

# Risk Based Inspection and Maintenance Procedures for European Industry\*

## RIMAP project



Risk Based Inspection and Maintenance Procedures for European Industry (RIMAP) is a European project that aims at developing a unified approach to making risk based decisions within inspection and maintenance. The project started on March 1, 2001 and will run for three year. The project has a large industry participation:

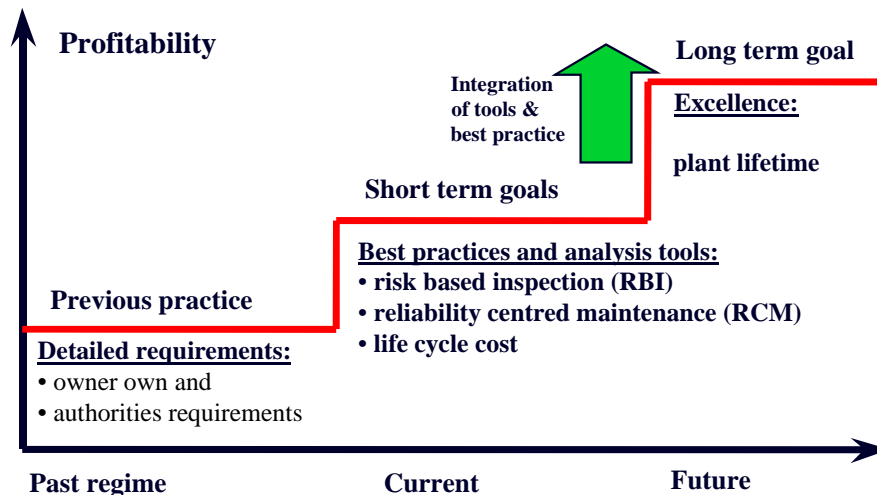
Det Norske Veritas (Project co-ordinator)	(NO)	ExxonMobil Chemical Ltd	(UK)
Bureau Veritas	(F)	Energie Baden-Württemberg Ingenieure GmbH	(D)
Statliche Materialprüfungsanstalt (MPA Stuttgart)	(D)	Siemens Aktiengesellschaft	(D)
Technical Research Centre of Finland (VTT)	(Fin)	European Commission, Directorate General Joint Research Centre, Petten	(NL)
TÜV Süddeutschland Bau und Betrieb GmbH	(D)	Electricity Supply Board	(IRL)
Netherlands Organization for Applied Scientific Research (TNO)	(NL)	Corus UK Ltd.	(UK)
Hydro Agri Sluiskil B.V.	(NL)	DOW Benelux N.V.	(NL)
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## RIMAP overview

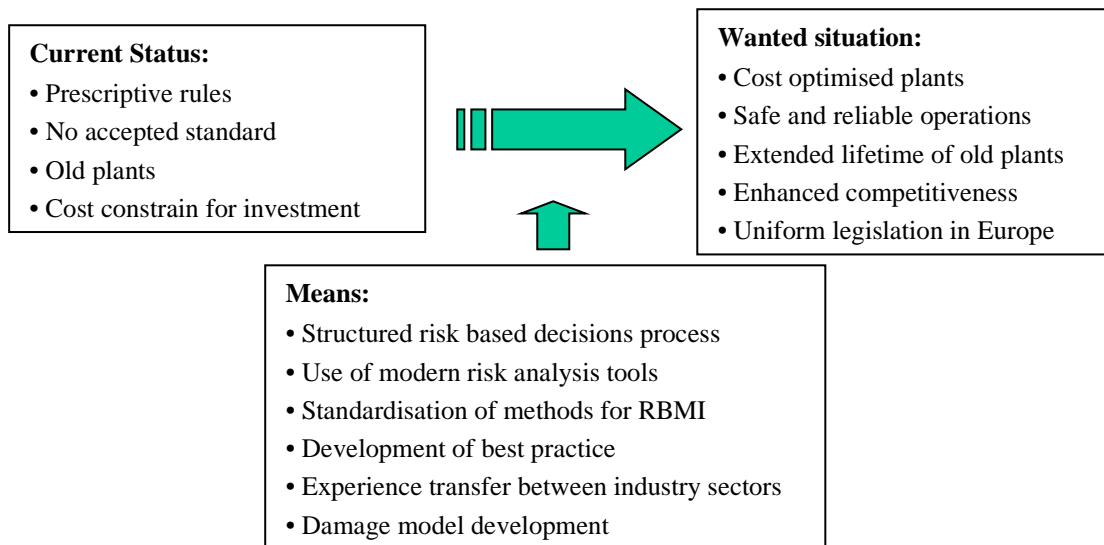
**Background:** Current practice to inspection and maintenance planning is for most industries based on tradition and prescriptive rules, rather than being an optimised process where risk measures for safety and economy are integrated. New technology for taking risk based decisions is emerging within a broad range of sectors, and has proven to be a very efficient tool (Fig. 1). However, there is a great need to define the technical content, links to local legislation and to integrate this approach with the day-to-day operation.



**Figure 1** The evolution of decision making in inspection and maintenance.

This is the main background for the RIMAP project, where a consortium of 16 European companies representing a broad industry base have joined forces to develop a European best practice and to demonstrate its applicability in several case studies. The project addresses the petrochemical, chemical, steel works and the power industry in particular, but the techniques can easily be extended and be used in other industry sectors as well.

**Objective:** The objective of the project is to define a unified approach to making risk based decisions, within the field of inspection and maintenance (Fig.2). Risk is here understood as the combined effect of probability of failure and the consequence of a failure (personnel safety, quality of product, environmental damage, and economic loss).



**Figure 2 RIMAP objective: to develop unified approach for risk based decisions within inspection and maintenance.**

The main benefits of the work will be:

- cost-optimised inspection/maintenance plans that will save operational and risk costs in the order of 10 to 40% for the involved industries
- improved safety for plant personnel and the society en-large
- a technical framework for a European standard

**European technology progress and social benefits:** There is a great need for standardisation within the area of inspection and maintenance in Europe (ref. EPERC - European Pressure Equipment Research Council). Several initiatives in the US (API, ASME & EPRI) have proven to be successful, but these may not be in line with European legislation and design practice within safety and environment.

**The RIMAP project aims at:**

- Developing a unified approach to risk based maintenance and inspection planning
- Setting requirements to the contents of an analysis, personnel qualifications, and tools
- Forming the basis for future standardisation in this area.

**Scope of Work:** The project is organised in one RTD phase (RIMAP RTD) and one demonstration phase (RIMAP DEMO).

The RIMAP RTD project is divided in 5 main technical work packages (Figure 4, page 10), in addition to administration. The WP's are structured with a clearly defined interrelation in order to achieve an efficient execution of the project.

- WP1: Current practice within the involved industries.
- WP2: Development of a generic RBMI method, based on a multi-criteria decision process.
- WP3: Development of detailed risk assessment methods, damage models for participating industry sectors, the use of inspection data.
- WP4: Development of RIMAP application workbooks: guidelines for development of Risk Based Inspection and Maintenance plans.
- WP5: Validation of the RIMAP methodology.
- WP6: Project management

The RIMAP DEMO is organised in 5 work packages:

- RIMAP DEMO 1: Industry group: Petrochemical.
- RIMAP DEMO 2: Industry group: Power Industry.
- RIMAP DEMO 3: Industry group: Steel works.
- RIMAP DEMO 4: Industry group: Chemical
- RIMAP DEMO 5: DEMO Support

**Deliverables:** The main deliverables from the RIMAP RTD project will be:

- A method describing a unified approach to maintenance and inspection planning based on risk decision criteria and cost optimisation.
- Documented validation and testing of the method within several major industry sectors.
- Guidelines for practical use, in the format of one "Workbook" for each industry sector.
- Spread knowledge between industry sectors.

The RIMAP method will be tested within 4 industry sectors in the RIMAP Demonstration project and, as such, it will be a major contribution to European standardisation.

## RIMAP Deliverables

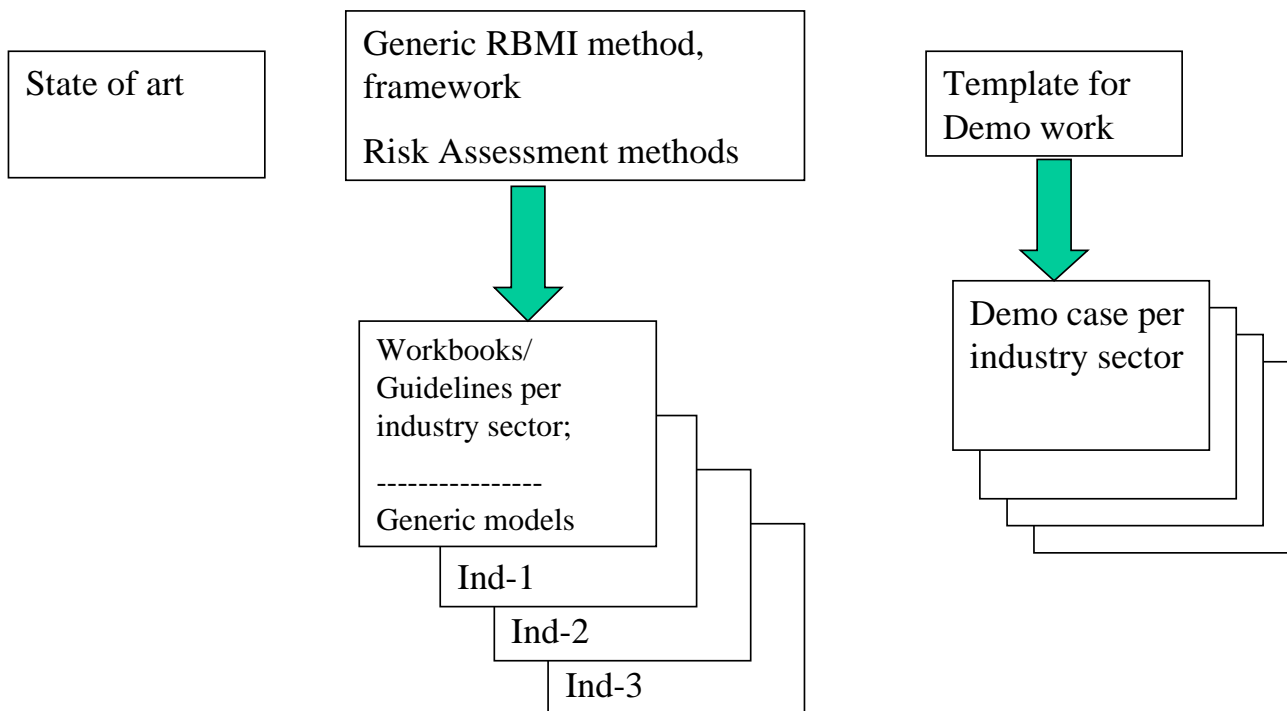


Figure 3 Overview of RIMAP deliverables

### Networking:

The RIMAP project will co-operate with the RIMAP Thematic Network (see <http://www.mpa-lifetech.de/rimap>) to establish the state-of-the art, and use this as a basis for further development of the technical framework for a European Standard. The generic RBMI method will be supplemented by RIMAP workbooks, that is industry sector specific guidelines. The workbooks will contain instructions on how to use the RIMAP methodology in the industry. As there are a number of competing software packages supplied by RIMAP partners available at the market, the RIMAP project will not favour any of those directly, but rather recommend when it can be effective to apply a software package. The software packages are usually flexible enough to be linked to the clients systems. It will also be developed a general workbook aimed at industries that are not directly taking part in the RIMAP project, in order to enable wider application of the project results. The templates for the RIMAP Demo work will contain a detailed description on how the Demo sites are expected to carry out the demonstration in order to demonstrate the usefulness of the RIMAP methodology in a uniform way to enable learning across industries.

The work will be disseminated via the RIMAP Thematic network and several existing networks like EPERC, workshops, seminars, and papers in order to achieve acceptance and feedback for the methods. Public project results will be disseminated through the RIMAP web site (<http://research.dnv.com/rimap>), and e-mail notifications will be sent to main stakeholders and interested parties whenever major updates of the web site are made.

**Innovation:** The main innovation aspects of the RIMAP project are:

- The integration of maintenance (RCM) and inspection (RBI) into a uniform decision process with balanced effort between the expenditures.
- The use of probabilistic decision analysis for process systems is in its infancy, in particular when it comes to use of inspection and monitoring data. This will be explored and tested in the case studies.
- Combining the theoretical modelling of plant failure ("hard" knowledge) with plant experience ("soft" knowledge) will be developed into a rational method.
- Technology transfer between industry sectors, i.e. some sectors have used risk based decision for many years, whereas other have not. The project will facilitate such transfer.

**Goals and Benefits:** The expected benefits of the RIMAP project are;

- For the plants/end-users: Savings in operational expenditures and failure costs. A clearly defined philosophy for how the planning can be done.
- For the inspection companies: Tailoring of tools and methods to satisfy the industry needs and give awareness of their limitations.
- Regulators: Knowledge and ability to set proper requirements to the Risk based decision analysis work performed at the plants. Derive a technical basis for a new standard in the field.
- Consultants: A framework for providing enhanced services for the industry in particular during plant-networking and outsourcing.

**Contacts:** For further information see

RIMAP RTD or RIMAP Demo project: <http://research.dnv.com/rimap>  
RIMAP TN: <http://www.mpa-lifetech.de/rimap>

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## Appendix

The work in the RTD part of the RIMAP project is organised in five technical workpackages (WP1 to WP5).

**WP 1** is a description of the State-of-practice within the industry sectors involved in the project, hereunder the different available methods used in inspection and maintenance planning. The aim is to describe the present practice, experience with the different techniques used for planning, inspection and testing. This WP will act as a general knowledge platform for the companies involved as well as give guidance and directions for the further development work in RIMAP. This task will receive information from the RIMAP thematic network and from the existing EPERC organisation.

**WP 2** aims at developing and defining a common framework for decisions related to maintenance and inspection. The RCM methodology will be applied, but expanded to include *predictive* probability of failure assessment as used in RBI and RBLM (Risk-based Life Management). Multi-criteria decision logic will be developed including acceptance criteria, risk matrixes for safety, environment and financial costs. The European standards within design and maintenance will be adhered to as far as possible. The generic framework developed in WP 2 will be the platform for the further work in the other work packages.

**WP 3** concerns risk assessment methods and will develop, test and document the calculation process used to assess the high-risk components. Methods for estimating the Consequence of Failure (CoF) and Probability of Failure (PoF) (or lifetime if relevant) will be described and in particular the effect of inspection data and monitoring results included (updated PoF). This task will also address the inspection/testing effectiveness in relation to the damage mechanisms in question, i.e. to consider the Probability of Detecting (POD) degradation of a component at an inspection. Both qualitative and quantitative techniques will be explored – the most important innovative feature in this WP will be the development of a new approach for determining and optimisation of the overall risk level for the whole plant. The approach will be generic, and intend to meet the need for an approach that is more flexible than existing approaches by being flexible enough to take advantage of both “hard” and “soft” data in one decision process. This will be a major improvement of the current state-of-the-art approaches (e.g. API). Software development will be done as part of this task, see below. Further, the issue of human factors will be addressed.

**WP 4** will be devoted to the development of practical inspection/maintenance plans based on risk results decisions. This will be used to set-up risk reduction measures like inspection, testing, monitoring, replacement or any maintenance actions and address the practical aspects of this process (working process) and its implementation. A new (“mixed” qualitative/quantitative) approach for determination and optimisation of overall risk level for the whole plant will be developed – i.e. to determine where the risk-optimisation level will be the most beneficial. This WP will develop the RIMAP “Application Workbooks”, which will be validated in WP 5 and applied in the RIMAP Demonstrator project.

**WP 5** is dedicated to verification and validation of the developed RBMI methodology and the RIMAP Application workbooks. The validation will be carried out through testing at some of the industrial sites that participates in RIMAP. Minor recommended improvements will be implemented, but recommendations that require extensive research or development will be used to propose further extensions of the methodology and the workbooks. Templates will be developed to guide end users on how to carry out the RIMAP demonstration.

The work in the **demonstration part of the RIMAP project** is organised in four technical work, one for each of the four industry sectors, and one support work package packages (WP DEMO 1 to WP DEMO 5). The RIMAP Demonstration project will demonstrate the applicability and value of the RIMAP methodology, including the Generic Method and the RIMAP Application Workbooks. The demonstration consists of testing and demonstration of RIMAP models and methods, use of the models and methods in practical application, documentation of results from each test case, and finally an overall comparison across industries and recommendations for further improvement and standardisation work. The templates developed in WP 5 will be used as guidelines.

The four industries covered by the RIMAP Demonstration project are:

WP DEMO 1: Petrochemical industry

WP DEMO 2: Power industry

WP DEMO 3: Steel Works

WP DEMO 4: Chemical industry

In addition there will be a Demo support and management workpackage (WP5).

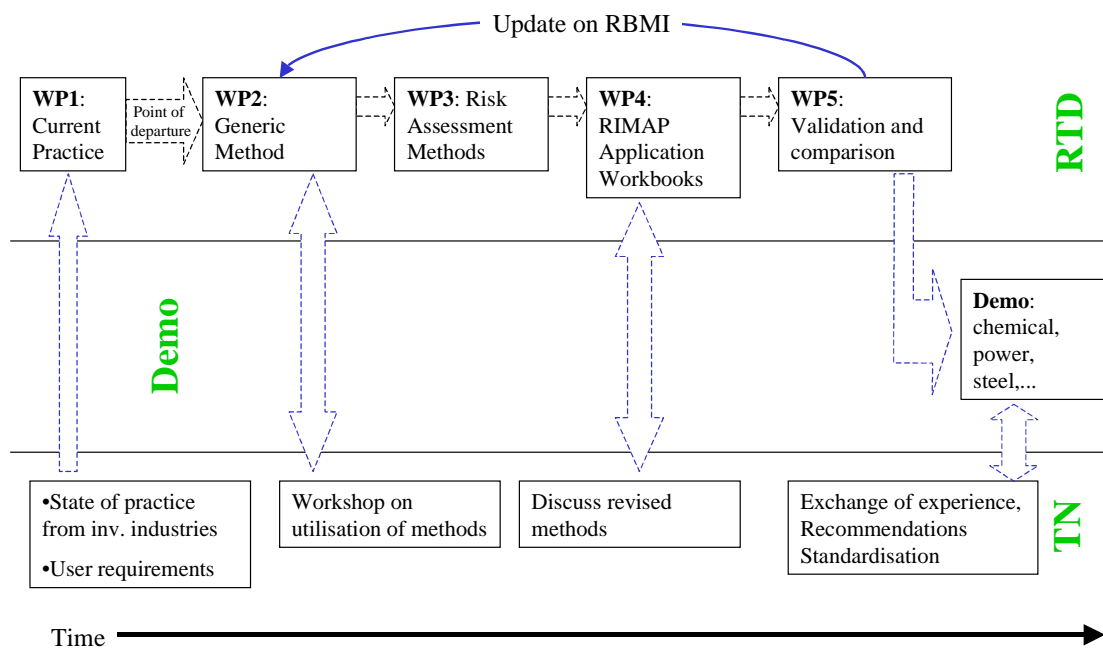
The RIMAP combined project will work closely with the RIMAP Thematic Network (RIMAP TN). RIMAP TN will be used actively as a source of information, and as an instrument disseminate and discuss the preliminary results from RIMAP, and to ensure co-ordination and harmonisation with other ongoing related standardisation work. Interested parties can join the RIMAP Thematic Network as an observer.

**Table 1 Project work packages**

<b>No</b>	<b>WP</b>	<b>Budget (PersonMonths)</b>	<b>WP-leader</b>
WP 1	Current Practice	11	<b>DNV</b>
WP 2	Generic RBMI-method	30.5	<b>DNV</b>
WP 3	Risk assessment methods	66.7	<b>DNV</b>
WP 3.1	Probability of failure		<b>MPA</b>
WP 3.2	Consequence of failure		<b>TNO</b>
WP 3.3	Inspection efficiency (POD)		<b>MBEL</b>
WP 3.4	Human aspects and risk calculation		<b>DNV</b>
WP 4	RIMAP Application Workbooks	59.1	<b>MPA</b>
WP 5	Validation of the RIMAP methodology	29.5	<b>DOW</b>
WP6	Project Management	15	<b>DNV</b>
WP RIMAP DEMO	RIMAP Demonstration		
WP DEMO 1	Petrochemical	8	<b>ExxonMobil</b>
WP DEMO 2	Power Industry	22	<b>EnBW</b>
WP DEMO 3	Steel Works	4	<b>CORUS</b>
WP DEMO 4	Chemical	22	<b>DOW</b>
WP DEMO 5	Support	9	<b>DNV</b>
	Sum	<b>276.8</b>	

**Relationship:** Figure 4 illustrates the relationship between the RIMAP RTD work packages, the interaction with the RIMAP Thematic Network. The RIMAP Thematic Network will function as an arena for gathering information on state-of-art in practise and academia, and a forum for dissemination of RIMAP results and discussion of the standardisation aspects of RIMAP.

## RIMAP WP-relations



**Figure 4** Relationship between the RIMAP RTD workpackages, the RIMAP Demo and the interaction with the RIMAP Thematic Network.