Business meets Systems Engineering: Facing and Handling Collaboration Challenges in Requirements Analysis

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Abstract. Traditional requirements analysis models focused on system- and user interactions. Whereas, much effort – in particular industrial – is devoted to the logical breakdown, management, dissemination and proof on the level of implementation of requirements without being strongly connected to the organization and its business intents. Recent works focus on "front-end negotiations", i.e. early requirements analysis activities concerned with reconciling business problems, opportunities and high-level product/system requirements. Literature shows that communication and coordination is challenging in conjunction with the visualization and representation of knowledge in a cross-community/domain constellation of Business and Product Development (PD) teams concerned with early requirements analysis. In this context, we present our research results (within an empirical context) with emphasis on establishing interactivity structures and creating group-awareness at the interface of Business and Systems Engineering (BSE). Our work articulates a knowledge-driven concept that anchors a value-oriented organization of intentional structures (i.e. business needs and expectations) and traces to engineering definitions (in our case with a focus on product/system requirements). In addition, this concept serves the organization, representation and deployment of BSE knowledge illustrating how to perform valuation and verification of intentional structures implemented in forms of specified product/system requirements.

1 Introduction

The early requirements analysis phase is characterized through a lack of formalized design artifacts and product models (e.g. system, physical, geometrical). Decisions in regards to organizational intents might change since the availability of more accurate and useful information increases along with the product development process[1, 2]. Early requirements analysis activities are concerned with reconciling business problems, opportunities and product (high-level) requirements. Literature has shown that communication and coordination (collaboration facets) is

[1] However, along the PD process environmental conditions evolve and could change in contrast to initial assumptions.
[2] Cf. Browning et al. (2002) "[…] getting the right information in the right place at the right time."

challenging in conjunction with the visualization and representation of knowledge in a cross-community/domain constellation of business and PD teams concerned with early requirements analysis[3] (see Table 1).

Challenging Fields	Elicitation	Communication & Coordination incl. Knowledge Visualization	Completeness and consistency
Context	Determining stakeholders and their needs and expectations.	Collaboration across the organization and its structures, actors using instruments for knowledge conversions.	Fitness for purpose, classifying the degree to which extent needs, goals, and/or mission of the product/system are "covered" in terms of engineered requirements.
Some Techniques in use	• Goals: to elicit high-level stakeholder concerns that the systems is expected to achieve • Scenario models: to describe behavioral system properties • Viewpoints analysis: to collect and organize 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	• 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 prioritization and effort estimation • Requirements traceability and interdependency • Grouping requirements into bundles (cluster): to ease requirements structuring and work portioning • Visualization of organizational knowledge (e.g. Eppler/Burkhard 2004)	• 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. vanLamsweerde 2001; Anton/Potts 1998) • Stakeholder identification and interface quantification • Scenario analysis • Non-Functional Requirements Analysis (e.g. Chung et al. 1999) • Graphical goal modeling and notation (e.g. Liu/Yu 2004) • FBCM 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-organizations
Gaps & Opportunities	Hickey/Davis (2002): • A unified model of the elicitation process • Integrate tacit knowledge which expert analysts use, while applying and selecting elicitation techniques	• Karlsson et al. (2007): communication and coordination are still corner stones in software development • Kavakli/Loucopoulos (2003): lack of means that enables to perform stakeholder cooperation within the product development process. • Karlsson et al. (2007): "How to make marketing and development communicate regarding requirements? How to encourage people to change their way of working". • Eppler/Burkhard (2004): "communication between the many different organization's participants (business management, project management, systems and specialty engineering groups) and their specific professional backgrounds is a major problem in organizations. Visualization 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.	• Sommerville (2005): "academic research aimed at supporting completeness and consistency, but hasn't had yet major impact on practice" • Carson et al. (2004): "develop and validate a methodology that can produce a complete set of requirements and that can determine the completeness of a set of requirements". • Kokone et al. (2006): "future work will include strategic modeling with business process modeling method" • Gonzalez/Diaz (2007): "organizational concerns must be taken into account and RE approaches must provide new ways of elicitation". • Karlsson et al. (2007): "consistency, i.e. fluctuating and conflicting requirements is still a challenge for requirements engineering"

Table 1. Some challenges put in context of requirements analysis

Whereas establishing, maintaining and visualizing mental evolutions between BSE in the volatile phase of early requirements analysis is key towards establishing coherency-development within product/systems definitions, early requirements analysis approaches often aim at increasing confidence and rationalization of product/system definitions using the concept of goals (see e.g. El Ghazi 2007, Kavakali 2004), while BSE *collaboration* aspects and the feature of *transparency* is perceived as being underdeveloped. An empirical study [4] performed in a specific

[3] In this paper early requirements analysis is concerned with both business intents and requirements elaboration in context of establishing a top-level product/system definition.

[4] We have conducted 17 experts' interviews (semi-structured) in a large European collaborative research project on the scale of an aeronautical research and industry sector with a survey focus on collaboration at the interface of BSE.

inter-organizational environment has shown that challenging aspects in cross-domain collaboration and knowledge conversion within establishing product definitions are *different backgrounds (variety of business approaches, objectives, cultures, working principles…), a missing common/shared perspective (visibility on the project: shared view on business intents), environmental influences (external factors, lack of early involvement of business customer and end-user)*. We have seen that the concept of *perspective making and taking* (see Eppler/Burkhard 2004) is essential for collaboration. This retrieves in the aspect of transparency and is requisite for people to share business intents throughout the organization on all levels and areas, so that contributions can evolve in cohesion along the PD process.

To sum-up, we concluded that early phase requirements analysis is identified as requiring a collaborative and knowledge-driven, rather than a process-oriented (i.e. stringent step-by-step) concept. Recent early requirements analysis approaches are challenged within balancing formalisms versus usability (e.g. Lamsweerde/Letier 2004). Our proposed approach aims at establishing a "synthetic meeting place" to strengthen BSE collaboration and create reflexive transparency on business intent and specified requirements structures (see Figure 1).

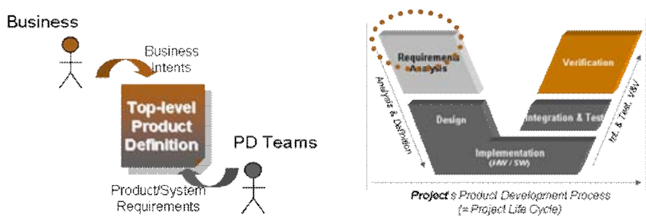

Figure 1. Context and scope

Furthermore, we offer an instance for structuring, organizing and deploying early requirements analysis information (informally) before entering into semi-formal and formal modeling and analysis approaches. Therewith, it is a rather preparatory vehicle for stronger formalisms proving coherent product/system structures at that level. In addition, the proposed concept emphasizes the currently under-developed issue in requirements analysis of outlining a total value improvement baseline that is founded on the notion of *business intent* and in turn creating a basis for an evolutionary control instance for a (collaborative) project.

2 Empirical Context and Purpose

We orient on ISO 15288 Systems Life Cycle Standard as basis for considering project- and engineering-based organization and its structures. In this sense we put emphasis on collaboration between BSE, whereas we consider project management as part of the business domain considered as orthogonal and mediating instance between BSE. In the following we concretize our cognitions gained from the empirical world (large European Project, i.e. an inter-organizational environment) in form of an industrial problem and resulting needs that we address in our work. In this context, Figure 2 left outlines the collaborative situation to be improved at the interface between business and engineering as follows:

- **P1. Reconciliation process of business intents (industry partner) and specified requirements (research centres, universities) are challenging** since both are managed merely quasi-independently of each other or often only maintained in forms of requirements developed by PD teams only. Rather PD teams collect information (sometimes vague and mostly informal) from everywhere and attempt to perform the validation of those themselves, evolving and developing engineering definition dossiers which are managed quasi-independently from organization's business intents.

- **P2. Flat and non-contextualized representation** (macro-viewing on documents) of business intents
- **P3. PD teams often loose the justifying connection** to business intents throughout the project life cycle (PLC) or PD process respectively
- **P4. PD teams are often unsure** if they implemented business intents completely and consistent in forms of specified requirements
- **P.5 Difficult to prove and trust the correct implementation** of business intents in engineering processes and information spaces

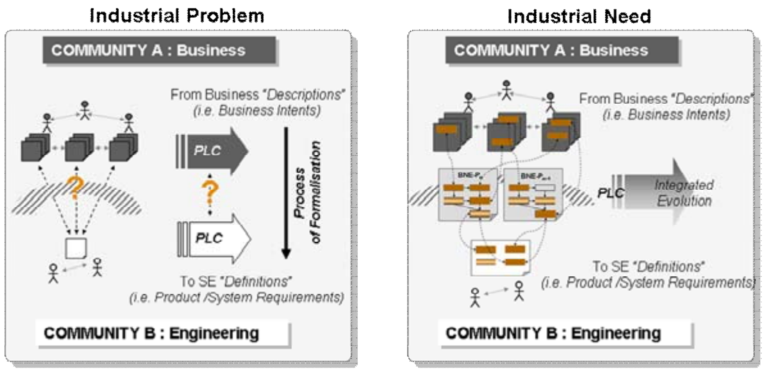

Figure 2. Industrial problem (left) and resulting industrial need (right)

We concluded that the reconciliation process of business intents and specified product/system requirements is challenging. This process appears as a shift from '*black*' (i.e. business intents) to '*white*' (i.e. top-level product/systems requirements) that is requiring an intermediate step. In this context, a *domain boundary layer* (a sort of transition area) characterizes the critical pass, a shift from one thought-world to another. Conversely, Figure 2 (right) draws this interface as the *synthetic meeting place* that creates a sense-making and negotiation forum in which actors follow a logic of "perspective making and perspective taking" (i.e. establish a cohesive awareness between business intents and requirements). In consequence, we characterize this envisioned collaborative situation at the interface between BSE with the following needs:

- **N1. Methodological approach to structure, organize and specify perceived business intents in alignment with specified requirements**
  → To answer Problem P1. & P2. in terms of: High-level product orientation and collaboration baseline towards which business and PD teams can activate all their efforts
- **N2. Traceability mechanisms**
  → To answer Problem P3. & P4 in terms of: Trace and update business intents and requirements
- **N3. Goal conflict and resolution mechanisms**
  → To answer Problem P5. in terms of: Relaxation and stabilization of business intents before entering into "heavy" specifications
- **N4. Evaluation engine**
  → To answer Problem P5. in terms of: Measuring and estimating business intent fulfillment in relation with assigned requirements

In conclusion, we expect to contribute towards 1) avoiding late and heavy iterations in progressive stages of the PD process; and 2) create an increased transparency and by that improve BSE collaboration.

3 Conceptual Model Definition

In general the study of collaboration and knowledge conversion (share and create) in a cross-domain constellation – as we perceive BSE – is confronted with some challenges (Novak/Wurst 2004): different "thought worlds" and knowledge perspectives, establishing a shared context of knowing, enable perspective making and perspective taking, definition of boundary objects (interpretable knowledge artifacts), visualization of cross-domain knowledge perspectives. Within Table 2 we summarize principle key features of reviewed concepts that we think are pre-requisites to study collaboration and knowledge conversion in BSE constellations.

Concept	Issue	Key feature
Collaboration	To understand principles of social interaction	– Two individuals or larger collectives of individuals (communities) [OED 2003, Bahrdt 2000] – Modes of communication, cooperation and coordination towards the established objective for collaboration (group awareness, emergence) [cf. Elsen 2007]
Knowledge	To understand the object of collaboration	– Knowledge should be exchanged within the objective of collaboration [Elsen 2007] (different natures of knowledge, different knowledge conversion modes)
Context	To understand how other people can understand and learn from knowledge in its initial meaning	– Essential for knowledge conversion of organization and its actors for taking appropriate and valuable actions [Klemke 1999; Kivijärvi 2004]
Ontology	To understand how to coordinate and organize knowledge conversion	– Offering a skeletal and relational organization for knowledge bases associated to represent different viewpoints based on the organizational level and area [Huettenegger 2006; Swartout et al 1996]
Organization	To understand the frame in which collaboration appears	– Organizations are "immense" interpretation systems [cf. Daft/Weick 1984; Baumard 1999] – Organization and the smaller unit domain provide the frame in which collaboration could occur

Table 2. Reviewed concepts to study BSE collaboration

All these concepts fulfill a particular role within the organizational context essential to study BSE collaboration and associated knowledge conversions towards a top-level product/system definition. The confluence of those concepts results into a construct that we titled *Knowledge-CoCoOn* (**Co**llaboration, **Co**ntext, and **On**tology, see Figure 3).

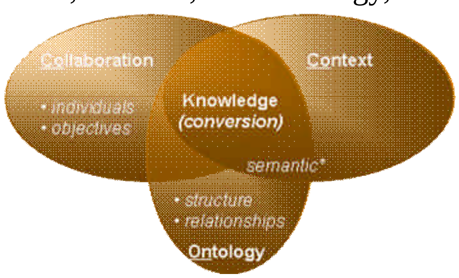

Figure 3. Confluence of theoretical concepts reviewed to study collaboration projects

In a subsequent step, we put forward the conceptual model of Knowledge-CoCoOn in an operational context of BSE collaboration. In this context, we defined an information model called Business Needs & Expectation Perspective (BNE-P). This model offers structure (objects and logics) for customizing business intents in specific perspectives. Those organize the variety of different business information spaces (i.e. documents) and articulate thoughts and viewpoints that can be taken into domain-specific consideration by systems engineering. Subsequent sections are devoted to explain how we considered the different solutions offered by Knowledge-CoCoOn within the BNE-P model.

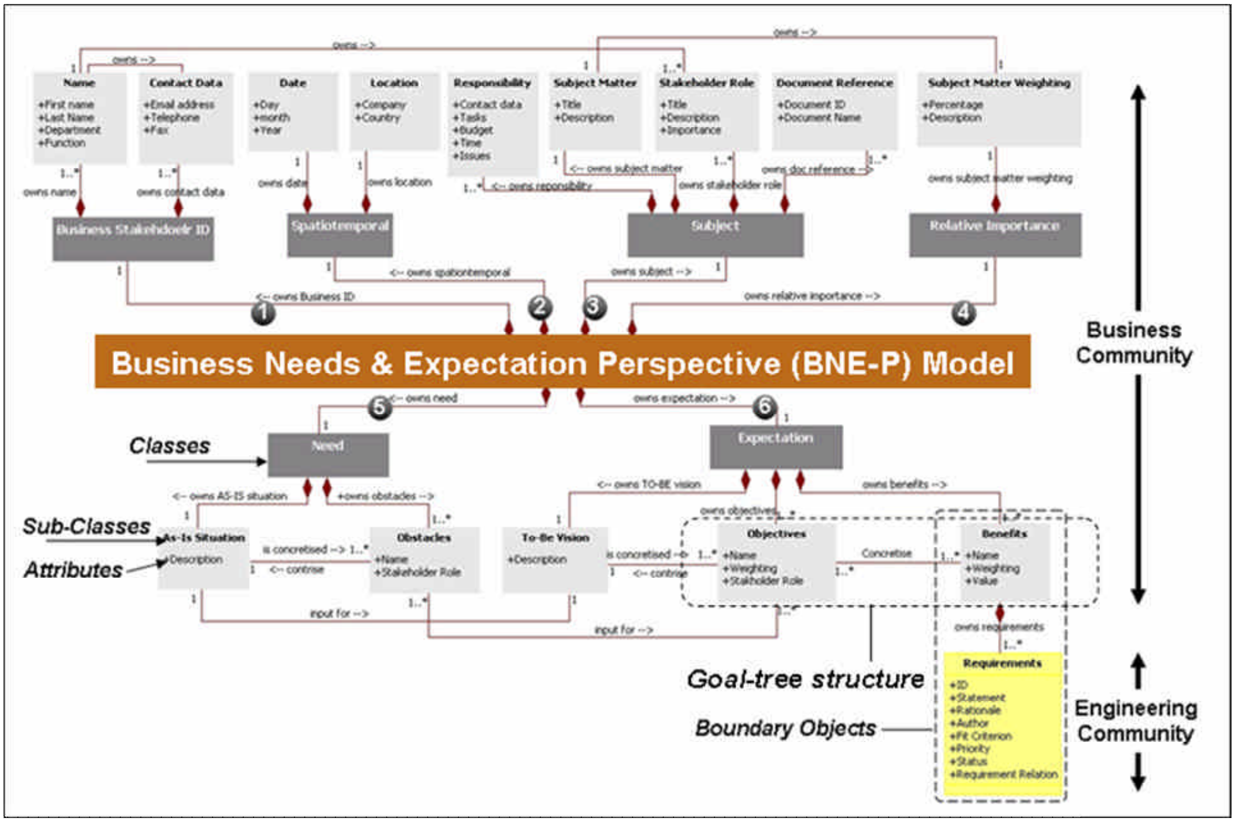

Figure 4. BNE-P Model[5]

Collaboration Component: Principles of BSE interaction. As mentioned previously we adapted the ISO/IEC 15288 Systems Life Cycle standard to illustrate different organizations' actors interacting and converging knowledge in regards to the project's product[6] (see Figure 5).

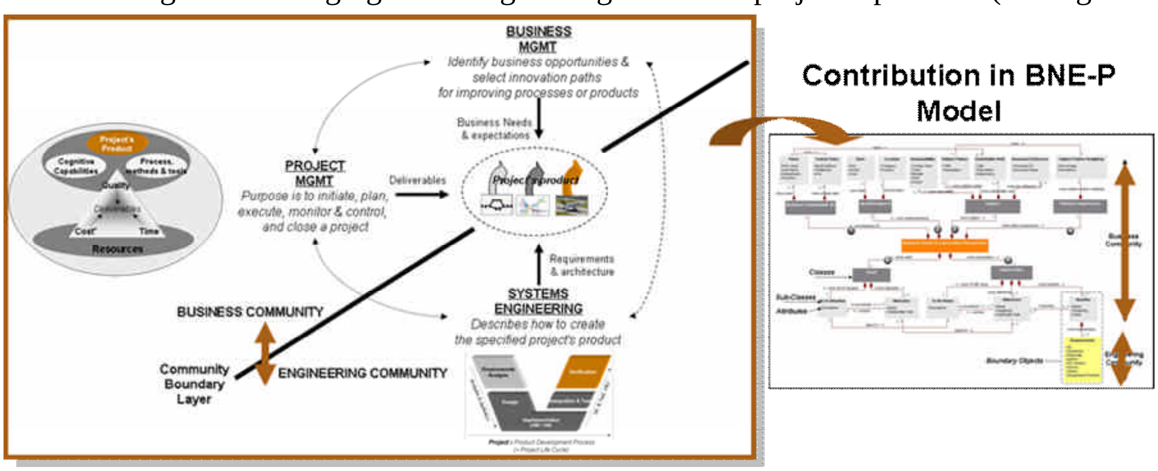

Figure 5. Principle collaboration in context of project-and engineering-based organizations

[5] For our investigation it was sufficient enough to consider engineering definitions in a simplified view within only a requirements class.

[6] The project's product is constituted of engineered things/objects (product, service, system, process, result) 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.

We defined both business management and project management representing the domain of business in front of the domain of systems engineering and specialty engineering (not further considered in our works) associated to the domain of engineering. Both business and engineering domains perform different task models exchanging knowledge on a regular basis. *Business management* (BM) articulates business opportunities (situations to be improved and/or problems to be solved) and selects innovation paths for improving products or processes and addresses business needs and expectations towards the project's product. Projects are potential vehicles towards achieving organization's strategic business plan, which is not attainable during ongoing organization's operation sustaining the business. In turn, *project management* (PM) is established as a mediating instance, authorized and responsible for implementing addressed organization's conceived business needs and expectations, and carrying out appropriate responses in terms of project's products. *Systems engineering* (SE) is considered as the technical PM instance concerned with the development of *project's product* and processes. 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. In this given collaboration thought-model it is anticipated that the organization and its communities are interacting differently with the environment.

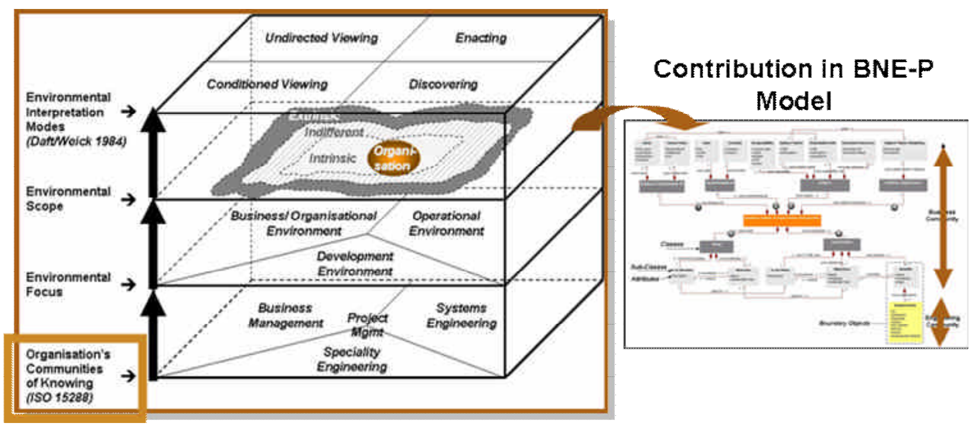

Figure 6. How organizational structures consider the environment

The important point is that each organization and its actors on different levels interact with and focuses on different parts of the environment. A clear delimitation of these environmental focuses is important in order to not confuse logical levels of incoming stakeholders' information. We consider organization's environmental aspects within a cubic model that differentiates four facets (see Figure 6): *environmental interpretation modes*[7] (enacting, undirected viewing, conditioned viewing, discovering), *environmental scope* (extrinsic, intrinsic, indifferent), *environmental focus* (business/organizational environment, operational environment, development environment) and the related *organizational communities*[8] (business management, systems engineering, specialty engineering).

In conclusion the aspect of collaboration corresponds to Need N1. "Methodological approach to organizing and specifying high-level product definition".

Ontological Component: Coordination of knowledge conversion between BSE. We introduce the notion of ontology as vehicle serving towards an organized and transparent mobilization of

[7] Adapted from Daft/Weick (1984)
[8] Adapted from ISO/IEC 15288 Systems Life Cycle Standard

knowledge conversions. In our context ontology provides a shared (accepted and understood) skeletal and relational organization of complex business information spaces (referred to as business domain perspective making). Transition points in a cross-domain context (referred to as perspective taking) allow tracing and updating knowledge between BSE (see Figure 7).

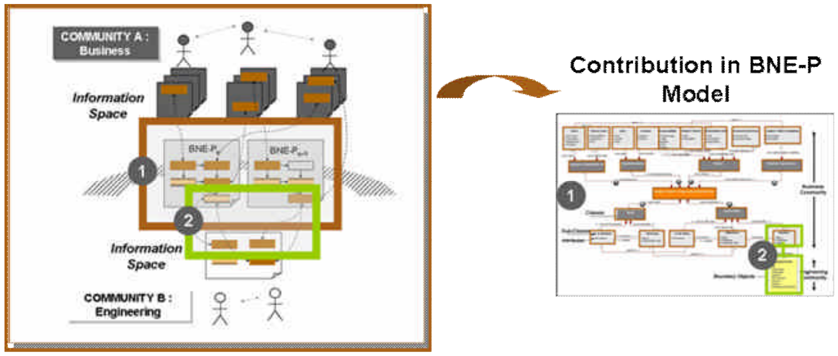

Figure 7. Structure (1) and transition points (2)

Those are boundary objects and identified as *business benefits* (product qualities) and specified *requirements* that are constituents for the objective of collaboration between BSE providing a reflexive representation of each others' understanding towards the level of emergence (group awareness). The domain boundary layer characterizes a sort of transition area representing the *critical pass*, a shift from one thought-world to another. In this sense, 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) domain's knowledge and gain new insights and understandings towards a shared understanding ready to be reflected onto the domain's homogeneous perspective. It is attempt of "promoting" knowledge and makes it accessible for one or more targeted communities of knowing. Existing domain-related perspectives evolve and might change as a result of changes from the inside or the outside of a domain. New perspectives can emerge, which requires a proof of coherence amongst existing ones. Important feature is the ability to *trace* and *update* evolutions that requires *transparency* across BSE.

In conclusion the aspect of ontology corresponds to Need N1. "Methodological approach to organizing and specifying high-level product definition"; and N2. "Traceability Mechanisms".

Context Component: Communication of knowledge between BSE. The notion of *business intent* is central creating the synthetic meeting place in contents at the interface of BSE. We define the notion of business intent being composed of two components: *need* and *expectation*. The notion of "need" is defined in accordance to Merriam-Webster Online Dictionary 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 characterizes 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 8). Further, 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 characterized through two main features:

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

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

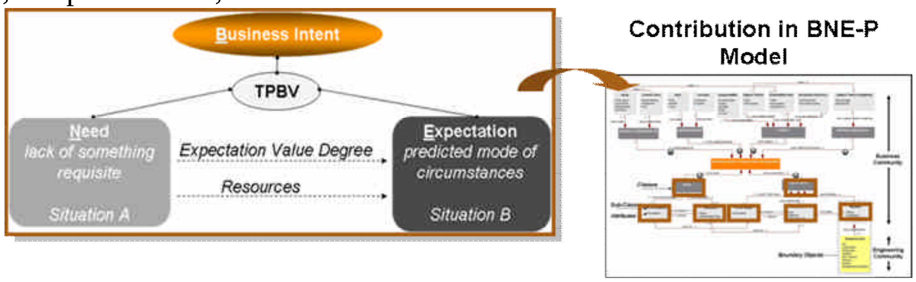

Figure 8. Definition of business intent as basis for prioritizing decompositions of product features

In conclusion this aspect corresponds to Need N3. "Goal Conflict and resolution mechanisms"; and N4. "Evaluation Engine".

Next, we studied the nature of the concept of *message*. It represents a sort of organized and multilayered information-package that is further acting as a vehicle for contextualization within cross-domain knowledge conversion. Knowledge conversion involves a transmitter (owner/initiator of information, e.g. a business domain member) and a receiver (holder or interpreter of the information, e.g. a SE domain member). We use the construct of *message* (M) as bearer for transmitting information that is a function of Identity (ID), Transmitters-Situation (S_T), Content (I) and its Significance (S).

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

These constituents are organized in a twofold structure: a *label* that comprises ID and S, while *object* encompasses I and S of a message. This conceptual differentiation is considered in the operationalized model of BNE-P within six classes (see also Figure 4): *1) Business Stakeholder Identification, 2) Spatiotemporal, 3) Subject, 4) Relative Importance, 5) Needs, and 6) Expectations*. Figure 9 illustrates a "funneling" principle, i.e. a concretization of specified business intents towards the level of engineered product requirements[9] managed in a requirements specification document[10]. Hereafter, the BNE-P model within its classes and attributes is described in further details.

In conclusion we provide an answer to Need N1. "Methodological to approach to organizing and specifying high-level product definition".

We specify the information model (see Figure 4), i.e. the synthetic meeting place embodying interactivity-structures for BSE as follows:

(1) – Business Stakeholder Identification

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

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[9] Product requirements are defined as the first level of elaborated engineering definitions building the intellectual connection to the organisation and its intents.

[10] 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-Ps.

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

(2) - Spatiotemporal

This class complements the previous one within the following situational attributes respective to when and where a *"Subject* (3)" was created.

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

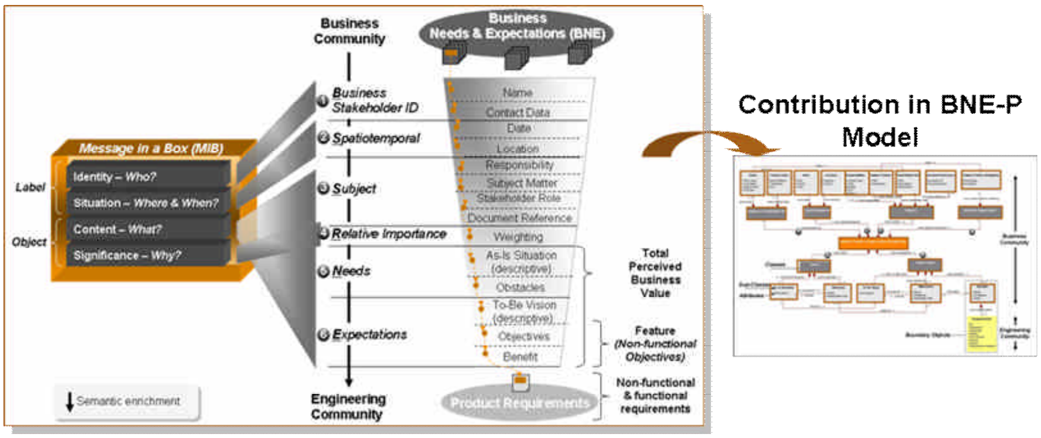

Figure 9. Nature of Message anchoring the concept of BNE for specifying contents (classes, attributes) of a business intent

(3) - Subject

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

- *Responsibility:* Provides the person (contact data) in charge, i.e. the respective cognitive capability to control the evolution of fulfilling the addressed *subject matter* and coordinates communications towards the business customers and relating PD team members. 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[11] needed to perform the intended level of change (see intentional analysis below). An issue indicates a problem within the process of business intent fulfillment and that may disturb the project continuation with its given constraints.
- *Subject matter*: Provides the BNE topic that indicates business intents bundled in context of a BNE-P.
- *Stakeholder role*: Business domain members' identified within the class *"Business Stakeholder Identification (1)"* are associated with a stakeholder role.
- *Document Reference:* References to domain-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)

BNE elaboration – An intentional analysis

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

In our context, intentional analysis 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 *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 domain and its members within a given amount of resources. For both need and expectation, information is determined from business domain-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 specified functional and non-functional requirements on engineering level; the former characterizes non-functional objectives, soft-goals indicating product/system qualities; the latter implement features expressing expected system capabilities. This separation of features (but staying interrelated) sort from the product/system it is applied to. Established relations enable vertical traceability for both domains having integrated and mutual insights, i.e. follow product qualities to respective functionalities and conversely.

(5) - Need

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 concretization 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

The class of expectation is refined into three sub-classes:

- *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 in context of the BNE-P.

- *Objectives*: are concrete features, soft-goals characterizing 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 characterization). Benefits are sorts of key performance indicator and further constrain the possible solution space from a business stakeholders' value perspective. A benefit is most concretized 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 requirement statements in regards to elements of the soft-goal tree itself. Whereas, an element of the soft-goal tree results in 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.

4 Conceptual Model Implementation

In this section we present a prototypical environment operationalizing what has been discussed as synthetic meeting place for BSE collaboration and knowledge conversions. We call this prototypical environment "BNE-P Tool" (see Figure 10).

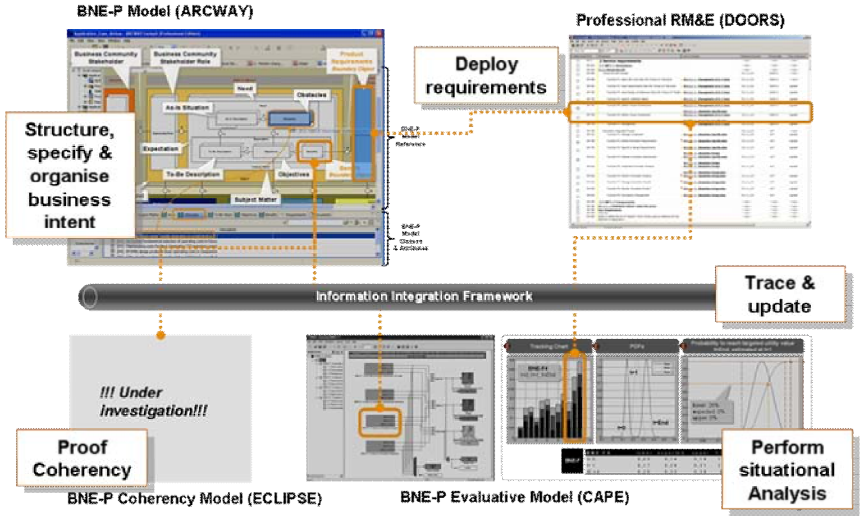

Figure 10. The BNE-P Tool

The BNE-Tool allows structuring, specifying and organizing business intents in accordance to the BNE-P model including the deployment of those in forms of specified requirement structures. The BNE-P Model offers business intent structures that enable to perform situational analysis (valuation of soft-goal tree structures) while using tracing and updating functionalities. A new area that copes with proving coherency (completeness, consistency, adequacy) within both the horizontal (i.e. transversal to BNE-Ps, across specified requirements on the same level of granularity) and vertical (i.e. across BNE-Ps and specified requirements) axis is under investigation.

BNE-P Model. The BNE-P model is implemented in form of an architectural organization towards which respective classes and attributes within its contents can be associated (see Figure 11). This 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 specification document. Relationship establishment across different model classes in context of one *subject matter* is considered hereby towards which related *responsibilities*, required *resources* and upcoming *issues*, *documents*, etc. 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-domain perspective making.

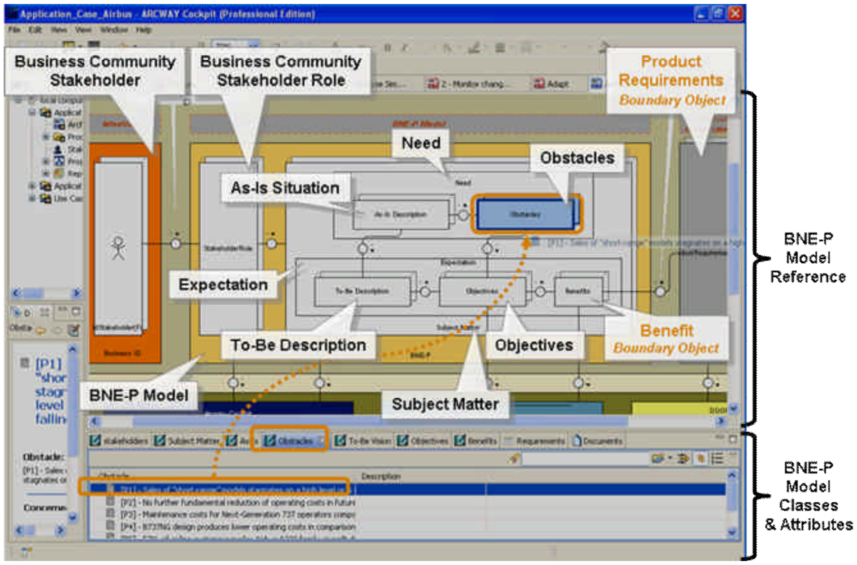

Figure 11. Implemented BNE-P Model

BNE-P evaluation model. First step deals with the characterization of evaluation criteria using utility value function and uncertain information using interviews with responsible BNE-P leader.

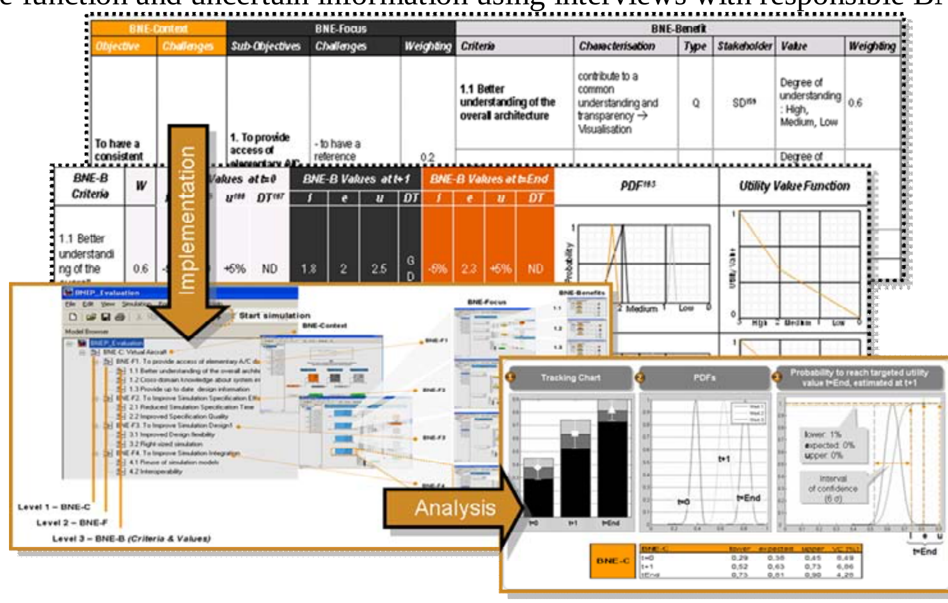

Figure 12. Implementation & analysis of probabilistic soft-goal tree structures

The evaluation principle underlying the establishment of BNE-P soft-goal tree structures is a temporal distinctions at t=0 (current business, before project), t+1 (intermediate, somewhere in the project), t= End (targeted situation, end of project) using uncertain information. In turn, value-zones can be defined threefold: *Current Zone*, *Improvement Zone*, *Targeted Zone* (see Figure 13). Finally, goal-tree structures are implemented within EADS in-house software for performing probabilistic evaluations of uncertain systems (see Figure 12).

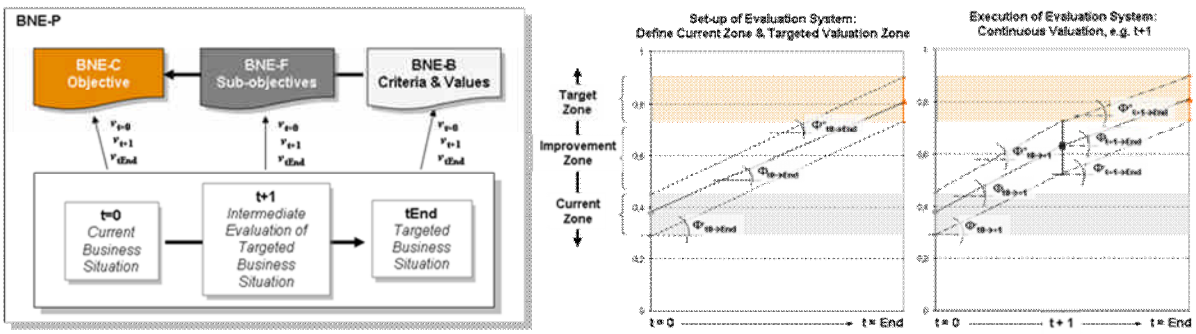

Figure 13. Temporal distinction of goal-tree values (left) & expectation value degrees ‘Φ’ (right)

Tracing mechanisms. We established the relationship framework between boundary objects, i.e. between probabilistic evaluated benefits and specified requirements based on interviews and implemented through information integration framework (see Figure 14).

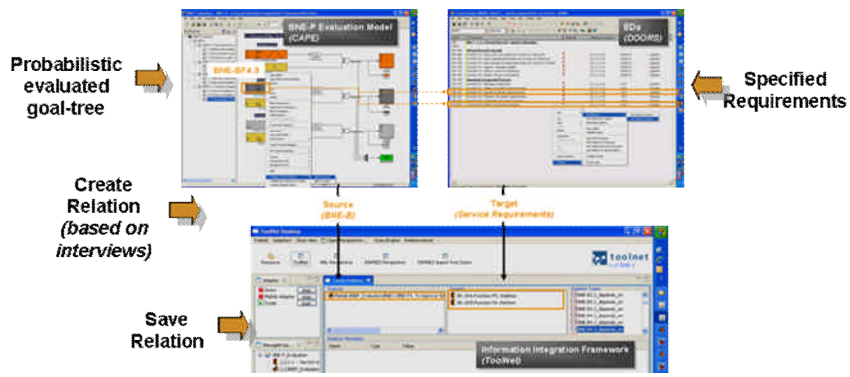

Figure 14. Implementation of tracing logics at the interface of BSE

Having established the relational framework arbitrary tracing scenarios can be performed. Those are a sort of situational analysis that aims at identifying unsatisfied business intent areas towards specified product/system requirements structures and conversely (see Figure 15).

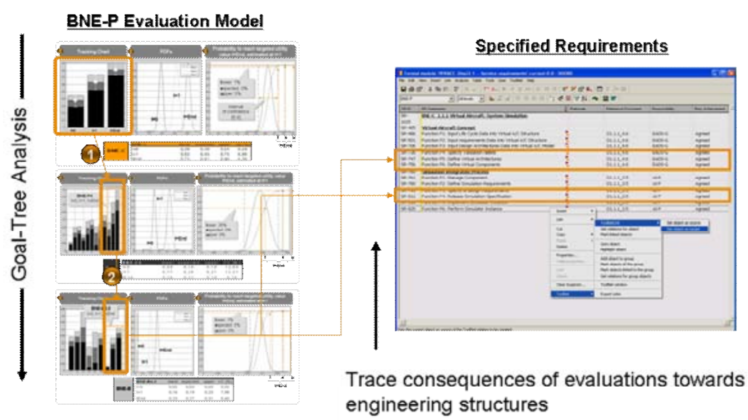

Figure 15. Situational analysis

Return of experiments. The experiences we gained in the inter-organizational environment represented through a large European research project were limited to the closure and exploitation phase of project (see Table 3). Thus, we perceive a clear lack of our experimentations in set-up and execution phase within investigating the BNE-P Model along a PD process including phase-specific surveys: interview cycles, questionnaires, etc. and analyzing business and engineering domain members' behaviours during collaborations and knowledge conversions using the BNE-P model. We will continue our investigation within both EADS internal PD projects as well as in European projects.

BNE-P Model	N1. Methodological approach to structure, organise and specify perceived business intents in alignment with specified requirements	
P1. Business intents are stored in different information formats and spaces P2. Flat and non-contextualized representation (macro-viewing on documents) of business intents	▪ Helps to get common understandings of and transparency on business intents addressed and functional components developed. ▪ The specification of business intents in BNE-P helps in communication towards business management inside the partner's company. ▪ Identified as key deliverable supporting exploitation phase enabling a logic of business value and engineering capability view ▪ The model could help to reach common value-oriented understandings more efficiently	
BNE-P Tracing Mechanisms	**N2. Traceability mechanisms**	
P3. PD teams often loose the justifying connection … P4. PD teams are often unsure if they implemented…	▪ Capable to perform critical path analysis ▪ Prepare a situational picture in context of a business intent (e.g. serve moving business targets (Top-down) or difficulties in implementing engineering definitions (bottom.-up))	
BNE-P Evaluation Model	**N3. Goal conflict & resolution mechanisms**	**N4. Evaluation engine**
P5. Difficult to prove and trust the correct implementation…	▪ Implicit proof only (through traceability mechanisms)	▪ BNE-P provide evaluation structures ▪ In real case situation higher negotiation effort characterizing evaluation criteria ▪ Concept of uncertainty helpful, but time-consuming defining it ▪ More confidence providing figures using uncertain information

Table 3. Summary of feedbacks (gained from *interviews*) against empirical findings (problems and needs)

5 Conclusion

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 BSE evolutions within collaboration and knowledge conversions along a PD process, then it could be valuable to have a mediating instance that organizes those. 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 domain. It provides organization of knowledge bases, i.e. domain-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 BSE.

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