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REMOTE MAINTENANCE for FACILITY EXPLOITATION

DELIVERABLE 8.3

Distributed Maintenance System:

Expandability possibilities in oil offshore industry

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CONTENTS

1. EXECUTIVE SUMMARY 4

2. OIL OFFSHORE INDUSTRY: MAINTENANCE SITUATION 6
2.1 THE OIL OFFSHORE INDUSTRY IN NORWAY. A BRIEF INTRODUCTION 6
2.2 MAIN TOPICS OF THE MAINTENANCE SITUATION 6
2.3 OUR WORK IN REMAFEX TOGETHER WITH OIL OFFSHORE INDUSTRY 7

3. OIL OFFSHORE INDUSTRY: IT SYSTEM REQUIREMENTS 8
3.1 THE IT-SYSTEM SITUATION 8
3.2 STANDARDISATION WORK IN POSC AND POSC/CEASAR 8
3.3 OIL OFFSHORE INDUSTRY: REMAFEX REQUIREMENTS 11

4. MAINTENANCE REFERENCE MODEL AND OIL OFFSHORE INDUSTRY 13
4.1 CMMS MODEL PROPOSED TO OIL OFFSHORE INDUSTRY 13
4.2 INTERFACE BETWEEN REMAFEX AND TECHNICAL MANAGEMENT SYSTEMS IN OIL OFFSHORE INDUSTRY 14
4.3 REMAFEX CAN GIVE SAP AND OTHER MMS ADDED VALUE 16

5. MAINTENANCE MONITORING TOOLS (MMT): OIL OFFSHORE INDUSTRY 17
5.1 RESULTS FROM A MARKET SURVEY 17
5.2 PRESENTATION OF MMTS IN USE IN THE OIL INDUSTRY 19
5.2.1 Trendmaster 2000 for Windows from Bently Nevada Corporation (BNC) 19
5.2.2 MultiLog from CorrOcean ASA 22
5.3 REQUIREMENTS TO A REMAFEX PLATFORM OUTLINED FROM THESE MMTS AND SYSTEMS 23

6. REMAFEX EXPLOITATION AND DISSEMINATION. 24
6.1 INTRODUCTION 24
6.2 HOW TO APPROACH THE OIL SECTOR 24
6.3 ORGANISATION OF THE WORK 24
6.3.1 To exploit the system 24
6.3.2 Exploitation and dissemination activities 25
6.4 HOW TO EXPLOIT THE APPROACH TOWARDS THE OIL SECTOR. 25
6.5 FINISHING THE TASK T8.2 AND THE DELIVERABLE D8.3 26
6.6 POSSIBILITIES TO PERFORM FUTURE REMAFEX EXPLOITATION IN THE OIL SECTOR. 26
6.7 SYSTEM REQUIREMENTS DERIVED FROM WORK TOGETHER WITH THREE OIL COMPANIES 27

7. CONCLUSION 29

ANNEX I: MAINTENANCE MONITORING TOOLS IN USE 30

ANNEX II: ACRONYMS USED IN THE DELIVERABLE 39

ANNEX III. DIPLOMA REPORT FROM GERALD CARON 40

1. EXECUTIVE SUMMARY

The REMAFEX project aims at defining and proposing new IT solutions with **Distributed Maintenance System** (DMS) which manages the **global maintenance activity for industrial facilities.**

The **Distributed Maintenance System** has to help maintenance operators to take the right decision at the right place on the right time, by the right people in order to manage continuously all maintenance activities and to replace in a stepwise fashion the current maintenance actions (corrective and scheduled preventive) by more advanced ones (predictive and condition based).

At the end of this project, REMAFEX Consortium can be proud of the work achieved, the results obtained are fully in line with the expected results.

Project results, documented in different deliverables are today available to the maintenance European community on the REMAFEX Web-page address:

http://www.gsip.cran.u-nancy.fr/remafex/wp9_remafex/index.html.

At the beginning of the Project, REMAFEX Consortium decided and scheduled to analyse all the potential exploitation use of these REMAFEX results in different industrial sectors: Oil offshore platform and airport. **It was the WP8 scope**.

This deliverable D8.3 is dedicated to the oil offshore industry potential use of REMAFEX results.

As it was impossible to integrate an oil offshore end user into the REMAFEX Consortium, it was decided that the Norwegian REMAFEX partner will analyse this with an external view but through deep enquiries in oil offshore industry and company.

The first contact with the oil sector was through the market survey in Task 8.1, asking also the oil companies about their interest in maintenance and their possibilities to do a job together with the project.

Three oil companies gave a positive answer. Eight others got the information package, but they did not answer the questionnaire about maintenance in general neither did they have time to participate in the project work. Due to this response, our strategy for this WP8 work in oil offshore can be summarised as follows:

- In order to exploit the REMAFEX concept, REMAFEX WP8 Team decided to survey requirements from the oil sector to such a system. Requirements may be to hardware and software (architecture, standardisation (openness), interface), organisation philosophy, maintenance technology.
- Exploitation and dissemination of the REMAFEX Concept to the oil sector was first encouraged by presenting the Project and the Concept in oil offshore related newspapers and periodicals, seminars, conferences and other events where REMAFEX Partners were meeting oil industry persons.

- In order to exploit the REMAFEX results and to survey maintenance requirements in oil offshore industry, REMAFEX WP8 Team organised several meetings:
  - with these three Norwegian oil companies, ELF Petroleum Norway, Statoil and Norsk Hydro. We have also had a meeting with the Norwegian Petroleum Directorate (NPD).
  - with central persons in the CEC ESPRIT project URGENT (User Reference Group for the Exploitation of New Technologies), and with persons directly working in the standardisation activities under POSC (Petrochemical Open Software Corporation) and POSC/CAESAR, a collaboration between POSC and CAESAR Offshore.

The Aim of this deliverable D8.3 is therefore to describe the REMAFEX results expandability possibilities to Oil offshore industry with analysis of :

- oil offshore industry : maintenance situation in section 2
- oil offshore industry : IT system requirements in section 3
- Maintenance Reference Model application in Oil offshore industry in section 4
- Maintenance Monitoring tools (MMT) used in Oil offshore industry in section 5.

All the tasks performed by the REMAFEX Consortium to analyse this potential expandability and disseminate REMAFEX results in oil offshore industry are presented in section 6.

Recommendations and conclusions are presented in section 7.

2. OIL OFFSHORE INDUSTRY: MAINTENANCE SITUATION

2.1 THE OIL OFFSHORE INDUSTRY IN NORWAY. A BRIEF INTRODUCTION

The world oil production was i 1995 about 67,5 mill. barrels/day of which the Norwegian production was about 4,3 %. Totally Norway has about 1,3% of the known exploitative oil resources and 1,8 % of the known exploitative gas resources in the world.

Since the start in 1965 there has been about 200 oil/gas discoveries on the Norwegian continental shelf and 54 oil fields are put into production. There exist plans for developing 36 fields and the rest may be built out in the future depending on market situation for gas.

About 13-15 oil companies participate in the oil and gas exploration on the Norwegian shelf, and they have drilled nearly 900 wells. In addition to the production operators mentioned below, the main exploration companies are: Agip, Amerada, Amoco, BP, Conoco, Mobil. These companies spend about 7-8 bill. NOK each year in exploration activities.

7 oil companies are production operators on the shelf. The production platforms are usually fixed installations built in steel or concrete staying on the seafloor but today it is more common to use sub-sea installations or floating arrangements. The companies are: Statoil, Esso Norway, Phillips Petroleum, Norske Shell, Norsk Hydro, Saga Petroleum and Elf Petroleum Norway.

Investments in the petroleum sector from 1985 to 1997, has been increasing. In 1985-90, this spending totalled about NOK 30 bill per year. Since then it has increased substantially, totalling some NOK 45-60 bill. per year in fixed currency for the period 1992-97.

2.2 MAIN TOPICS OF THE MAINTENANCE SITUATION

All these platforms and installations represent large investments. They have also to be maintained and it is calculated that the maintenance cost is about 30 bill NOK pr year. Of course there is large profits for the companies if the maintenance can be made in a more effective way.

An increasing amount of the installations are ageing. Less income foundation and increasing maintenance costs as a result of this ageing process will also give the industry demands for more effectiveness and cost reduction methods.

The Norwegian Petroleum Department (NPD) is the Governments tool to set standard and monitor the level of safety and reliability. The companies maintenance strategies, plans and maintenance management today is not at the level the Department desire and require from the oil industry. Together with the operating companies they therefore are doing a job trying to improve these situation. Among other things they have worked out Guidelines how to organise and manage maintenance. In this connection it is expected that condition based maintenance can be a tool for the companies to achieve the required standard in the future.

Today condition based, preventive maintenance on oil offshore platforms is increasing but still on a low level. It is normally used on large, critical equipment, as stand-alone solutions or

integrated in the control system (SCADA). Large amounts of data are collected, but without good enough analysing and diagnostic methods, these efforts have so far not given the operator the expected benefits. The instrumentation is also introducing a maintenance problem on the instrumentation equipment itself.

Requirements from the authorities, demands for cost reduction together with improved tools and monitoring methods and instrumentation quality, will probably give an increased interest for condition based maintenance.

Solutions from REMAFEX (maintenance user needs, maintenance functions to plug into a platform) could therefore be the tools the oil industry is asking for in the future.

2.3 OUR WORK IN REMAFEX TOGETHER WITH OIL OFFSHORE INDUSTRY

The REMAFEX exploitation activities towards oil offshore platform industry are motivated from the situation described above. The main goal is to make the REMAFEX concept well known among the operators and also try to identify needs and requirements to a REMAFEX system from the industry. If they are different from what is identified in the hydro power industry, it is necessary and desirable to take these requirements into account when developing the REMAFEX Project.

For the project it was an ambition to use the methodology, the "REMAFEX way of working", who was established in the hydropower part of the project, in the work together with the oil industry to identify and specify needs, functions and data. It has been difficult to get the oil company persons involved to spend time together with us for this job. We have to realise that these persons are busy in their daily jobs, and in spite of their real interest in maintenance subjects, it is difficult for them to spend hour and days working on a project where they don't have any access or rights to the results.

Introducing REMAFEX to the oil industry has been made in many ways. REMAFEX project persons have presented a number of articles in relevant periodicals, seminars and conferences and it's also arranged presentation meetings together with Elf, Norsk Hydro and different departments in Statoil. As mentioned, it also has been presentations and discussions together with the Norwegian Petroleum Department and in different connections with supply industry, consults and R&D-institutions working up towards the oil industry.

Together with Elf, Norsk Hydro and Statoil we have done some work to identify needs and requirements. In meetings, workshops and "technical reviews" of documents, we have identified a lot of needs and functions, mostly existing functions realised as Maintenance Monitoring Tools (MMT) in operation on platforms.

This deliverable D8.3 reports on the work already done and provides to the next future the work which will have to perform the REMAFEX solution commercialisation: **The necessary REMAFEX solutions large dissemination.**

3. OIL OFFSHORE INDUSTRY: IT SYSTEM REQUIREMENTS

3.1 THE IT-SYSTEM SITUATION

Petroleum companies all over the world have long struggled with problems of disparate data formats, different database systems, in-house developed and purchased applications that do not communicate with each other, and diverse workstations that have specialised capabilities but differing operational requirements and application interfaces. Thus, they have been unable to take advantage of new computing opportunities in a timely or cost-effective manner.

This long list of problems also directly affects software and hardware vendors that are operating in this industry segment. They face difficult economic trade-offs of what languages, communication protocols, software and hardware interfaces to develop and/or support.

The advent of sophisticated data modelling tools, better database management systems, and need to deploy cross-discipline methodologies for technical and business solutions, gives oil and gas upstream businesses a new, more focused desire to maximise information management.

It is on this background the oil offshore industries large engagement in standardisation work in POSC and POSC/CAESAR has to be understood.

The Information Technology System situation in oil offshore industry demonstrates clearly that the main requirements to the future Information System are :

- **to be open in order to reuse all existing systems, tools, software products already used and available.**
- **to be distributed all around the enterprise to have a consistent information at the global level of the oil offshore company.**
- **to be flexible in order to introduce all along the IT system life new functions and all the evolutions needed .**
- **to be standard in order to use all existing products, to communicate all around the world if needed, to be able to evaluate and introduce if necessary new user needs to be satisfied.**

This IT system requirements in oil offshore industry are in accordance with REMAFEX objectives

3.2 STANDARDISATION WORK IN POSC AND POSC/CEASAR

Petrotechnical Open Software Corporation (POSC), is a not-for-profit, vendor neutral membership corporation founded in 1990. Major sponsors are BP Exploration, Chevron, Elf Aquitaine, Mobil, Saudi Aramco, Statoil and Texaco. Its mission is to benefit the oil and gas Exploration and Production (E&P) industry by establishing, maintaining and promoting specifications to be used as standards for the sharing of information through asset life-cycle. The

benefits of using international industry standards are better business decisions through sharing and collaboration and reduced cost and time.

POSC is now a 130 member organisation representing large and small vendors and suppliers of products, services and data, government agencies, universities and research centres, other standards organisations and oil companies.

POSC has devoted the last six years collaborating with its members and other industry standards groups (PPDM, PIDD, SEG, API, SPE, etc.), computer standards groups (XOPEN, OSF, ODMG, ANSI, SQL, etc.) and other industry groups (STEP, CADDETC, PISTEP, EPISTLE, PLANT STEP, etc.). POSC uses existing specifications and technologies where appropriate, and invites contributions from the industry where additional ones are needed.

The POSC community has established and delivered technical products with recommendations to buyers, vendors and developers to the industry [1]:

- **Epicentre** – an integrated, lifecycle E&P (Exploration and Production) logical data model. Provides a common vocabulary and enables E&P organisations to reduce, in a systematic manner, wasted efforts on reformatting data, modifying databases and storing data redundantly.

- **Data Access and Exchange Specifications** – Application Programming Interface (API) for the Epicentre Data model. Provides standard programming interface so that applications can read, write and exchange data stored in POSC data stores independently of how the data store is implemented.

- **Epigramme and PEF** – POSC exchange file format specifications. Provides a reduction in the need for many different formats for exchanging E&P information.

- **User Style Guide** – specifications for a common look and feel for E&P applications. Provides a means for users to move easily between applications without having to be retrained on the use of the graphical user interface of each.

- **Base computing standards** – underlying generic hardware and software standards required to support a POSC-based computing environment.

[1] The following standards and specifications contain sections which, through reference in the text, constitute part of the POSC specification:

- C Language International Organisation for Standardisation: ISO/IEC 9899: 1990 C Language Standard.
- *EXPRESS* International Organisation for Standardisation: ISO 10303-11: 1993 Industrial automation systems and integration – Product data representation and exchange – Part 11: The EXPRESS Language Reference Manual.
- SQL International Organisation for Standardisation: ISO 9075: 1992 Database Language SQL
- *Epicentre* Petrotechnical Open Software Corporation: 1993 POSC93a Software Integration Platform, ***Epicentre Logical Data Model, version 2.2***, Epicentre Logical Data Model, version 2.1 and Epicentre Data Model, version 1.0.

CAESAR Offshore is a joint industry data standardisation project initiated in 1993 to reduce the life-cycle cost and development time of offshore oil and gas facilities. The initial sponsors of the project were Aker, BP, Brown & Root, DnV, Elf, Kvaerner, Norsk Hydro, The Research Council of Norway, Saga and Statoil. From 1997 IBM, Intergraph, Lloyd's Register and Oracle have also become sponsors. The initiative was reorganised in 1994 and collaboration agreement was entered into with POSC. The POSC/CAESAR Project was funded by the CAESAR Offshore Sponsors to develop specifications for efficient electronic exchange, sharing and integration of oil and gas facility life-cycle information.

The initial project was designed to achieve:

- Solutions that will meet industry requirements for data sharing as well as exchange
- Useful results within two years (industry have already started implementation).

The project focus has been on requirements for technical information used in engineering, construction and operation of upstream oil and gas facilities. Provision is also made to include some cost, administration and planning information where it is required to support technically based life-cycle activities.

Three priority areas of work have been identified:

- Produce agreed standards for digital descriptions of facility products
- Understand and facilitate the use of available technology for implementation of the standards
- Encourage and assist take-up of the standards and technology by the business.

The project has been international in scope and has used the POSC open process to ascertain requirements and agree on the necessary standards. The project will develop demonstration implementations based on the standards and provide support to organisations involved in take-up and implementation. The main technological basis for the project is the relevant parts of ISO/STEP and POSC/Epicentre (data model).

Summary of POSC/CAESAR overall requirements [2]

- Implementations of the Product Model shall use open standards (if available).
- Implementations shall run on an open systems infrastructure – i.e. computer platforms and system software that follow open standards within the following system areas: user interface, APIs to operating system and other system software, interface to data communication software, access to the stored data in a DBMS, programming languages.
- Implementations must follow the three-schema architecture (also called the ANSI/SPARC Architecture after the committee that proposed it). Therefore a POSC/CAESAR Data Access Method is required.

[2] This requirements are described in detail in the POSC/CAESAR Web-page: http://www.posccaesar.org/

- Implementations of the Product Model should support the users' concept of sharing the same data store – i.e. they should think of the data as being
  - stored in one common data store
  - available at their fingertips (independent of place/location)
  - available at any time (independent of time)
  - up-to-date – i.e. the data values are 'as-is-now' unless historical data is wanted.

- In computer terminology, the technical implementation of the virtual common data store should be transparent to the user. From the computer system developer's point of view therefore we may derive the requirement that adequate data management systems and tools must be in place, including:
  - a repository with information on the physical data stores and their mappings to the conceptual Data Model and the Reference Data Library
  - tools for data check-out from and check-in to data stores
  - tools for data consolidation.

- The implementation of the POSC/CAESAR Product Model should aim at interactive interoperability between the business' applications and should try to minimise batch-processing of data.

- Implementations of the Product Model must support the requirements of the application developed. These requirements may require different technical implementations depending on the type of application – i.e. special purpose applications and information analysis applications. In terms of application development, this may include the following requirements:
  - support concurrent access to data
  - support on-line access to and manipulation of data in another physical data store, either visible or transparent to the user.

- POSC/CAESAR application interface: implementations of the Product Model should use a standardised set of graphical presentations of Product Model concepts (icons, symbols) and of lexical presentations of Product Model concepts (labels on screens and reports, menu entries).

- Implementations of the POSC/CAESAR Product Model should preferably be "components" that may be bought off the shelf and that may play together to support user tasks.

3.3 OIL OFFSHORE INDUSTRY: REMAFEX REQUIREMENTS

In order to be used in the next future in oil, offshore industry, REMAFEX has to meet the oil offshore requirements (open, distributed, standard, flexible i.e.) coming from these POSC and POSC/CAESAR projects.

As seen from the above mentioned, nearly all operators, suppliers and vendors in the Norwegian oil industry, participate and take into account the POSC and POSC/CAESAR standardisation work. For new software developers who want to exploit their products to this industry, it seems like an inevitable requirement to follow standards, data models, recommendations, terminology etc., coming from these projects.

This will be the main and the strongest requirement for the REMAFEX Consortium: to set up and to prepare REMAFEX solutions that fulfil these requirements due to standards.

To exploit REMAFEX in oil offshore industry REMAFEX Consortium will have to meet these requirements in details. But today we can be confident, all these requirements were expressed at the beginning of the REMAFEX project and constituted the starting requirements to the REMAFEX project to define and design the REMAFEX way of working and the REMAFEX architecture.

REMAFEX solutions meet the Oil Offshore Industry IT System Requirements, REMAFEX Consortium have worked for that and we shall continue now in the oil offshore detailed needs.

It will be a challenge to the REMAFEX Norwegian partner in the next future to follow up this work.

4. MAINTENANCE REFERENCE MODEL AND OIL OFFSHORE INDUSTRY

REMAFEX architecture was designed in order to be integrated into the Control Maintenance and Technical Management System model (refer to section 4.1 hereafter) to deal with the global Maintenance Reference Model of an enterprise and consequently REMAFEX architecture is able to:

- be open
- use the existing systems and tools already available in the enterprise (MMT)
- exchange data information with Control system
- exchange data information with Technical Management System (if they do exist)
- exchange data information with Maintenance Management System (if they do exist)

All these interfaces needed to meet the Maintenance Reference Model are defined in the REMAFEX architecture (See also D8.2, chapter 2).

4.1 CMMS MODEL PROPOSED TO OIL OFFSHORE INDUSTRY

The REMAFEX project aims at defining and proposing new solutions with **a Intelligent Distributed Maintenance System** which manages **the global maintenance activity for manufacturing facilities.**

To describe this global maintenance activity, REMAFEX who deals with the maintenance aided operation on industrial sites, has taken up the CMMS model (Control, Maintenance and Technical Management System) coming from the EC funded projects DIAS and PRIAM.

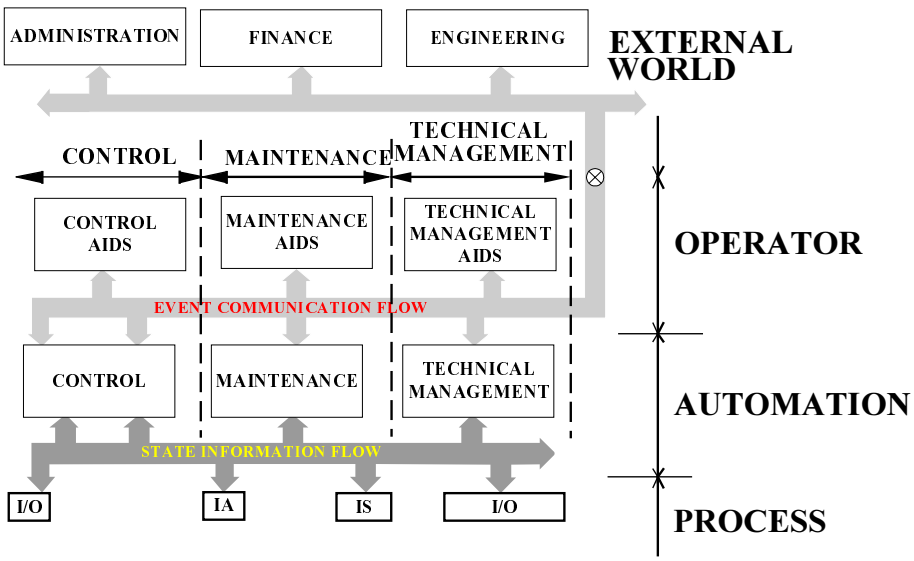


Fig. 4.1. : CMMS Architecture

This model demonstrate very well that IT systems for the future has to integrate this global vision related to its activities to an industrial facility, and around a common database, to distribute the functions associated to each of these activities.

This model was proposed and discussed as such to oil offshore partners. The model was agreed and a large discussion was engaged around the technical management island and the interface with REMAFEX solutions.

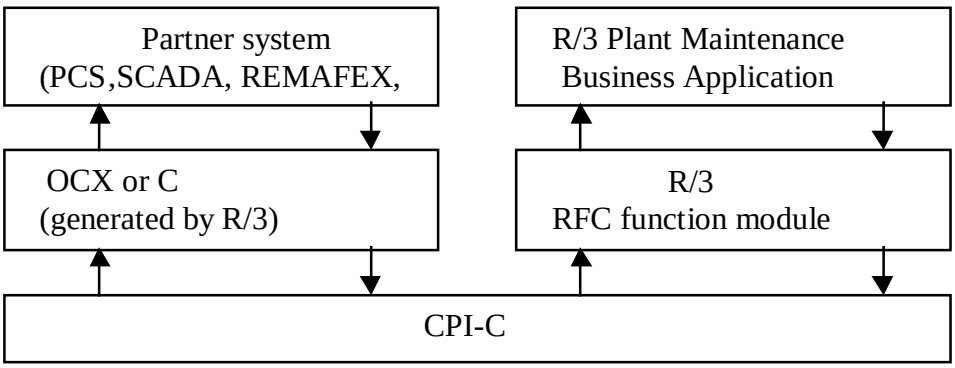
4.2 INTERFACE BETWEEN REMAFEX AND TECHNICAL MANAGEMENT SYSTEMS IN OIL OFFSHORE INDUSTRY

In the Norwegian oil industry today, the SAP system from SAP AG is introduced as the overall IT system (See also D8.2, chapter 5). This is the situation both in Statoil and in Norsk Hydro and they both make large efforts to take the system in use for different purposes.

In the Technical Maintenance Management area the SAP R/3 PM (Plant Maintenance) is the actual application. It is said to be a software solution that covers all management maintenance tasks for a company. It supports the planning and execution of all management maintenance activities, regarding system availability, costs, material and personal deployment.

The application is made open for integration with different external systems as:

- Geographical Information Systems (GIS)
- CAD-Systems
- Plant Data Collection Systems
- Systems for entering measurements and/or counter readings (SCADA)



OCX = OLE Custom Control eXtension

Figure 4.2.a Integration between SAP R/3-PM, SCADA and REMAFEX.

REMAFEX may be perceived as an application similar, or a supplement to the two last kinds of systems. Today no SCADA or Data Collecting System is known for predictive or condition based maintenance.

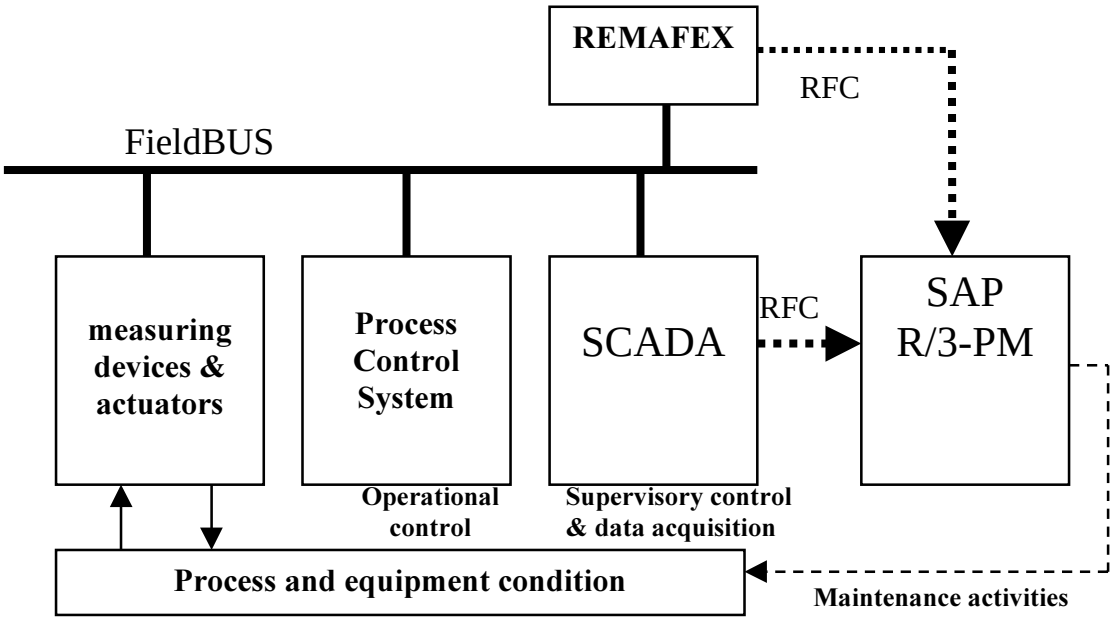


Figure 4.2.b Possible integration between SAP R/3-PM, SCADA and REMAFEX

In a more detailed way figure 4.2.b shows a possible integration between SAP R/3-PM as a Technical Management System, the SCADA and Process control system and REMAFEX as a system for predictive and condition based maintenance.

Both in Statoil (methanol production at Tjeldbergodden) and in Norsk Hydro Agri (fertilizer production in Herøya) they today use SAP R/3-PM as a Technical Management System. Manually they take measurements and counter based data or point in time data from the SCADA and process monitoring system over to SAP R/3-PM where they are followed up in work orders etc. It is said from SAP AG that the next version of SAP will have better solutions for integrating on-line condition based messages and alarms.

The RFC connection between SCADA /REMAFEX and SAP stands for "Remote Function Call" which is SAP's open standard programmable interface tool.

This solution has to be studied further before a possible implementation. Here it's taken as an example.

4.3 REMAFEX CAN GIVE SAP AND OTHER MMS ADDED VALUE

As mentioned, in SCADA systems today there are limited possibilities to handle numerous maintenance functions like we do in REMAFEX. Maintenance Management Systems like SAP R/3 – PM and others, also concentrate to realise a different maintenance functionality than we do in REMAFEX. As shown in 4.2 the three systems will gain great benefits from co-operation with each other.

In order to obtain integration with SAP and other MMS, vendors and developers of these systems has been contacted. Through SAP Norway who is a vendor of the SAP different modules, we have got a contact in the development department in SAP Germany. We have also been in contact with similar persons in other companies developing MMS, namely Powel Data AS, a developer and vendor of MMS to energy companies in Scandinavia and IFS (International Financial Service), a Swedish company, operating all over the world with MMS and other software systems.

Our contact and discussions together with these companies will hopefully give the result that these vendors map between REMAFEX and their MMS the global Maintenance Reference Model in the next future.

This study demonstrates that global maintenance approach gathering Real Time Maintenance (REMAFEX) and Management Maintenance (SAP) can be analysed, specified and developed through the Maintenance Reference Model proposed by REMAFEX.

5. MAINTENANCE MONITORING TOOLS (MMT): OIL OFFSHORE INDUSTRY

The aim of this section is to give examples on Maintenance Monitoring Tools in the market which are evaluated by users when introducing conditional based maintenance in their old and new facilities. By analysing their suitability to be plugged into the REMAFEX platform, we also say something about the openness in the platform. In the following MMTs for the oil offshore sector, hydro power sector and others are described.

5.1 RESULTS FROM A MARKET SURVEY

A brief Market Survey has been done by the partners to get an overview of already existing MMTs in the market. EFI (now SINTEF Energy Research AS) has concentrated on MMTs especially interesting for the oil offshore industry. From EDP and Iberdrola MMTs for hydropower has been introduced, while CRAN has lined up some tools for generic functions on fault analysis, functional tree i.e.

In spite of the fact that these tools normally are designed for equipment in specific industries, many of them will be independent of industry area. The same tools for vibration monitoring may be used for all kind of rotating machinery and of course the generic, analysing tools introduced by CRAN, may be used on all kind of processes.

The MMTs are recorded in the table below, and in Annex 1 it is given a short description for 39 of the most interesting tools are given. It is also said something about their suitability to be connected/"plugged into " the REMAFEX platform.

No	Name	Area of use	Introduced by
S101	Data Manager 2000 for Windows NT	Vibration	EFI
S102	Trendmaster 2000 for Windows NT	Vibration	EFI
S103	Vibronet	Vibration	EFI
S104	COMPASS	Vibration	EFI
S105	MetalSCAN	Oil Analysis	EFI
S106	MagNET	Oil Analysis	EFI
S107	FerroSCAN, model 310,	Oil Analysis	EFI
S108	FSM, Field Signature Method	Corr. monitor	EFI
S109	MultiCorr MKII, MultiLog	Corr. monitor	EFI
S110	System VKE	Monitoring	EFI
S111	QuickCheck II	Diagnosis	EFI
D101	TIGER	Diagnosis	EFI
D102	ROMEX	Diagnosis	EFI
A101	Engineer Assist 3.0	Analysis	EFI

Table 5.1. 13 MMTs introduced by EFI used in the oil offshore industry. These MMTs may all be suitable to be "plugged into" the REMAFEX platform, or they are systems similar to REMAFEX and may be integrated or used in parallel.

No	Name	Area of use	Introduced by
S201	AGMS, Air Gap Monitoring System	Vibration	EDP
S202	ZOOM	Vibration	EDP
S203	SBV, Stator Bar Vibration evaluator	Vibration	EDP
S204	HydroSCAN, rotor-mounted Scan	Monitoring	EDP
S205	PDA-IV	Discharge	EDP
S206	VIMOS, Vibration Monitoring System	Vibration	EDP
S207	CMS, Cavitation Monitoring System		EDP
S208	2210 Monitoring System	Vibration	EDP
S209	RF (Radio Frequency) Monitoring System HF-DIAG Diagnostic Model	Discharge	EDP
S210	GenGuard	Discharge	EDP
S211	HPM System (under development)	Vibration i.e.	EDP
A201	Advisor	Vibration	EDP
A202	GEMO – Monitor & Diagnosis system	Moni & Diag	EDP
D201	MICAA	Diagnosis	EDP
S301	PROMOSHYGES	Vibration	IBERDROLA

Table 5.2. 15 MMTs introduced by EDP and IBERDROLA used in the hydropower industry. Also these MMTs may all be suitable to be "plugged into" the REMAFEX platform, or they are systems similar to REMAFEX and may be integrated or used in parallel.

No	Name	Area of use	Introduced by
A401	OASYS	Analysis	CRAN
A402	RELIASEP	Analysis	CRAN
A403	SOFIA	Analysis	CRAN
A404	Event Tree	Analysis	CRAN
A405	Fail Mode	Analysis	CRAN
A406	Fault Tree	Analysis	CRAN
A407	FMECA	Analysis	CRAN
A408	PFA Pro	Analysis	CRAN
A409	RCM Cost	Analysis	CRAN
A410	RTP	Analysis	CRAN

Table 5.3. 10 generic MMTs introduced by CRAN used in all type of process industry.

5.2 PRESENTATION OF MMTS IN USE IN THE OIL INDUSTRY

5.2.1 Trendmaster 2000 for Windows from Bently Nevada Corporation (BNC)

Industries are actively searching for proven systems that can make them run more efficiently. About 200 companies around the world have found that implementing an online periodic machinery monitoring system, such as Trendmaster 2000 for Windows, is an effective method for improving overall plant maintenance efficiency. The system provide accurate current information on the condition of the machinery to the people who need it, when they need it and in the format they need. It allows one or more users, such as engineers, technicians, operators and machinery experts, immediate access to this information.

Trendmaster 2000 for Windows is more than just a software program, it's a complete new system architecture. Using Windows provides a flexible solution for both stand alone and distributed machinery information and management systems. Figure 5.1 outlines how Trendmaster 2000 for Windows can be configured as a distributed system with one or more data acquisition server and display computers.

Figure 5.2 outlines how the system can be configured as a simple stand-alone system, with a single computer used for both data acquisition and display.

This computer-based, on-line system automatically sample, processes and trends data for every point in the system. If a sample for a point exceeds alarm levels pre-defined by the user, an annunciation at the computer occurs. It's a data collection system flexible enough to accept signals from a variety of low-cost transducers and process inputs in a plant including:

- Acceleration
- Velocity
- Displacement
- Keyphasor (speed or phase reference)
- Temperature
- Others (REBAM, process signals +4 to +20mA or +1 to 5 Vdc)

With Trendmaster 2000 Remote Access Software and a high-speed modem (or RS422/ RS232 connection), the user can conveniently identify and diagnose possible machine problems from any location at any time.

For Trendmaster 2000 there is also a Distributed Control System Interface Software option. System "last read" data and alarm condition information can be read by a DCS and displayed to an operators screen, so he can make better informed operating actions.

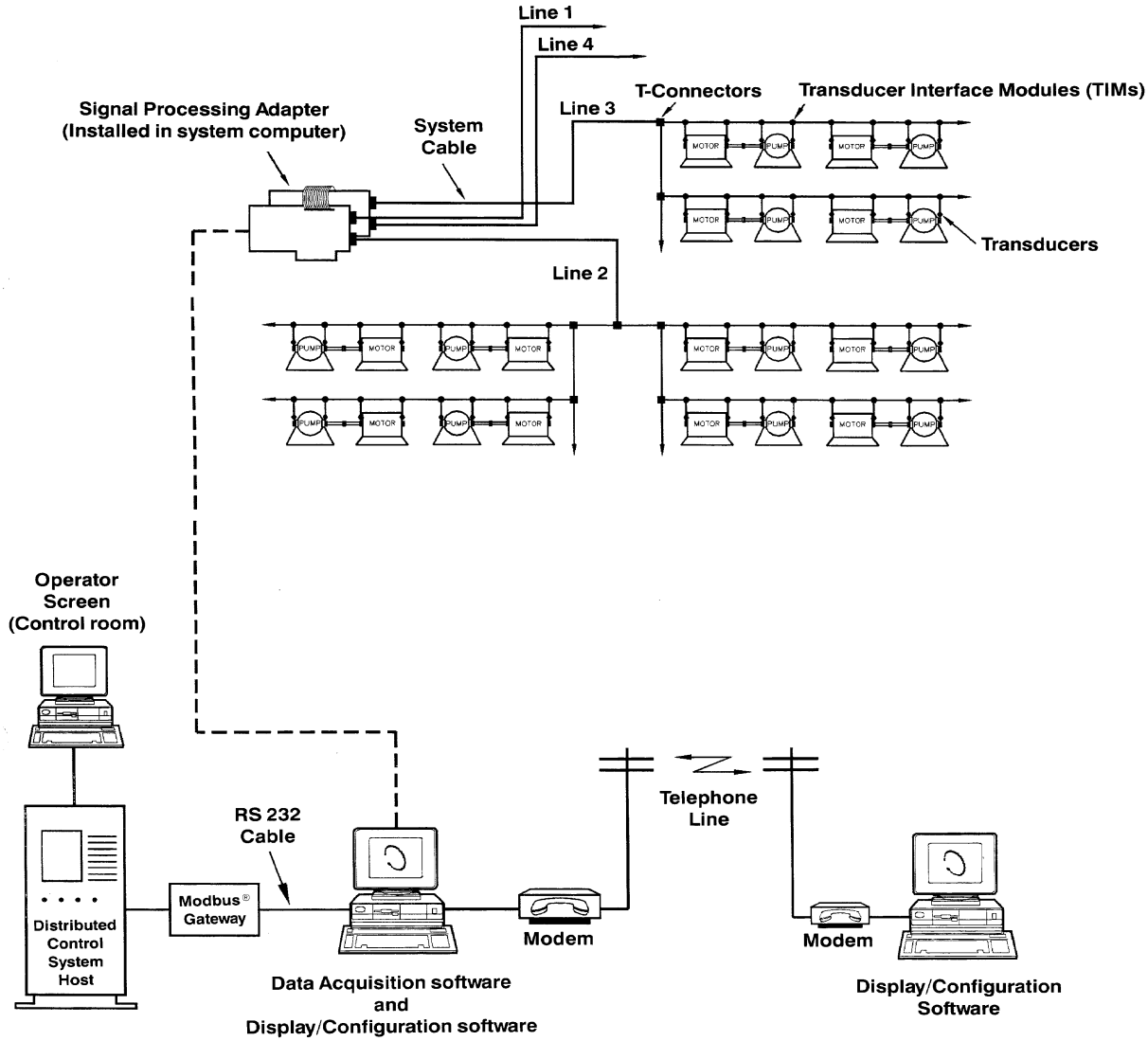


Figure 5.1: System architecture for a networked, multitasking Trendmaster 2000 for Windows

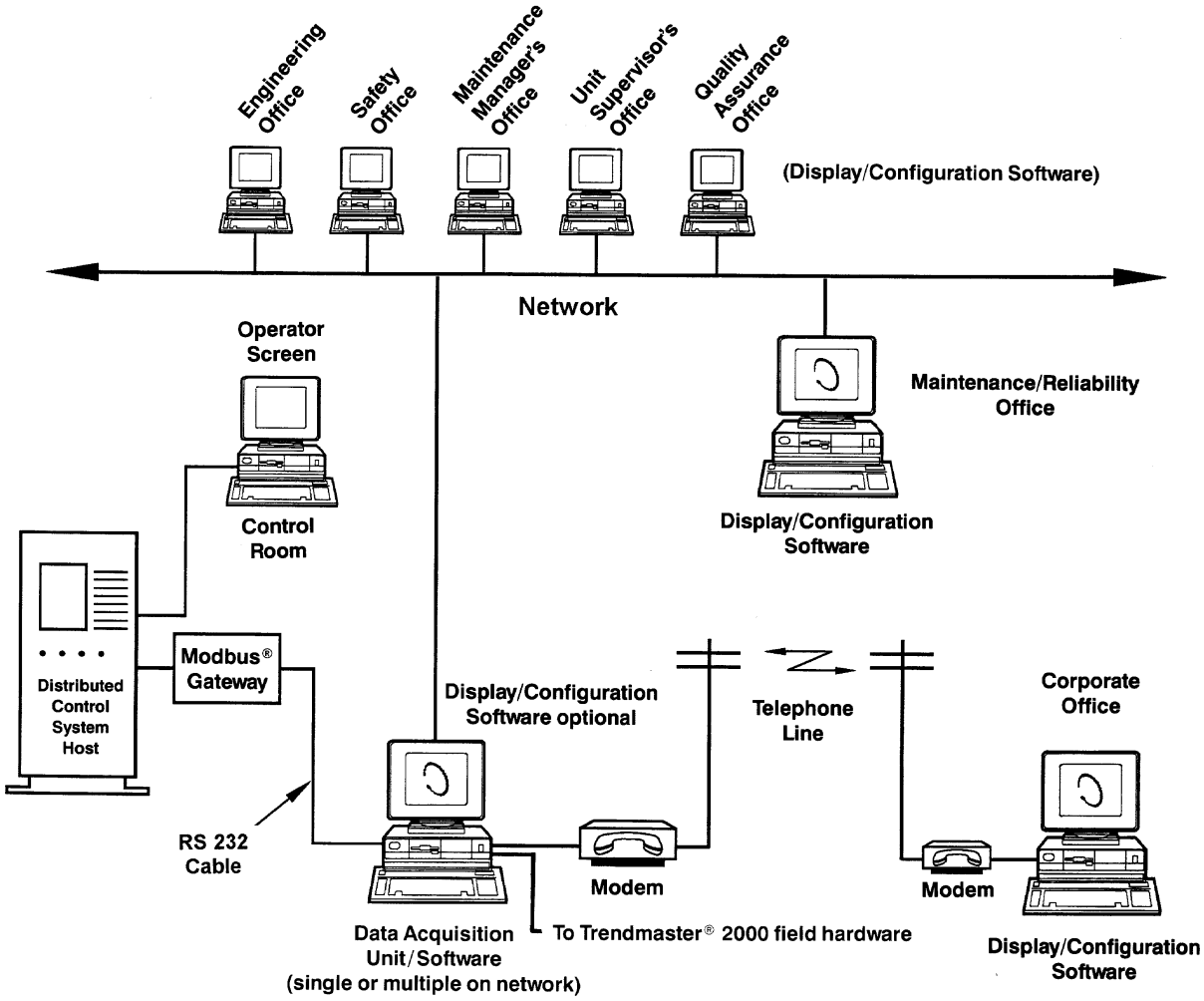


Figure 5.2: Trendmaster 2000 for Windows configured as a stand alone system.

A Trendmaster 2000 for Windows system is typically comprised of:

- One or more computers with Trendmaster 2000 Data Acquisition Software (Data Acquisition Server)
- Trendmaster 2000 Display/Configuration Software on the data acquisition server or on a separate Display Computer.
- Optional Trendmaster 2000 Distributed Control System interface software module
- Trendmaster 2000 System hardware.

The data acquisition server is responsible for collecting information from field transducers and sensors. It acts as the network server if installed on a network. It contains the Signal Processing Adaptor(s) and optional cards for networking, external annunciation and internal modem. Trendmaster 2000 Data Acquisition Software is loaded on the data acquisition server. For distributed systems, multiple data acquisition units can be located throughout a plant and interfaced together using a network. All servers can be configured and controlled either locally or remotely, using a display client.

5.2.2 MultiLog from CorrOcean ASA

MultiLOg is a flexible and powerful solution for remote corrosion monitoring. The MultiLog can be a rugged, stand alone battery powered multi-purpose field unit which can be used as a single or multi-channel data logger. Alternatively the MultiLog can be connected directly, or through CorrOceans FieldBus System, to a PC for online monitoring of multiple probes.

The FieldBus system will provide power for charging the MultiLog batteries and will interface between the MultiLog stations and the PC for data downloading. PC functions such as data downloading and MultiLog setup is performed with MultiTrend software. MultiTrend can also display data and store data in ASCII format.

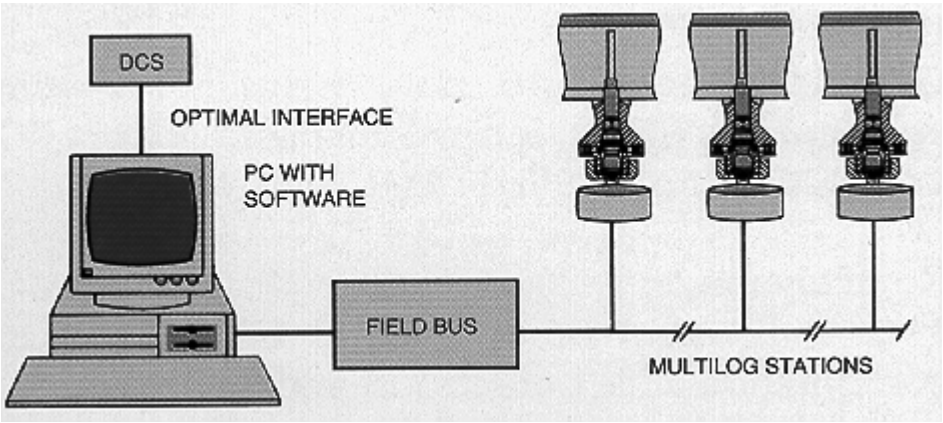


Figure 5.3: MultiLog connected through a Fieldbus system to a PC for online monitoring.

5.3 REQUIREMENTS TO A REMAFEX PLATFORM OUTLINED FROM THESE MMTS AND SYSTEMS

The Trendmaster 2000 for Windows is in many ways a parallel to REMAFEX. Outlined as a stand-alone system it can be looked upon as REMAFEX DAS/LMS, but may have more analysing and diagnosing software available.

The benefits for REMAFEX against Trendmaster 2000 is the remote solution where the DAS/LMS has a more displaying function, and the analysing, trending and diagnose software is located in the CMS. Because of that we can add more innovative functions.

The REMAFEX modelling method and "way of working" is also a tool giving benefits for REMAFEX by giving opportunities to easily integrate new functions into the platform.

Both systems are operating on a Windows/Windows NT platform and may therefore be integrated or used in parallel to enhance the total benefit for the user.

MultiLog is more like a MMT as we know it in the REMAFEX Project, Workpackage 4 (for example the EFI function S1-Partial Discharge Monitoring, described in Deliverable D4.2). Both for MultiLog and S1, the PC is a data acquisition system and may also be the analysing and display unit. As for S1, MultiLog may easily be integrated in a REMAFEX platform either by downloading software and data from the MultiLog PC to the REMAFEX LMS, or to go directly from the sensors through the MultiLog Fieldbus to REMAFEX LMS. In that case MultiLog analysing software may be installed in the LMS or in the CMS.

In any cases, openness of the REMAFEX platform through multi protocols hardware mechanisms (in particular field bus) performed through the Field Communication Interface makes possible the link of each MMT to REMAFEX.

These possibilities will be fully disseminated as MMT Requirements to MMT vendors.

6. OIL OFFSHORE INDUSTRY: REMAFEX EXPLOITATION AND DISSEMINATION.

6.1 INTRODUCTION

Task 8.2 aims at analysing the possible use of the REMAFEX concepts and results in the oil offshore platform industrial sector. By doing this, we want to make the REMAFEX concept more general, and make it usable in a wider context than possible by the companies directly involved in the experimental tasks of the REMAFEX project.

Due to this, EFIs activities have been a combination of exploitation and dissemination initiatives towards the sector. Our first challenge was to get contact with companies and persons willing to do a job in the project. Later we have also made efforts to make the REMAFEX concept known in a larger part of the sector.

6.2 HOW TO APPROACH THE OIL SECTOR

The first contact with the oil sector was through the market survey in T8.1, asking also the oil companies about their interest in maintenance and their possibilities to do a job together with the project. 3 oil companies gave a positive answer. 8 others got the information package, but they did not answer the questionnaire about maintenance in general neither did they have time to participate in the project work. Due to this response, our strategy for the work can be summarised as follows:

- In order to exploit the REMAFEX concept, try to survey requirements from the oil sector to such a system. Requirements may be to hardware and software (architecture, standardisation (openness), interfaces), organisation philosophy, maintenance technology.
- Exploitation and dissemination of the REMAFEX concept to the oil sector by presenting the project and the concept in oil offshore related newspapers and periodicals, seminars, conferences and other events were we are meeting oil industry persons.

6.3 ORGANISATION OF THE WORK

6.3.1 To exploit the system

Surveying system requirements has been organised as several meetings with the three Norwegian oil companies, ELF Petroleum Norway, Statoil and Norsk Hydro. We have also had a meeting with the Norwegian Petroleum Directorate (NPD).

There have also been meetings with central persons in the CEC ESPRIT project URGENT (User Reference Group for the Exploitation of New Technologies), and with persons directly working in the standardisation activities under POSC (Petrochemical Open Software Corporation) and POSC/CAESAR, a collaboration between POSC and CAESAR Offshore. The results from this requirement work are presented in ANNEX I in this report.

6.3.2 Exploitation and dissemination activities

In order to make the REMAFEX concept and software system well known in the oil industry, EFI persons have published several articles in technical periodicals, made presentations in meetings, seminars, conferences i.e. Directly related to the oil industry, the most important activities are:

- Eivind Solvang: Vedlikehold og tilstandskontroll i elkraftanlegg. ("Maintenance and condition monitoring in electrical installations").
  Paper presented on the annual conference at NTNU in January 1997.

- Eivind Solvang: Bedre vedlikehold – lavere regning. ("Better Maintenance – lower invoice").
  Article in the Norwegian technical periodical "TEKNISK UKEBLAD" nr 8/1997 (februar 1997).

- Jørn Heggset, Eivind Solvang, Birger Stene: REMAFEX – nytt IT-kosept for tilstandsbasert vedlikehold. ("REMAFEX - New IT-concept for conditional based maintenance").
  Article in the Norwegian electrotechnical periodical "ELEKTRO" in May 1998.

- E. Solvang; REMAFEX. Article in XERGI 2/98, the SINTEF Energy Research periodical.

Official presentations given to:

- 5 persons at Elf Petroleum Norway in February 1997
- 5-6 persons from different parts of Norsk Hydro (process, oil, hydropower) in June 1997.
- 4 persons at the Norwegian Petroleum Directorate, Supervision Department i June 1997.
- Presentation for the contact person in Statoil for the CEC-project "URGENT" in June 1997.
- 4 persons at Statoil, Bergen, Instrumentation and Automation Section in November 1997.
- Several meetings with Statoil R&D in Trondheim during 1996 and 1997.
- Presentation of REMAFEX to Mr. Schjølberg, NTNU, the Chairman of the Norwegian Maintenance Society and Secretary of the European Maintenance Society (EFNMS)
- Contact with the Maintenance Manager at Statoils Methanol Plant at Tjeldbergodden. May 1998.
- Contact with the Maintenance Manager at Norsk Hydro Agri, Porsgrunn. May 1998.
- Contact with the product manager of SAP R/3-PM, in SAP Norway. May 1998.
- Short Presentation for the Steering committee of the CORD forum (CORD – Co-operated Operation and Maintenance – Research and Development Offshore) May 1998.

6.4 HOW TO EXPLOIT THE APPROACH TOWARDS THE OIL SECTOR.

In this final part of the project we have to concentrate our resources in analysing our data and writing the reports. Our contact with the oil companies mentioned above, will continue, but now to finalise the discussions and to review the draft for deliverable D8.3. They will be reading and verifying drafts and may participate in a planned workshop. (3 March 1999).

We will continue our exploitation and dissemination work, and so far the following activities are performed:

- For the 11 members of the European Maintenance Society, at their annual meeting in Brussel at 29. May 1998. Presentation giving on behalf of the project by Mr. Schjølberg, NTNU.

- For representatives from Norsk Hydro European plants, a brief introduction to REMAFEX given by Mr. Ragnar Stokke, the Maintenance Manager at Norsk Hydro Agri. May 1998.

- To the CORD Forum Steering Committee in their meeting in August 1998.

6.5 FINISHING THE TASK T8.2 AND THE DELIVERABLE D8.3

With the available resources put on the exploitation and dissemination work towards the oil sector, we think the aim of task T8.2 is reached:

- We have identified a lot of user needs/functions in the oil offshore sector in our market survey of Monitoring Maintenance Tools. About 60 MMTs who was planned to be realised on the "Gullfaks" oil production platform are identified. 13 of them are of a type which may be "plugged" in a REMAFEX concept and we have analysed them regarding what kind of requirements they may have on the REMAFEX platform.
- We have made a lot of exploitation and dissemination activities in order to make it easy for a future REMAFEX product to be introduced in the oil industry sector.
- Some complementary advanced function requirements are identified and described.

6.6 POSSIBILITIES TO PERFORM FUTURE REMAFEX EXPLOITATION IN THE OIL SECTOR.

Three different possibilities are currently discussed:

- The CORD Forum.
  The Secretariat of this Forum is organised by one of the new Departments at EFI. From 1998-01-01, EFI merged with a part of SINTEF named SINTEF Energi, making a new company called SINTEF Energy Research (SEfAS). One of the three new departments coming from SINTEF Energi is deeply involved with the work in CORD.

- A CEC project for a REMAFEX Demonstration Site realised in a hydro power station in Norway. This work can be done together with the oil industry. It will be easier to make them engaged if we can demonstrate both functionality and the organisation around such integrated software.

- A Maintenance User Group in Europe, (Scandinavia or Norway). The work for that will be obligations regulated in the REMAFEX Commercial Agreement under work.

6.7 SYSTEM REQUIREMENTS DERIVED FROM WORK TOGETHER WITH THREE OIL COMPANIES.

Today most of the maintenance activity on oil offshore platforms are corrective (about 80 % corrective and 20 % preventive). There is ambition to do more preventive maintenance and also to use Condition Based Maintenance (CBM) in this connection. Possible cost-reductions in maintenance seems to be overruled by reliability consequences for the production of oil and gas. RCM-analyses (RCM-Reliability Centered Maintenance) for example for the Troll platform (Statoil), show that an increase in CBM will be too expensive regarding instrumentation and maintenance of instrumentation. In practice they therefore use CBM only on the most heavy and critical equipment.

The three oil companies mentioned find REMAFEX to be an interesting concept. Today they have very much data from monitoring and Conditional Based Methods, but they have no systematic way or systems to use the data for diagnosis and analyses purposes, or to store them in an appropriate way. Seeing maintenance as a global activity realised through the CMMS model on a REMAFEX platform, could therefore be a solution to increase cost/benefit from CBM methods.

To accept REMAFEX as a solution for the oil industry the meetings have identified some requirements or external conditions to be fulfilled:

- **Philosophy/strategy:**
- Most of the companies have chosen SAP R/3 as the overall platform for their office administration and management. The managers in maintenance sectors have got instructions to use SAP Maintenance Modules if possible. REMAFEX will have to be integrated in this environment.
- Top management in the oil industry is not focusing on CBM today. They wish to reduce maintenance costs, but reliability in production are more important for the economy. They have problems with defining the most critical components and it will be too expensive to use CBM on many components. Therefore CBM today will be used only on «heavy», critical equipment where CBM functions are well defined.

- **Organisation:**
- Together with the oil companies (so far Norske Shell) NPD are working out «Guidelines for Maintenance on oil platforms». These guidelines will be a part of the oil companies' «Internal Control System», and the Directorate will use them as checkpoints in their Supervision activity. The guidelines will put forward goals for the maintenance activities due to organisation, personal resources, tools, procedures, education and training.

- **Systems/tools:**
- A joint venture co-operation between many of the oil companies have worked out standards for IT applications and data systems in the POSC and POSC/CAESAR projects. On new platforms the companies now require these standards to be followed by software bidders and suppliers regarding:
    - Base Computer Standards (hardware solutions)
    - EPICENTRE Data model
    - Application Access to data
    - Exchange of Data

    - User Interface Styleguide and associated training material.
- There is close ongoing co-operation and harmonisation by POSC/CAESAR with related ISO/STEP projects, especially by being an active participant in the process industry forum EPISTLE meetings and work groups. The project has recently achieved an agreement with the process industry ISO/STEP AP221 project to have a common Reference Data Library.
- The Draft ISO/DIS 14224 describes standards for collection and exchange of reliability and maintenance data for equipment in the petroleum and natural gas industries. This is a result from the OREDA project who has been carried out by several major oil companies since the early 80's.

These standards have to be followed by a REMAFEX application exploited for the oil offshore industry.

7. CONCLUSION

In Norwegian oil offshore industry today there is little predictive maintenance based on condition monitoring, but both the industries themselves and the authorities are interested to improve this situation. A system like REMAFEX they see as an interesting one for these purposes, and the exploitation works performed within REMAFEX Task 8.2 have clearly demonstrate this.

No oil offshore industry end user has directly worked in or with the REMAFEX concept during our project, but in our exploitation work we have had a lot of contacts with central persons in the industry. The REMAFEX concept may be well known, and in a possible marketing situation in the future, it's a good basis to start on. Both vendors of such systems and buyers coming from the industry will have benefits from reading this report describing the situation.

Some requirements identified to IT-systems related to standardisation work in the industry in POSC and POSC/CAESAR project, are important to be aware of. System developers who want to introduce their systems to the offshore industry has to follow the standards and recommendations coming from this work.

Our work in the REMAFEX project has shown that maintenance is and will be a large activity in the oil offshore industry. The system and partners are now introduced, and we have a lot of contacts to follow up. One of the most promising contacts is through the new forum CORD, Co-ordinated operation and maintenance Offshore – Research and Development, a meeting place for users, researchers, vendors and buyers in the industry.

EFI (SINTEF Energy Research) will as the Norwegian REMAFEX partner continue the exploitation and dissemination of project results in the oil offshore industry through CORD and in other connections meeting the industry.

Oil offshore industry constitutes an excellent opportunity to exploit REMAFEX solutions. This as demonstrated in this Deliverable D8.3, provides a very important challenge to REMAFEX Consortium and its Norwegian partner EFI.

A first step for that may be the work started for a REMAFEX Demonstration Site in Norway. It may also be in a hydro power plant, but the REMAFEX platform can easily include some maintenance functions/MMTs relevant for the oil offshore industry. The methodology introduced in REMAFEX Project may here be tested out for identifying new maintenance needs and functions in the oil offshore industry.

This methodology has been used in parallel with the REMAFEX project at EFI by a French student, Gerald Caron, during the summer 1998. His work is presented in the Annex III in this Deliverable, and it show the usability and the power of the method for structural analysis of complex systems like hydro power stations or oil offshore platforms.

ANNEX I: MAINTENANCE MONITORING TOOLS IN USE

Maintenance Monitoring Tools (MMT) introduced by EFI. Especially interesting for oil offshore equipment.

Name	**Data Manager 2000 for Windows NT**	Supervision (S101)
Description	Online system for supervision of rotating equipment. Special designed for complex installations with large, critical equipment/components who needs continues monitoring (high metering frequency). The system collect and analyse vibration- and processdata and cover both stationary and transient operation conditions. Used together with Engineer Assist (A101) it's also a diagnose system.	
Producer	Bentley Nevada, USA.	
Relevance REMAFEX	It's a system similar to REMAFEX in the vibration area. Runs on Windows NT servers in a network with sensors and acquisition systems (MMTs) directly plugged in. May be a parallel system to REMAFEX or integrated, covering the vibration area.	

Name	**Trendmaster 2000 for Windows NT**	Supervision (S102)
Description	A vibration analysing system for automatic monitoring of rotating equipment. Similar to Datamaster 2000, but because of low metering frequency especially designed for less critical equipment.	
Producer	Bentley Nevada, USA	
Relevance REMAFEX	It's a system similar to REMAFEX in the vibration area, but designed for use on less critical equipment. Runs on Windows NT servers in a network with sensors and acquisition systems (MMTs) directly plugged in.	

Name	**Vibronet**	Supervision (S103)
Description	A rigidly mounted monitoring system for vibration control of rotating equipment. By multiplexing 9 accelerometers up to 1152 sensors can be mounted in the same network for acquisition of data. The central unit can be interfaced to different analysing instruments like VIBROTIP, a PC with analysing software or VIBROSPECT for frequency analyse.	
Producer	PRUFTECHNIC, Germany,	
Relevance REMAFEX	Vibronet is an acquisition system (MMT) to be plugged into the REMAFEX platform where the operator may use different kinds of analysing software available.	

Name	**COMPASS**	Supervision (S104)
Description	Compass (COMputerised Predictive Analysis and Safety System) is an advanced system for monitoring and conditional control of rotating equipment. Modules available for total vibration analysis and also for performance calculations. One version is an offline acquisition system which can be connected to a PC for analysing i.e. The online version is an extensive UNIX-based system with different kinds of analysing tools available and where data can be exchanged on networks.	

Producer	BRUEL & KJÆR, Denmark
Relevance REMAFEX	The offline version can be MMT to be plugged into the REMAFEX platform. The online version seems to be a parallel system, running on UNIX.

Name	**TIGER** (Result from a CEC/Esprit project)	Fault Diagnosis (D101)
Description	Knowledgebased conditional monitoring system for gas turbines. Three main functions: - KI diagnose system based on rules for the turbine physical process - analysing module with forecast hypothesis based on behaviour - interpret alarm sequences	
Producer	Intelligent Application Ltd, Scotland	
Relevance REMAFEX	TIGER is a system, not only a MMT, and may be used in parallel or integrated to REMAFEX on the network. Gives added value to REMAFEX and to the operator for the gas turbine.	

Name	**ROMEX** Result from a developing project with 4 oil companies: Norsk Hydro, Statoil, Saga and Total	Fault Diagnosis (D102)
Description	Diagnosis system for gas turbines, centrifugal compressors and pumps. An offline, Windows-based system presenting diagnosis for the operator by interpreting collected data from different kinds of conditional control systems. Input data are vibration parameters, oil analysis results, thermodynamic data, inspection data and historic.	
Producer	MARINTEK, Norway	
Relevance REMAFEX	ROMEX is a system similar to REMAFEX and may be used in parallel or integrated with REMAFEX on the network. Gives added value to REMAFEX and to the operator for the gas turbine, compressors and pumps.	

Name	**Engineer Assist 3.0**	Analysis/Decision (A101)
Description	Diagnosis system interpreting conditional information based on vibration analysis. Results are presented in easily read messages for which fault is going on. Accumulated diagnosis knowledge are built in as rules. Used as a top system, well integrated , with Data Manager 2000	
Producer	Bentley Nevada, USA	
Relevance REMAFEX	May be integrated in REMAFEX as a generic tool for advanced analysis on vibration parameters.	

Name	**MetalSCAN**	Supervision (S105)
Description	Online, inline, system for detection of metallic and non-metallic particles in oil systems (down to 100 micron). The sensor placed in the oil stream sending signals to a PC for analysis. Predict overflow of predefined future level of particle content.	
Producer	Gastops Ltd, England	
Relevance REMAFEX	MMT, may easily be plugged into REMAFEX.	

Name	**MagNET**	Supervision (S106)
Description	Magnetic sensor with a control unit for automatic metering of concentration of small (down to 1 micron or concentrations between 1-1000 ppm) ferro-magnetic wear particles in a oil reservoir (system- or hydraulic oil). The control unit can store data for 14 days and then download them for analysis, or it can be connected online to a data logger, a PC or an alarm system.	
Producer	Gastops Ltd, England	
Relevance REMAFEX	MMT, may easily be plugged into REMAFEX.	
Name	**FerroSCAN, model 310, Wear particle monitoring system**	Supervision (S107)
Description	Online, inline, system for continuos monitoring of the metallic particles concentration in oil systems. The sensor placed in the oil stream may send signals to different kind of control units. Model A and B can be connected to an alarm system or data logger. Model C can store up to 2000 measures, and then download them for analysing and trending.	
Producer	Gastops Ltd, England	
Relevance REMAFEX	MMT, model A and B may easily be plugged into REMAFEX. Analysing and trending generic tools in the local and remote server.	

Name	**FSM, Field Signature Method**	Supervision (S108)
Description	Online (and offline) system for monitoring and detection of corrosion, crack formation and erosion in pipelines and fixed structures. The structure condition can be trended on a PC.	
Producer	CorrOcean AS, Norway	
Relevance REMAFEX	MMT , the signals from the sensors may easily be connected to the REMAFEX platform for trending and analysis.	

Name	**MultiCorr MKII, MultiLog**	Supervision (S109)
Description	MultiLog is an online data acquisition system from one or more corrosion probes in oil- and seawater pipelines and other constructions with corrosion problems. Can store and download measured data or be set up for continues monitoring. MultiCorr MKII is used as an offline datacollector.	
Producer	CorrOcean AS, Norway	
Relevance REMAFEX	May be plugged into the REMAFEX platform for continues monitoring, trending and analysis.	

Name	**System VKE**	Supervision (S110)
Description	Online (or offline) instrument for monitoring condensate trap (stream trap). Signal from a sensor (electrode) is sent to a control unit giving an alarm when vapour bypasses the trap.	
Producer	GESTRA AgmB, Germany	
Relevance REMAFEX	MMT, may easily be connected to REMAFEX.	

Name	**QuickCheck II**	Supervision (S111)
Description	Condition control system based on a combination of acoustic and magnetic sensors for monitoring the mechanism for internal movements in valves, diesel engines, compressors (curcuit-breakers ?). Up to now used offline in function testing of the equipment.	
Producer	Liberty Technologies Inc, England	
Relevance REMAFEX	Similar to S3, may be plugged into REMAFEX for online monitoring of the equipment.	

MMTs introduced by EDP:

Name	**AGMS, Air Gap Monitoring System**	Supervision (S201)
Description	Air gap monitoring system	
Producer	VIBRO-METER Inc, Montreal, Canada	
Relevance REMAFEX		

Name	**ZOOM, Zero Outage On-line Monitoring System**	Supervision (S202)
Description	Monitors multiple parameters (air-gap, vibrations, temperatures, flow, etc.) simultaneously to determine machine condition and performance.	
Producer	VIBRO-METER Inc, Montreal, Canada	
Relevance REMAFEX		

Name	**SBV, Stator Bar Vibration evaluator**	Supervision (S203)
Description	Monitors in-slot bar vibration to determine wedge tightness and winding insulation conditions.	
Producer	VIBRO-METER Inc, Montreal, Canada	
Relevance REMAFEX		

Name	**HydroSCAN, rotor-mounted Scan**	Supervision (S204)
Description	Monitors air-gap, stator core temperature, radio frequency interference (RFI) noise, magnetic flux density and acoustic noise in air gap	
Producer	MCM Enterprice Ltd., USA	
Relevance REMAFEX		

Name	**PDA-IV**	Supervision (S205)
Description	Measures partial discharge for analysis of stator winding insulation.	
Producer	IRIS Power Engineering Inc, Canada	
Relevance REMAFEX		

Name	**MICAA** Expert System Software	Fault Diagnosis (D201)
Description	Determine the risk of failure of windings and cores as well as the possible causes of deterioration and provides maintenance recommendations	
Producer	IRIS Power Engineering Inc, Canada	
Relevance REMAFEX		
Name	**VIMOS, Vibration Monitoring System**	Supervision (S206)
Description	Monitor and analyses air-gap and vibrations and also other information (power, guide vane position, temperature, etc.)	
Producer	ABB Generation, Sweden	
Relevance REMAFEX		

Name	**CMS, Cavitation Monitoring System**	Supervision (S207)
Description	Provides on-line indication of turbine runner and/or draft tube cavitation severity	
Producer	ACCUSONIC, Massachusetts, USA	
Relevance REMAFEX		

Name	**2210 Monitoring System**	Supervision (S208)
Description	Monitors shaft position and displacement and displays current values, trend parameters, alarm indications, etc.	
Producer	Bentley Nevada, USA	
Relevance REMAFEX		

Name	**RF (Radio Frequency) Monitoring System** **HF-DIAG Diagnostic Model**	Supervision (S209)
Description	Analyses the frequency spectrum for detection of electrical discharges	
Producer	SIEMENS	
Relevance REMAFEX		

Name	**GenGuard**	Supervision (S210)
Description	Continues partial discharge monitoring system	
Producer	IRIS Power Engineering Inc, Canada	
Relevance REMAFEX		

Name	**COMPASS**	Supervision (See S104)
Description	EDPs description: Monitors multiple parameters (bearing temperatures, draft tube pressure, excitation current, power, distributor position etc.), correlated with vibration and position measurements, providing a picture of the machine condition.	
Producer	Bruel & Kjær, Denmark	
Relevance REMAFEX		

Name	**Advisor**	Analyses (A201)
Description	An expert system designed to interpret measurements from Compass	
Producer	Bruel & Kjær, Denmark	
Relevance REMAFEX		
Name	**HPM SYSTEM (UNDER DEVELOPMENT)**	Supervision (S211)
Description	The system Accomodates supervision of health indicators by means of acquiring data from subsystems such as Vibrations, Partial Discharge, Air Gap, Temperature, electrical operating characteristics and process values.	
Producer	ABB Power Generation, Switzerland	
Relevance REMAFEX	A system similar to REMAFEX ?	

Name	**GEMO – Monitor & Diagnosis system**	Analysis (A202)
Description	Its purpose is to assess and evaluate the data provided by the process control system or by subordinate system on the basis of a plausibility evaluation procedure.	
Producer	ELIN Energiversorgung, Austria	
Relevance REMAFEX		

From Iberdrola, PDA, Compass, 3000 Series (Bentley) and VIMOS are introduced. In addition a description of:

Name	**PROMOSHYGES**	Supervision (S301)
Description	Vibration Monitoring system for hydroelectric sets. It's a tool for predictive Maintenance.	
Producer	Developed in a BRITE/EURAM project.	
Relevance REMAFEX		

CRAN has introduced a lot of generic analysing tools:

Name	**OASYS**	Analysis (A401)
Description	Performs Technical and Functional Tree, functional blocks with functional and disfunctional characteristics, simulates functioning and disfunctioning with Petri Nets and Markov Graph. Generates Failure Tree, Failure Mode, and analyses causes, effects of failure, calculates the criticality from system mission, generates reliability graph, failure tree Many tools is linking with the Oasys kernel, like SIMTREE & ARALIA (Failure Tree and Binary Decision Diagram),... Advantages of OASYS : • Many tool for study • Custom tool with LISP programming	
Producer	IXI, France	
Relevance REMAFEX	Advantages of REMAFEX : • Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openess to REMAFEX will be difficult because of LISP programming	

Name	**RELIASEP**	Analysis (A402)
Description	Performs Functional Tree with performances and constraints, Function solving constraints.Generates Failure Mode, and causes, effects of failure, takes into account the criticality. Inconvenient of RELIASEP : • No exchanged flow between function • No simulation	
Producer	Transiciel Ingenierie Agence de Normandie	
Relevance REMAFEX	Advantages of REMAFEX : • Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openness with REMAFEX: ORACLE Database and known data model	

Name	**SOFIA**	Analysis (A403)
Description	Performs Technical Tree, functional blocks with functional and disfunctional state, simulates functioning and disfunctioning. Generates Failure Mode, and analyses causes, effects of failure, calculates the criticality from system mission, generates reliability graph, failure tree... Many tools is linking with the Sofia kernel, like DIANA (Logistician Integrated Support), DIAGSYS (Diagnosis Aided System)	
Producer	Sofreten, France	
Relevance REMAFEX	Advantages of REMAFEX : • Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openness with REMAFEX : difficult without cooperation with the company.	

Name	**Event Tree**	Analysis (A404)
Description	Design Event Tree, and analyses probabilities of event.	
Producer	Item Software Ltd, UK	
Relevance REMAFEX	Advantages of REMAFEX : • Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openness to REMAFEX; No	

Name	**Fail Mode**	Analysis (A405)
Description	Design Failure Mode, and analyses causes, effects of failure, calculates the criticality and failure rates. Advantages of REMAFEX :	
Producer	Item Software Ltd, UK	
Relevance REMAFEX	• Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openness to REMAFEX; No	
Name	**Fault Tree**	Analysis (A406)
Description	Design Fault Tree, analyses fault tree and calculates cut sets, failure frequencies,...	
Producer	Item Software Ltd, UK	
Relevance REMAFEX	Advantages of REMAFEX : • Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openness with REMAFEX: No	

Name	**FMECA**	Analysis (A407)
Description	Performs many types of analyses (Failure Mode and Effects Analyses (FMEA), Criticality Analyses (CA), Design FMEAs, Process FMEAs, Safety Analyses, Damage Mode and Effects Analyses (DMEA), Failure Mode, Effects, and Criticality Analyses (FMECA)).	
Producer	Innovative Software Design, USA	
Relevance REMAFEX	Advantages of REMAFEX : • Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openness with REMAFEX: No	

Name	**PFA Pro**	Analysis (A408)
Description	Perform HAZOP analysis	
Producer	Dyadem International LTD, Canada	
Relevance REMAFEX	Advantages of REMAFEX : • Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openness with REMAFEX: No	

Name	**RCM Cost**	Analysis (A409)
Description	Takes into account the prime objectives of a maintenance program (Minimize Costs, Meet Safety and Environmental Goals, Meet Operational Goals)	
Producer	Item Software, UK	
Relevance REMAFEX	Advantages of REMAFEX : • Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openness with REMAFEX: No	

Name	**RTP**	Analysis (A410)
Description	Simplifies the construction of statistical reliability test plans for the exponential and binomial distributions.	
Producer	TRADOC CD Engineering, USA	
Relevance REMAFEX	Advantages of REMAFEX : • Systemic Approach • Maintenance Focus Area • Coherent approach from User Needs to Operational Distributed Architecture Openness with REMAFEX: No	

ANNEX II: ACRONYMS USED IN THE DELIVERABLE

CBM	Condition Based Maintenance
CMS	Central Maintenance Server
CMMS	Control, Maintenance and Technical Management System
CORD	Co-ordinated operation and Maintenance Offshore – R & D
DAS	Data Acquisition System/Server
DCS	Distributed Control System
DMS	Distributed Maintenance Systems
EFNMS	European Federation of National Maintenance Societies
LMS	Local Maintenance Server
MMS	Maintenance Management System
MMT	Maintenance Monitoring Tool
MUG	Maintenance User Group
NPD	Norwegian Petroleum Directorate
POSC	Petrochemical Open Software Corporation
PM	Plant Maintenance
RCM	Reliability Centred Maintenance
SCADA	Supervisory Control And Data Acquisition
URGENT	User Reference Group for the Exploitation of new Technologies

ANNEX III. DIPLOMA REPORT FROM GERALD CARON

FUNCTIONAL AND DYSFUNCTIONAL ANALYSES OF AN HYDROELECTICAL INSTALLATION, VOLUME 1&2.