PROMISE Final Activity Report

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Abbreviations:

Abbreviations used in this document:

BOL	*Beginning of Life*
BOM	*Bill of Material*
CRM	*Customer relationship management*
DSS	*Decision Support System*
ECU	*Electronic Control Unit*
ELVs	*End of Life Vehicles*
EOL	*End of Life*
IMDS	*International Material Data System*
MOL	*Middle Of Life*
OBD	*On Board Diary*
OEM	*Original Equipment Manufacturer*
PDKM	*Product Data Knowledge Management*
PEID	*Product Embedded Information Device*
PLM	*Product Lifecycle Management*
PMI	*PROMISE Messaging Interface*
RFID	*Radio Frequency Identification*
SOM	*System Object Model*
TCP/IP	*Transmission Control Protocol/Internet Protocol*
UpnP	*Universal Plug and Play*
WH	*WareHouse*

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1 The Challenge

There is a general desire of many stakeholders in the product supply and value chain (from designers to users and recyclers) to enable the seamless flow, tracing and updating of information about a product, after its delivery to the customer and up to its final destiny (decommissioning, deregistration and EOL) and back to the designer and producer. This is illustrated in the Figure 1 below; where dashed thick lines represent material flow along the product lifecycle including 'recycling' loops, while dotted lines represent information loops.

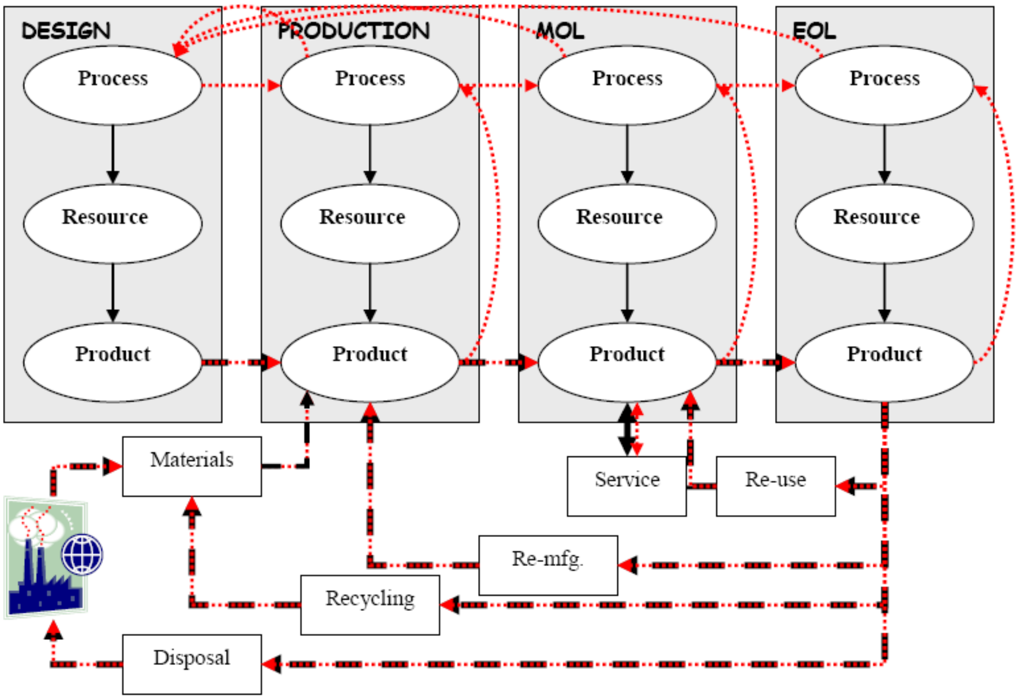

Figure 1 Closing the information loops

The breakthrough challenge for PROMISE was to develop concepts, models, methodologies and technologies allowing information flow management to go beyond the customer, to close the product lifecycle information loops, and to *enable the seamless e-Transformation of Product Lifecycle Information to Knowledge*.

Closing of the product lifecycle information loops has the following consequences:

1. producers can be provided with complete data about the modes of use and conditions of retirement and disposal of their products
2. service and maintenance and recycling experts can be assisted in their work by having:
   - a complete and always up-to-date report about the status of the product
   - real-time assistance and advice through the internet.
3. designers are thus able to exploit expertise and know-how of the other players in the product's lifecycle and thus improve product designs towards product lifecycle quality goals
4. recyclers/reusers are becoming able to obtain accurate information about 'value materials' arriving via EOL routes.

A closed-loop PLM system allows all the actors who play a role during the lifecycle of a product (managers, designers, service and maintenance operators, recyclers, etc.) to track, manage and control

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product information at any phase of its lifecycle (design, manufacturing, MOL and EOL), at any time and any place in the world.

The main elements of the closed-loop PLM concept and requirements are:

- use of smart Product Embedded Information Devices (PEID)
- local (short distance) connection mode for product data and information exchange
- internet (long distance) product information and knowledge retrieval
- data and information flows
- decision support software.

The development of Product Embedded Information Devices (PEID) is expected to progress rapidly and largely used for advanced Product Lifecycle Management and real-time data-monitoring throughout the Product Supply Chain and it will expand greatly and explode into a **multi-billion dollar market**. This technology will particularly allow producers to dramatically increase their capability and capacity to **offer high-quality after-sales services** while, at the same time, being able to **demonstrate responsibility as producers of environmental friendly and sustainable products**.

The above concepts and requirements compose what is referred to as seamless e-transformation of data to information to knowledge.

Figure 2 explains the basic principle of business operations in closed-loop PLM. Although there are a lot of information flows and inter-organisational workflows, the business operations in closed-loop PLM are based on the interactions among three organisations: *PLM agent*, *PLM system*, and *Product*. The PLM agent can gather product lifecycle information from each product at a fast speed with a mobile device like a personal digital assistant or a laptop computer with a Product Embedded Information Device (PEID) reader. The PLM agent sends information gathered at each site (e.g. retail sites, distribution sites and disposal plants) to a PLM system through the internet. The PLM system provides lifecycle information or knowledge created by PLM agents whenever requested by individuals or organisations. The above concept can be used for product lifecycle KM and can be partitioned into three phases: BOL, MOL and EOL.

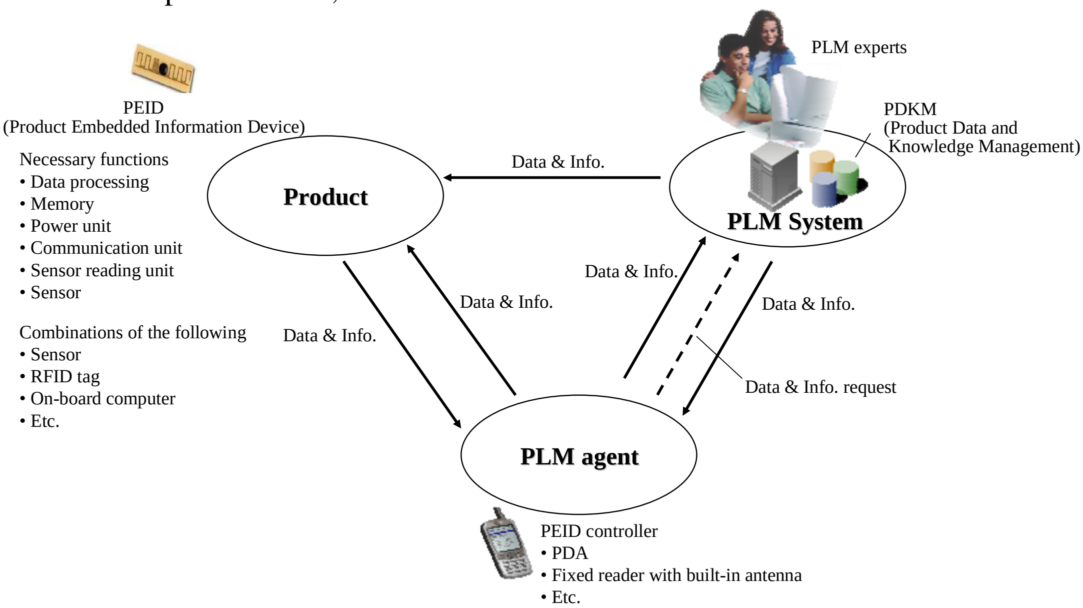

Figure 2: The closed-loop Product Lifecycle Management concept

An additional challenge was to offer a new ambitious business proposition to the Product Lifecycle stakeholders**: to create value by transforming information to knowledge at all phases of the product lifecycle and thus improve product and service quality, efficiency and sustainability**.

The product and service value may be created at various levels, with respect to the above statement, as follows:

Technical: optimal accomplishment of the expected functions and user expressed and unexpressed needs, after exploiting "field" knowledge gathered through the product lifecycle.
Economical: creation of value for the producer (better products, better CRM), for the service provider (new business opportunities, better CRM), for the product owner (extended product life).
Environmental: minimisation of pollution, of resources and of energy consumption by applying optimal BOL (Beginning of Life), MOL (Middle of Life) and EOL (End of Life) planning.
Social: comfort, safety, security and satisfaction of the product user, either the operator of the product (e.g. the driver of a truck) and /or the user of the service (e.g. the passenger of a bus, the user of an elevator, etc.).

2 Addressing the Challenge: the project's proposition

The core concept of PROMISE is that the information generated by Smart Products – products that are able to sense their condition and environment – can be transformed into knowledge that can be used to better support existing products and to create new product and service value.

PROMISE focuses on the complete lifecycle of a product with special emphasis on tracking and managing information during the last two phases of life – the Middle-Of-Life and the End-Of-Life – and how information from these phases can be fed back to the design and production phases of future products, thus closing the product information loops.

PROMISE goes beyond current business models in which the flow of product information stops once the product goes to the customer. In the new business model, the product information loops are closed, enabling the flow of product feedback information (such as information about the use and environment of the product) to the manufacturer and/or operator. With such information available, new products and services, corresponding ever closer to customer needs and desires, can be developed and supported.

The PROMISE project extends existing Smart Product and PLM technologies, making use of industry- and product-specific Product Embedded Information Devices (PEIDs) based on a combination of existing technologies, such as bar-code, RFID transponders and short- as well as long-range wireless communication technologies. PROMISE technologies are being tested in 10 demonstrators in the automotive, railway, heavy vehicle, electronics and white goods sectors.

2.1 The PROMISE System Architecture

The purpose of the PROMISE architecture is to provide a secure infrastructure for the exchange and processing of product lifecycle management data throughout all lifecycle phases, but with a particular emphasis on improving the accessibility and usability of lifecycle data during the middle-of-life (MOL) and end-of-life (EOL) phases.

The PROMISE architecture defines standards, interfaces and components. These allow the creation of a PROMISE implementation in a flexible and reliable manner.

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The PROMISE architecture supports the development of innovative new technology components, yet at the same time allows the integration of existing technologies and systems to form a consolidated infrastructure that creates a flexible medium for the collection, processing and exchange of lifecycle data. It is designed to support and encourage the flow of lifecycle data between multiple enterprises throughout the life of a product and its components.

The figure below gives a conceptual impression of the variety of systems, technologies and products that can participate in PROMISE, and, using PROMISE architecture, interfaces and technologies, can exchange product life cycle data, thus closing the life cycle information loop.

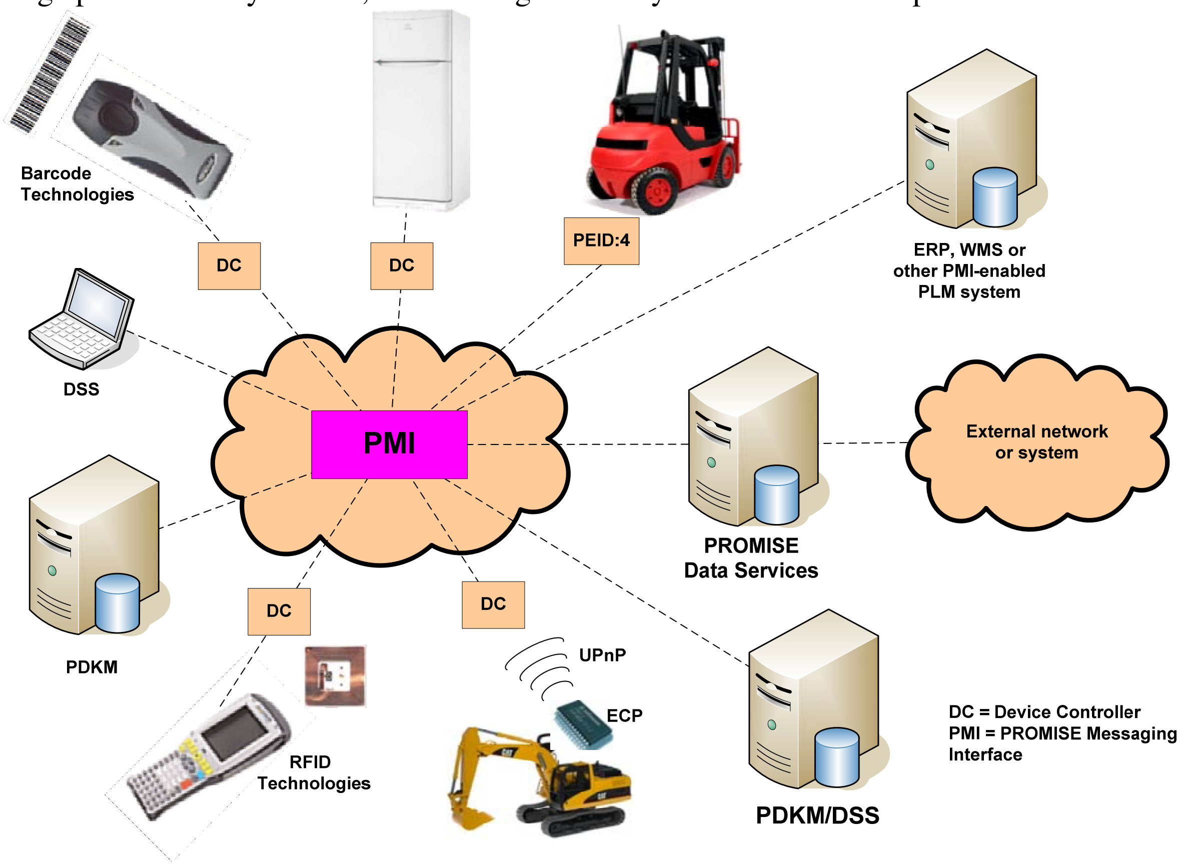

Figure 3: PROMISE Connectivity

In PROMISE, the Internet is the main medium for communication between the different information sources, no matter if they are Product Data and Knowledge Management (PDKM) systems, Decision Support Systems (DSS), Product Embedded Information Devices (PEID) or some other source.

These different information systems can be grouped together under the concept of a "**node**", whose internal implementation is not critical so long as it is capable of communicating using the PROMISE Messaging Interface (PMI). The PMI is a key interface which enables a web-services based approach, permitting any PMI-enabled user to exchange data with another. Depending on the complexity of any specific application, this can be achieved on a simple peer-to-peer basis if the two users are known to each other, or on a more complex wide-area basis using advanced PROMISE Data Services (middleware). The PROMISE connectivity model is similar to that of the Internet itself. Where the Internet uses the *HTTP* protocol for transmitting *HTML*-coded information mainly intended for *human users*, PROMISE uses *PROMISE Messaging Interface (PMI)* for transmitting *XML*-coded information mainly intended for automatic processing by *information systems*. It is important to understand these relationships because PROMISE in effect proposes an extension to the Internet itself.

2.2 *The PROMISE components*

The following representation of the PROMISE architecture, comprising four layers as shown in Figure 4 below, is a convenient way to identify the main components of PROMISE.

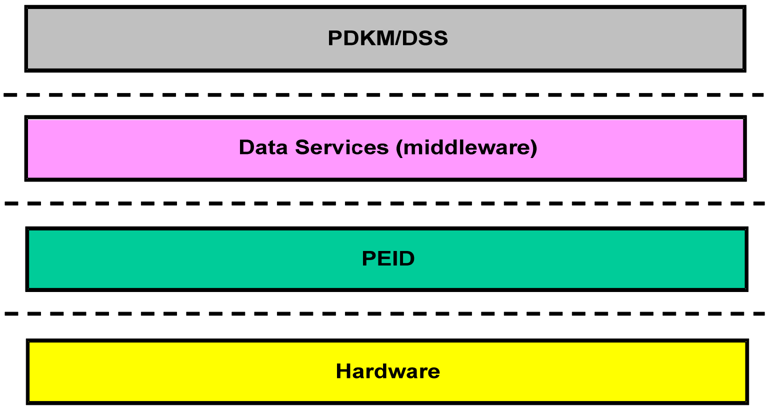

Figure 4: PROMISE components

Each of these layers is introduced in some more detail in the following paragraphs and sections of this document, and in full detail in the appropriate PROMISE Architecture Series volume:

1. The hardware layer represents identification technologies, sensors and other data collection mechanisms on the product which are accessed via the PEID.
2. The PROMISE PEID represents a product's embedded <u>information</u> device, which may be either a physical or logical device implementation.
3. PROMISE Data Services (middleware) can provide a variety of services such as subscription, buffering, aggregation and filtering, and support discovery services, which permit PROMISE users to make simple product data requests independently of the product's whereabouts.
4. The PROMISE PDKM/DSS represents the most important back-end system in a PROMISE implementation. It is often represented as a single entity, but may also be implemented as separate, distributed components depending on the needs of any individual application.

2.3 *The PROMISE demonstrators*

In PROMISE, 20 partners from 9 European countries have participated in industrial applications from various sectors such as railway, heavy construction equipment, automotive, brown goods, and white goods. Table 1 below shows the PROMISE demonstrators:

Table 1: PROMISE demonstrators

Demonstrators	Main focus	Partner
A1: Monitoring End of Life Vehicles	EOL	CRF
A2: Heavy load vehicle decommissioning	EOL	CATERPILLAR
A3: Tracking and tracing of products for recycling	EOL	BIBA/INDYON
A4: Predictive maintenance for trucks	MOL	CRF
A5: Heavy vehicle lifespan estimation	MOL	CATERPILLAR
A6: Predictive maintenance for machine tools	MOL	FIDIA
A8: Predictive maintenance for EEE	MOL	INDESIT
A9: Predictive maintenance for Telecom equipment	MOL	INTRACOM
A10: Design for X	BOL	BT-LOC
A11: Adaptive Production	BOL	POLIMI

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2.4 The PROMISE standards

As a result of the research and development undertaken during the PROMISE project, two candidates for standards submission have been identified:

1. The PROMISE Messaging Interface, or PMI, and
2. The PROMISE Product Data and Knowledge Management (PDKM) System Object Model (SOM).

3 Who can benefit from PROMISE

Closing the information loop creates benefits for many participants in the product lifecycle:

- Customers get better products and services
- Manufacturers get more information about the conditions and modes of product use and disposal
- Service engineers get up-to-date information about the status of the product and its parts
- Product developers use real-life experience with previous products to improve future products, reduce over-engineering and achieve lifecycle quality goals
- Recyclers get complete information about the EOL value of products, parts and materials

New services and improvements made possible with PROMISE include:

- Innovative products and services that go far beyond competitor offerings, and are difficult for less-skilled competitors to copy
- Improved customer relationship management based on up-to-date real-life product data
- Simplified product authentication, enhancement of product and user security and safety
- New types of product leasing and insurance services
- Improved maintenance and service at reduced cost

4 Highlights of Achievements

This section provides:

- an overview of the general project mission and objectives,
- shows the project's current relation to the state-of-the-art and
- highlights the major project achievements

4.1 Overview of the general project mission and objectives

Mission: PROMISE develops technology and business models enabling and exploiting the seamless flow of product information throughout the entire product lifecycle. This will allow for a closed-loop information flow starting from product design and production, to the tracing and updating of product information after its delivery to the customer, up to its final destiny and back to the designer and producer. The technology to be developed for such a closed-loop information flow comprises novel product lifecycle models, Product Embedded Information Devices (PEIDs) with associated firmware and software components, middleware solutions for collecting and aggregating the data from PEIDs, and tools for decision making based on data gathered through a product lifecycle.

General objectives*:* In order to implement its mission, the PROMISE consortium has agreed upon four main objectives:

- Develop new closed-loop life cycle information flow models for Beginning-Of-Life (BOL), Middle-of-Life (MOL) and End-Of-Life (EOL)
- Develop new PLM system and IT infrastructure exploiting the capabilities of smart product embedded information devices

- Develop new standards to allow the technologies and associated tools to be developed by the PROMISE to be accepted by the market
- Develop new working and business models appropriate for the use and exploitation of the new technologies and tools

4.2 Project's current relation to the state-of-the-art

The PROMISE developments are going beyond state-of-the-art in several respects. This may be observed in the following areas:

- **Information flow models**: We have successfully used industry approved modelling methods and tools and produced models for all PROMISE elements, including the complete design of the PROMISE demonstrators. These models are new and innovative and improve the state of the art in that direction. A number of PROMISE publications demonstrate the quality of the produced models.
- **PLM system and IT infrastructure**: a new IT infrastructure has been developed in terms of middleware for PLM. The followed approach is totally new as it is demonstrated in the produced publications.
- **Business models**: though it is difficult for the industrial PROMISE partners to assess and evaluate the business benefits of the innovative PROMISE technologies, the closer we go towards the implementation of the demonstrators, new business opportunities become clearer. This is reflected in the so far produced business models.

PROMISE has for the first time developed an integrated solution comprising elements of all of the above areas. PROMISE has implemented its solutions in 10 real-world demonstrators covering a broad range of industrial domains (automotive, railway industry, white goods, brown goods, etc).

4.3 Main achievements

PROMISE provides a **Closed-loop Product Lifecycle Management**, which is a new generation of PLM systems that use smart embedded IT systems which allow the seamless flow and transformation of data and information to knowledge (see figure 5).

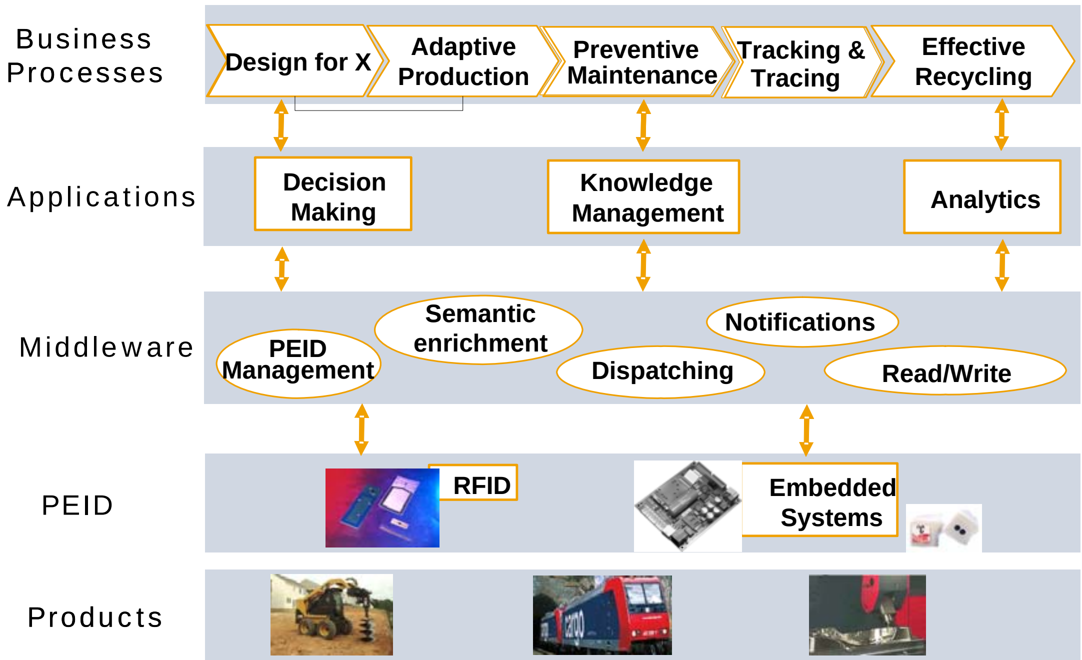

Figure 5: Overview of PROMISE PLM Architecture

The main achievements and work performed to fulfil the objectives have been:

- Consolidated lifecycle models of all demonstrators have been developed and evaluated.
- A PEID core prototype has been implemented.
- Algorithms for transformation of data to information to knowledge have been implemented and integrated in corresponding decision support systems. A number of them are already integrated with the PDKM prototype.
- Implemented object model for management of product item instances and respective field data.
- Running PDKM prototype with basic functions for management and visualization of product item instances and respective field data
- Methods and software tool for the import of heterogeneous field data
- The concept and architecture of the PROMISE Middleware has been developed and implemented in a prototype.
- As further important steps towards the PROMISE's vision of closing information loop, a comprehensive strategy has been developed and work has been initiated accordingly to integrate and deploy the various PROMISE technologies (PEID, Middleware, PDKM, DSS) in real-world application scenarios.
- Requirements analysis and real data evaluation
- Modelling and system framework for evaluation of quality degradation
- Reliability design method based on evaluation of quality degradation
- Maintenance planning for life-cycle management
- Product lifecycle management using feedback of operational information

- A realistic strategy on standards development has been implemented and contacts initiated with the OpenGroup initiative and the ISO relevant STEP committees.

- Development of 10 industrial demonstrators focusing on BOL, MOL and EOL in different industrial domains (automotive, railway industry, tool manufacturing, white goods, brown goods, IT industry etc) have been developed as shown in Table 1.

- Development of 9 training courses consisting of totally 63 modules as shown in the following table and available at: http://training.promise.no/training/.

Table 2: PROMISE training modules

Course	Deliverer	Number of modules	Public availability
TC 1: PROMISE Technologies at System level	SINTEF	8	● (green)
TC 2: PROMISE DSS Technology	Cognidata	3	● (green)
TC 3: PROMISE PDKM Technology	InMediasP	2	● (green)
TC 4: PROMISE PEID Technology	Cambridge	7	● (yellow)
TC 5: PROMISE Middleware Technology	HUT	3	● (green)
BC 1: Business course on whole lifecycle	EPFL	7	● (green)
BC 2: Business course on BOL Phase	POLIMI	5	● (green)
BC 3: Business course on MOL Phase	BIBA	11	● (yellow)
BC 4: Business course on EOL Phase	CIMRU	10	● (yellow)

● (green) *fully available* ● (yellow) *partially available*

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Promise Innovation International Ltd.

The commercial company "PROMISE Innovation International Ltd." is founded to provide PROMISE technologies to a broad industrial community. Promise Innovation will deliver services and products related to the gathering of lifecycle information and decision support functionality by closing the information loop and communicating across all phases of life. Promise Innovation International Ltd. will guide and assist its clients to develop products and business processes which benefit their industry, customers and the environment.

4.4 International IMS cooperation

PROMISE was also organised as an IMS project with partners from six IMS regions:

- European Union (EU)
- Switzerland (CH)
- USA (US)
- Japan (JP)
- Australia (AUS)
- South Korea (ROK)

Consortia of partners in the above regions run five complementary projects that are funded and locally coordinated at a regional level according to corresponding management structures of each region. The collaboration schema of the PROMISE consortium may be illustrated as in the following Figure 6. This schema reflects the main technical work:

- "DFX implementation" corresponds to the main research activity of the CH partners
- "Logistics/Decision Making, Information Modeling and Management, PEID Technology" corresponds to the main research activity of the EU partners
- "MOL implementation" corresponds to the main research activity of the US partners
- "EOL implementation" corresponds to the main research activity of the AUS partners
- "MOL & EOL implementation" corresponds to the main research activity of the ROK partners
- "Modelling and Simulation" corresponds to the main research activity of the JP partners
- "Requirements and Specifications, Test cases and scenarios" correspond to all regions

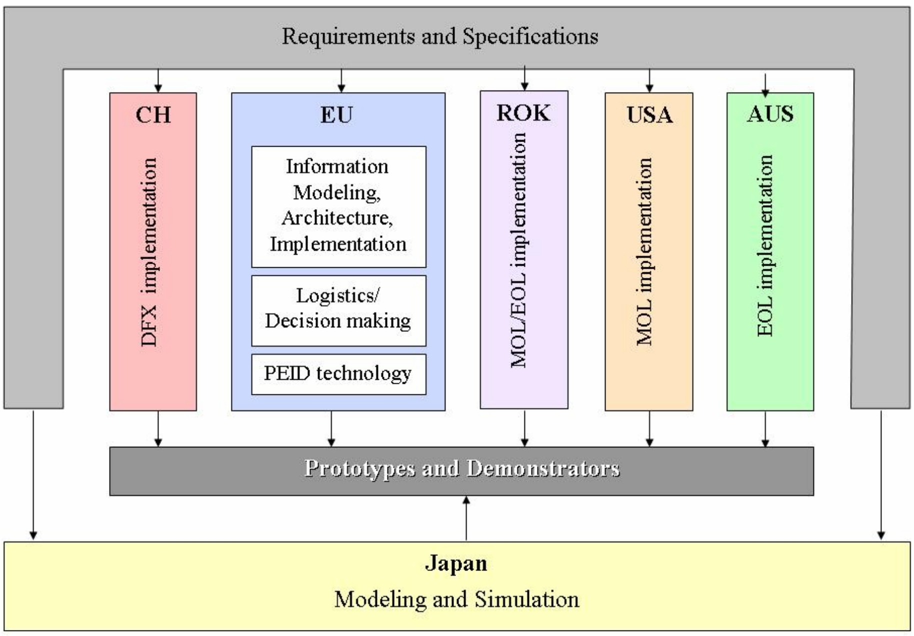

Figure 6: Co-operation between regions

5 The results

The PROMISE components presented in Figure 4 above are described in sections 5.1 to 5.3 below.

5.1 Product Embedded Information Device (PEID)

The primary purpose of the Product Embedded INFORMATION Device (PEID) is to be the link between a product/article/machine/component and its electronic representation in an information system.

As a minimum, it is responsible for uniquely identifying a product or component of a product. In the case of a very simple product, or even a complex product having a requirement for a very high level of security or confidentiality, the PEID may contain only the GUID (Globally Unique ID) of the product.

More commonly, the PEID also provides a means to collect information from the product/component and its environment, either directly or via reference to a backend system. This information may remain on the PEID throughout the lifetime of the product to which it applies. In most cases, some or all of that information may also be transferred to one or more back-end systems. Individual application requirements determine whether information should be kept only on the PEID, only in the back-end systems, or a combination of both.

As the PEID may not be connected to the backend system all the time, it may provide means of local information storage, until the information can be relayed to the backend system at a later point in time.

The communication with the backend system can either be directly from the PEID or via a PEID reader (Device Controller). This depends to a large extent on the computing power and facilities of the hardware upon which the specific PEID implementation is based.

PEIDs are based on available sensor and communication technologies. They are attached to or are an integral part of various types of products, ranging from small electronic articles to larger items like cars or other heavy vehicles.

Their main task is to sense, capture and save data about the use and maintenance of associated products. If a PEID does not have sufficient computation capacity for implementing the PMI, then it can join the network through a proxy device, such as a DC.

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5.1.1 The PROMISE Core PAC

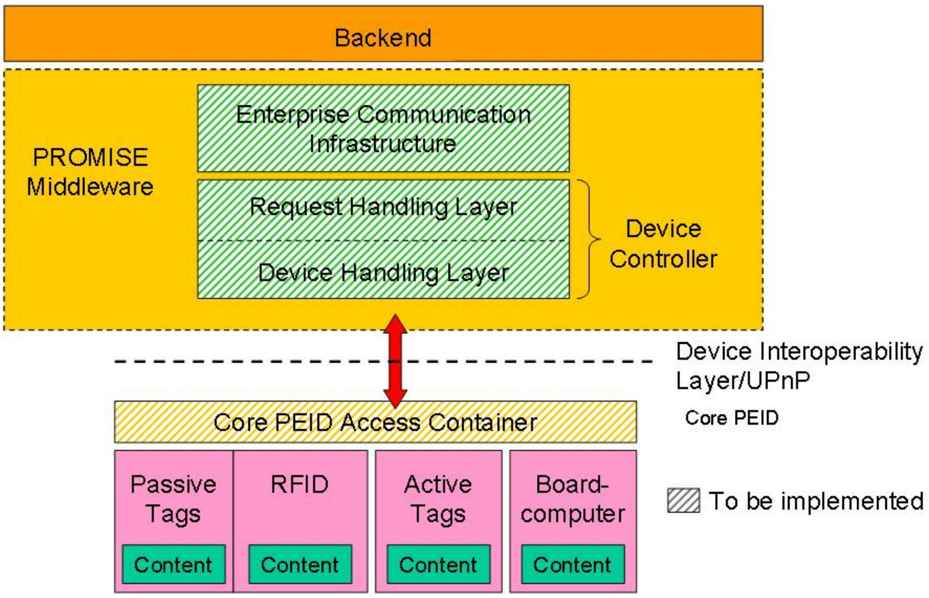

Figure 7: PROMISE Core PAC component relationship

Figure 7 shows the relationship of the Core PAC to other components in the PROMISE architecture. The Core PAC is an interface between the device layer and PROMISE Data Services (middleware). Depending on the specific PROMISE Data Services implementation, the Request Handling Layer (RHL) and the Device Handling Layer (DHL) may be either closely or loosely coupled.

5.1.2 Definitions

Core PEID: The Core PEID is an identification, data collection and storage system that is, at least partially, attached to a product to provide lifecycle monitoring and management. Note that the Core PEID does not provide information to the backend directly. Data is communicated to the backend application via the Core PAC that may contain one or more Core PEIDs.

In order to make the concept of the Core PEID clearer, let us consider some PEID examples that represent Core PEID functionality:

1. a stress sensor that monitors a bearing in a drilling machine may be a Core PEID since it can measure and convey data about the current status of the machine. That data can then be used to predict required maintenance tasks.
2. an RFID reader which can read the passive RFID tag attached to the drilling machine's chassis may be a Core PEID since from the RFID tag's content we can identify the machine's serial number.

Using the data from the stress sensor together with the serial number of the drilling machine, a decision can be made when to replace the bearing and also identify the correct part.

The data may be retrieved from a wide variety of products, ranging from small electronic articles to large, complex items like cars, locomotives etc. Owing to the environmental conditions in which different products operate, as well as variations in product lifecycle, cost and industry specific management requirements, it is not anticipated that a single overall Core PEID design suits all specific requirements.

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Content: Content is the data that is collected by or stored on the Core PEID. Its format and semantics varies widely for different application cases. The definitions below define access mechanisms on the Core PEID that are independent of the format and semantics of the content, so that these issues are only addressed on the application level in the backend layer and tunnelled through the lower layers.

Device Interoperability Layer: The Device Interoperability Layer provides the mechanism by which devices can be automatically discovered by the backend layer. It supports the description of the device's functionalities, and provides communication mechanisms that allow it to convey and receive the content to and from the backend layer in a service-oriented, standardized, and uniform way.

Core PEID Access Container (Core PAC): The Core PAC is a functional representation of a collection of Core PEIDS. The Core PAC provides networking functionality to communicate with the backend via the PROMISE Data Services (middleware) layer, and implements a Device Interoperability Layer that must be supported be the Device Controller (DC) in the middleware layer. In this way, the Core PAC hides the Core PEID's specific implementation allowing uniform access from the backend layers. Note that neither the semantics nor the format of the content is addressed by the Core PAC definition. The PEID must support different hardware platforms and PEID architectures, e.g. RFID readers, passive or active RFID tags, sensors, or tags with some computing power. The Core PAC interface is based on existing standards, and its implementation is language and platform independent. The Core PAC defines the set of functionalities that allows access to one or more PEIDs. The Core PAC contains methods to access unique product identification, and the content of one or more PEIDs in a key/value fashion, methods to store content on one or more Core PEIDs, or security features like access control on the content or parts of the content of a Core PEID collection.

Application Specific PEID: The Application Specific PEID extends the Core PEID by a PEID specific interface. Access on data is not limited to key-content compositions, but the Application Specific PEID may provide a semantic method interface to read or write portions of the content of the PEID. Further, it may provide a semantic method interface for functionalities that are not addressable from the Core PEID and thereby extend the Core PEID. The binding of a Core PEID with its Application Specific PEID(s) is static. It is conveyed by an appropriate semantic method of the Core PEID. Note that the Application Specific PEID may define the format and the semantics of portions of content of the PEID. Let us try to provide an instructive example. Consider for instance the RFID-based Core PEID described above. Usually, RFID readers offer several options how they are configured. This is entirely irrelevant to PROMISE Data Services, but reader configuration is important in practice. The way how this issue is solved in PROMISE is that reader configuration methods are implemented by an Application Specific PEID of the PEID, which is addressed from an RFID reader maintenance program. The configuration methods usually differ from one RFID reader manufacturer to another, so that the implementation of the maintenance program depends on the RFID reader that is actually used. Since PROMISE Data Services uses the Core PEID's functionalities, Core PEID-specific implementation issues are therefore hidden to PROMISE Data Services. Let us consider the stress sensor as a second example. Here, the Core PEID provides content on a key-value basis, without necessarily providing the semantics of the sensor readings. This may or may not be desired by PROMISE Data Services. An Application Specific PEID grants access to the sensor readings in a semantic way by offering services like *getTemperature*, *getTemperatureSeries*, or *getAverageTemperature*.

The semantics of the Core PAC Interface are described in detail in a companion volume of this PROMISE Architecture Series, Volume 2: Architecture Reference: PROMISE Core PAC Interface.

5.1.3 PROMISE PEID Grouping

Five PEID groups have been defined, which include all PEID types which can be found in the PROMISE demonstrators, and will be just as applicable to other future application scenarios. These groups are as follows:

Type 0 PEID: Identifier-only PEID. The PEID contains only a GUID (Globally Unique ID) that is usually of write-once-read-many (WORM) type. Examples include barcode, RFID tag or any information device for which only the GUID is accessible, no matter how "computationally powerful" the PEID is.

Type 1 PEID: Only identifier and data storage capabilities, no computation capabilities. Data storage may also be re-writable. Examples: barcode and passive RFID tag with data contents in addition to GUID. Intermittent network connectivity through proxy device (e.g. barcode reader, RFID tag-reader)

Type 2 PEID: Limited computation power; possibly including sensors and other "measuring" capabilities. Wireless network connectivity when "in range". Examples: Sindrion®[1] based PEID, active RFID, WiFi-enabled devices etc.

Type 3 PEID: Medium-level computation power, sensor connectivity, data processing power. Wireless network connectivity when "in range". Example: vehicle ECUs, embedded controllers in general. UPnP is a good option for these, but for some it might be simpler to embed the PROMISE Data Services (middleware) connectivity.

Type 4 PEID: PEIDs with "sufficient" computation power e.g. for implementing "client" connectivity to PROMISE Data Services (middleware) Web Services or even implementing the full service. The Type 4 PEID applies typically where the product has an on-board computer of sufficient power and functionality to support an Internet network connection, which may be either a persistent or an on-demand connection, and the flexibility to imbed the necessary PROMISE Data Services (middleware) support.

Additional information on implementation of a PEID, including choice of the type of PEID, packaging and technologies, may be found in a companion volume of this PROMISE Architecture Series, Volume 6: Developer's Guide: PROMISE Product Embedded Information Device (PEID).

5.2 PROMISE Data Services

PROMISE Data Services is the name given to the middleware component of the PROMISE architecture that connects together the different systems in a PROMISE infrastructure, and provides the means for communicating and gathering product data.

PROMISE Data Services integrates PEIDs with applications such as PDKM systems and other backend systems *and* integrates different PROMISE systems with each other permitting data exchange related to the different life cycle phases, BOL, MOL and EOL.

PROMISE Data Services handles tasks such as:

- Location of correct data sources; for example, where will a PEID connect next time or in which PDKM system is the data stored?

[1] Sindrion is a registered trade mark of Infineon Technologies AG.

* Buffering and aggregating requests; for example, one request from the PDKM may be split into several requests destined for several different nodes, and then aggregated back into a single response.
* Device management
* Integrating proprietary Device Controllers (DC) and PEID communication methods
* Locating metadata
* Event communication; such as PLM events, alarm events, etc.

A PROMISE Data Services implementation is logically divided into two parts as shown in Figure 8 below.

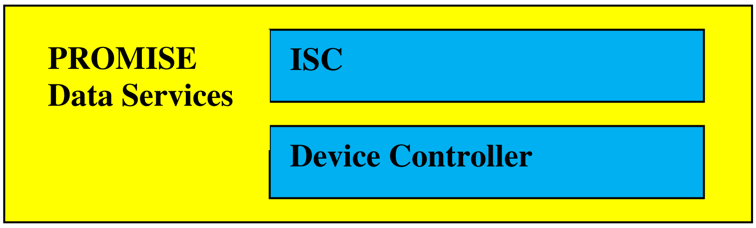

Figure 8: Simplified PROMISE Data Services internal structure

The so-called lower layer, the Device Controller (DC), handles the hardware interface towards readers, PEIDs and other ID devices such as RFID.

The upper layer, Inter-System Communication (ISC), connects different DCs, back-end systems, PDKM systems, Field Databases, etc., and handles the communication between these systems. The term back-end system should be understood as a vast definition varying from a standalone workstation to a distributed environment consisting of several information providers across different companies.

A PROMISE Data Services implementation may consist of an ISC network connecting several DCs, PDKM systems, Field Databases, etc., or in its simplest form, can consist of only one DC. The implementation requirements are highly dependent on the application. Therefore we have designed a flexible and adoptable architecture.

The complexities of a PROMISE Data Services implementation are hidden from connected systems using a common data services interface. The PROMISE Data Services interfaces to back-end applications using information requests regarding the product data and PEID hardware.

The same PROMISE data services interface may be used for communication between the ISC and DC layers. This makes it possible to combine different ISC and DC implementations.

Some PROMISE Data Services implementations may integrate both the ISC and DC functionality. In this case the interface between ISC and DC may be any internal interface suitable for the system in question. ISC and DC might also be combined in one system so no clear interface would exist.

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5.3 *PROMISE PDKM/DSS*

The PROMISE PDKM/DSS is a very important component of the overall PROMISE product lifecycle management (PLM) system. It must incorporate data from several different software systems, e.g. legacy CAD, CRM and/or SCM systems as part of a company's IT infrastructure. Consequently if data from these systems is required for generating specific decision support information, it should be made available through the PDKM system.

The PDKM system aims to systematically integrate and manage data from all product lifecycle phases. The ultimate goal is to integrate product data throughout the entire lifecycle from different sources, to support comprehensive analysis on such data so enabling the enhancement of operational businesses through the more detailed insight on products thus obtained.

A simple structural view of the PROMISE PLM system is shown in Figure 9 below. This diagram shows that the PROMISE PLM system consists of different subsystems and that the DSS is an integral part of the PDKM system. The dots imply that there are also other subsystems that are not considered here.

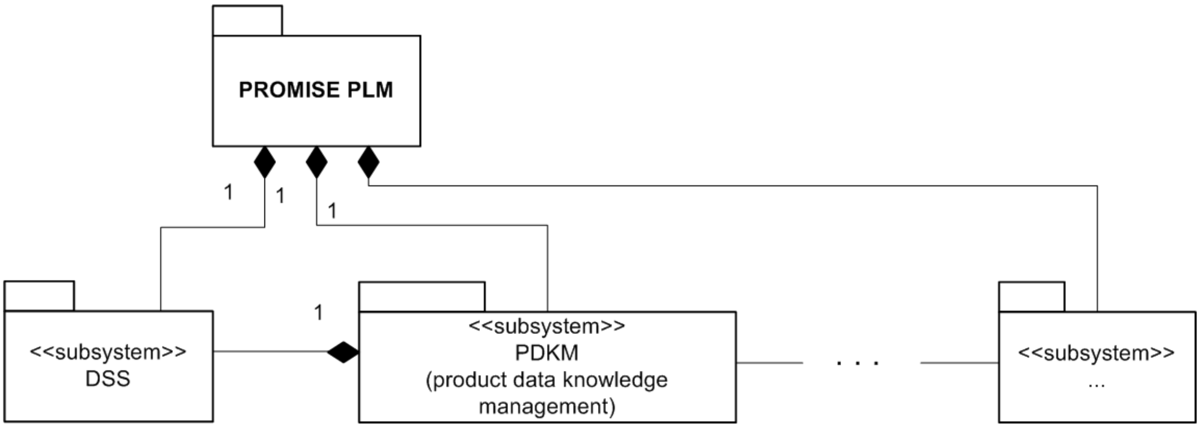

Figure 9: PROMISE PLM system aggregates different IT systems

In practice the PROMISE PDKM/DSS may be implemented as two separate, communicating components, but there can be a significant performance advantage if the two are closely-coupled. Nevertheless, the PROMISE architecture permits both closely-coupled and distributed implementations of the PDKM and DSS according to the requirements of specific applications.

PDKM: The Product Data and Knowledge Management system (PDKM) manages data from all lifecycle phases of products, in particular, from design, development, production, through use and maintenance, to recycling, and finally, end of life, to support comprehensive data analysis in business intelligence applications. Its main functions are decision support, knowledge management and data-analytics.

DSS: Decision Support System utilizes data from the PDKM for making decisions related to the product's different life cycles, BOL, MOL and EOL. A closely coupled DSS has access to the databases of the PDKM, and is thereby able to access and process the large amounts of information stored in the PDKM. A loosely coupled DSS can access the PDKM system through a PMI interface provided by the PDKM. A loosely coupled DSS does not have same easy access to all information as a closely coupled DSS, but loosely coupled DSS systems can be placed out in the field close to the PEIDs for service and maintenance applications or be distributed between different nodes.

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5.3.1 General System Object Model (Semantic model of the PDKM)

In this section, the General System Object Model of the PDKM system is outlined.
Then an overview on the main classes and the relations among them is given as a first guidance.

5.3.1.1 Important notes on the modelling criteria adopted

The semantic model of the PDKM system presented here provides a conceptual view of the system, by representing the main concepts belonging to the domain of interest. These concepts are in a natural correspondence with the rest of the PDKM system and with the way all of them are implemented. The model was designed with the aim of providing the PDKM system with a basis for representing product data throughout the whole product life cycle. The focus is more on data modelling than on complete software systems modelling.

In the Semantic Object Model presented in the following, particular importance was given to the representation of the information whose loops across the product's life have to be closed by the PROMISE project in the different application scenarios. This required a proper modelling activity for the information one wants to be attached to each product instance, or even product components and subassembly instances where requested, by means of smart product embedded devices. A certain degree of abstraction was required in order to make the model capable of representing the different needs coming from the whole set of PROMISE application scenarios. Considerable importance was given to the pieces of information describing each of the product life cycle phases, such that the PDKM system is able to manage data and knowledge in the way required by each application scenario. The pieces of information concerning product types, rather than those concerning product instances, are also included, even if they do not represent the main focus here.

Another key aspect of the Semantic Object Model is that it describes field data, relating them to the different life cycle phases where they are first collected and then analyzed. To develop this portion of the model some abstraction was required, again in order to be compliant with the different needs of the different PROMISE scenarios.

The model is explicitly object-oriented, by this following today's most used paradigm for software development. UML, an important standard language for graphical modelling purposes was chosen and used, thus also following the general tendencies in the PROMISE project. The model is compliant with version 2.0 of the standard.

Since the Semantic Object Model only contains the static view on the PDKM system, the UML Class Diagram was chosen as the main UML tool to be used in the modelling activity. The focus is on the classes building up the model, as well as on the attributes describing their main features. Associations among classes are used, as well as the generalization construct. Sometimes associations are described as compositions to show where complex objects (e.g. more complex products) are built out of components and subassemblies, for which information must be stored and managed. Some other constructs, such as the aggregation, have intentionally not been used, since the object community has not reached a common agreement on its meaning and utility yet, despite of the fact that aggregation is sometimes widely used (but with different meanings). Therefore, instead of aggregations, normal associations have been used.

Cardinalities of associations and attributes are shown, while only some generic reference is reported on data types corresponding to the defined attributes. For instance, when an attribute refers to the date and time a certain event on the product has occurred, e.g. the date and time when the clutch of a car broke, it is stated that the attribute is of type "Date" even if "timestamp" would be more appropriate. The "Boolean" data type is also indicated, as well as some other data types.

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5.3.2 Class Diagram of the Semantic Model: an overview on classes and associations among them

A first insight into the Semantic Object Model can be given as follows (Figure 10). Regarding the viewpoints cited in the previous section, two main groups can be recognised in the whole model:

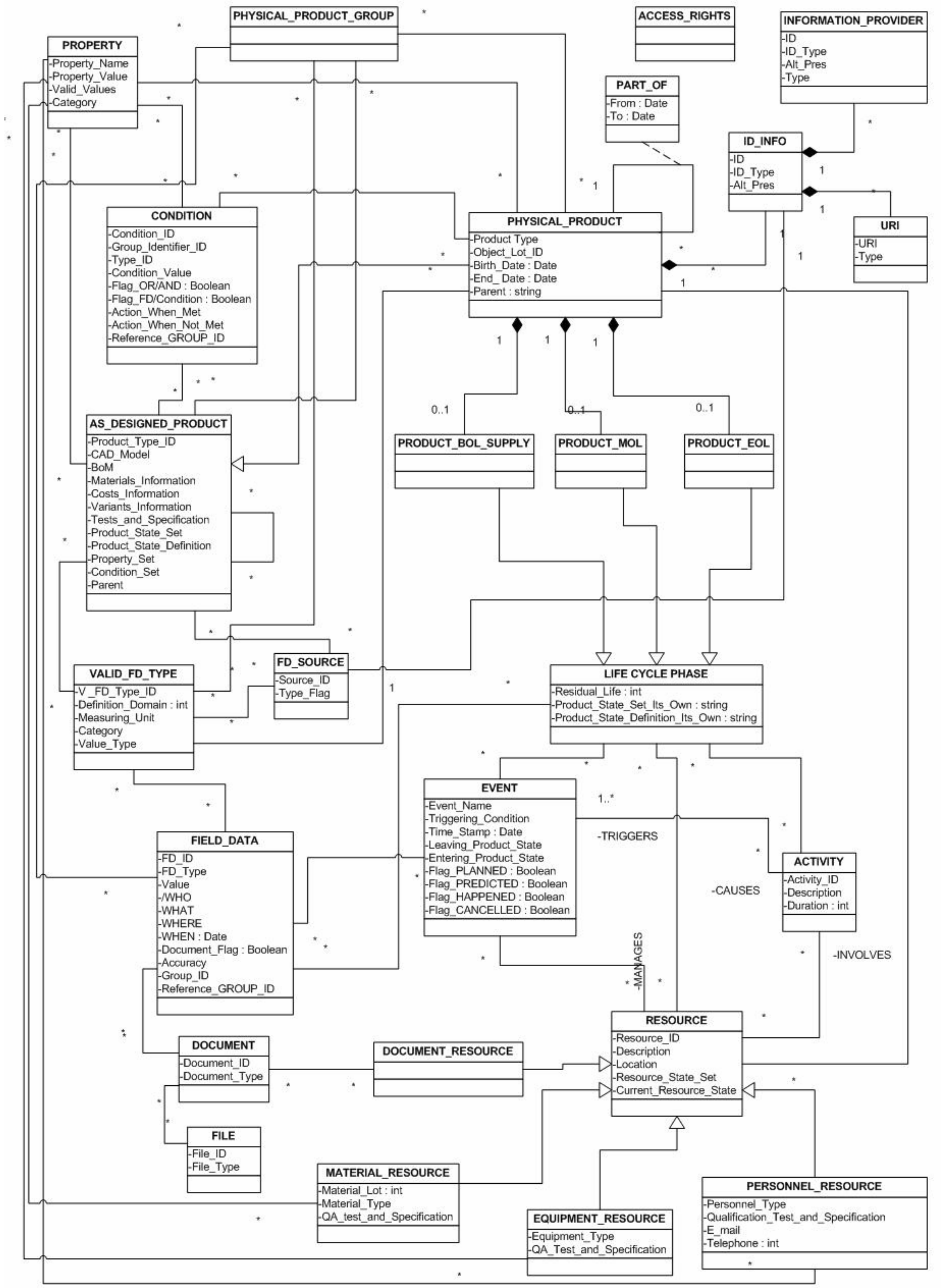

Figure 10: Complete schema of the semantic object model

- A first group comprises the basic pieces of information on each product instance, whose information loops the PROMISE end-user wants to be closed, when making use of the technologies developed by the PROMISE project. These pieces of information reveal some important information such as the serial number of the product instance, the product type to which it belongs, the product structure of the product if needed, the main properties valid for the product instances, the conditions to be checked on them, etc. In addition, this area also describes the product as a product type. The product type is closely related to the other elements in this area of the diagram, as stated by many associations, and models pieces of information such as the different BOL structures, properties and conditions applicable to the different product types etc.
- A second group models the pieces of information connected to the different life cycle phases in which the PROMISE end-user is interested. This enables the description of the main events out of which a certain life cycle phase is composed (i.e. product failures or breakdowns, etc.), of the PROMISE end-user's resources involved in that life cycle phase (i.e. the designer, the production manager, etc.), and also the activities performed by these resources in that life cycle phase (e.g. dismantling of a car's components, maintenance of a truck, etc.). Besides that, an important portion of this area is dedicated to the representation of field data, one of the crucial elements in PROMISE.

5.3.3 The PROMISE Decision Support System (DSS)

In this part of the document, the architecture for the PROMISE Decision Support System (DSS) is presented. Because the DSS has to cover a large set of applications, the architecture must be as generic as possible. It locates the needed functionality in corresponding components and describes the decision processes. The design is structured as follows:

1. Identification and description of use cases
2. System architecture
3. Subsequent steps

5.3.3.1 Description of use cases

In this part we explain the process steps which a user executes when he/she is using the DSS for a particular purpose, e.g. diagnosing the product or analyzing the current state of the product etc.
Following the objectives of PROMISE, the decision support system is going to deliver support in various product development fields such as

- decision support for Design for X
- product diagnostics
- predictive maintenance
- decision support for product decommissioning
- production planning and operation

Driven by the eleven application scenarios of PROMISE, the DSS must implement different modules for industries with different purposes. The modular architecture of the DSS allows an easy inclusion of modules that are going to solve different analytical tasks for different applications. A generic use case for DSS can be described as shown in Figure 11.

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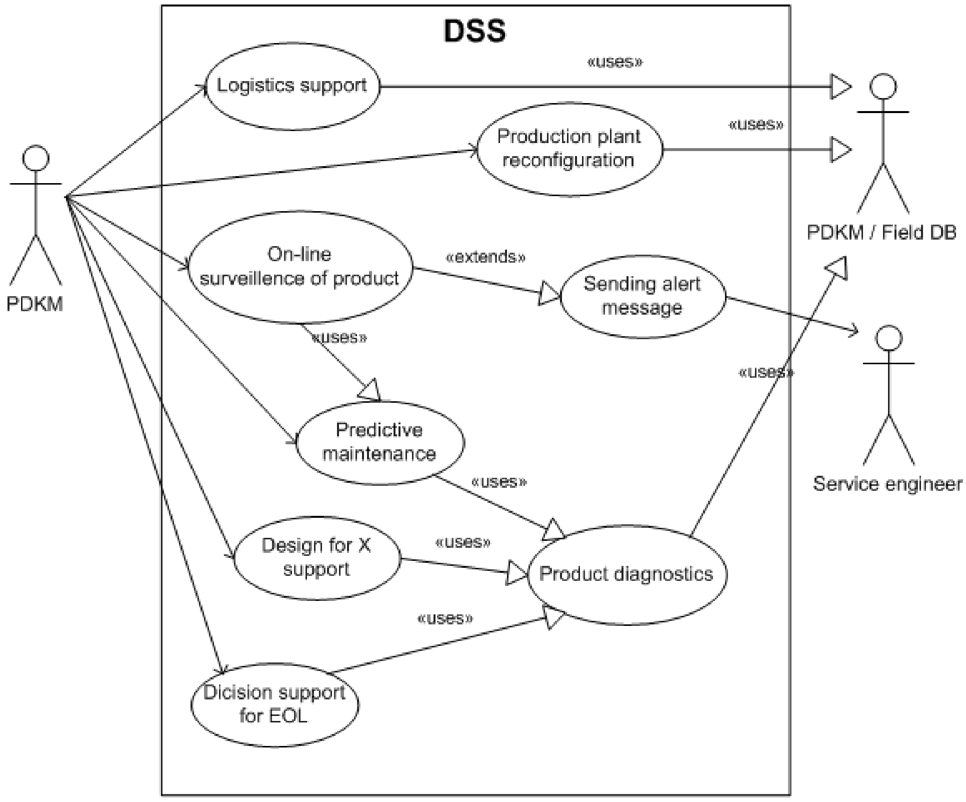

Figure 11: Generic use case diagram of DSS

PDKM is the Product Data and Knowledge Management System of PROMISE described in volume 4 of the PROMISE Architecture series.

To summarize, we can say that the decision support system has been used for

- Service
- Feedback to BOL (identifying repetitive problems that will lead to product improvements)
- Production plant configuration decisions
- Preventive and predictive maintenance
- Decision for product performance degradation
- Technical support (best practices, symptoms, problem, solution)
- EOL dismantling decisions
- Logistics problem solving

For specific applications, the generic use case was split into more detailed use cases. This was done for each application.

5.3.3.2 DSS system architecture

The PROMISE product lifecycle management (PLM) system incorporates different software systems, e.g. legacy CAD, CRM and/or SCM systems as part of a company's IT infrastructure. Consequently if data from these systems is required for generating specific decision support information, it principally is available through the PDKM system.

PLM is an approach to manage the product related information efficiently over the whole product lifecycle. A PLM system aims to move beyond engineering aspects of products and provides a shared platform for creation, organization, and dissemination of product related knowledge across the extended enterprise.

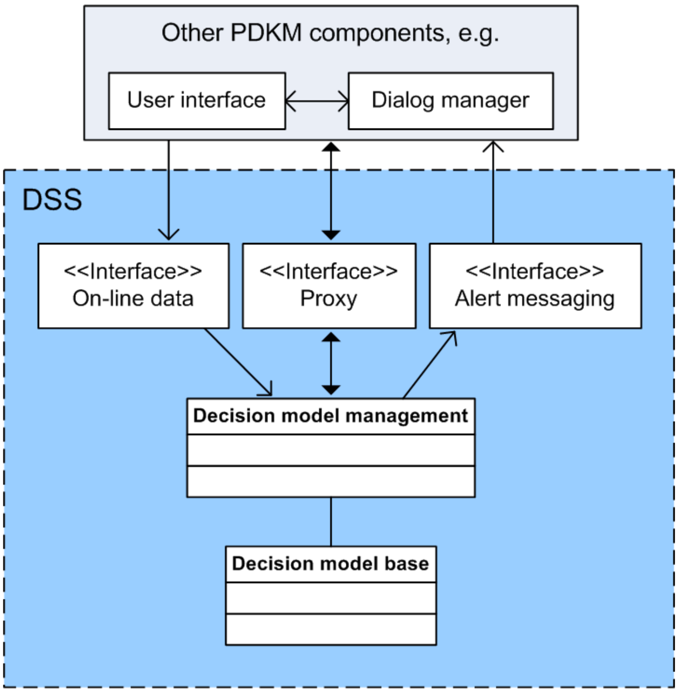

Figure 12: Generic DSS architecture

The modular architecture of the PROMISE DSS system is shown in Figure 112. This diagram shows a strongly simplified view of the system, but it illustrates that there are some dependencies between the DSS and the PDKM. That is because the realizations of the generic analysis methods and analysis strategies used in DSS are strongly coupled to the kind of data to be analysed and the special kind of decision support requested. The dependency becomes clearer further down where *connectors* are described.

Web service standards have been used as a way of communication, since they offer great flexibility and are independent of specific languages and platforms.

The *Proxy* object acts as request dispatcher. It receives different decision requests concerning different products and life cycle phases. It passes the request on to the *Decision model management* that takes over the control during the following analysis process. Wrong or not satisfiable requests are identified and an appropriate message is sent back the user. According to the request which contains information about the decision problem, the *Decision model management* chooses the appropriate analysis strategies from the *Decision model base*. The *Decision model base* can be thought of as a repository of analysis strategies including the algorithms for computing the required decision support. There are two interface objects for life-monitoring purposes of a product. They handle incoming real-time data of products and alert messaging functions for end users.

As stated previously, the *Dialog manager* controls the user interface so that the results are presented in a way appropriate to the maintained product and the goal of DSS employment. In standalone decision support systems, such a dialog manager is part of the DSS, but in the PROMISE context the user interaction is done through the PDKM, so that PDKM presents the requested DSS results to the user and thus does not need to be modelled in this document.

Figure 13 shows the modular nature of the *Decision model base* that can be divided into three components holding BOL, MOL and EOL strategies for decision making. Each part can be easily extended without disturbing the old functionality.

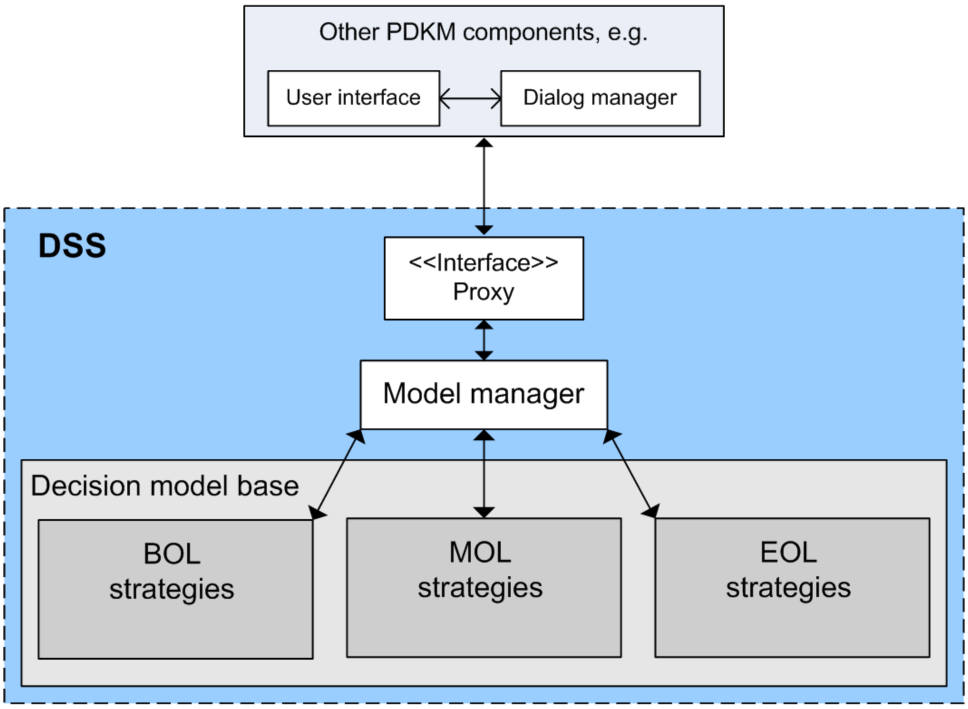

Figure 13: Modular Decision model base architecture

At this point, we want to mention that it is quite imaginable that if desired, external and already existing DSS systems could be linked by the model manager to the PROMISE DSS in order to retrieve the requested results, since it was not planned to reinvent systems that are available and have proven their functionality.

To be able to handle the different application scenarios, the realization of DSS modules and functions must be based on a two dimensional generic model that covers all life-cycle phases and different application specific demands. These facts are represented in Figure 14.

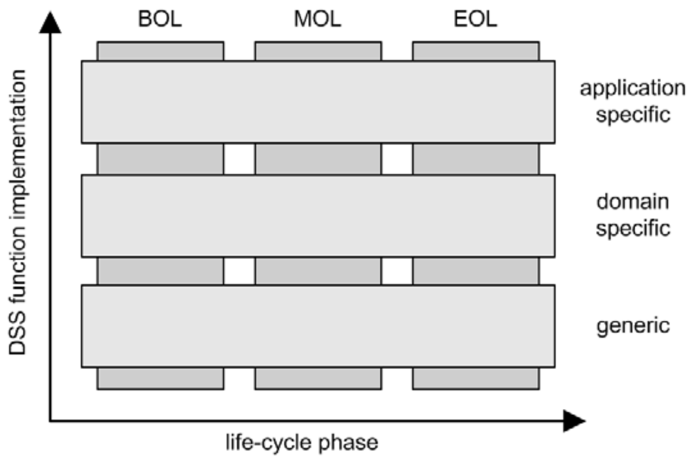

Figure 14: Generic DSS function realization

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5.3.3.3 Data flow of the DSS

The following diagram (Figure 15) illustrates the generic data flow in creating decision support for the different applications. The processes *Data quality checking*, *Product analysis* and *Process optimization* represent generic processes which are different for each application and which depend on the strategies applied in order to get the requested information. This means that they use the appropriate algorithms from the *Decision model base* to generate requested decision support.

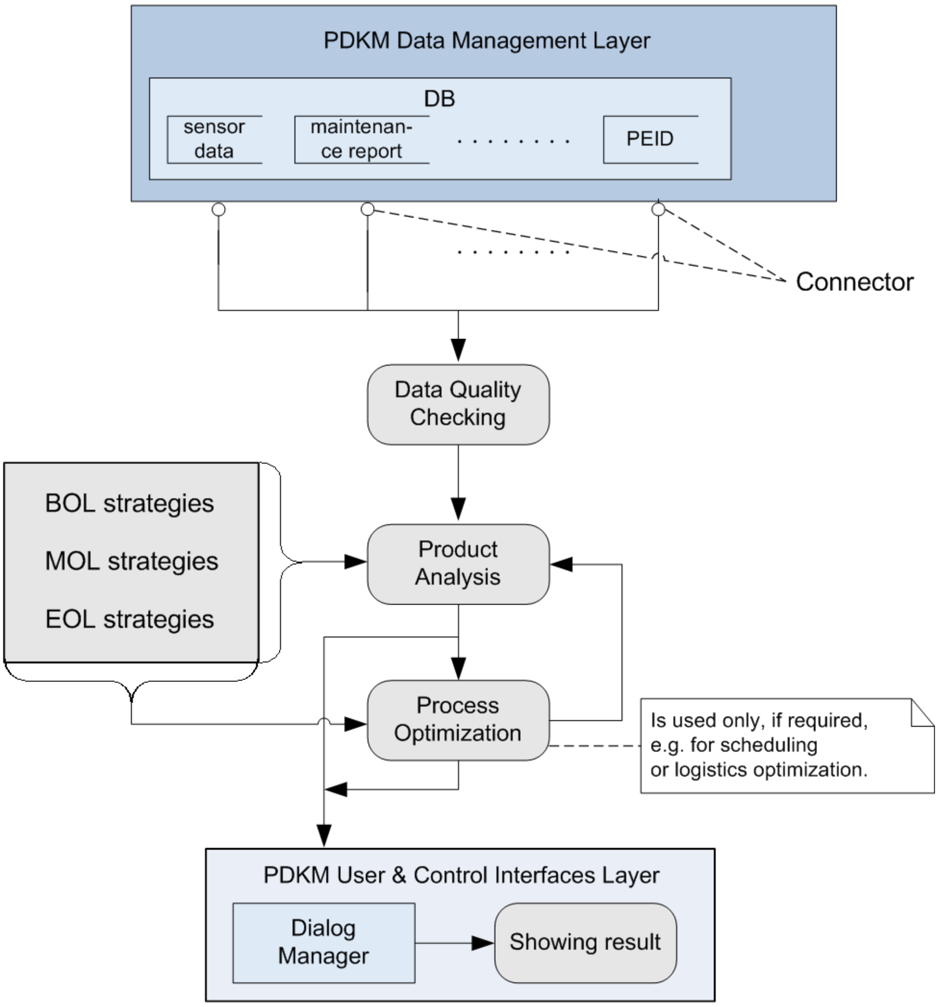

Figure 15: Generic data flow of DSS

- The *Connectors* are software objects that connect the DSS to different information sources of the PDKM, e.g. PEID, field DB, etc.
- The *Data quality checker* tries to minimize the risk of operating on a faulty information base; it filters out data that, for example, due to logical implications cannot be correct.
- The *Product analyzer* is controlled by the *Decision model management* of the DSS. It gets the data from *Data quality checker* and processes it in order to generate decision support.
- The *Process optimizer* realizes the optimization of the results from *Product analyzer*, e.g. the coordination of a truck fleet driving to the garages for maintenance work to be done.

On the next pages, the individual processes are described in detail.

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5.3.3.4 DSS processes in detail

5.3.3.4.1 Connecting information sources

The decision support system must be connected to many other systems. Some interfaces are by direct access to an underlying database, some are by exchange of messages in an arbitrary format, e.g. EDIFACT, XML, etc. The PROMISE DSSs are connected to these systems by special connectors. Some connectors are

- Connector to a database, e.g. to the database underlying the PDKM system,
- Connector to unstructured text documents like a collection of maintenance reports and
- Connector to PEIDs

These different sources provide information about one and the same product (category). Some of this information is related to one specific product instance, i.e. the PEID integrated in the product with a given product ID. Some of this information is related to a group of products, e.g. subcomponents, size or weight of the product.

For the PROMISE DSSs it is important to analyze all available data in order to meet the best decisions. Therefore, we propose the following strategy to connect the DSS system to the information sources:

- Connect to the PDKM system in order to receive information about a specific product or a category of products.
- Create a standardized description (e.g. an ontology) out of these data.
- Use this ontology to analyze and relate available information from other sources to
- The product (or category) under observation.

In contrast to the parallel and uncoordinated connection to the different sources, this strategy exhibits interesting advantages:

- The vocabulary is fixed by the PDKM. Misunderstandings are minimized
- The gathered information is directly related to the DSS problem.

The problem of relating information from arbitrary sources to the specific product is solved by ontology/schema matching techniques proposed in the literature.

As the result of all connectors we should receive valuable information in a standard format. This format should be defined in a way that it can be used by the subsequent DSS modules, e.g. some standard form of rules formulated in XML which can be put together with each other.

Ontology/schema matching and its application to the PROMISE DSS

Ontologies/schemas consist of nodes which contain (syntactic) representations of real world facts. Schema integration attempts to semantically “understand” what is represented in the source schema and to connect it to the corresponding information in the target schema. Schema matching is the task of finding semantic correspondences between elements of two schemas, i.e. for PROMISE the schema of the information source and the description taken as ontology.

The PROMISE DSS schema matching component consists of the following components:

- The ontology describing the product, e.g. all attributes of the product category, the specific description of the observed product.
- Schema Database: XML schemas for all message formats, e.g., EDIFACT, X12, ebXML or XCBL, used by the information sources.

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- Matching Engine: library of matching algorithms including a control unit for the execution of these matchers and the combination of their results.
- A Mapping database consisting of previously found mappings. E.g. in maintenance reports a certain abbreviation might often be used for a specific component. Having related this to the complete part name might be reusable.

5.3.3.4.2 Possible connectors

Connector to the PDKM system

The respective engineer needs to have a clear semantic description of the product. This can be found in the PDKM system. PROMISE can use this complete and correct product description and uses it as a standard for further processing.

The interface to the PDKM should be realized as an access to the underlying database. The result of such a query is the product description formalized as facts in a rule-based system.

Connector for unstructured text

The PROMISE matching strategy uses information from ontologies (see previous section), in order to find match candidates in the messages received from any source providing unstructured text, e.g. maintenance reports.

To understand the state of the product from the sentences detected in the document, this connector needs to deal with natural language. There are different methods:

- First, there is a set of pre-processing steps such as stop-word elimination, tokenization, stemming, etc.
- Then, the text analyzer tries to grasp the idea behind the sentence by relating the remaining words with each other.

For the PROMISE Connectors we start with the ontology and then we form a set of possible alternatives describing the state of the product/subcomponent, etc. Then the matcher has only to identify the nearest alternative. The information is evaluated and formalized as a set of rules, for instance maintenance policies, unexpected breakdowns and its causes, etc.

The subsequent systems access this information base consisting of rules. Starting with the respective product component, all relevant rules are loaded from this connector.

Connector for PEIDs

Like the evaluation of information from unstructured text, PROMISE needs to evaluate information gathered from the PEIDs. Only a few differences have to be considered:

- The quality of the PEID data is typically unreliable. Pre-processing steps dealing with noise filters etc. have to be integrated.
- The amount of data can be enormous. Therefore, intelligent mechanisms have to be developed, so that only a subset of data has to be stored.

This information is stored as the current state of the system component and is augmented by some trend information.

5.4 *PROMISE Standards*

An important objective of the EU-funded PROMISE project has been to influence and make a concrete contribution to the standards related to Product Lifecycle Management.

Throughout its lifetime, the PROMISE project has taken great care to take advantage of existing standards and avoid duplication of standards or creation of competitive standards.

As a result of the research and development undertaken during the PROMISE project, two candidates for standards submission have been identified:

1. The PROMISE Messaging Interface, or PMI, and
2. The PROMISE Product Data and Knowledge Management (PDKM) System Object Model (SOM).

The PROMISE Project Consortium is actively pursuing the promotion of these candidate standards items for the remaining duration of the EU-funded project. After that time, this work will be continued by Promise Innovation International's European Centre of Excellence for Closed-loop Lifecycle Management, which is being established to further the results of PROMISE.

This promotional work includes active discussion with organisations including the Open Group, the British Standards Institute (BSI), and the European Committee for Standardization (CEN). Work is also in progress through contact with the PLCS and STEP working groups to find the optimum relationship between the PDKM System Object Model and those standards.

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6 The PROMISE Demonstrators

PROMISE allows all actors that play some roles during the lifecycle of a product (managers, designers, service and maintenance operators, recyclers, etc.) to track, manage, and control product information at any phase of its lifecycle (design, manufacturing, MOL, EOL), and at any time. Table 1 presented before shows the PROMISE applications.

6.1 Description of the PROMISE Demonstrator

In this section we present a brief description of each PROMISE demonstrator. More detailed descriptions of the PROMISE demonstrators are available at: www.promise-innovation.com.

6.1.1 A1: Monitoring End of Life Vehicles

The domain of the Application Scenario A1 is the End of Life (EOL) phase of the product lifecycle. It specifically deals with the take back of End of Life Vehicles (ELVs) by dismantlers so that they can be reprocessed: this strategy allows for both the feedback of vital information (design information, usage statistics on components etc.), and the materials / components themselves to the Beginning of Life (BOL) stage of the product lifecycle; as well as the take back of selected components into the Middle of Life (MOL) phase of the product lifecycle as second-hand parts.

This Application Scenario focuses specifically upon the dismantler and the operations performed to achieve the correct removal decision (i.e. removal for reuse (BOL or MOL); removal for remanufacturing (BOL); disposal etc.); and the correct categorisation and analysis of various environmental usage statistics associated with specific components from the ELV.

The generalised strategic steps to be followed in the A1 application scenario by the dismantler are outlined in Figure 16.

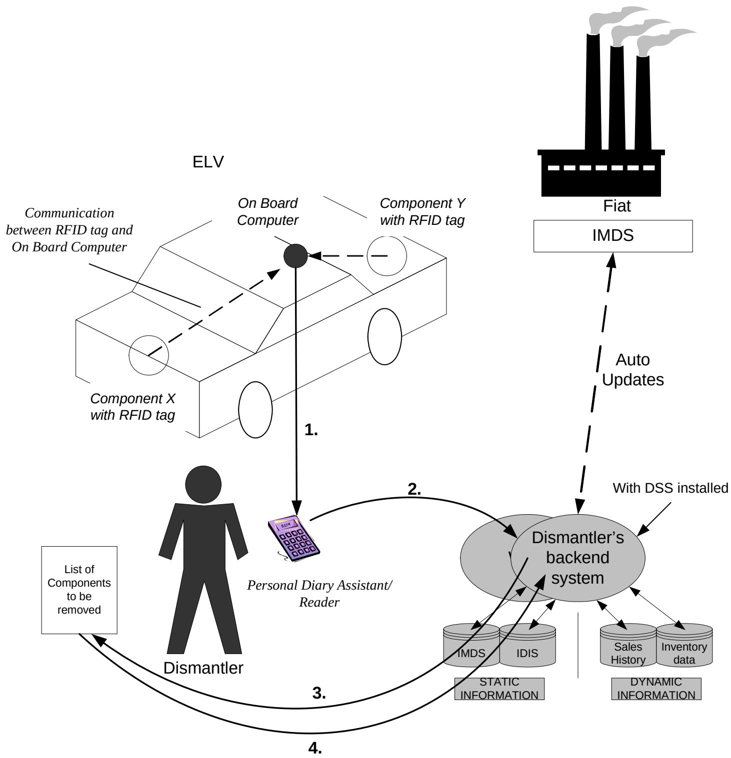

Figure 16: General description of A1 strategy

6.1.1.1 Objectives of the A1 EOL Demonstrator

The goals of the FIAT demonstrator in A1 are:

- The selection of the correct removal decision for specified components that are part of the incoming ELV;
- The recording and analysis of the usage statistics associated with each specific component, ultimately to be rerouted back to the BOL / MOL phase;
- The development of closer ties between the Original Equipment Manufacturer (O.E.M.) Fiat and the specific dismantler in question, as well as a greater analysis of the role of reverse logistics in the BOL / MOL practices of the OEM.

6.1.1.2 Business Opportunities

The A1 demonstrator belongs to the family of "Internal Processes Support" in FIAT Group Innovation projects, i.e. optimisation of OEM processes for a service geared towards internal clients and not to external clients (the owners of the vehicle). In this case the client is thus a dismantling centre affiliated to FGA.

The A1 business is based on the integration of the PROMISE demonstrator with the platform already used by Fiat Group Automobiles (FGA). The PROMISE prototype uses the following hardware and software elements already available in FGA:

- a telematics device on-board of vehicles (Convergence, developed by CRF in collaboration with Microsoft, industrialised and supplied by Magneti-Marelli). Blue&Me® is the commercial name of Convergence;
- connections to on-board networks (B and C-CAN, K-line, OBD,…)
- a user interface and connections towards consumer devices (USB, Bluetooth)
- an architecture enabling the flow of information from the vehicle to a data dispatcher (Convergence Centre)
- web-services developed using data flowing through the Convergence Centre

Services for final users have been sold to FGA clients from 2006, with functionalities such as infotainment (phone, MP3, navigation), emergency services, planned maintenance… Nonetheless the value creation in A1 takes profit of the hardware and software elements illustrated above.

Thus industrialisation efforts are additional efforts to implement a new functionality, building on the existing hardware and software architecture. The added elements developed in PROMISE regard:

- Integration of active tags and wireless sensor networks for identification of components (PEIDs)
- Communication from the vehicle towards the web-service provider, bypassing the Convergence centre (PMI, PDKM)
- Web-service for residual life assessment (DSS)

In this framework, the business enabled by the PROMISE demonstrator regard the possibility to use part of the existing infrastructure to optimise internal processes, thus allowing a consequent decrease of the Blue&Me optional tag price for the client, allowing a further increase of the penetration (more than 50% on some FGA vehicles).

To summarise the business model envisaged is the following, where two departments of Fiat Group Automobiles (FGA) are involved (Aftersales and Spare Parts):

- Clients: dismantling centres, FGA Aftersales and Spare Parts
- Service: increase the reuse/ recycle and remanufacture of FGA components;
- Service enabler: the actual Blue&Me® hardware (Convergence), with additional hardware and software.
- Components: 8 FGA families of components.
- Rationale for earnings: reduced analysis costs and time, reduction of errors, increase of quality of recycled object, certification of quality of remanufactured object, certification of quality of reused object, decrease of raw material consumption and logistics costs.

6.1.2 A2: Heavy load vehicle decommissioning

During multiple life cycles of engine components, useful information can be collected to be able to improve decision-making at end of life of the engine for deciding whether to re-use or salvage components or purchase new ones for building remanufactured engines.

Data collection can be made along the life cycle of the new engine, from BOL data with fabrication plant and built date to EOL data with type of failure and number of running hours of the engine, as well as MOL data with the service maintenance operations performed during service of the engine / machine.

All the data are available at EOL for main engine components (block, head, crankshaft) on a back-end system and canl be used for both Logistics department for “Reman” and Engineering department for engine designers’ knowledge.

Separate engine components at EOL also contain useful information for remanufacturing diagnosis because components tagged with data are up-dated throughout the life of the component, such as component built date, component total number of running hours, etc.

6.1.2.1 Objectives of the A2 Demonstrator

The A2 demonstrator objectives are to collect data with part tracking and information from the engine regarding use conditions, to be used for decision making at end of life, with the end goal to increase the whole lifetime of engine components

6.1.2.1.1 Part tracking capability

For supply chain processes improvements throughout multiple life cycles of engine components, the objectives are to be able to track components able to be remanufactured with:

- List of components able to be remanufactured at EOL of an engine before dismantling operation (for a new or a “Reman” engine)
- Tracking of engine component to be salvaged along the remanufacturing processes
- Record number of times a component has been remanufactured when it leaves the remanufacturing factory for another life
- List of components that could be remanufactured equipping a new “Reman” engine when it leaves the “Reman” factory for a new BOL.

6.1.2.1.2 Decision-making at EOL of an engine / engine component

For increasing reusability of engine components, historical data of engine use and service conditions are captured and accessible at EOL of the engine or of the engine component:

- BOL data of the engine or engine component available at EOL (built date, fabrication plant, type of machine equipped with the engine…)
- Totalised data about the use of the engine component available at EOL (at least number of total running hours)
- Maintenance operations made onto the engine when equipped with the specific engine component, available at EOL of the engine / engine component (at least, check on maintenance made as required or not, as well as special maintenance events)

6.1.2.2 Business Opportunities

The vision is to optimize our Reman engine business by reducing costs of global Reman processes as well as improving rebuilt engines reliability, to enhance dealers and customers satisfaction for owning and selling CAT products.

Other opportunities are the commercial impact of marketing sustainable products (and maybe a differentiation against competitors) and have regular customers using CAT products & services.
Providing technology that increases the visibility of incoming core would add significant value to all Reman facilities.

Improving the velocity of core process flow, and product identification enables increased production. Additionally, improved inflow information could lead to reduced core processing times, core inventory, material costs, warranty costs, and New Parts Usage (NPU).
This application provides the following benefits:

- Reduced inventory due to core visibility
- Reduced new parts usage due to core visibility
- Reduced Caterpillar remanufacturing costs due to elimination of wasted energy/resources in the Reman process
- Increased number of cores to be remanufactured

6.1.3 A3: Tracking and tracing of products for recycling

The aim of the scenario is to improve the information flow throughout the EOL phase of used plastic materials (e.g. car bumpers) and the BOL phase of the resulting recycled material (e.g. granular plastic), bridging the information gaps present in the state-of-the-art and completing the information loop.

On that basis, it aims to optimise processes within these phases by providing real-time product and context information to a number of back-end systems, and by integrating DSS into the existing backend in order to more effectively and efficiently handle these processes.

The application scenario takes advantage of the results of a nationally funded German research project, OPAK. The demonstrator from the OPAK project has been used as the foundation for the PROMISE A3 Demonstrator.

The A3 Demonstrator comprises the following scenes or locations where the activities take place:

1. 1st stage identification of materials for plastics recycling
2. 2nd stage identification to separate mixed materials
3. 3rd stage identification for "unidentifiable" materials
4. storage and transport (Warehouse Management)
5. materials re-processing
6. despatch of finished products

6.1.3.1 Objectives of the A3 Demonstrator

The objectives of the A3 Demonstrator application are as follows:

- To use PROMISE technologies in combination with indoor and outdoor navigation systems in order to enhance the processing of plastics products identified for recycling.
- To increase the probability of recycling in response to legislative directives which demand reduction in waste and increased reuse of materials, at the same time reducing cost and increasing profitability.
- To track and trace materials and manage the availability, security, accuracy and integrity of all relevant product data at every stage of the recycling process.
- To use all available information during the EOL phase of the chosen product (e.g. car bumpers) to optimise decision making at input to the recycling process.
- To use all available information during the BOL phase of the resulting recycled material (e.g. granular plastic) to enable optimal use of the material in both existing and new compounds to meet customer and market demand.

6.1.3.2 Business Opportunities

Within the constraints of the original definition of the A3 plastics recycling scenario, we already foresee the following business advantages:

- Elimination of paper-based processes leading to better quality, security, integrity and availability of data
- Increased productivity through reduction of manual work
- Reduction of errors and waste during production owing to improved accuracy of data about which materials are being used for recycling
- Reduction of recycling costs and increase in profitability
- Higher rate of recycling, reduction in materials rejection and saving resources
- Better prices for recycled material using PROMISE data

Looking beyond the specific A3 scenario, INDYON GmbH, as the commercial partner in WP A3, and also as a technology provider and systems integrator in the logistics sector, can see significant generic business opportunities and advantages in applying PROMISE technologies to the logistic and/or re-processing phases of a number of sensitive and potentially hazardous products.

Unlike all other PROMISE application scenarios, the A3 partners do not include a real end-user. This means that for the purposes of the demonstrator we are unable to actually measure the benefits, we are only able to estimate them at this stage in the project.

6.1.4 A4: Predictive maintenance for trucks

The fleet of trucks work under normal conditions and acquire data from the field. The data are elaborated and synthetic data (indicators) are calculated and continuously updated. On the ground station the data are stored in the system data base (PDKM), where diagnostic algorithms work on the stored data for the extraction of predictive information. As input for the computation, the ground station should access and receive the gathered MOL data via a GPRS wireless connection.

After analyzing MOL data, the DSS situated in the ground station PC should send information to each vehicle, garage, design dept., production dept., and suppliers. A calendar of maintenance interventions to be performed on each truck belonging to the analysed fleet is obtained.

6.1.4.1 Objectives of the A4 Demonstrator

The overall objective of the IVECO demonstrator is to support the maintenance of a fleet of trucks, optimising the maintenance plan and increasing the overall availability of the trucks.
Closing the information loop using the Demonstrator "Information management for predictive maintenance" will improve the knowledge about the customer habits and the mission profile of the vehicle and finally enable to:

- Reduce the number of vehicle stops for maintenance
- Minimise the overall lifecycle costs of the components
- Avoid component breakdowns
- Take into account vehicle availability while planning maintenance interventions
- Take into account maintenance crew availability for performing maintenance

The idea behind predictive maintenance is the identification of slow degradation trends in the performance of specific systems in order to identify with reasonable warning the need of an intervention. This allows the optimisation of maintenance intervention with the implementation of a customised maintenance policy and contributes to make explicit the residual life of the component in order to better manage the total Life Cycle Cost (LCC).

6.1.4.2 Business Opportunities

The Europe market for commercial vehicle shows some signs of saturation/ marginal increase, while the other markets have still short-to-medium term potential of increase. Growth is expected in emerging markets, like India, China, Brazil and East Europe.

Regarding the fleets, the business model developed in an earlier stage of the project (see references) shown that the market, following the examples of the US and UK markets are correctly oriented, towards the emergence of bigger fleets, managed by third-parties.

Furthermore the opportunities for Telematics systems, and in particular for remote diagnosis and maintenance management is growing, based on the perceived utility of remote monitoring and predictive maintenance (see document mentioned above).

These are the driving forces which will sustain the growth of the development of more and more improved and performing Fleet Maintenance Systems. This will constitute an opportunity for companies involved in the production and marketing of FMS.

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The business is based on the integration into the services already designed and developed by CRF, IVECO and IVECO-Eltrac, which will be sold to the public under the commercial name of Blue&Me Fleet. The official launch will be around October 2008, providing the following services under the commercial name Blue&Me Fleet®:

- Fleet management
- Maintenance plan management (fixed)
- Mission Management
- Track & Trace
- Driver Management
- Entertainment & other

The architecture for the PROMISE A4 demonstrator is perfectly aligned with the Blue&Me Fleet hardware and software architecture, ensuring an high feasibility of integration of a new service, and the maximum potential for industrialisation of the PROMISE A4.

The competitive advantages with respect to the rest of the competition includes:

- Integration with Blue&Me Fleet;
- Comprehensiveness of the approach, based on the optimisation of maintenance for the fleet.

The weak points envisaged at the time (compatibility of the solution, integrability in the truck/ fleet management ground station, reliability in any circumstances) has been settled, and the business and legal aspects, the selling price and the willingness to pay of the clients, the protection of privacy, the increased responsibility of the solution provider/ fleet manager/ OEM have been studied.

6.1.5 A5: Heavy vehicle lifespan estimation

The A5 application deals with the capability of **product lifecycle management of heavy vehicles and Structures through fatigue monitoring of Structures** by using new devices attached onto the structures indicating fatigue damage of local points. These physical measures, as well as data collection linked to machine configuration and application type specify customer use of their machine and enable scheduling maintenance operations accordingly.

For each heavy vehicle, decisions may be made for preventive maintenance considering remaining life estimated. Inspection, reparation and part change could be scheduled to avoid machine downtime and further costs due to failures on structures. Owners could make decisions on whether or not to perform certain maintenance or part replacement if they knew how much life remained, saving money and time. Furthermore, owners could use remaining value of the structure for any resale decisions. For a fleet of vehicles, field data collection is used for improving the Design of our structures dedicated to different applications and markets. In order to associate fatigue damage data to application type, machine configuration is described by list of attachments on the machine when ordered (included in the MSO), as well as existing sensors characterising application are registered. During service life of the machine, up-date on machine configuration may be done either manually by the owner operator or automatically if structures are tagged and change of attachment is automatically recognised, while other loading conditions are captured by current sensors and available through on-board systems.

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6.1.5.1 Objectives of the A5 Demonstrator

The objectives are to optimise the design and usage of our structures due to structural health monitoring system with:

- Service inspection & repair scheduled during the life of the machines and performed by CAT dealers
- Design optimisation made considering field results versus wear life target of the structure, and opportunities for certified re-built machines as well.

In order to be able to schedule maintenance on structures regarding their fatigue status, we use embedded sensors onto our machines with data collection on fatigue status and on parameters linked to application severity, i.e. machine configuration and historical payload:

- "CrackFirst" devices located around weak areas of the structure monitor the fatigue damage of the near weld, as a percentage of fatigue damage considering Class F design criteria.
- Machine configuration is described by the list of attachments equipping the machine, or, to simplify, by the main attachment size;
- Application severity is described by totalized payload information, such as fuel consumption rate

It will then be possible to schedule inspection interval considering fatigue of structures and both machine configuration and application severity.

It will then be possible to schedule inspection interval considering fatigue of structures and application severity.

6.1.5.2 Business Opportunities

The vision is to implement structural monitoring system to **design, maintain and sustain** our heavy load vehicles with optimal use of the main structures of our machines.

Benefits come from structures designed to customer use (1) with all the internal processes for product life cycle management of optimised structures (2).

(1) Services to customer will be improved for:

- CAT dealers (maintenance on structures)
- Certified-rebuilt machines with re-use of structures (feasibility and expected durability)
- Rental management (selling value, fleet management)

(2) Field results knowledge will help our internal CAT processes for the Design and the Support to customers and dealers:

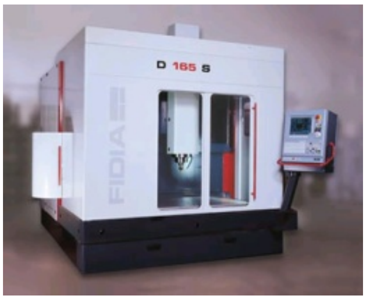
- Design engineering for new product (validation & design optimisation)
- Custom products (design optimisation)
- Marketing (segment markets & identified configurations)
- Product support (service to dealers and final customers)

Resulting in expected cost reduction:

- 5% to 10% weight reduction on lifting structures (increase in machine productivity)
- Decrease downtime of machines due to unexpected fatigue failures (during whole lifetime period, from warranty period to end of life)
- Increase % of re-usable structural parts
- Increase reliability of Certified-rebuilt machines with re-use of structures

Future strategy onto structural parts will be to enhance the design depending on structure's target life (half-life for usable attachment, one life for other attachment, 2 lives for certified re-built) and type of market (two categories of machines: utility or productivity which are sensitive to purchased price and ownership costs or operational costs).
Strategy will then take into account size and cost of the machine to focus on maintenance and machine availability or costs of structures to focus on ownership price; decision support system and business models should be built accordingly.

6.1.6 A6: Predictive maintenance for machine tools



The product in this application is a milling machine and precisely its mechanical components (e.g. screw, nut, bearings, etc.) and electronic components (e.g. electronic boards, etc.). PEIDs (i.e. barcodes, RFIDs, sensors, etc.) are all embedded devices. BOL for these components is when they are assembled and belong to a new machine. DSS during MOL, executes Predictive Maintenance tests and provides an automatic decision system. Service maintenance and part change may occur according to its wear status. PDKM collects all useful data and information about all the machines sold from FIDIA all over the world, statistical evaluations can be done from design and service department and decision making is improved. Design department has a feedback to its work from all the amount of data available on the PDKM remote database. Service department has a better knowledge of the machine lifecycle and the planning of the repair actions is improved.

6.1.6.1 Objectives of the A6 Demonstrator

The Fidia demonstrator is relative to application in the area of MOL for machine tools, and specifically to the following objectives:

- Predictive Maintenance: We want to get useful information about the mechanical components state by performing periodic checks on the machine. This can help to single out the machines failure causes, allowing the optimization of the technical interventions and thus minimizing machine unavailability.
- Traceability of components: The components do not reside on the same machine throughout their lifecycle. Often after a repair intervention a fixed component is re-installed on a different machine. It would be highly desirable to keep track of the 'history' and the characteristics of the components installed on each machine because knowing their exact features makes the service interventions easier.

6.1.6.2 Business Opportunities

The main objective of the demonstrator is the implementation of a strategy for Predictive Maintenance on the mechanical components of a Fidia machine tool (in fact mechanical components have a long and slow degradation, in opposition to electronic components, that break down all of a sudden). This allows avoiding production stops and sudden interruptions, with the consequent heavy economical impact on the user. Thus the main benefits will be:
For end users:

- Possibility to schedule service interventions and to harmonize them with production needs.
- Reduce the number of unexpected breakdowns.
- Higher quality and lower fares for Service.
- Machine tool always working in an optimized condition, in case a strategy for self-tuning is also implemented, based on the same data (which is, anyway, out of the scope of the project).

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For Service

- Lower travelling and manpower costs for each intervention, because interventions can be scheduled in advance and only a low percentage of them is unexpected.

6.1.7 A8: Predictive maintenance for EEE

In WRAP's demonstrator the actors are: a refrigerator DA (Digital Appliance), an interface device SA (Smart Adapter) placed between the power cable of the household appliance and its electric plug (Outlet), a wireless communication link (RF comm. system) between said SA device and a remote monitoring centre, where the Decision Support System (DSS) performs predictive maintenance. The SA device simply communicates with a local monitoring system, represented for instance by a notebook Computer or a PDA. The WRAP refrigerator is the product on which PROMISE technology has been tested in order to deliver predictive maintenance. Field data (statistical and diagnostic data), coming from sensors and actuators, are logged by the Refrigerator control system in its non-volatile memory. These data are primarily sent to the Smart Adapter (that provides data related to appliance energy consumption) and later to the PROMISE back-end, where they are stored (in PROMISE PDKM database) and analyzed (in PROMISE DSS) in order to find out if eventual malfunctioning problems are going to occur on one of the refrigerator components. If an incipient failure is detected, an e-mail is sent to the Service Company which is so enabled to perform predictive maintenance actions on the refrigerator.

6.1.7.1 Objectives of the A8 Demonstrator

The objective of WRAP's application scenario, is to apply PROMISE technologies to perform predictive maintenance of a household appliance (refrigerator), by using exchanging of data day-by-day, with a remote monitoring centre, using a data transmission system compatible with the cost restrictions of white goods.

6.1.7.2 Business Opportunities

The main purpose of WRAP demonstrator is to assess benefits to medium and long term period, related to:

- **Medium term benefits coming from:**
  - In line test procedure improvements
  - Better on site assistance
- **Long term benefits coming from**
  - Smart adapter selling
  - ULP business opportunities
  - Extension of warranty period

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6.1.8 A9: Predictive maintenance for Telecom equipment

The aim here is to improve the information creation and flow throughout the iBAS (iBAS is an INTRACOM Telecom proprietary system). MOL phase by exploiting PROMISE technologies. Technologies used to optimize the MOL processes are: PEID-RFID technology, Promise Middleware, PDKM and DSS. In particular, the A9 demonstrator uses the of PROMISE PEID technologies for collection of all the information relevant to the performance and fault profiles of the product. In addition, this system is used for storage and collection of data relevant to the physical location of product installation iBAS products installed in different sites. Use of Promise Middleware facilitates the transparent upload to the Promise PDKM of data collected during the life cycle of the iBAS. The promise PDKM system is used to store and manage all data relevant to demonstrator, i.e. field data and data from the existing backend systems. The collected data are gathered into the PDKM system, and further aggregation is implemented in the DSS. During maintenance procedures technicians on the field is supported in diagnosis and problem-solving by utilizing the information resides on DSS. Finally, vital information residing on the PDKM and DSS can be available to designers for product improvement efforts.

6.1.8.1 Objectives of the A9 Demonstrator

INTRACOM aims to test and validate technology and tools for addressing the business issues highlighted in the previous subsection based on the company's product IBAS, INTRACOM Broadband Access System. IBAS is a Next Generation Multi-Service Access Node (MSAN) featuring broadband and narrowband subscriber interfaces. It is one of the DSLAM family products, which is the last element in the access network before the subscriber's home, and is thus the vehicle for delivering broadband services.

The IBAS product is a compound product including software and hardware components (line cards). IBAS by its nature uses appropriate technology (software, hardware, sensors etc) for recording information about its performance and producing alarms indicating performance degradation. The Network Management System (NMS) uses this information to support efficient operation management of the network. Due to security reasons, INTRACOM does not have access to the NMS system, as this system manages the whole network.

The A9 demonstrator is aiming at using appropriate technology and mechanisms to test and validate:

- The receive and integration of field data produced by an IBAS with product information existing in the back – end systems
- Tracking and maintenance of the history of an IBAS instantiation at a specific customer site
- Track IBAS line cards through their lifecycle
- Registration and maintenance of past service cases to support decision making on diagnosis.
- Integration of the product information existing in the various systems
- Provision of appropriate information views to support decision making on product improvements.

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6.1.8.2 Business Opportunities

INTRACOM's case in PROMISE is related to the business-to-business (B2B) market. INTRACOM's customers are big telecom operators or services providers that use INTRACOM's products in their network. Depending on the specific SLA (Service Level Agreement), INTRACOM also provides support and maintenance services to the customers.
As the analysis of the current situation indicated, operating in such a business environment the following business issues are of highly importance:

- Reduction of maintenance cost
- Increase of the customer calls resolved at the 1st level support (remotely) without the need to proceed to second level support activities (maintenance on the field).
- Reduction of maintenance cost in the field
- Reduce technicians on the field
- Increase customer satisfaction due to improved fulfilment of customer requirements.
- Reduce design effort (availability of accurate product information that can be used for product redesign / design)
- Reduce hardware failures (based on preventive Maintenance)
- Reduce stock capacity

6.1.9 A10: Design for X

In the A10 demonstrator, the product on which PROMISE technology has been tested in order to generate DfX knowledge from product field data is the traction chain of an electric locomotive. The focus was on: Gate Drive Unit, Wheel (profile) and Main Circuit Breaker. Field data is gathered from different systems: PEID (TCMS), FRACAS process, CM/CBM and Event recording. All this field data is aggregated into a unique database called Field Info Database. Then data from the Field Info Database and Other Info Sources is sent to PDKM for storage and management. The PROMISE PDKM provides input to PROMISE DSS and also receives output from PROMISE DSS for storage and management.

Main functionalities / requirements are:

- Efficient collection of all available product related field data and information, which is currently spread across a number of systems and geographic allocations
- Aggregation and categorisation of field data and information
- Reduction of redundant and nonrelevant field data and information
- Translation / transformation of field data and information into DfX characteristics and / or Design for X knowledge
- Translation / transformation of DfX characteristics into Design for X knowledge
- Project oriented field data and information (e.g. failure reports, lessons learnt) shall be transformed in product oriented DfX characteristics and Design for X knowledge
- The field data and information, the DfX characteristics and the Design for X knowledge shall be accessible and manageable in a PDKM system, structured according to a predefined **W**ork **B**reakdown **S**tructure
- A **D**ecision **S**upport **S**ystem shall support the specialist engineer in the translation / transformation process from field data and information into DfX characteristics and Design for X knowledge

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6.1.9.1 Objectives of the A10 Demonstrator

Within Bombardier Transportation (BT), specifically for the TRAXX™ Platform, there is currently quite a substantial history of collection and analysis of product lifecycle data. However, the primary purpose of the use of this data has been to implement it in a project oriented framework. A product oriented framework with an appropriate analysis of this data and with a deliberate focus on issues related to the design aspects can provide an efficient mean for generating useful knowledge which can help designers in improving specific aspects of their (re)design activities.
A10 demonstrator aims at generating knowledge to use for the improvement of the design of next generation of BT locomotives through an appropriate analysis of field data mainly from maintenance records of BT locomotives.

The main focus of this demonstrator is to develop and assess the DfX decision strategy within Promise DSS (Decision Support System) and DfX knowledge management within PDKM.

The reason of this focus is that the main interest of BT is to improve the availability of locomotives to reduce life cycle costs and increase the satisfaction of customers.

In addition to the knowledge regarding RAM/LCC (reliability, availability, maintainability/life cycle cost), the demonstrator aims also at generating knowledge regarding safety and environment.
The main benefits of the DfX knowledge generation strategy are:

- improved and more competitive product designs through the reuse of adequate proven designs and enhancement of weak aspects of the previous designs,
- increased customer satisfaction due to improved fulfilment of customer requirements regarding, e.g., reliability, availability and safety,
- reduced design effort by allowing engineers to have direct access to discrete and meaningful DfX product knowledge in every design phase,
- minimized design changes during product service life (respectively warranty period) due to improved component selection during initial design.

6.1.9.2 Business Opportunities

The main benefit of establishing a process (incl. supporting tools) for "translation" and "transformation" of field data and information into DfX characteristics and Design for X knowledge is resulting in:

- improved and more competitive product designs, mainly by adequate re-use of proven designs by aspiring a consistency of nearly 80% on component level
- increased customer satisfaction due to improved fulfillment of customer requirements e.g. by reaching an operational availability of 85%
- reduced design effort by 10% by allowing engineers to have direct access to discrete and meaningful DfX product data in every design phase
- minimized design changes during product service life (respectively warranty period) by 5% due to improved component selection during initial design

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Effects on business partners

The following downsides/upsides are expected for the business partners and shall be appropriately considered:

Customer:

A downside is mainly the disclosure of information about service usage of locomotives by the operators. On the other hand the operator benefits from improved products.

Suppliers:

System suppliers could benefit from improved field information respectively knowledge regarding their scope of supply. But for the system integrator, more detailed conclusions on their system performance & quality becomes possible.

Maintainer:

A long term profit for the maintainer may be that it will get possible to plan their jobs better, based on sound information and get the knowledge to optimize the maintenance programs, thus reducing LCC.

Partners companies / consortiums:

They could benefit from improved field data and information respectively knowledge regarding their scope of supply. But more detailed conclusions on their system performance & quality will be possible for all partners - which could also be competitors in other areas.

6.1.10 A11: Adaptive Production

This application is focused on the scenario defined by CRF, in which FIAT buys, from the Teksid Aluminium company, the main engine components of its cars, such as the upper and the lower cylinder heads, camshaft carriers and engine blocks. The product of interest is the *4-cylinders engine head of the FIAT multi-jet engine* (car models of reference: e.g. FIAT STILO, FIAT PUNTO, etc.).

Teksid Aluminium often receives requests for product modifications from its customers (FIAT, Volvo, OPEL, etc.) which continuously try to gain competitiveness by improving the quality of components, also decreasing production costs, distribution costs, maintenance costs, etc. These requests for product modification represent the major source of business for Teksid Aluminium, which try to accomplish the customer requests at minimum cost. However, the time Teksid Aluminium has to answer to a request for product modification with a commercial and technical offer is shorter and shorter; more precisely, the available time for preparing the offer ranges from only a few days to a couple of weeks at maximum.

Most of the requests for product modifications derive from the information and knowledge acquired by product instances during their BOL, MOL and EOL phases. In most cases it is possible to predict these requests for product modifications on the basis of the data collected from the product instances during their lifecycle, of expert opinions and of case histories.

In the designed application scenario, Teksid Aluminium is supported by a DSS during the preparation of the offer, both from the technical and commercial sides. Accomplishing a request for product modification means for Teksid Aluminium the modification of its production systems.

6.1.10.1 Objectives of the A11 Demonstrator

The A11 Demonstrator on Adaptive Production aims at closing the information loops between the experience in the product's MOL and EOL phases and the decisions needed to adapt the production system in the BOL phase. Teksid Aluminium made available:

- technical data on the cylinder head of the multi jet engine.
- technical data on the manufacturing line that produces the cylinder head of the multi jet engine
- technical data on the past modifications related to the cylinder head of the multi jet engine.

Teksid Aluminium has been intentioned, since the beginning of the project, to use the Decision Support System developed in A11 to:

- manage the request of product modification
- support in the preparation of the technical offer

6.1.10.2 Business Opportunities

The DSS offers to Teksid Aluminium the following advantages during the preparation of the technical and commercial offer:

- Estimating the impact of a product/process modification on the product machining times. This task is necessary to understand how the modification changes the product manufacturing processes. This task is currently executed by Teksid Aluminium's technicians without the help of any tool.
- Estimating the impact of a product/process modification on the production rate of the manufacturing system. This task is necessary to calculate the new capacity of the adapted production system. This task is currently executed by Teksid Aluminium's technicians without the help of any tool.
- Estimating the impact of a product/process modification on the production cost. This task is currently executed by Teksid Aluminium's technicians without the help of any tool.
- Selecting the most profitable system adaptation to respond to the current request for product modification. Since this task is very complex and the time available is short, only a small subset of all possible alternative solutions is explored by Teksid Aluminium. The adoption of a sub-optimal solution may cause Teksid Aluminium to run its production system at non-optimal conditions or to lose the modification request. This task is currently executed by Teksid Aluminium's technicians without the help of any tool.
- Selecting the most profitable system adaptation to respond to the predicted future requests for product modification. This task is not currently executed in Teksid Aluminium.
- Sharing information and knowledge among all the technicians participating to the adaptation process. This reduces the lead time of the modification request because information becomes fast accessible and concurrent engineering concepts can be fully adopted. Currently no Knowledge Management tool or platform for managing the modification request in all its aspects is used in Teksid Aluminium. This sharing of information could lead also to advantages for FIAT, when using the DSS together with Teksid Aluminium, for a shared management of product modifications.

The above advantages can be translated in the following business benefits for Teksid Aluminium:

- lower production costs, due to the adoption of optimal solutions for adapting production systems

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- higher revenues, due to the reduced lead time of the request for product modification, which in turn causes an increase in the number of offers accepted by Teksid Aluminium customers
- higher profits, also due to the improved accuracy in deciding the price of the modification to be proposed to their customers.

6.2 PROMISE components employed for each Demonstrator

The following Table 3 contains an overview on which specific component has been customized for and integrated into each of the demonstrators. As can be seen, all demonstrators are based on the interface definitions that have been developed in PROMISE, and that various implementations of each of these components have been implemented and are used.

Table 3: Components employed for each Demonstrator

	A1 (CRF)	**A2** (CAT)	**A3** (Indyon)	**A4** (CRF)	**A5** (CAT)	**A6** (Fidia)	**A8** (Indesit)	**A9** (ICOM)	**A10** (BT)	**A11** (Polimi)
DSS status	Cognidata's part of the DSS has been developed as a generic framework in which solutions of all PROMSE application scenarios can be embedded. The embedding of the algorithms was successful. The integration of scenarios with database and GUI is still under construction except for A3. The reason for that is that the algorithms underlie a steady course of development and change quite frequently. The A3 demonstrator has its own stand-alone DSS framework into which all of its algorithms are integrated, and this framework has its own GUI. This has been fully completed.									
	SAP Research has developed the DSS GUI for all other application scenarios and deployed them on the central PDKM instance for demonstration (except A3).									
	Stand-alone	Stand-alone, integration in progress	ready	Stand-alone, integration in progress	Stand-alone	Stand-alone	Stand-alone	Stand-alone, integration in progress	Stand-alone	Stand-alone
PDKM status	The PDKM system has been developed as a generic framework in order to support all promise application scenarios. The functional scope of the PDKM system has been successfully utilized in all application scenarios with the exception of A3. A3 has successfully implemented the PDKM model and application specific data model subset using open source components.									
	ready	ready	ready	ready	ready	ready	ready	ready	ready	ready
MW status	MW (DC+ISC) with PMI	SAP RHL & DHL with PMI, MOMA	INDYON MW with PMI & external DCs	MW (DC+ ISC) with PMI	SAP RHL & DHL with PMI, MOMA	MW (DC+ISC) with PMI	PMI mpl., DC, additional GUI	SAP RHL & DHL with PMI, MOMA	File based import	
	ready	ready	ready	ready	ready	ready	ready	ready	ready	N/A
PEID status	Blue & Me, Blue & Me sensors, ECU	RFID Tags, ECM	IFX ECP, RFID Tags, Track and Race®	Blue & Me, Blue & Me sensors, ECU	Crack First™ + IFX ECP	ECU on Machine	Refrigerator ECU, Indesit Smart Adapter	RFID tags, Protocol Convert.+ IFX ECP	ECU data integration via file and BT infrastructure	
	ready	ready	ready	ready	ready	ready	ready	ready	N/A	N/A

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6.3 *Exploitation of PEIDs in PROMISE Demonstrators*

The following Table 4 shows the deployment of different PEID technologies and types across the different PROMISE Demonstrator applications:

Table 4: Deployment of PEID types and technologies

No.	PEID	Type	Description
A1	**Blue&Me** **Blue&Me Sensors** **ECU**	**PEID:3** **PEID:2** **PEID:3**	Central device for in-car data acquisition Sensory for in-car data acquisition On board unit
A2	**RFID Tags**	**PEID:1**	Storage and retrieval of engine component information
	ECM	**PEID:3**	On board Electronic Control Module
A3	**RFID Tags**	**PEID:1**	Storage and retrieval of container and plastic items information
	Track and Race®	**PEID:1**	RFID transponder coordinate position matrix mounted in the floor
	Track and Race®	**PEID:4**	Calculation of position coordinates in T+R On Board Computer
	ECP with sensor	**PEID:2**	Temperature monitoring of goods
A4	**Blue&Me** **Blue&Me Sensors** **ECU**	**PEID:3** **PEID:2** **PEID:3**	Central device for in-car data acquisition Sensory for in-car data acquisition On board unit
A5	**Crack First PEID** **ECP**	**PEID:1** **PEID:2**	Measuring fatigue damage, integrated via ECP Storage and modification of structural part information and fatigue damage
A6	**ECU on Machine**	**PEID:4**	Local acquisition of data and direct PMI connectivity
A8	**Smart adapter** **Internet Gateway**	**PEID:2** **PEID:4**	Acquisition of status information of the refrigerator Communication to smart adapter and middleware connectivity
A9	**RFID tags** **ECP** **Protocol Converter**	**PEID:1** **PEID:2** **PEID:2**	Identification and data storage for line cards Communication of monitoring information Conversion of SNMP information and forwarding to ECP
	Monitoring Assembly	**PEID:3**	Combination of APU + ECP + Protocol converter as comprehensive PEID solution for the A9 needs
A10	**ECU data integration via file and BT infrastructure**	**PEID:3**	Exact up-to-datedness of field data in PDKM is secondary since the scenario deals with BOL decision support and focuses on clustering algorithms.
A11	None	N/A	N/A

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6.4 *Table of DSS Algorithms*

The following Table 5 shows the deployment of different DSS algorithms and types across the different PROMISE Demonstrator applications:

Table 5: Table of DSS Algorithms

Demonstrator	Type	Notes
A1	Bayesian Network	
A2	Bayesian Network	
A3	Decision Tree	
A4	"Life Cycle Residual Cost optimisation"	A4 computes the optimal calendar for maintenance of trucks, based on the estimated wear-out of components, the vehicles and garage operator availability, the cost of maintenance and of stoppage. The DSS scheduling algorithm then leads the user (the fleet manager) to the identification of the proper calendar of maintenance actions for all his/ her vehicles.
A5	Regression Analysis (polynomial / exponential)	
A6	Fuzzy Expert System	
A8	Fuzzy Expert System	
A9	Weighted sum, normalization	
A10	1. Failure code event rate evaluation + multi linear regression model 2. Clustering	1. Failure code event rate are evaluated based on the historical data. Multi linear regression model is used to relate evaluated failure code event rate with field data (environmental and operational data) to find correlation between them. 2. Clustering is applied into the field data (environmental and operational data) to provide general overview of field data.
A11a	"What...If? Analysis"	1. Discrete-Time (Finite-State) Decomposition - as physical performance evaluation algorithm 2. Continuous-State Buffer Allocation Optimization - as the buffer allocation optimization algorithm.
A11b	"Optimal System Reconfiguration"	1. Finite-State/Finite-Time Dynamic Programming

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7 Availability of results

The main results of PROMISE are available through the PROMISE Architecture Series and the Public Deliverables. All of them are available through www.promise-innovation.com, www.promise-plm.com and www.promise.no.

The purpose of the PROMISE Architecture Series is to provide a consolidated and definitive reference library for the concepts and interface specifications, which have resulted from the PROMISE project.

It allows the periodic revision of the reference volumes as continuing work both during and after the project leads to the need to supersede technical information, which would otherwise be impossible if it remained only in the Research Cluster deliverables.

7.1 The PROMISE Architecture Series

Table 6 below presents both the available and planned volumes of the Architecture Series in 3 logical groupings: the Architecture Overview, the Architecture Reference and the Developer’s Guide. The scope of each of these will be described in more detail shortly.

The table also proposes a possible system of classification to distinguish between reference materials which is considered public and freely available, and material which comprises valuable intellectual property of the consortium partners. Individual partners and groups of partners wishing to exploit commercially results from PROMISE after the end of the project may wish to protect certain volumes and license those volumes to other parties.

Table 6: Architecture Series: Structure

Title	Classification
Volume 1: PROMISE Architecture Overview	PUBLIC
Volume 2: Architecture Reference: PROMISE Core PAC Interface	PUBLIC
Volume 3: Architecture Reference: PROMISE Messaging Interface (PMI)	PUBLIC
Volume 4: Architecture Reference: PROMISE PDKM System Object Model and Interfaces	PUBLIC
Volume 5: Architecture Reference: PROMISE Decision Support System (DSS)	PUBLIC
Volume 6: Developer’s Guide: PROMISE Product Embedded Information Device (PEID)	LICENSED
Volume 7: Developer’s Guide: PROMISE Data Services	LICENSED
Volume 8: Developer’s Guide: PROMISE Product Data and Knowledge Management (PDKM)	LICENSED
Volume 9: Developer’s Guide: PROMISE Decision Support System (DSS)	LICENSED

7.1.1 Architecture Overview

Volume 1 of the Architecture Series gives an overview of all aspects of the architecture and concepts of the PROMISE architecture and technologies. Its purpose is to position and explain the structure of PROMISE and the relationships between the architectural components and to present options for their exploitation.

7.1.2 Architecture Reference

There are four separate Architecture Reference volumes, each one focussed on a major element of the PROMISE architecture:

Volume 2: Architecture Reference: PROMISE Core PAC Interface
Volume 3: Architecture Reference: PROMISE Messaging Interface (PMI)
Volume 4: Architecture Reference: PROMISE PDKM System Object Model and Interfaces
Volume 5: Architecture Reference: PROMISE Decision Support System (DSS)

Each of these volumes contains a description of the rationale and concepts of its respective element, together with its most current fully detailed interface specifications.

7.1.3 Developer's Guide

Four separate Developer's Guide volumes are also proposed, and each one focusses on the relevant major element of the PROMISE architecture:

Volume 6: Developer's Guide: PROMISE Product Embedded Information Device (PEID)
Volume 7: Developer's Guide: PROMISE Data Services
Volume 8: Developer's Guide: PROMISE Product Data and Knowledge Management (PDKM)
Volume 9: Developer's Guide: PROMISE Decision Support System (DSS)

The value of the Developer's Guides will be seen after the end of the formal PROMISE project. Their use is mainly intended for technology providers outside of the original consortium who would like to consider developing new products or adapting existing ones that conform to PROMISE architecture concepts and specifications.

7.2 Promise Innovation International Ltd.

After more than three and a half years of intense activity by some twenty academic, industrial and technology partners the first phase of the PROMISE project is coming to an end.

Building on this, Promise Innovation International Ltd. is a PROMISE spin-off company that is preparing to bring these results to a wider audience and enable companies to start taking advantage of the benefits that PROMISE can bring.

We will over the next few months work towards creating the

European Centre of Excellence for Closed-loop LM.

This will enable interested parties world-wide to find experts in the field of closed-loop PLM as well as initiating new projects.

Promise Innovation International Ltd. proposes to take responsibility for the future maintenance and development of the PROMISE Architecture Series in collaboration with other partners from the consortium who are motivated to give continued support to the development of the PROMISE architecture.

The website of Promise Innovation International Ltd. is: www.promise-innovation.com.

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8 Potential impact of the results

8.1 *Five key benefits of PROMISE-based products*

The Smart Product, middleware and knowledge management technologies developed in the PROMISE project enable new applications to increase product and service quality. By feeding up-to-date lifecycle information back into design (design for X) and production (adaptive production) it will be possible to make fast modifications and have an immediate impact.

By bringing together PLM and Smart Products, the PROMISE project opens the way to a new business model and the following ways to add value to the business:

1. PROMISE increases business value and product revenues by enabling the development and support of innovative products that are clearly differentiated from those of competitors, and allow you to define and create new market segments. PROMISE-based products add value for your customers, yet continue to increase your revenues and earnings. They provide a clear competitive advantage over basic products and services proposed by companies in lower-cost countries. PROMISE-based products maintain the loyalty of existing customers who see the benefits of the company's products and services relative to those of competitors. PROMISE helps increase sales by lengthening the life of existing products, e.g., enabling more frequent product enhancements, product derivatives, niche offerings, and add-ons to product platforms. PROMISE-based products attract new customers. Their added value stimulates customers of competitors to switch away from the competitor product to the PROMISE-based product.
2. PROMISE helps reduce product costs and operating costs. Information received from products in the field about their use helps eliminate unnecessary features and costs, and reduce product cost. With more experience and better information available about real product needs, manufacturing and support costs can also be reduced. For example, the length and cost of service visits can be reduced due to knowledge of the exact status of the product
3. PROMISE makes it easier to comply with the increasing number of environmental standards and requirements. PROMISE provides precise information for regulators during the Middle-Of-Life and at the End-of-Life. And, during the Beginning-Of-Life, it helps ensure that new products will comply with regulations.
4. PROMISE-based products create a new channel for communication with your customers. The information they provide helps you to increase customer satisfaction with existing products. And information about use of the product can be jointly reviewed with the customer to identify improvements to be included in upgrades and future products.
5. PROMISE-based products enhance the corporate image. Customers associate the company name with the high-tech image projected by products with the PROMISE logo.

8.2 *PROMISE technologies can be used in many industry sectors, for example:*

- In MOL, a PROMISE-enabled train carriage can send a message to the operator when it needs maintenance, and send a message to the manufacturer to say which parts were over-engineered
- In MOL, use of white goods can be optimised to minimise energy loss and pollution
- At EOL, full information on a car's history will be available, enabling selective component reuse and recycling
- In BOL, development processes can be improved, taking account of more field data
- In MOL, key components can be replaced before failure, rather than after failure, avoiding costly out-of-operation time
- In MOL, maintenance activities can be optimised, thereby reducing costs and time
- During MOL, the amount of carbon dioxide produced by a car can be measured to be sure it is within environmentally acceptable limits

- PROMISE provides benefits for many participants in the product lifecycle:
- Customers benefit from intelligent, user-friendly, reliable, high-value products
- Customers preferring to buy functionality rather than hardware can be offered attractive customised leasing contracts based on actual usage
- Marketers get complete data about the modes of use and conditions of retirement and disposal of their products
- Service, maintenance and recycling engineers get real-time assistance and advice as well as complete and up-to-date data about the status of the product over the Web
- Designers can, based on extensive know-how and experience of the product's lifecycle and behaviour, improve product designs
- Recyclers and re-users get accurate information about the value of residual parts and materials arriving via EOL routes. This will help them take refurbish/recycle decisions
- Companies can show good governance for their products, showing they are in control of the product both during its life and when it gets to the end of life
- Companies achieve a positive environmental image through improved and more efficient refurbishment and recycling decisions and actions

8.3 Visibility and dissemination of results

PROMISE achieved a high level of visibility with an impressive number of publications:

- 14 book chapters
- 22 journal articles
- 87 conference papers
- 40 presentations (not related to the listed conference papers)
- 6 conference sessions
- other workshops etc

A list of the PROMISE publications and reports is available at www.promise.no and www.promise-plm.com.

In addition to the above, PROMISE was visible in various market electronic and written media such as:

- BBC,
- Euronews,
- The Parliament and
- other specialised publications and Newsletters.

PROMISE had also a stand at the IST 2006 exhibition in Helsinki.

The A1 PROMISE demonstrator (CRF EOL) was presented at a European Parliament event in Strasbourg where it was honoured with the visit of Mrs Reading.

8.4 Exploitation of results

All PROMISE partners have evaluated their business opportunities, prepared exploitation plans and performed activities according to company specific objectives and goals in the PROMISE project. The project achievements and results in all areas of the project: models, algorithms and methodology developments, technological developments and demonstrators implementations have been evaluated. In addition, the application/demonstrator owners have carried out business effect evaluations related to targets, risks and economics through a subsequent cost-benefit and sensitivity analysis.

The figure below summarizes the commercial exploitation approach in PROMISE. With regard to the academic exploitation, the focus has been set on identifying and transferring knowledge.

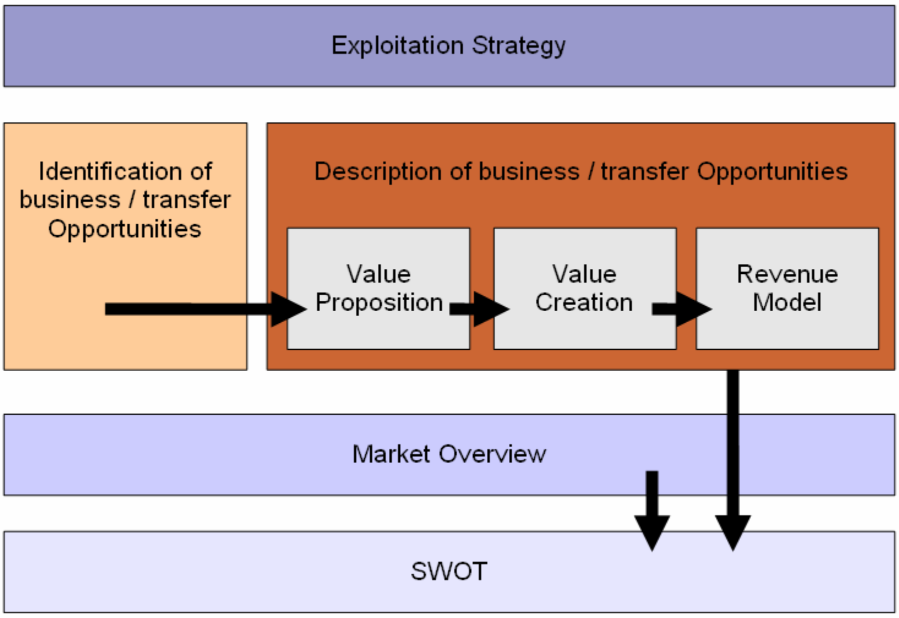

Figure 27: Commercial exploitation approach in PROMISE

The following parties in the value net are creating the benefit of the Promise Innovation offering:

Benefits and offering				
benefit	Awareness	Potential benefits	Specific benefits	Implementation
offering	Information seminars	Business opportunity assessments	Feasibility and Viability studies	Managing implementation projects
The benefits and offering will be created by the following value chain parties:				
Development: Technology Partners	'smart product' / AIDC technology providers Infrastructure technology providers Decision support, knowledge management, data enrichment, PKDM methods			
CL2M Service development	Promise Innovation IP creation: seminar concept & contents	Promise Innovation IP creation: CL2M process / consulting methodology	Promise Innovation IP creation: CL2M process / consulting methodology	Promise Innovation IP creation: CL2M process / consulting methodology
Marketing communications	Promise Innovation Center of Excellence Industry Organizations License partners Reference Clients CL2M research networks			
Sales channels	Promise Innovation Center of Excellence License partners			
Service delivery	Promise Innovation Center of Excellence License partners			
Post-service delivery	Business opportunity assessments	Feasibility and viability studies	Integration projects	Promise Innovation Licensees

Figure 18: PROMISE Innovation benefits and offering

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9 Lessons learned

Among the lessons learned during the exciting period of the PROMISE project, the following can be particularly highlighted:

- The fact that all developments have started with initial descriptions of Applications Scenarios from the very first phase of the workplan facilitated a lot the extraction of requirements and specifications as well as the organisation of the feedback to appropriate research developments.
- The early development of a Quality Management policy and the appointment of a Quality and Integration Manager contributed to the early recognition of pain points and the production o quality results and deliverables.
- The creations of a specific WP on Integration helped a lot in the harmonisation of the technology developments and the associated implementation in the corresponding demonstrators.
- We want also to stress the importance of having established a marketing and exploitation manager. Future projects would be well advised to build this in from the start.
- The chosen model of collaboration within the IMS framework proved to be efficient in terms of production of results in each region. There was no direct collaboration in terms of production of deliverables but the workshops and other contacts that we had among the partners of the involved IMS regions contributed to the common understanding of the project challenges and the mutual interests.
- The concept of a management group combined with regular short teleconferences proved instrumental in securing progress between meetings
- Communication between application owners and technology providers needs special attention
- Earned value concept helped to obtain progress and adequate resource spending
- Progress measured by person hours is difficult – milestones and costs proved effective

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10 Partners

10.1 The PROMISE consortium.

BIBA (Germany)
Bremen Institute of Industrial Technology and Applied Work Science, located in the northern part of Germany, has 120 employees including five professors, 70 research scientists, PhD-students and administrative staff. It is an interdisciplinary research institute, which develops technical / organisational solutions and puts them into practice in SMEs as well as multinational companies. The BIBA is closely connected to the faculty of Production Technology at the University of Bremen.

Bombardier Transportation (Switzerland)
Serving a diversified customer base around the world, Bombardier Transportation is the global leader in the rail equipment manufacturing and servicing industry. Its wide range of products includes passenger rail vehicles and total transit systems. It also manufactures locomotives, freight cars, bogies, propulsion & controls and provides rail control solutions. Bombardier Transportation's revenues for the fiscal year ended Jan. 31, 2005 amount to $7.6 billion US. In Switzerland, Bombardier Transportation manufactures commuter and regional trains, trams and passenger coaches. In addition, Bombardier Transportation in Switzerland is responsible for the design, engineering and project management of electrical locomotives, propulsion and control systems for locomotives and high-speed trains, and offers a complete range of operations and maintenance services to railway operators.

Cambridge University (UK)
The Centre for Distributed Automation and Control, headed by Dr Duncan McFarlane, is part of the Institute for Manufacturing, in turn a part of the Cambridge University Engineering Department. A world-leader in research into distributed, intelligent and agile manufacturing systems, CDAC also contains the European Auto-ID Centre, part of a global project to set standards in RFID technology in the supply chain.

Caterpillar (France)
Caterpillar is the world leader in the manufacture of construction and mining equipment, diesel and natural gas engines and industrial gas turbines. It currently has an annual turnover more than 20 billion Euro, and its strategy is for this to increase to 30 billion within the next five years. Caterpillar's European operations include manufacturing facilities in France, Belgium, England, Germany, Hungary, Italy, Netherlands, Northern Ireland, Poland, Russia and Sweden. These operations currently employ more than 20 000 people. European growth of at least 25% is expected as part of the planned corporate growth.

CIMRU (IRELAND)
CIMRU is located in the Faculty of Engineering at the National University of Ireland, Galway. Founded in 1985, CIMRU has participated in a number of large European R&D projects. Based on this experience, CIMRU has developed expertise in the fields of systems modelling and simulation, innovation management, product data management, logistics including inbound logistics (Supply Chain Management) and outbound logistics (distribution), performance measurement and in more recent times reverse logistics and the modelling of End of Life (EOL) product recovery and resource sustainement systems.

COGNIDATA (Germany)
COGNIDATA GmbH is an SME consisting of a number of leading computer science experts who support industry companies in carrying out complex research and development projects. Current activities include the building of prototypes for fault diagnosis, XML message mapping, metadata harmonisation, and the application of RFID technology. The customer base includes among others Altana, SAP, Microsoft, Deutsche Telekom, ALSTOM, Lufthansa Airlines and State Nordrhein-Westfalen.

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CR FIAT (Italy)

Centro Ricerche FIAT (CRF) is an industrial organisation with 980 employees, having the mission of promoting, developing and transferring innovation in order to provide competitiveness to its clients: FIAT Group and Suppliers, companies from other sectors, SMEs, research agencies. CRF attains this objective by focussing on: the technology development in the telematics area, the optimisation and implementation of new processes (manufacturing and organisational), the development of advanced methodologies (including optimisation and statistics), consultancy and the training of human resources. Priority areas of R&D at CRF include Energy and the Environment, Safety and Well-Being, and Sustainable Growth.

EPFL (Switzerland)

The Swiss Federal Institute of Technology in Lausanne (EPFL) is one of the two Swiss Institutes of Technology, educating more than 7000 students in all engineering disciplines and participating in numerous national and international research projects in all engineering domains. The Computer Aided Design and Production Laboratory (LICP) of the Institute of Production and Robotics of EPFL is involved in various fundamental and applied research projects in the CADCAM and PLM area in collaboration with Swiss and European industrial partners, mainly SMEs. To respond to the scientific challenges presented by important research problems in Product Lifecycle Management (PLM) and Life Cycle Engineering (LCE) the following three activities have been defined within LICP: Product Modeling and Reasoning for Manufacture/ Assembly/Remanufacture; Informatics for Planning and Scheduling for Manufacture/ Assembly/Remanufacture; Product Data Pre-Processing and Exchanging for Part Production.

FIDIA S.p.A. (Italy)

FIDIA is one of the European leaders in manufacturing Numerical Controls and High Speed Milling Machines for dies and moulds making. The company has also developed and offers CAM modules suitable in particular for on line generation of part programs (HIMILL). FIDIA is present on the world Market of Numerical Controls and High Speed Milling Machines. FIDIA NC and Machine Tools are dedicated to mould and dies of medium/large size production.

Helsinki University of Technology (Finland)

Helsinki University of Technology (HUT) is the oldest and largest University of Technology in Finland, dating back to the nineteenth century (1849). It has twelve faculties, nine separate institutes, 17 degree programmes, 232 professors, 14 264 under- and postgraduate students, 853 Masters´ degrees awarded and 107doctorates in 2001 (June 2002). PROMISE is mainly related to the research projects Dialog and Netlog. The departments involved are Computer Science, Industrial Management and the TAI research institute. HUT can therefore offer a wide range of competence from software engineering and computer networks to logistics, production and economics. This is demonstrated by one of the first operational RFID-based systems for global tracking of shipments, developed in the Dialog research project.

INDYON (Germany)

The main focus is Total Product Traceability for industries with the requirement of batch tracing (EU directive 178-2002 for batch tracing) and industries with bulk goods like wood or other building materials. The core system consists of several building blocks: 1 Warehouse management software, 2 Positioning and navigation hardware and software for fork lifts, 3 Identification technologies with focus on RFID, 4 Total-Physical-Product-Traceability-ASP server.

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INFINEON (Germany)

Infineon is a leading innovator in the international semiconductor industry. Various teams design, develop, manufacture, and market a broad range of products targeted at selected industries. The product portfolio consists of memory and logic products and includes digital, mixed-signal and analog integrated circuits as well as discrete semiconductor products and complete system solutions. The products serve applications in the wireless and wired communications, automotive, industrial, computer, security and chip card markets.

InMediasP (Germany)

Founded in May 1998 as a spin-off from the Fraunhofer-Society, and still co-operates closely with the Fraunhofer-IPK Institute. InMediasP's main business focuses on optimisation of innovation and product development processes as well as on application of advanced information technologies. InMediasP is active in the design and implementation of distributed processes for global engineering, virtual enterprises and supplier integration. Concepts and applications for Product Lifecycle Management is one of InMediasP's main areas of activity.

INTRACOM TELECOM (Greece)

INTRACOM TELECOM is a leading telecommunications solutions provider, headquartered in Athens, Greece. More than 100 customers in over 50 countries select INTRACOM TELECOM for state-of the-art products and tailor-made solutions.

In June 2006, JSC SITRONICS (Russia) acquired a 51% stake in INTRACOM TELECOM. JSC SITRONICS is controlled by JSFC SISTEMA, the largest diversified holding company in Russia and CIS. INTRACOM TELECOM is part of SITRONICS Telecom Solutions business division. The company develops and provides products, solutions, and professional services primarily for telecommunications operators and large enterprises. The systems and products offered by INTRACOM TELECOM address the network and service requirements of incumbent and competitive local exchange carriers operating wireline, wireless, and mobile communications networks.

INTRACOM TELECOM participates in PROMISE as an industrial user providing requirements, and designing and implementing a pilot case in order to demonstrate and evaluate the results of the PROMISE Fundamental Research Clusters.

ITIA-CNR (Italy)

The RTD activities of CNR-ITIA aim at innovating Products, Processes and Organisation referring to the following research areas: Innovative Mechanical Components, Machine and Manufacturing, Industrial Robotics and Automation Systems, Dynamic Analysis and Simulation of Machinery, Simulation and Engineering Applications, Virtual Manufacturing Environment, Supply Chain and Production Management, Extended Evolving Enterprise, Innovation Management. The Institute acts in tight collaboration with Enterprises, Universities, other Research Centres and Institutions to transfer technologies, training and implementing new tools.

Politecnico di Milano (Italy)

POLITECNICO DI MILANO is a leading Italian technical university, recognized as an important research institution with high competencies both in the design and the management of production and logistic systems. Since its foundation, Politecnico di Milano keeps intensive liaison and co-operation with entrepreneurial, institutional and social entities throughout the country. Nowadays, relations between the university and industry in the area of technological innovation have become particularly significant as also the participation in several research European projects.

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SAP (Germany)

SAP is the recognized leader in providing e-business solutions for all types of industries and for every major market, and the world's third-largest independent software supplier overall. Through the mySAP(tm) Business Suite, people doing business around the globe are improving relationships with customers and partners, streamlining operations, and achieving significant efficiencies throughout their supply chains. SAP Research is SAP's worldwide organization responsible for researching and developing new technologies and e-business solutions that may impact the future of SAP's products. Its primary goal is to establish SAP as the thought leader in the area of innovative and breakthrough information technology. To this end, SAP Research determines the business value of new technologies and then passes them on to SAP development groups for integration into new or existing product lines. SAP Research has been researching on pervasive e-business solutions for almost a decade, and has key responsibility for defining SAP's RFID and embedded systems strategy.

SINTEF (Norway)

The SINTEF Group in Trondheim is a private research institute that performs contract research and development for industry and the public sector. It is the largest independent research organisation in Scandinavia with a total of around 1800 employees. SINTEF performs projects primarily within the technology area, but also in natural sciences, medicine, and the social sciences. SINTEF collaborates closely with the Norwegian University of Science and Technology (NTNU). About 90% of SINTEF's projects are funded by industry.

Trackway (Finland)

Trackway Oy is a Finnish software vendor and system integrator. The company was started in 2001 and it has extensive experience in creating value to its customers by offering turn-key business process optimization and advanced Auto-ID solutions which improve the visibility of logistics processes. Trackway has delivered software solutions for logistics, manufacturing and asset-tracking based on barcodes, RFID and GPS technologies. Trackway is part of Stora Enso Group.

INDESIT (Italy)

Born in June 2000 as the spin-off of the Corporate Electronics R&D unit from Merloni Elettrodomestici, INDESIT is committed to the evolution of a networked world in which everything is smart and connected. INDESIT works toward a networked world, in which electrical devices are first capable of generating and memorizing meaningful information and second capable of interacting among themselves and with the external world. INDESIT is part of Indesit Company Group and actively support its mother compay in Innovation and Technology research project to developed solutions focused on White Goods Appliance Industry.

10.2 The PROMISE spin-off company.

Promise Innovation International Ltd. (Finland)

Promise Innovation International Ltd. is a PROMISE spin-off company that is preparing to bring the PROMISE project results to a wider audience and enable companies to start taking advantage of the benefits that PROMISE can bring.

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