enhance operational businesses with the obtained insights.

The PROMISE PDKM system is based on the PDKM System Object Model (SOM) (Cassina et al., 2009), which provides a detailed model of the core of the Data Management layer component of the PROMISE PDKM system through UML notation. The PROMISE EU project intended the model to serve as a detailed formalization of all the requirements for standards for closed-loop PDM. Any implementation of the PROMISE PDKM should adhere to the following set of requirements:

- It should cover all of the product life cycle phases needed for the particular application case.

- It should be explicitly field-data oriented. Each piece of field data should be described in terms of:
  - WHAT is represented by each record of the field data
  - WHO is responsible for recording each record
  - WHERE the field data is stored – and HOW it can be accessed
  - WHEN the field data record was recorded

- It should be capable of including proper knowledge representation.

- It should provide a means for detailed descriptions of each life cycle phase, at the level of detail needed by the end user. In particular, it should make available a means for describing events that transpire during each life cycle phase, the activities performed by different actors, and the resources involved and required/used by different activities. It should also be possible to specify the link to the collection and management of field data, as well as to the rest of the information mentioned above.

- It should be flexible enough to achieve a cost-effective usage of the system resources for both complex and expensive products (e.g., locomotives, airplanes, production systems), and simple, less expensive ones (e.g., household appliances).

The following standards were identified and studied:

- STEP (ISO 10303) - STEP (STandard for the Exchange of Product model data) is an international standard for the computer-interpretable representation and exchange of product definition data. It was developed to provide a mechanism capable of describing product data as defined in ISO 10303-1 (i.e., "representation of facts, concepts, or instructions about one or more products in a formal manner suitable for communication, interpretation, or processing by human beings or by automatic means"), and independently of any particular system.

- STEP-NC (ISO 14649) - STEP-NC is a standard focused on the design and production phases of the product life cycle. As the acronym NC (Numerical Control) suggests, this standard focuses on the integration of activities performed at the backend, during the design phase, i.e., the construction of CAD/CAM models and those directly performed at the shop floor level by numerically controlled machine tools.

- PLCS (ISO 10303-239:2005) - Product Life Cycle Support (PLCS) is an Application Protocol of ISO 10303 (STEP). It was defined to accelerate the development of new standards for product support information. It was intended to describe the whole life cycle of a product with particular emphasis on support and work required to sustain and maintain the products under operational conditions. The main feature of PLCS is its focus on complex high-value products, typically with long service life and demanding in-service support requirements, which lead to in-service support costs encompassing a significant portion of the total cost of ownership. PLCS was built around STEP, and shares the same interface as other STEP-based software.

- MANDATE (ISO 15531) - MANDATE (MANufacturing DATa Exchange) defines a common representation for all pieces of information related to manufacturing. Its scope is the representation of production and resources information, including capacity, monitoring, maintenance (from a global point of view in relation to their impact on the flow control), and control, as well as the exchange and sharing of production and resources information, including storing, transferring, accessing, and archiving. While STEP takes a product-oriented view of manufacturing, MANDATE is concerned with the processes undertaken by organizations to carry out the desired production activity.

- PLM@XML - PLM@XML is an open standard proposed by EDS to facilitate high-content product life cycle data sharing. This standard focuses on the design phase of the product's BOL.

- ANSI/ISA-95 (ISO 62264) – The ANSI/ISA-95 standard, accepted by ISO and published as ISO 62264, describes the interfaces and activities between an enterprise's business systems and its manufacturing control systems; thus, it mainly focuses on the area corresponding to the production phase of a product.

Figure 3.7-1 shows the mapping of these standards onto the different product life cycle phases.

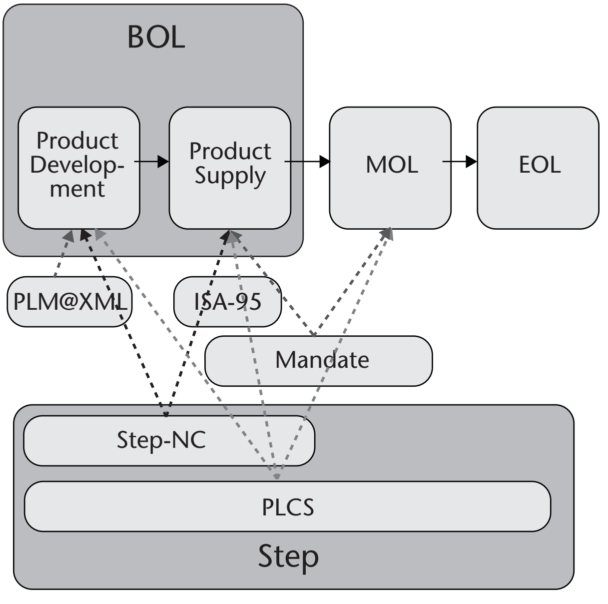

Figure 3.7-1 Product Data Management standards throughout life cycle phases

Though none of the standards cited above was sufficiently complete to be used as the unique reference in the development of the PROMISE PDKM SOM, each of them had some important features meeting part of the needs of the PROMISE EU project. Hence, all of these standards were used in building one or more of the building blocks of the PROMISE PDKM SOM. For instance, the ability of PLCS to cover the whole product life cycle was used; some capabilities of PLCS, MANDATE, and—though only partially—ANSI/ISA-95 were used to model product-item-related information. For product-type-related information modeling, PLCS, PLM@XML, and STEP-NC were taken as a reference. Moreover, none of the above standards was entirely capable of efficiently dealing with field-data, as required by the PROMISE architecture. Finally, PLCS's item-related events modeling capability was also considered; however, this was not sufficient for the scope of PROMISE and had to be expanded in the PROMISE PDKM SOM.

In sum, the PROMISE PDKM SOM was inspired by PLCS, but used a much simpler and more schematic structure, because it had to be used to model simpler products than those for which PLCS was originally designed. Another major difference, between the PROMISE PDKM SOM and the above standards, is its accuracy in dealing with field data, particularly sensory data—be it large amounts of simple and repetitive data or "once-only" life cycle events. The PROMISE PDKM SOM is also compliant with existing solutions for product traceability based on Auto-ID technologies.

Conclusions and next steps

This chapter introduced the scope of the PROMISE EU project in standardization and identified and discussed the relevant standards for different areas of the PROMISE architecture. It showed (as summarized in Table 3.7-1) how existing standards in two areas of the PROMISE architecture presented major gaps to be targeted during the PROMISE EU project, namely the PMI interface and the PDKM SOM. In these areas, the consortium used developments achieved during the project as seeds for new standards by initiating the necessary relationships with relevant standardization bodies.

Since the end of the PROMISE EU project (June 2008), the PDKM SOM was further expanded and tested on a larger set of application scenarios. This new version was then "translated" to comply with the more comprehensive STEP family of standards, in order to submit it as a proposal for a new AP (Application Protocol) of the STEP family of standards. Regarding the PMI, a new initiative, called QLM (Quantum Life Cycle Management, http://www.opengroup.org/qlm/), has been established at The Open Group. This may include the latest developments of the PDKM SOM. Its scope greatly exceeds product life cycle management. Based on the lessons learned during the PROMISE project, it exploits common information exchange technologies in order to encompass other products and services including healthcare, supply chain and logistics, food, beverage, pharmaceutical pedigree, and traceability. The "quantum" leap referred to in the name is fitting, since the technology has greatly expanded by harnessing the "Internet of Things," which enables the inclusion of numerous networked entities that will be brought into the domain of life cycle management.

PROMISE Architecture component		Relevant standards	Identified gaps
Hardware layer/Core PEID		All standards related to AIDC devices	None
Core PAC interface		e.g., UPnP	None
PROMISE Data Services (middleware)		e.g., Web Services	None
PMI	Protocol level	e.g., HTTP, CORBA, SOAP	None
	Syntax level	e.g., XML, HTML	None
	Semantic level	e.g., WSDL, XML	PLM Event Notification Messaging
PDKM		PLCS, STEP, STEP-NC, MANDATE, PLM@XML, ANSI/ISA-95	- Capability of properly dealing with field data of different types and volumes - Flexibility in modelling less complex products than those to which PLCS was tailored

Table 3.7-1 Synoptic framework of the relevant standards and related gaps

References

Brusey, J., Harrison, M., and McFarlane, D. (2006). "PROMISE deliverable DI1.3: Standardisation Strategy." PROMISE EU project FP6-IST-IP-507100.

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3.8

Identifying and Evaluating the PROMISE Demonstrators' Business Effects

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The PROMISE project was a technically-oriented R&D project partly funded by the European Commission, with the main portion of funding from the participating partners themselves. The Commission emphasized from an early stage the business aspects of the project and strategies for exploitation, both at the partner and project level. Due to the nature of the PROMISE project, it was necessary to justify and to make visible the business impact of the technologies developed. This section presents how business outcomes, business/technology targets, and risks were identified, evaluated, and then used as the basis for Cost-Benefit and Net Present Value analyses for all the PROMISE demonstrators.

Why focus on the Demonstrators' business effects?

The PROMISE demonstrators were instrumental in defining the technological dimension of the project, but they also showed how the PROMISE technologies would impact the business world. Technological solutions would impact business solutions, while the demonstrators' business targets would impact requirements for the technological solutions. At the start of the project all demonstrators had defined their overall business objectives. One example from one demonstrator was to create a solution that can make expert decisions on maintenance in order to improve customer support. Even though these requirements were well defined, targets were not adequately specified or prioritized. Starting from the premise that this project was technology driven, business effects methodologies were developed and employed to refine objectives and perform cost/benefit analyses for demonstrators.

With a total of 10 developed demonstrators participating as industrial partners in PROMISE, business exploitation was central to the project. The project's owners and stakeholders outside the consortium established these requirements and expectations at the outset. But the most important reason for working on exploitation was the partners' desire for a return on their investment in the project. The exploitation of PROMISE's results and generated knowledge for their own businesses was an important criterion of success. Understanding the potential for exploitation and how it can be measured and managed was therefore essential to the success of the PROMISE project.

Methodologies for assessment of business potential, targets, and effects

The partners' businesses and their business models were diverse and opportunities varied accordingly. New business opportunities might arise from new or transformed processes and practices or from innovative services that became possible using PROMISE technology. As a result, the platform for evaluating business potential sought to capture this diversity by illustrating how, for example, different business models could have a set of common methods, approaches, and references to the PROMISE project.

The methodologies developed in the project were first tested and refined through two pilot runs. The pilot runs, FIDIA and INTRACOM, resulted in some adjustments in the methodologies, which were implemented on-site during the working sessions. Adding risk-elements was one of the major changes.

The first pilot meeting took place at FIDIA on 29–30 March 2007 and the second at INTRACOM on 23–24 April 2007. For the second meeting, major improvements to the methodology had been made and it was now suitable for the INTRACOM – demonstrator. After the meetings at FIDIA and INTRACOM, these demonstrators completed their individual analyses. Some further adjustments in the formats and the content of the analyses were made after the pilot-sessions. The developed Business Effect Evaluation Methodology (BEEM) was then implemented as a working methodology together with the cost-benefit and sensitivity methodologies by all the demonstrator owners.

The next two sections present, first, the Business Effect Evaluation Methodology (BEEM), and second, the cost-benefit and sensitivity analyses.

Methodology 1: Business Effect Evaluation Methodology (BEEM)

The Business Effect Evaluation Methodology (BEEM) was inspired by the approach used in Quality Function Deployment (QFD) and the "House of Quality." Yoji Akao (1994) developed QFD, which represents a customer-oriented approach to product development. QFD is useful for ensuring that the organization's strategy and overall requirements are maintained throughout the planning process, just as the voice of the customer is maintained throughout the research and product development process. It is a general approach to analyzing relationships between ends and means. BEEM is a methodology for structuring customer needs, expectations, and requirements, and then translating them into detailed product and process specifications. This methodology can be used for comparing and prioritizing R&D projects. The principles can also be used for a number of other purposes.

BEEM and the steps in the methodology

BEEM has been developed to link the expected effects of PROMISE in the demonstrators to business outcomes and to the businesses' overall objectives. This methodology can also quantify business outcomes and set company-specific targets. BEEM also identifies risks that might prevent a company or project from reaching its goals. BEEM involves a total of six steps. Figure 3.8-1 illustrates the basic BEEM template.

Business outcomes	Weight 1=Low 6=High	Positioning in the market			Appl. target	Score	Weighted score	Risks of not achieving target
		Stay even 1	Significant advance 3	Technology breakthrough 9				
Step 1	Step 2	Step 3			Step 4	Step 5		Step 6

Figure 3.8-1 Template for evaluating business outcomes of PROMISE (Henriksen & Røstad, 2010)

BEEM Step 1: Identification and categorization of Business Outcomes

BEEM represents a "bottom-up approach" where detailed business outcomes are identified and linked to a set of predefined, overall objectives during brainstorming sessions with moderators and the demonstrator owners. Overall objectives are divided into five generic categories, A to E below (examples given under each category are not limited to the list shown):

A. Best Products and Services, Quality:

Value flows to the customer – increase revenues – External view:

- Improve customer efficiency/cost effectiveness
- Differentiate existing products from competitors
- Improve product quality

B. Cost, Profitability:

Value flows to company – reduce costs, increase efficiency – Internal view:

- Reduce company costs