

Closed-Loop Product Life Cycle Management — Using Smart Embedded Systems

Edited by Markus Frey
PROMISE Interregional Coordinating Partner
Bombardier Transportation



This is a preview. Click [here](#) to purchase the full publication.

Closed-Loop Product Life Cycle Management— Using Smart Embedded Systems

Copyright © 2011 by ISA—International Society of Automation

67 Alexander Drive
P.O. Box 12277
Research Triangle Park, NC 27709

All rights reserved.

Printed in the United States of America.

10 9 8 7 6 5 4 3 2

ISBN: 978-1-936007-61-5

No part of this work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the publisher.

Notice

The information presented in this publication is for the general education of the reader. Because neither the author nor the publisher has any control over the use of the information by the reader, both the author and the publisher disclaim any and all liability of any kind arising out of such use. The reader is expected to exercise sound professional judgment in using any of the information presented in a particular application. Additionally, neither the author nor the publisher have investigated or considered the effect of any patents on the ability of the reader to use any of the information in a particular application. The reader is responsible for reviewing any possible patents that may affect any particular use of the information presented.

Any references to commercial products in the work are cited as examples only. Neither the author nor the publisher endorses any referenced commercial product. Any trademarks or trade-names referenced belong to the respective owner of the mark or name. Neither the author nor the publisher makes any representation regarding the availability of any referenced commercial product at any time. The manufacturer's instructions on use of any commercial product must be followed at all times, even if in conflict with the information in this publication.

Library of Congress Cataloging-in-Publication Data in Process

Preface

Developing a “Closed-Loop Product Life Cycle Management (PLM) using Smart Embedded Systems” was the challenging mission for the IMS Project PROMISE (Product Life Cycle Management and Information Tracking using Smart Embedded Systems), which successfully concluded in 2008.

PROMISE developed a new type of closed-loop PLM based on product embedded Information Devices (PEID), which allows product information to be tracked at all times and in any location around the world. This new PLM system enables product users, maintainers, and manufacturers to manage the life cycle information of their products seamlessly over all life cycle phases: beginning of life (BOL), middle of life (MOL), and end of life (EOL).

Over the next five chapters, this book will provide industrial users as well as the broad R&D community with an understanding of the principles behind the PROMISE technologies, their successful implementation in the PROMISE demonstrators, and their enormous potential across the industrial spectrum:

- Chapter 1. Introduction with overview on the IMS PROMISE project
- Chapter 2. Description of the PROMISE ‘Closed-Loop PLM’ approach
- Chapter 3. Explanation of principles and achievements for the main PROMISE technologies
- Chapter 4. Presentation of approach and results for various successfully developed demonstrators in different industrial areas
- Chapter 5. Highlights on benefits using PROMISE technologies and its applicability for broad industrial fields

The material for this book is taken from the PROMISE work and deliverables with contribution from all project partners.

Acknowledgments

On behalf of the IMS PROMISE project consortium, I gratefully acknowledge the IMS organization and all regional funding organizations for their great support in carrying out the PROMISE project so successfully.

I extend our gratitude and appreciation to O³neida and especially to Allan

Martel and Susan Colwell for their invaluable support and efforts in making this book possible.

I would like to send special thanks to the various authors of the chapters in this book for their great efforts, as well as to the Regional Coordinating Partners for always keeping this large interregional project team on a successful track, and last—but not least—to all project partners for their collaboration and their contributions to this project.

Markus Frey

PROMISE Interregional Coordinating Partner

Bombardier Transportation

Table of Contents

List of Figures	xvii
List of Tables	xxvi
1 Introduction.....	1
The main objectives	1
The PROMISE deliveries in brief	4
Managing the PROMISE project	7
2 Objectives, Principles, and Cornerstones.....	11
The PROMISE Challenge.....	11
Addressing the Challenge: the PROMISE proposition....	15
PROMISE PLM system architecture.....	16
Who can benefit from PROMISE?.....	24
Highlights of achievements	24
The PROMISE demonstrators.....	27
Conclusions.....	29
References.....	30
3 PROMISE Technologies.....	31
3.1 PROMISE System Architecture	
PROMISE architecture concepts.....	35
Hardware layer	41
Product embedded information device (PEID).....	42
PROMISE Data Services	45
PROMISE PDKM/DSS	67
3.2 Product Embedded Information Device (PEID).....	69
Concept of PEID.....	69
Definition of Core PAC	73
Semantics of Core PAC interface.....	77
Core PEID Prototype Implementation.....	83
Summary	89

3.3	Middleware.....	91
	Locating information sources	94
	PROMISE messaging interface	98
	PMI implementation in Dialog.....	102
	Conclusions.....	107
	References.....	108
3.4	Product Data and Knowledge Management (PDKM)	111
	Introduction	112
	Users and user roles.....	112
	Functional requirements.....	114
	Design criteria	115
	The PROMISE PDKM system.....	120
	The PROMISE PDKM SOM.....	128
	PDKM system prototypical implementation	133
	Concluding remarks.....	135
	Acknowledgment	135
	References.....	136
3.5	Decision Support System (DSS)	139
	Abstract	139
	Introduction.....	140
	Previous work.....	141
	A short history of DSS	141
	Main components of a DSS.....	142
	DSS in PROMISE.....	145
	The DSS platform PARASUITE.....	147
	Architecture overview	149
	Data Exchange Interface	151
	Flow-based computation engine.....	152
	Benefits	153
	Summary	155
	References.....	155
3.6	Integrated Design Support	157
	Outline	157
	Requirements analysis and real data evaluation	158
	Modelling and system framework for evaluation of quality degradation.....	158
	Reliability design method based on evaluation	

of quality degradation.....	159
Maintenance planning for life cycle management	159
Product life cycle management using feedback	
of operational information	159
Prototyping and evaluation	159
Application examples.....	160
Maintenance planning for life cycle management	164
Product life cycle management using feedback	
of operational information	171
User preference.....	175
Supporting consumers in use and maintenance	
of HDD of their PCs	176
Summary	178
References.....	178
3.7 Standardization	181
Introduction	182
Scope of standardization for the PROMISE	
EU project.....	183
Hardware layer and Core PEID	184
Core PAC interface	185
PROMISE Data Services (middleware).....	186
PMI (PROMISE Middleware Interface)	187
PDKM	188
Conclusions and next steps	192
References.....	194
3.8 Identifying and Evaluating the PROMISE	
Demonstrators' Business Effects	195
Why focus on the Demonstrators' business effects?	195
Methodologies for assessment of business	
potential, targets, and effects.....	196
Methodology 1: Business Effect Evaluation	
Methodology (BEEM).....	197
Methodology 2: Cost-benefit and sensitivity analyses....	202
Work sessions/meetings at demonstrator	
owners' sites	205
General comments on the analyses of demonstrators	
business potential	207
Conclusion	208
Bibliography	208

4	PROMISE Demonstrators.....	209
4.1	Demonstrators Covering Multiple Life Cycle Phases.....	213
4.1.1	Product Quality Evaluation Based on Product Life Cycle Modelling with Disturbances	215
	Product life cycle modelling with disturbances.....	215
	Product reliability design.....	217
	Product reliability based on product life cycle modelling	218
	Product life cycle modelling under disturbances	222
	Product functional modelling.....	226
	Summary	230
4.1.2	Tracking of Material from Receipt, Processing to Storage and Shipping, Including Customer Claim Tracking	233
	Beginning Of Life (BOL).....	234
	Middle of Life (MOL)	235
	End of Life (EOL).....	235
	PLM for BOL management	237
	Conclusion	242
4.2	Beginning of Life Demonstrators.....	243
4.2.1	Transformation of Field Data into DfX Knowledge	245
	Introduction	245
	‘Design for X’ application scenario.....	246
	Characteristics of the BT DfX demonstrator	248
	Implementation of DfX demonstrator	251
	Analysis of obtained results	254
	Conclusions.....	261
	References.....	262
4.2.2	Adaptive Production.....	263
	Introduction	263
	Adaptive Production scenario	264
	Requirements for Adaptive Production	267

Modification of the cylinder head and block	268
Modification of the car body	270
Adaptive Production in PROMISE.....	271
Algorithms.....	275
Physical Performance Evaluator.....	276
Economic Performance Evaluator.....	279
Optimal Buffer Space Allocation Algorithm	280
Conclusions.....	284
References.....	285
4.3 Middle of Life Demonstrators	287
4.3.1 Predictive Maintenance for Trucks.....	289
Overview of the application	289
Overview of maintenance strategies.....	290
Architecture and results	292
Innovation	295
4.3.2 Predictive Maintenance for Machine Tools	297
Introduction	297
State of the art in maintenance management.....	298
The proposed integrated approach to maintenance management	300
Description of the testing module.....	301
Description of the aging module	302
Cost maintenance management module	304
Conclusion	305
References.....	307
4.3.3 Smart Bridge Health Monitoring and Diagnostics	309
General methodology	310
Case study	312
Conclusion	320
Acknowledgment	320
References.....	321
4.4 End of Life Demonstrators	325

4.4.1 Tracking and Tracing of Products for Recycling	327
Introduction	327
Specifics of the recycling sector	329
Application scenario	331
Implementation of the demonstrator.....	332
Analysis of results.....	339
Conclusions.....	339
References.....	340
4.4.2 Recycling of Plastic Consumer Durable Products	341
Making decisions in plastic recycling	341
Prediction of plastics volumes available for recycling in automotive industry	345
The effect of contamination on the properties of engineering plastics.....	349
References.....	353
5 Benefits of Using PROMISE Technologies.....	355
Key business benefits of PROMISE-based products.....	357
Coverage of broad industrial field and whole product life cycle.....	358

1

Introduction

Authors:

Prof. Asbjorn Rolstadas (SINTEF/NTNU)
Markus Frey (Bombardier Transportation)

The main objectives

The manufacturing sector has driven research and the implementation of new technology for decades. It is in a special position, providing end-user products for households, capital intensive products for national infrastructures and production facilities and machine tools for other industries. Its products are often highly complex, involving supply chains in several tiers.

Manufacturers employ advanced technology in both their products and their manufacturing processes. Products are frequently mechanical with embedded electronics and manufacturing equipment is often computer controlled.

But manufacturing is not simply a technological matter. It also has a substantial managerial component connected to planning, scheduling, logistics, quality assurance, as well as providing maintenance and service at individual plants and across supply chains. Lately, recycling has been added to the list.

Parts and product identification has always been important and it is essential for competitive products in today's market. Product classification systems were developed to control product variants early on. The bill of material at the top level could be extracted from the product identifier, which helped immensely in the development of cost-effective logistics, maintenance, and service. Classification codes were later developed for individual parts. This was necessary for au-