level of understanding, having already being developed with the initial person in partner (cf. Interview_05).

> *"Changing people which require new training and understanding of the project." [Interview_05, WPL, Aero Company]*

2.3 Focus

Interviewee_09 states that it is challenging to let the many partners start to work all together.

> *"The problem of the project is the size – you have 60 partners. The problem is to let them work all together at the same time." [Interview_09]*

People in partnership underlie varying companies' orientations and objectives, which in turn are also driven by several different environmental influences (e.g. competitors, regulation authorities, market). People in partnership adapt to the evolutionary prioritisations of their company, while having a dimension that reflects their own personal interests (cf. PreTest_03).

> *"People have varying personal interests: People changing their mind due to changing objectives of their organisation." [Pre-Test_03, WPL, Research Centre]*

Thus, during the execution of a project it could appear that new topics are going to be stimulated and decided to be a prioritised subject by one partner but not transparent and reasonable for the other project partners. In consequence, this leads to the fact that it is not easy to work commonly focussed on a topic while sharing work activities between project partners [cf. Interview_02].

> *"Complex to share work. A lot of people discovering interesting fields of activities to work on with sometimes hidden objectives" [Interview_02, TL, Aero Company]*

Grasping a statement of Interviewee_03, there is also the challenge that some partners are just intending to create their own networks or trying to benefit from partners' knowledge and results.

> *"Partners try to build their own networks." [Interview_03,VPO, Consulting]*

Interviewee_03 states that people in partnership perceive companies' internal projects as a better means of promoting themselves within the company's hierarchies. Perhaps internal company projects already have a higher management attention and are connected to the operational business as well as the activities shared with other company's individuals. Thus, it could appear that some people in partnership take the

European project within a different level of responsibility in comparison to internal company projects.

> *"Partners do not take the project as serious like internal company projects, which drive business more obviously." [Interview_03, VPO, Consulting]*

Further, Interviewee_12 is mentioning that within the project's preparatory phase the partners' attitude was rather risk oriented and neither orienting on opportunities.

> *"One of the biggest problems in the beginning was to focus too much on risks and problems." [Interview_12, WPL, Aero Company]*

2.4 Structure

A European project like VIVACE is a multicultural-formed project composed of individuals with different cultural backgrounds. It needs consideration within the management style while leading and interacting with project individuals having different cultural attributes. This in turn requires cultural experiences; otherwise time is needed to get management roles skilled in this aspect (cf. Interviewee_14).

> *"The deliverance of the culture of how individual is coached is challenged and that has to be handled differently. " [Interview_11, WPL, Aero Company]*

Interviewee_14 additionally mentions that partnerships like those within European projects are limited and have to deal with cultural differences. An effective lasting business relationship requires additional effort, but in fact in such a one-off corporation it is a matter of balancing it towards economical efficiency.

> *"If you have a one off corporation between other companies you encounter difference between countries, even between countries which are quite closed. The longer distances you will have more different perceptions of what is normal and then you have different companies that behave in a different fashion. If you know you have a corporation that will last long you can invest in such relations. If it is basically a kind of one off than it is more hard to get to that level of understanding." [Interview_14, WPL, Research Centre]*

Another issue is the matter of dedicated expertise in partnerships having the needed cognitive capabilities in correlation to the work that is required. In this context, Interviewee_14 denotes that some commercial companies utilise European project as an environment for education issues of company's newcomers, but within VIVACE this is rather not the case.

> *"In certain cases commercial companies they employ new young people first do some small projects internally and than position those in one or two European environment to let them learn to corporate in an international environment. [...] In VIVACE this phenomenon has been less then in other European projects." [Interview_14, WPL, Research Centre]*

2.5 Empowerment[196]

The description of work (DoW) is part of the contract's annex. The DoW contains the description of the work packages established and the different tasks to be performed. Partners and budget are associated to those work entities and responsibilities, and their contributions are defined. Besides the formal embodiment of work activities and project roles (sub project-, work package-, task-leader, etc.), it could appear that partners do not fulfil what has been contractually stated in the DoW.
However, once management by consensus is not sufficiently working anymore, it is difficult to act in a partnership on the partner's performance (Pre_Test_03).

> *"Inside a task, partners are integrated but do not potentially contribute to the work. Work package leader should have the opportunity to take action on the performance of a partner." [Pre-Test_03, WPL, Research Centre]*

In correspondence to the next Interviewee_09, the project coordinator is the only person able to report insufficient partner's performances to the European commission. Lower management roles (sub-project, work-package, task-leader, etc.) in turn have to inform the project coordinator about an insufficient partner's contribution.

> *"You cannot force companies. But the project manager can make reports to the commission. It is not the work package leaders' role…Some of the partners do not do anything and it is not very good for the dynamic of work – all are paid but only a few work. But I cannot do anything… I even haven't seen some partners of my work package since the beginning of the project." [Interview_09, WPL, Research Centre]*

Interviewee_05 also stresses that responsibility and guidance depends too much on the project coordinator only.

> *"The responsibility depends too much on the coordinator due to his strong personality." [Interview_05, WPL, Aero Company]*

The difficulty identified by Interviewee_03 is that middle management roles on sub project level are less skilled and capable to strongly deputise and not only transfer decisions made on project level to the level of work packages.

> *"The project coordinator has strong leadership capabilities, but on the middle management level those are missing." [Interview_03, VPO, Consulting,]*

However, the funding scheme in European projects contains difficulties for partners to obligate insufficient partners at consortium level (cf. Interviewee_14).

> *"If you corporate it is difficult to have an authority which is respected to make decisions. Because everybody pays its own half." [Interview_14, WPL, Research Centre]*

Interviewee_13 states that management authority and relating reporting and controlling mechanisms would be different once partners are fully funded for the work they contracted to perform. However, the level of management and directive

[196] Authorising, licensing, give power to (Oxford dictionary); The act of authorising (Webster's-online-dictionary).

given is perceived as sufficient, being enough for a research project by this interviewee.

> *"If we were in Aircraft project, developing a system, etc. budget can be identified from the beginning, to be distributed to the partners funded 100% the rules and mechanisms would be completely different. But we are in a research project, and in this context it is quite balanced I cannot imagine having more directive management." [Interview_13, SPL, Research Centre]*

3rd Dimension: *Resources*

3.1 Workforce

Interviewee_11 highlights that in most cases people in partnerships have additional commitments related to their business entities besides working in the European project VIVACE, which has been discussed previously within the perimeter of 2.1 Interdependence & Communication, Availability of People.
It could appear that people in partnership sometimes have to decide which business environment is going to be prioritised. This in turn has an impact on the quality of the project products going to be developed in one or another environment.

> *"VIVACE is always in competition with industry. […] In VIVACE research fortuned experts in their filed were involved from many of the industry companies, the same people challenged or required to solve other problems within there business as well. There is a problem of resources commitment." [Interview_11, WPL, Aero Company]*

The execution of work activities at different levels of the project requires a specific expertise and cognitive capabilities in partner's human resources. In this context, Interviewee_07 argues that the composition of partners in teams is not always at optimum and human resources are not skilled at the required level to perform the expected contributions.

> *"When you have 5 or 6 partner it is quite difficult to manage. Especially, when partners – and that is important - are not really relevant on the subject of work." [Interview_07, WPL, Aero Company]*

In consequence it could appear that such partners are not completely recognised and considered, within work activities and in terms of management, difficult to treat and guide (cf. Intervieweee_01).

> *"Some lost partners, they don't know what to do inside the project and they will not be recognised by other partners." [Interview_01, TL, Aero Company]*

In comparison Interviewee_13 mentions that the assignment of cognitive capabilities could be done more efficiently and effectively once the expected results had been characterised at the project's beginning. However, such diversity in partner's expertises and their perspectives contains many-sided facets to which extent project results can converge to a higher robustness.

> *"If the result would be defined clearly from the beginning you were right, but I mean the result depend also on the knowledge what the people bring to the project and in this perspective it is better to have the rich experiences and several people coming from several types of activities involved in systems, structure, software development, involved methods, …thanks to this diversity we can improve and converge to a more robust result at the end. Thanks to the*

diversity of the people. And if we would have tried from the beginning to restrict the result to one view I think we would have lost robustness of the result, diversity and richness of diversity." [Interview_13, SPL, Research Centre]

Even so, Interviewee_09 states that not enough IT competencies were considered, so that could (nevertheless) lead to sub-contracting other external firms.

"In my work package no IT resources are foreseen. We can build models, concepts, and so on." [Interview_09, WPL, Research Centre]

Nevertheless, the way the activities were shared between the several work packages and sub projects created some difficulties, because those activities were to a certain extent not clear enough and shared between the partners (cf. Interview_13).

"Difficulties during the project - their was the understanding that sub project1,2 had to specify and use sub project 3 to develop. That was not true, there was also development in sub project 1,2 – there was involvement and users also in sub project 3. In fact the structure the way the activities were shared between the several work packages and sub projects was not clear enough and shared between the partners." [Interview_13, SPL, Research Centre]

Interviewee_01 argues that the involvement of partners and their cognitive capabilities could temporally be optimised with respect to their cognitive capabilities and when those are sufficiently needed within the project's life.

"Sequence of contribution; partially partners should have been integrated in accordance to their capabilities inline with the project iteration phase" [Interview_01, TL, Research Centre]

3.2 Adequate Budget

Interviewee_10 states the difficulty in allocating budget for human resources assigned to perform various activities in several tasks in different work packages and sub projects.

"Every partners company has an internal planning and budgeting system. There is a kind of double view of the budget one for the project which official for the commission and internal sites." [Interview_10, WPL, Aero Company]

Interviewee_10 further states that the budget split between sub project one and two addressing essentially concrete business needs, and sub project three basically leading the relating development activities, is not effectively proportioned.

"The budget is not really good proportional distributed between SP1, 2 responsible for specification and SP3 responsible for development." [Interview_10, WPL, Aero Company]

In addition, it is difficult to be reactive and secure the work performance while shifting budget from one partner to another, or subcontract external partner once the contribution of an initial partner is insufficient (cf. Interviewee_10). This has been discussed also within frame of category 2.5 Empowerment.

"And some organisations just get the money from the commission and try to do the minimum as possible. The only way to push partners to work, is to be more flexible to move allocated budget from company A to B, difficult thing – a lot of political problems because the share of

> *the complete budget is somehow agreed at higher level." [Interview_10, WPL, Aero Company]*

In addition Interviewee_07 highlights that financing IT infrastructure (e.g. PC) and some developments for demonstration and validation were not considered in the budget planning.

> *"Nothing was anticipated in term of financing the infrastructure itself and some development. So, we have some difficulties to buy machines to and to really perform something." [Interview_07, WPL, Aero Company]*

3.3 Schedule

The project duration is planned for about four years. But, Interviewee_07 mentions that additionally one year for preparation and another two years are needed to bring the VIVACE project results to something applicable for business operations.

> *"And that means that in the project we started in 2004. To set up this kind of project takes at least 1 year. […] That means you have the idea (of the project) at the end of 2002 - to set up the project 2003. You have four years for your project and at the end of 2007 you have at least 2 years of work, at least, to bring it into something in terms concrete results. So that means it takes 7-8 years to go from the beginning to the result" [Interview_07, WPL, Aero Company]*

But following the statement of Interviewee_12, it seems that exploitation of VIVACE results came up during the project.

> *"Our company already substantially benefiting from VIVACE results closing the gap within the project timescale." [Interview_11, WPL, Aero Company]*

In subsequence to the previous statements, Interviewee_02 points out that deploying a result during the project duration ties up resources (cost, schedule and cognitive capabilities), which were potentially needed to continue ongoing development activities.

"Difficult to deploy results during the project. Exploitation means to maintain resulting into less time to work on development. When deploying to customers, this requires real use cases. And this means to keep the link to the end user…" [Interview_02, TL, Aero Company]

<u>4th Dimension: *Environment*</u>

4.1 Top Management Support

Substantially, the exploitation of results during the project VIVACE can be prepared or initiated by the single partners as depicted previously. The plan for exploitation and relating activities is a common task for all partners in the last part of the project and shall endorse "advertising" results for broader exploitation in the company's business environment. Interviewee_10 mentions that the success of internally selling the developed results depends not at least on the level of top management's support.

> *"Internal exploitation is a big issue. Problem of internal selling of project result for real application. Some have strong commitment from their organisation other not." [Interview_10, WPL, Aero Company]*

Thus, exploitation activities require a closed communication between partners' representatives in VIVACE and the relating company business senior managers. And convincing the business seniors is key towards exploiting VIVACE results to operative units (cf. Interviewee_11).

> *"Complement VIVACE work with work in the company it is about to win the business seniors." [Interview_11, WPL, Aero Company]*

In addition, the own corporate hierarchies and the strategic as well as technical orientations influence the conduction of the project tasks within people assigned to work within VIVACE. Nevertheless, partners have addressed concrete business problems and situations going to be improved within VIVACE and this should essentially induce a corporate interest to certain extent.

> *"VIVACE partners have their own corporate hierarchy they have to contribute somehow and thus their own corporate objectives…But on the other hand: through the organisation of the overall project through various scenarios, indicates business needs and industrialisation wants." [Pre-Test_01,SPL, Aero Company]*

Interviewee_09 describes how within the project's preparation phase it would have been valuable to reach reconciliation between partner's different objectives and establish an overall commonly shared objective for orientation towards which people in partner can focus their work.

> *"We should have a common objective when each company signed the contract. Obviously every company have its own objectives. The problem is to find a common understanding of what could be the VIVACE final objective in order to able to make the people work." [Interview_09, WPL, Research Center]*

It is has been also previously discussed that some partners have mainly the objective to promote themselves and trying to strengthen their business network. But there is also a kind of a natural discontinuity given through the type of partner (aero company, research centre, vendor, etc.) and their scope (cf. Interview_07).

> *"[…] You have at the time for instance large companies, medium sized companies, laboratories and they don't have the same objective. Large companies, they really having ideas for improvement and some clear objectives. Medium sized companies just want to extend their product offer to increase their competitiveness at shorter term. Small companies would be interested to make some business with larger companies, particularly from this project. Or, with some other companies, which you have some short ROI. And Laboratories, they are not so connected to industrial aspects. They want to make some theories. So you have this different kind of partners and they don't have the same objectives." [Interview_07, WPL, Aero Company]*

4.2 Competition

A European project like VIVACE is a multiform partnership. This has been discussed extensively already. But it is also a meeting place of competing partner's, which have to collaborate once the composition of the work packages is organised to that extent.
The composition of a European project is characterised through a partnership composed of various companies having rights and duties. Nevertheless, due to

intellectual property rights it could be difficult to gain insights in partner's work and its achievements, e.g. in terms of results (cf. Interviewee_03).

> *"Problem of confidentiality and visibility of work." [Interview_03, VPO, Consulting]*

In fact, the most important dimension enabling a process of sharing knowledge (e.g. data and information) associated to work activities in a partnership is trust, which could be for example a personal but also strategic dimension.
However, each partner's company environment influences and could also restrict the level of knowledge exchange between persons in partner (cf. Interviewee_04)

> *"Problem to share information due to company confidentiality." [Interview_04, WPL, Aero Company]*

4.3 Location

Another aspect is given by the partners' geographical dispersion as a mixture of people originating from several different nationalities, having different cultures and languages. Geographical dispersion connotes a physical distance between partners at all level of the projects (e.g. at team level or between individuals). Different nationalities could also mean operating in different time zones, but this was less the case within this project. Beside the physical distance, other aspects are important to be considered. Interviewee_01 states attributes of nationalities and the related various cultures as well as languages is a challenge in gaining a shared understanding and starting to work together.

> *"Challenge in terms of different nationalities and cultures, common language and understanding." [Interview_01, TL, Research Centre]*

Communication between people is one attribute of graphical dispersion. In particular communication in a partner's consortium where different companies and associated people are meant to collaborate throughout management hierarchies within both directions: horizontal and vertical (cf. Interviewee_11).

> *"VIVACE is necessarily hierarchical organised: starts with hierarchical top level committing, then work package and task leader, at least research and scientist are involved themselves within the companies. Information goes from level to level, to level, and so forth. Also in the other way detailed information goes upwards, not always communication is at optimum." [Interview_11, WPL, Aero Company]*

In fact, the management challenge to be dealt within distributed project teams is a combination of the geographical dispersion (different locations, cultures, languages) and the relating collaboration aspects: communication, cooperation and coordination aspects.

Interviewee_05 describes the management challenge as a kind of remote team management that is meant to lead a team geographically dispersed and within flat hierarchies.

> *"Remote team management, different locations and nationalities with flat hierarchies […]"[Interview_05, WPL, Aero Company]*

This variable has been identified to have strong correlation with the variable *Interdependence & Communication* related to the dimension *Socio*.

4.4 Organisational Style

During the 17 interviews no data could be surveyed with respect to the variable *Organisational Style*. However, the author perceives parallels with the variable 4.6 *Orientation and Scope* and recommends to sees this section.

4.5 Politics

During the 17 interviews no data could be surveyed with respect to the variable *Politics*.

A.1.5.2 Surveyed Suggestions for Improvements within Managing the European Project VIVACE

<u>2 Socio</u>

2.1 Interdependence and communication

Project reporting and other document templates are means for standardised communication between project members and different roles. Since each partner is trained and experienced in company internal formats and rules, some time is required for adapting new project templates. However, once document template formats experienced some evolutions, a certain level of explanation in front of the project participants should be given for reason of understanding and convincing project members to follow these new templates effectively.

> *"Changing template format and intervals should be justified" [Interview_02, TL, Aero Company]*

The kind of explanation on why project documents or processes have changed should have reasonable reasons of effectiveness. These should be easy to learn and to apply by those project members that are actively impacted and need to adapt to these changes. Thus, the effectiveness of guidelines respectively to the introduction of new or modified working processes corresponds to how effective people are going to adapt these changes.

> *"Reduce the amount of information in order to introduce project partner to new or modified processes" [Interview_03, VPO, Consulting]*

The following interviewee (Pre-Test_03) requires establishing a milestone oriented reporting mechanism, which enables indication of partners' performance in project teams respective to its responsible tasks.

> *"Ongoing e.g. milestone oriented reporting mechanism, which partners perform inside a task and who is not" [Pre-Test_03, WPL, Research Centre]*

However, with the VIVACE project the perimeter of the individual work package is different, but the management reports that have to be performed are equal. Interviewee_01 suggests sustainability within a well-balanced reporting effort that corresponds to the perimeter of work (tasks, partners involved, results, etc.) going to be performed.

> *"Reporting concept for work packages should be adapted to the amount of work. Small work packages do not need to have such a complete reporting mechanism." [Interview_01, TL, Research Centre]*

In turn, this would require higher management effort on project level, e.g. the project office is obliged to synthesise not only the many reports but also adapt to the different formats. Probably, it is more a matter of establishing the right level of reporting applicable for the all work packages.
By comparison, Interviewee_05 depicts that reporting templates should be considered due to its current level of criticality in a spatiotemporal context within the project. The frequency and contents of reporting tools could be also designed in correspondence to the characteristics of project life cycle and its different phases.

> *"Adapt project management tools onto the criticality that is existing inside the project." [Interview_05, WPL, Aero Company]*

The challenge of project's status and progress reporting's is to establish attributes which are capable to determine in a lean manner the project's "fitness" without decelerating development activities too much.

> *"Find balance between making progress on developments and having to report on developments" [Interview_05, WPL, Aero Company]*

Interviewee_14 advises establishing more objective-oriented reporting mechanisms, while suggesting more reactive and interactive feedback from management instances in regard to operational work entities reported difficulties and risks.

> *"It has been hard to defining some kind of metrics. But I think something more condensed more objective reporting […] And some kind of feedback (e.g. phone, email) from the management and you report on this. And than at least you know that your report is read and judged as doing okay or there is problem could you please explain. And than you have the feeling that it is done more with your reporting." [Interview_14, WPL, Research Centre]*

2.2 Cohesion

Interviewee_13 perceives establishing coherence within partners' individual and the global project orientation (objectives) in terms of a common development direction as an improvement for collaboration on common results developments.

> *"Better to link the global objectives that we have stated with the results. This is an important issue. To better share a common understanding, common approach in regard to the global objective. This is the key aspect: to be able to work together to a common result that we had agreed from the beginning." [Interview_13, SPL, Research Centre]*

Moreover, the creation of transparency within technical integration viewpoints: individual (single working entity) and global (project level), should support partners' self-recognition and provide orientation, but also visualise as well as stimulate interrelationships with other partner's, their business needs and associated results. Interviewee_10 summarises this circumstance as having a vehicle for effective communication between project partner's acting on several different levels of the project.

> *"You should have a very powerful communication tool to drive technical integration from the beginning. Otherwise you have to place all the people in one big room." [Interview_10, WPL, Aero Company]*

2.5 Empowerment

Implicitly Interviewee_14 states that the opportunity to empower management is basically a matter of peoples in partner's attitude whether or not respecting other partner's management functions in the project. This statement corresponds with a circumstance mentioned in the challenges part (2.2 Cohesion), where a dominant partner (e.g. market leader) is empowered through its special business position to act towards a common direction on project level. Nevertheless, it the co-existence of collaboration and hierarchies is challenging.

> *"You can only empower if the partner respect the power." [Interview_14, WPL, Research Centre]*

In addition, Interviewee_12 stresses the importance of the project coordinator's leadership skills including social and cognitive capabilities and provide guidance within the multidimensional collaborative project composition in partners and the many associated people in partners.

> *"I don't see any intermediate need to do it very differently. I think it is very hard to copy the way it has been led by Philippe (project leader). Very stringent skill you need to have in order to do it the way he has done it." [Interview_12, WPL, Aero Company]*

3 Resources

3.1 Workforce

Since a European project is a meeting place of people in partners coached and skilled differently in their business environments, it could be beneficial to have dedicated trainings on common management principles to follow. This could be a vehicle for improving the axis of project quality in terms of common project management processes, methods and tools.

> *"More training for management roles on a common VIVACE management approach in order to be prepared on a European Project" [Interview_01, TL, Research Centre]*

A.1.5.3 Surveyed Complementary and Distinguishing Project Characteristics

2.3 Focus

The common orientation within company internal projects is anticipated as being more commonly shared in comparison to European projects. People's common focus is rather effectively characterised towards developing a product that fulfils customer expectations at best.

> *"In other projects there is less useless discussion. [...] Clearer defined customer requirements" [Interview_01, TL, Research Centre]*

Moreover, the motivation for a commonly shared project orientation is attributed through objectives and its connection to common business aspects-the reason for collaboration is attributed by shared partner's objectives to follow. However, collaborating partners may share an objective, but for one partner - not obviously for the collaboration partner - it could still interfere with some organisational objectives but:
Interview_04 experienced this circumstance not only in the collaboration environment of the VIVACE project, but also in company internal programmes.

> *"In an aircraft development project, which is very complex, there is one single objective, to supply the best aircraft suiting the best to the customer's requirement, and due to that I think it is better but I don't say easier. In the case of the involvement of several partners, as it is now the case for quite all helicopter development, it is also the case, one single objective because behind that there is business. But sometimes it is not completely true because for example one of our programmes some partner are in competition with other own product." [Interview_04, WPL, Aero Company]*

Similar to some competitive structures (within the partners compositions) in VIVACE, it could appear that those individuals assigned to a company internal project developed at department level also competing structures (e.g. political reasons), which are counterproductive on project level for achieving the overall project objectives.

> *"Also in company internal industrial project environments, different departments and disciplines have varying objectives and competing with each other." [PreTest_01, SPL, Aero Company]*

2.5 Empowerment

Empowering management has been already stated as being interrelated with the funding scheme. European projects are characterised as a shared funding between the European commission and the industrial partners, whereby universities are fully funded. In comparison, company internal projects are mostly fully funded project environments and in turn project activities bond full project members' (individuals) responsibility. Interviewee_10 indicates fewer differences within the project's preparation phase, where project activities face equal difficulties in terms of collaboration and developing the strategic and technical project baseline.

> *"EU projects in which your budget is partially funded by the commission and your power to the partner is more related trustiness and the vision. In more real environments, you should do something that should be used by your company. Project duration is less and you have more*

power in the sense that you own the budget. The company give you the budget and you are fully responsible for using it efficiently – you have power to put pressure on people and partners. When you deal with projects in informational context and put together people from different companies, the problems in the beginning are the same: problems of communication, language, sharing the idea, the requirements." [Interview_10, WPL, Aero Company]

Internal company structures and management hierarchies respectively, are perceived as another means beside the different funding concept to gain effective individual's contribution within projects.

"Existing company hierarchies and more disciplined contribution to the project" [Interview_03, VPO, Consulting]

3 Resources

3.1 Workforce

The vehicle of management processes, methods and tools is part of the dimension project quality. One interviewee previously denoted common training on VIVACE management principles as a suggestion for improvements. Interviewee_08 confirms this suggestion. The VIVACE project environment required management roles to learn and apply specific management principles, to deal with fewer acceptances in management authority and also to treat a less effective process of requesting additional resources.

"The management methods in an internal organisation are different. The authority and resources can be easier requested. In VIVACE you always have to adapt." [Interview_08, TL, Research Centre]

European projects are differently organised in terms of the selection process of partners. Those sorts of projects have been earlier characterised as being influenced due to establishing a representative distribution within the partner's composition. In accordance, Interview_07 states that the management effort correlates also with the appropriateness of individual's knowledge and cognitive capabilities in relation to the project tasks going to be performed.

"[…] Internal projects, I can rely on subcontractors the companies and anyway I can choose them. In European project you get some times partners you do not choose, the workload in terms of management is much higher." [Interview_07, WPL, Aero Company]

Management authority and the development of a common project orientation depend on the contractual relationship: partner or sub-contractor, established between different companies. Nevertheless, Interviewee_07 stresses the importance of having the appropriate skills integrated in and available for work packages that believe and share the project objectives (whether it is a partner or a subcontractor).

"We have the same within internal project when you set up a project you can either take a partner or a subcontractor. When it is a subcontractor you paid, so you can ask for it. When it is a partner it is not so easy! That is a dimension also! This is not such a big deal if choose the right partner. With the right skill and the right objective. If you have a partner has not the objective we can to set up the framework to help the partner to go into the right objective - when he has the right skills this is ok." [Interview_07, WPL, Aero Company]

In this context the importance of adequate capabilities is not only a matter of the partner as such, but rather the individual talents (people) in partner. Interviewee_12 refers to a former European project, where the correspondence of skills in terms of people in partner conducting the project tasks was not managed sufficiently. The difficulty is given through the availability of those people who should perform project tasks.

> *" […] So, one of things was commitment of persons to roles, not only partner to roles in the work package, but also persons do that role. Those who didn't manage that in the beginning have big problems. Because even though the partner were committed nobody do the work, so something happen." [Interview_12, WPL, Aero Company]*

4. Environment

4.1 Top Management Support

Company internal projects are benefiting from perhaps more effectively established and closer connections to operational business entities. Nevertheless, Interviewee_06 highlights that a multicultural environment like VIVACE stimulates partners thinking towards more extended business solution, which could drive competitiveness.

> *"Within internal projects you feel at home. Your boss knows what you are doing at consulting the benefits. Within VIVACE you have a multicultural environment and different things to learn, that helps open the scope and help to learn within a broaden view again. Go a bit away from the core business view and get open minded again." [Interview_06, EDI, Aero Company]*

The exploitation of results corresponds to the degree of interrelationship between company representatives in VIVACE and the company internal operative business entities (perceived as a sort of customer). In addition, Interviewee_13 mentions that one sponsor who completely funds the project have more complete results expectations in front of developments and results going to be exploited. This in turn could be anticipated differently once a project has two or more sponsors and the degree of influence on developments and results is by half.

> *"[…] The problem is the link with the exploitation people and how can we really understand and apply the technologies and methods of such a European projects. This link is really difficult. If you have a project founded 100% you have a clear result expected from the sponsor." [Interview_13,]*

4.3 Location

The VIVACE project comprises a multinational consortium of partners distributed all over Europe. However, partners and their relating organisational environments could have similar multinational formations as once those are distributed in their location (geographically) and underlie the several different environmental influences.

> *"Company internal projects are also spread and influenced by the environment and nationalities" [Interview_05]*

A.2 Chapter 5: Complementary Information

A.2.1 Industrial Application Case 1: VIVACE

A.2.1.1 9-Step Information Integration Process

Step1 – Provision of a guideline explaining the information contents in regards to BNE descriptions (use cases & business process requirements, scenarios & service requirements) and engineering product definitions (and generic services). ***Step2*** – BNEs perspective leader in VIVACE provide relevant information, i.e. deliverables or other internal VIVACE documents. ***Step3*** – Mapping of document contents respective to BNEs descriptions and engineering product definitions on the toolbox architecture: starting from the use case layer down the generic service level, will be processed. The mapping is realized in a PowerPoint document indicating parts of the deliverables (with indication of chapter, section, pages) relevant for a specific layer: Use case, business process requirement, scenario, service requirements and generic services. Further, the elicitation/breakdown of and the relations between the layers are illustrated (see Figure 5). ***Step4*** – Agreement on proposed mapping/association in accordance to the toolbox architecture. ***Step5*** – Respective to the agreed identification and mapping of information gained in step 4, the so called VID is fulfilled with content in regards to defined sets of attributes. ***Step6*** – The fulfilled VID content is exported into a specific prepared VIVACE Word document template and sent to the BNE leader. ***Step7*** – The BNE leader receives the VID report and validates it. Last revision of information extracted and organised contently mapped correct in terms the defined attributes. ***Step8*** – In this step T0.1.3 receives the final validated VID report and updates the VID content accordingly if required. ***Step9*** – The Information Integration Process (IIP) has been successfully processed. Future updates and modifications shall be done based on the mapping slides and the VID report.

Table 21: Information integration process (adapted from Laudan 2006; 2007a)

A2.1.2Calculated Utility Values

BNE-C

BNE-C	lower	expected	upper	VC [%]
t=0	0,29	0,38	0,45	8,49
t+1	0,52	0,63	0,73	6,86
tEnd	0,73	0,81	0,90	4,28

BNE-B

W	BNE-F1	lower	expected	upper	VC [%]
	t=0	0,04	0,05	0,06	8,39
0,20	t+1	0,08	0,11	0,15	13,01
	tEnd	0,11	0,13	0,16	7,51

W	BNE-F2	lower	expected	upper	VC [%]
	t=0	0,07	0,08	0,10	8,00
0,20	t+1	0,10	0,15	0,19	11,47
	tEnd	0,14	0,17	0,19	6,36

W	BNE-F3	lower	expected	upper	VC [%]
	t=0	0,04	0,11	0,16	23,02
0,20	t+1	0,08	0,13	0,17	17,29
	tEnd	0,15	0,19	0,22	8,72

W	BNE-F4	lower	expected	upper	VC [%]
	t=0	0,09	0,14	0,18	12,84
0,40	t+1	0,17	0,24	0,31	12,21
	tEnd	0,26	0,33	0,39	8,29

BNE-B

W	BNE-B1.1	lower	expected	upper	VC [%]
	t=0	0,10	0,13	0,16	10,20
0,60	t+1	0,19	0,30	0,46	22,00
	tEnd	0,27	0,35	0,43	9,82

W	BNE-B2.1	lower	expected	upper	VC [%]
	t=0	0,04	0,06	0,10	22,99
0,50	t+1	0,18	0,30	0,44	22,79
	tEnd	0,33	0,38	0,44	5,61

W	BNE-B3.1	lower	expected	upper	VC [%]
	t=0	0,00	0,02	0,04	91,84
0,30	t+1	0,07	0,22	0,31	43,72
	tEnd	0,07	0,29	0,31	15,35

W	BNE-B4.1	lower	expected	upper	VC [%]
	t=0	0,18	0,21	0,24	6,45
0,40	t+1	0,20	0,24	0,28	8,52
	tEnd	0,20	0,32	0,43	15,09

W	BNE-B1.2	lower	expected	upper	VC [%]
	t=0	0,07	0,09	0,11	10,11
0,20	t+1	0,09	0,11	0,12	6,97
	tEnd	0,10	0,13	0,15	7,08

W	BNE-B2.2	lower	expected	upper	VC [%]
	t=0	0,30	0,35	0,41	6,15
0,50	t+1	0,36	0,42	0,49	6,74
	tEnd	0,39	0,45	0,51	5,47

W	BNE-B3.2	lower	expected	upper	VC [%]
	t=0	0,18	0,54	0,72	23,03
0,30	t+1	0,34	0,43	0,56	11,23
	tEnd	0,55	0,66	0,77	7,76

W	BNE-B4.2	lower	expected	upper	VC [%]
	t=0	0,02	0,10	0,17	36,79
0,30	t+1	0,06	0,17	0,28	36,10
	tEnd	0,19	0,23	0,27	8,91

W	BNE-B1.3	lower	expected	upper	VC [%]
	t=0	0,02	0,02	0,02	5,92
0,20	t+1	0,13	0,16	0,19	7,10
	tEnd	0,16	0,18	0,21	5,40

W	BNE-B4.3	lower	expected	upper	VC [%]
	t=0	0,02	0,03	0,03	5,92
0,30	t+1	0,16	0,19	0,23	7,98
	tEnd	0,23	0,27	0,31	5,40

Table 22: Calculated Utility Values

A.2.2 Industrial Application Case 2: Airbus

A.2.2.1 Stakeholder and Stakeholder Roles

Stakeholder & Stakeholder Role Notation	
	STAKEHOLDER ROLE
	GENERAL INTENTION
	STAKEHOLDER

I Environment

Customer	
	Low cost / value stability
	Low operating costs / maintenance costs
	High performance (capacity/weight/fuel consumption)
	High passenger acceptance (comfort, space, travelling duration, image)
	Airline
Competitors / Restricting Markets	
	Raise market share (by developing better products)
	Improve image
	Boeing
Restricting Environment	
	Define regulations and control strict observance
	Airport
	Regulation Authorities: Airworthiness Authorities (JAA, FAA), others
	Environmental Affairs as Interface

II Business Community

Investor	
	Rate of Return
	Image
	Strategic Partner (Technology/Market Position)
	AIRBUS Shareholders: EADS
R&D Strategy	
	New technologies
	Introduce new methods, processes and tools, e.g. for product development teams
	Chief technology office related departments (Airbus, Eads)
Business Strategy	
	Develop and implement long-term strategy
	Define long-term product portfolio
	Define AIRBUS commercial objectives (image, benefit)
	Airbus, EADS
Marketing & Sales	
	Raise customer satisfaction (customer care)
	Improve image
	Raise sales
	Raise margin (price policy)
	Understand the rules of the market and dominate it (market research)
	Customer Affairs, Customer Services
Engineering and Maintainability	
	Identifying the optimum solution in terms of positive high-level product features while taking into account expenses-causing parameters such as production costs, construction time or application of future technologies as constraint.
	Airbus
Manufacturing	
	High capacity
	High flexibility in terms of quantities

High flexibility in terms of product changes Low investment cost Low downtime
Airbus

III Engineering Community

Product Development Teams
Implement business level intentions in terms of engineering definitions, e.g. top level product requirements
Customer Affairs, Customer Services

Table 23: Stakeholder and Stakeholder Roles

A.2.2.2 Requirement Quality Characteristics

Source	Requirement quality characteristics
Halligan 2007	• Correctness • Completeness • Consistency • Clarity • Non-Ambiguity • Traceability • Testability (Verifiability) • Singularity • Feasibility • Functional Orientation • Freedom from Product/Process Mix
Denger/Olsson 2005	• Comprehensibility • Completeness • Verifiability • Feasibility • Correctness • Unambiguity • Consistency • Ranked for Importance/Stability • Modifiable • Traceable • Right Level of Detail
DOD 1985/IEEE 1993	• Complete • Consistent • Correct • Modifiable • Ranked • Traceable • Unambiguous • Verifiable
Airbus RBE 2006	Individual requirements: • Necessary • Attainable • Clear/Unambiguous • Verifiable • Not premature design Set of requirements (requirements document) • Complete

	• Consistent • Non-redundant • Structured • Validated

Table 24: Requirement Quality Characteristics

A.2.2.3 Requirements Quality Quadrants

<u>Quadrant I – Collective documentation quality</u>

- **Complete**
  - Does the set of requirements cover all aspects intended on this level of abstraction (i.e. A/C)?

  → All necessary requirements are present (RBE 2006).
- **Consistent**
  - Does the set of requirements contain incompatible requirements?

  → No two requirements are in conflict (RBE 2006)
- **Non-Redundant**
  - Does the set of requirements contain requirement intends which are implied also by other (one or more) requirements?

  → Each requirement is expressed once – no duplications! (RBE 2006)
- **Structured/organised**
  - Does the set of requirements belong to a logical requirement cluster?

  → There is a clear structure with requirements that belong together in the same section (RBE2006)

<u>Quadrant II – Subjective documentation quality</u>

- **Singular**
  - Does the requirement state a single demand?

  → Avoid expressing several demands or intends in one single requirement statement. That does not mean to differentiate quality or performance characteristics as well as conditions form the major intend (e.g. use of table)
- **Necessary**
  - Does the requirement need to be expressed?

  → Think about what would be worst that could happen if you left this requirement out? (RBE 2006)
- **Attainable**
  - Does the requirement allow achievability?

  → Be realistic and consider the combination of technical feasibility, budget and project time-scales (RBE 2006)
- **Clear/Unambiguous**
  - Does the requirement give no room for misinterpretation in its intent?

  → Keep it simple! Utilise principles of simplified technical English (STE, RBE 2006). Apply requirement template (follow the requirement template structure)
- **Verifiable**
  - Does the requirement have qualitative or quantitative assessable characteristics?

→ If you cannot demonstrate that a requirement has been met, then why specify it? (RBE 2006)

- **Not premature design**
  - Is the requirement appropriate assigned to the level of abstraction and thus does not limit design freedom?

  → Do not constrain more than necessary at your level. Think about whether you are imposing a solution rather than stating a need (RBE 2006).
- **Traceable**
  - Is the requirement allocatable?

  → Check that the requirement has a *unique identifier*

  → Check that has a relation as required in the Project Plan. Requirements shall have relations to the:
  - *Higher level of abstraction*:
    - Source of cognition/motivation: stakeholder and the relating contextualized product needs, means of compliance
  - *Lower level of abstraction*:
    - Requirement, physical and logical architecture (design/-concept)

<u>Quadrant III – Subjective validation quality</u>

- **Understandable**
  - The requirement is “self”-explicable for upper and lower level of abstraction
  - Readability of technical document assessed by Coleman-Liau factor. Functionality is given with MS Word
- **Correct**
  - Followed a formalised sentence structure (parsed requirement statements and template structure applied)
  - No ambiguity (RBE 2006)
  - No errors (RBE 2006)
  - Does the set of requirement associates to the right level of abstraction
- **Complete**
  - The requirement statement is essential and sufficient to allow a solution to be determined (RBE 2006)
- **Desired**
  - Is the requirement accepted by the upper-level stakeholders who motivated the particular product need (as a response to their own objective or request)?
- **Pertinent Traceability**
  - Pertinence of the higher level of abstraction:
    - o Source of cognition/motivation: stakeholder and the relating contextualized product needs, means of compliance
  - Pertinence of the lower level of abstraction:
    - o Requirement, physical and logical architecture (design/-concept)

<u>Quadrant IV – Collective validation quality</u>

- **Correct**
  - No inconsistency (RBE 2006)
  - No contradictions (RBE 2006)
- **Complete**
  - Defined intended behaviour in all operating conditions and modes (RBE 2006)
  - All essential higher level product needs have been addressed

- Level of specification met? Whether over-, under, or mis-specified

A.2.2.4 Readability Score

Flesch Reading Ease Score

Rates text on a *100-point scale*: the higher the score, the easier it is to **understand** the document. For most standard documents, aim for a score of approximately 60 to 70.

The formula for the Flesch Reading Ease score is:

$$206.835 - (1.015 \times ASL) - (84.6 \times ASW)$$

Flesch-Kincaid Grade Level score

Rates text on a U.S. school grade level. For example, a score of 8.0 means that an eighth grader can understand the document. For most documents, aim for a score of approximately 7.0 to 8.0.

The formula for the Flesch-Kincaid Grade Level score is:

$$(0.39 \times ASL) + (11.8 \times ASW) - 15.59$$

Where:

ASL = average sentence length (the number of words divided by the number of sentences)

ASW = average number of syllables per word (the number of syllables divided by the number of words)

PhD Thesis: ***Context-oriented Product Development:***
Collaboration between the Business and Engineering Domain
An Investigation with a Focus on Project & Engineering-Based Organisations

Abstract

Early requirements analysis in context of project and engineering-based organisations deals with the establishment of the top-level definition of the project's product. Literature shows that communication and coordination is challenging in conjunction with visualisation and representation of knowledge in a cross-community constellation of business and Product Development (PD) teams concerned with early requirements analysis. Recently debated formalisms insight software and systems engineering community produce (coherent) intentional models that aim at increasing rationalisation and confidence in engineering definitions using the concept of goals. But most goal-oriented approaches fall short in establishing usable intentional structures that are able to provide the transparency for supporting continuously business-engineering evolutions within collaboration and knowledge conversions along a PD process. In this sense, the present thesis provides a complementing approach that emphasises on business and engineering collaboration and knowledge conversions. In this context a knowledge-driven concept is proposed that anchors a value-oriented organisation of intentional structures (i.e. business needs and expectations) and traces to engineering definitions. In addition, this concept serves the organisation and representation of knowledge and illustrates how to perform valuation and verifications of intentional structures implemented in forms of requirements.

This work was developed along a hybrid action research methodology that employs an empirical study and two industrial application cases.

Key words: Project and engineering-based organisation, systems engineering, early requirements analysis, knowledge management, intentional modelling, business and engineering collaboration and knowledge conversion