Product Lifecycle Management and Information Tracking using Smart Embedded Systems

EU FP6 IP 507100
IMS 01008
European Union
Research partners (BIBA, Cambridge University, CIMRU, HUT, ITIA-CNR, SINTEF, POLIMI): system modeling, knowledge management and logistics and decision making.
Solution providers (SAP, Infineon, Indyon, Stockway, InMediasP, COGNIDATA): Infineon, Indyon and Stockway will develop e-integrated hardware and software infrastructure of PROMISE. SAP, COGNIDATA and InMediasP will be responsible for the Product Data and Knowledge Management issues.
Industrial partners (Centro Ricerce FIAT, Caterpillar, Merloni, WRAP, INTRACOM, FIDIA): specifications and requirements tasks, scenario specification and testing & evaluation.

Switzerland
Research partner (EPFL): DFX and Product Data and Knowledge Management issues in close collaboration with the respective CH & EU participants.

Industrial partners (Bombardier Transportation, ENOTRAC) are interested in the information flow and management for design, service and maintenance of railway systems.
IMS PROMISE
regions & partners

**Japan**
Research partners (University of Tokyo, Waseda University, Chuo University) will develop the product life cycle models, simulation algorithms and tools for the validation of the PROMISE developments. Industrial partners (Toyota Motors) will contribute as end-users mainly for testing the results produced in Japan.

**USA**
Research partners (University of Wisconsin-Milwaukee, Stanford University, University of Michigan) will develop e-Maintenance and e-Service web-enabled systems used in the MOL phase of a product’s life cycle. Industrial partners linked with the Intelligent Maintenance Systems Center (IMS) run by the above academic organisations will provide the necessary input from the industrial point of in the above activity.

**AUSTRALIA**
Research partners (IRIS) will develop EOL management systems. Industrial partners (MTI, AEEMA) linked with IRIS will provide the necessary input from the industrial point of in the above activity.
Closed-loop PLM
The PROMISE approach
The 4 phases of a product system life cycle:

1. **Design**
   - Process
   - Resources
   - Product

2. **Production**
   - Process
   - Resources
   - Product

3. **Use & Service**
   - Process
   - Resources
   - Product

4. **End-of-Use**
   - Process
   - Resources
   - Product

**Processes** are designed, resources used and products produced and treated in each phase.

**Materials** flows:
- End-of-Use to Design
- Production to Use & Service
- Use & Service to Production

**Service** flows:
- End-of-Use to Recycling
- Recycling to Re-use

**Re-use** flows:
- End-of-Use to Re-use

**Recycling** flows:
- Use & Service to Recycling
- Recycling to Disposal

**Disposal** flows:
- Use & Service to End-of-Use

**DFMA** flows:
- Design to Production

**DFS** flows:
- Production to Use & Service

**DFE** flows:
- Use & Service to End-of-Use

**Information flows**, complete or incomplete.
PROMISE: Closing the information loops

DESIGN
- Process
- Resource
- Product

PRODUCTION
- Process
- Resource
- Product

MOL
- Process
- Resource
- Product

EOL
- Process
- Resource
- Product

Materials

Service
Re-use

Recycling
Re-mfg.

Disposal
PROMISE enabling technologies

- A possible & feasible approach:

  Applications based on PLM systems enabled via PEID and wireless Internet

PEID

Reader

PLM system

Internet

Frequency Waves

Transmits

Receives

data

data
Ideas in a nutshell

- **Product delivery**
  - Initial product info is written in the product embedded device
  - Wireless connection between mobile device and product embedded device
  - Update information in the embedded device and in the producer's PDKM

- **Service & maintenance**
  - A certified agent for service or End-Of-Life operations

- **End-Of-Life**
  - Wireless Internet connection between mobile device and producer's PDKM
With emerging technologies, in particular, product identification technologies, the whole product lifecycle can be made visible and controllable.

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Definition</th>
<th>Product lifecycle</th>
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<tbody>
<tr>
<td>RFID</td>
<td>Radio Frequency IDentification: Communication technology for collecting and transferring information via radio waves</td>
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<tr>
<td>EPCglobal</td>
<td>Electronic Product Code: Product unique code</td>
<td>• • •</td>
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<tr>
<td>ID@URI</td>
<td>Identifying physical product items and linking to the product agents that handle their information</td>
<td>• • •</td>
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<tr>
<td>WWAI</td>
<td>Application-level protocol for distributed article information, peer-to-peer networking</td>
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</tr>
<tr>
<td>GPS</td>
<td>Global Positioning Systems: Satellite navigation system used for determining one's precise location and providing a highly accurate time reference</td>
<td>_ • •</td>
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<tr>
<td>GIS</td>
<td>Geographical Information System: Information system capable of assembling, storing, manipulating, and displaying geographically-referenced information</td>
<td>_ • •</td>
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</tbody>
</table>
Concept of PROMISE:
Closed loop PLM

PEID (Product Embedded Information Device)
- RFID tags
- Sensors
- On board computers
- ...

PLM Knowledge agent
- Diagnosis
- Decision making

PDKM (Product Data Knowledge Management)

PEID reader
- PDA
- Fixed reader built in antenna
Characteristics of closed-loop PLM

- Using PEID
  - Product identification
  - Memory
  - Communication unit
  - Power management
  - Data processing

- Horizontally closed
  - The product lifecycle information can be used to streamline operations of middle of life (MOL) and end of life (EOL). The product lifecycle information also goes back to the designer and producer (BOL) so that the information flow can be horizontally closed over whole product lifecycle

- Vertically closed
  - Information control flow is vertically closed. This means that based on gathered data by PEID and sensors, we can analyze product-related information and take some decisions on the behavior of products, which will affect data gathering again.
Framework for closed-loop PLM

Product lifecycle phase

Instantiation

Application Layer

Closed-loop

Layer 1

Layer 2

Layer n

Application-Specific

Domain-Specific

Generic

BOL MOL EOL

Closed-loop
PLM modeling

- Management of whole product lifecycle activities,
- Management of product related data and resources,
- Collaboration between customers, partners, and suppliers,
- Enterprise’s ability to analyze challenges and bottlenecks, and make decisions on them.
Lifecycle information

- Mode of use,
- Conditions of retirement and disposal,
- Recovery information

- Product usage info.,
- Failure,
- Maintenance,
- Service event

- Product status,
- Recovery information

- Product definition data,
- Up-to-date product data

- History data

- Assembly/disassembly info.,
- Material info. for reuse

With smart PEID system,
Information visibility
Product lifecycle information modeling

- Which lifecycle object should be traced?
- Relations between lifecycle objects

**Contents**

- Use conditions
  - Number of use cycles
  - Runtime in each use cycle
  - Temperature
  - Humidity
  - Voltage, Current, Power
  - Service data: data on service inspections, parts replaced or repaired.
  - Demand for spare parts
  - Demand and prices for components, materials, etc.
  - Disassembly cost
  - Recycling cost
  - Chemicals prohibited

- Logistics, supply chain
  - Item identification
  - Specifications
  - Order numbers
  - Locations
  - Update transactions

**Meta**

- Who are you?
- Who created you?
- Who owns you now?
- What kind of a product are you?
- Do you contain hazardous materials?
- Who repaired you?
- What has been happening to you?
- When are you going to expire?
- Where are you going?
- What is your destination?
- When should you arrive at your destination?
- Are you on the right route?
- Are you going in the right direction?
- To which order do you belong?
- To what shipment do you belong?
- To what sub-assembly do you belong?
- What service procedure was carried out on you?
- Who is responsible for what information and data?
- In which form and where do the data exist?
- How can the data be accessed?
Overview System Architecture

Business Processes
- Design for X
- Adaptive Production
- Preventive Maintenance
- Tracking & Tracing
- Effective Recycling

Applications
- Decision Making
- Knowledge Management
- Analytics

Middleware
- PEID Management
- Semantic enrichment
- Dispatching
- Notifications
- Read/Write

PEID
- RFID
- Embedded Systems

Products
PROMISE Component Architecture: Functional View
PROMISE PLM scenario

selection of relevant field data; generation and provision of report

analysis and aggregation of field data; generation of knowledge

data for an incident report of all products of specific type that are in operation

improving design of new products using knowledge of reliability of similar products

Metadata flow
Data flow
Control flow
## PROMISE closed-loop PLM

### Instantiation

<table>
<thead>
<tr>
<th>Generic model for closed-loop PLM</th>
<th>Lifecycle phase-specific</th>
<th>Domain-specific</th>
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<tbody>
<tr>
<td></td>
<td>BOL-DfX</td>
<td>Automotive</td>
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<tr>
<td></td>
<td>BOL-Reconfiguration of production system</td>
<td>Machinery product</td>
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<tr>
<td></td>
<td>BOL-Production logistics and warehouse management</td>
<td>Network device</td>
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<tr>
<td></td>
<td>MOL-Predictive maintenance</td>
<td>White goods</td>
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<tr>
<td></td>
<td>EOL-Decision making</td>
<td>Locomotive</td>
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<table>
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<tr>
<th>Application-specific</th>
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<tbody>
<tr>
<td>Target product</td>
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<tr>
<td>Locomotive</td>
</tr>
<tr>
<td>Car bumper (Plastics material)</td>
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<tr>
<td>Heavy vehicle</td>
</tr>
<tr>
<td>Passenger vehicle</td>
</tr>
<tr>
<td>Tractor</td>
</tr>
<tr>
<td>Tractor</td>
</tr>
<tr>
<td>Milling machine</td>
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<tr>
<td>Gas boiler</td>
</tr>
<tr>
<td>Passenger vehicle</td>
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<tr>
<td>Broad band access system</td>
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<tr>
<td>Refrigerator</td>
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# PROMISE Demonstrators

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<th>Demonstrators</th>
<th>Main focus</th>
<th>Partner</th>
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<tr>
<td>Information management for</td>
<td></td>
<td></td>
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<tr>
<td>A1: Monitoring End of Life Vehicles</td>
<td>EOL</td>
<td>CRF</td>
</tr>
<tr>
<td>A2: Heavy load vehicle decommissioning</td>
<td>EOL</td>
<td>CATERPILLAR</td>
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<tr>
<td>A3: Tracking and tracing of products for recycling</td>
<td>EOL</td>
<td>BIBA/INDYON</td>
</tr>
<tr>
<td>A4: Predictive maintenance for trucks</td>
<td>MOL</td>
<td>CRF</td>
</tr>
<tr>
<td>A5: Heavy vehicle lifespan estimation</td>
<td>MOL</td>
<td>CATERPILLAR</td>
</tr>
<tr>
<td>A6: Predictive maintenance for machine tools</td>
<td>MOL</td>
<td>FIDIA</td>
</tr>
<tr>
<td>A7: EEE (1)</td>
<td>MOL</td>
<td>MTS</td>
</tr>
<tr>
<td>A8: EEE (2)</td>
<td>MOL</td>
<td>WRAP</td>
</tr>
<tr>
<td>A9: Telecom equipment</td>
<td>MOL</td>
<td>INTRACOM</td>
</tr>
<tr>
<td>A10: Design for X</td>
<td>BOL</td>
<td>BT-LOC</td>
</tr>
<tr>
<td>A11: Adaptive Production</td>
<td>BOL</td>
<td>POLIMI</td>
</tr>
</tbody>
</table>
PROMISE demonstrators closing the loops

- Transforming MOL Data & DSS for BOL
- A10, A11 + A4-A9
- Producing MOL Data for BOL
- A1, A2, A3
- DSS for MOL
- A4-A9
- Producing EOL Data for BOL
- A1, A2, A3
- Producing MOL Data for EOL
- A1, A2, A3
- DSS for EOL
- Lifetime

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