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X-ARA Cross-asset risk management

Dissemination - Education program for users of X-ARA

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IFSTAR



CEDR Call 2013: Ageing Infrastructure Management

X-ARA Cross-asset risk assessment

X-ARA Dissemination Education Program

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Executive summary

The Dissemination - Education program has been designed as an introduction to the X-ARA demonstration that will be performed during the planned dissemination workshop or webex-meeting.

Indeed, it is not part of our X-ARA scope to perform training for users of the X-ARA. However, this demo introduction could be expanded into an optional full training program for the NRAs.

This document provides the syllabus of the proposed **demo introduction**.

The proposed optional **training** would follow the same **programme**.

Difference lies only in the level of details and timeframe.

In case of the demo, the theoretical part will cluster over one session the presentations of the X-ARA risk methodology and tool.

It presents the objectives of the dissemination and the required logistics for the organisation of the demo as well as of the training sessions in terms of pre-requisites for the trainees and facilities to be made available to the trainer.

It provides an overview of the scope of each of the three sessions of the training programme:

- Presentation of X-ARA risk methodology
- Presentation of the X-ARA tool
- Practical application on an example

1 Introduction

The X-ARA Risk tool is a software tool to model and assess the strategic risks facing a network and the major assets on it. As such it is intended to be used for examining scenarios of changing economic pressures, environmental factors and alterations to safety regimes and how they impact a risk to a highway network.

The X-ARA tool has two main purposes:

- Establish the relative maintenance risk across a network, taking into account the asset specific maintenance risk of different types of assets;
- Enable the user to run “what-if” scenarios to determine the change of the risk according to a scenario that deviates from the baseline scenario.

1.1 Objectives of the dissemination

The present educational program is user oriented, with the objectives of sharing the methodology to:

- implement a risk approach on a specific road network; and
- compare different maintenance strategies at network level, taking into account the influencing factors over medium and long term.

The main purposes of the programme will be to:

- present the X-ARA risk methodology approach and the users benefits for a better prognosis of risk against different scenarios;
- describe the use and results of the X-ARA risk tool;
- present the implementation of the calculation of risk on a road infrastructure network and key identified assets;
- present the variable factors affecting the different assets and the possible effects of these factors; and
- go through a practical example from the network implementation to the results analysis.

The dissemination programme can take two forms:

- an overview of the X-ARA tool followed by a demo (see § 1.2 below)
- a full training programme (see § 1.3 below)

1.2 Demonstration

The X-ARA demo will be delivered in two sessions carried out over a ‘short day’ period, with the objective of providing sufficient information for the attendees to understand the methodology developed in the course of the X-ARA project and be able to follow up the demo of the tool and the benefits that can be derived from using it.

It is made of two parts:

- Overview of the X-ARA risk methodology and presentation of the tool / use and results (~2-h morning session).
- Demo itself (~2-h afternoon session)

To present the tool and run the demo, a room with one large screen to display the 'presentation' and the demo is required. A presenter lap-top with the X-ARA application is required as well.

1.3 Optional training sessions

1.3.1 Organisation

The optional dissemination training will be delivered in sessions for up to [six] persons, with the objective of keeping interactivity of the training, and limit the practical training to 3 teams of two trainees.

It is made of three parts over a one and a half day period.

- Presentation of XARA risk methodology (half day)
- Presentation of the XARA tool / use and results (half day)
- Practical example, organised by teams of two trainees (half day)

1.3.2 Prerequisites

For maximum benefit of the training, the trainees should

- have experience of asset management on their network
- be computer literate and
- have read the Users' Manual (D 4.2, Implementation and User Guidance Document)

1.3.3 Facilities

To deliver the training, the NRA shall make available the following facilities

- one 'training' room with space capacity to house up to [10 people] equipped with:
 - o a large screen to display the 'presentation'
 - o fast Internet access (optional)
- one PC/ workstation (to install the X-ARA application) per team of two trainees.
 - o To save time, we strongly recommend that SQL Management Studio be already installed on each PC (this free software may require authorisation of IT department)
 - o Minimum / recommended configuration is described in Deliverable 4.2

2 Introduction to the demo

The introduction to the demo is an overview of the XARA risk methodology and presentation of the tool / use and results.

It will generally follow the same agenda as detailed in Chapters 3 and 4 below, within a shorter timeframe.

This theoretical part is supported by a PPT presentation as per Appendix.

3 Presentation of X-ARA risk methodology

3.1 Asset management stakes

Brief presentation of asset management stakes in order to provide a general overview before running X-ARA application.

This presentation will include key messages on the asset management stakes.

3.2 Global approach to maintenance risk modelling methodology

Before running an X-ARA application, a general presentation of the methodology used to build the model will be provided.

The maintenance risk modelling methodology itself is the core part of X-ARA risk tool. The following topics will be covered:

- the maintenance risk in general;
- the maintenance risk for different types of asset;
- the risk model functioning; and finally
- the output of the risk assessment modelling.

3.3 Objectives of X-ARA tools and user benefits

This part aims at providing the objectives of X-ARA tool and user benefits.

The objective is to present the advantages of the approach and an overview of the benefits the user can draw in terms of risk based analysis and maintenance strategy.

The two main purposes are to

- establish the relative maintenance risk across a network (including the different asset maintenance risks); and
- enable the user to run “what if” scenarios (evaluation of the impact of a risk change on a baseline scenario).

3.4 Presentation of the practical guideline

This part aims at presenting the practical guideline before using the tool.

The idea is to present to the users where they can find information, how to configure the IT tool and how to run the X-ARA application.

4 Presentation of the X-ARA tool / use and results

4.1 Description of the tool

4.1.1 Type of users

This part will include the description of the different types of data base users, with their role membership and access rights: database administrator, asset manager, decision maker/ database owner, back-up operator,...

4.1.2 Definition of the network and its attributes

This part describes the network taken into account in the tool.

The section is divided in "X-ARA sections" (homogeneous sections) defined by attributes:

- unique identifier;
- user measured length;
- annual average daily traffic
- average number of lanes
- class of section (motorway, expressway, ordinary road).

The sensitivity factors to be assigned to the section will also be described.

4.1.3 Types of assets in the XARA tool and their attributes

This part provides the description of the six types of assets taken into account in the X-ARA application and the description of their attributes assigned to X-ARA section.

4.1.3.1 Pavement construction

This part includes the description of the pavement construction asset regarding X-ARA tool.

The pavement construction asset is defined by three user definable attributes:

- material type of pavement,
- comfort and safety index and
- Structural index.

Those attributes will be described.

Two condition indices (comfort and safety index and structural index) are used and evaluated for each X-ARA section.

4.1.3.2 Structure

This part includes the description of the structure asset regarding X-ARA tool.

The structure asset is defined through four user definable attributes:

- Material type,
- Severity of defects
- Sensitivity of defects
- Structural condition index

The structure asset risk is evaluated regarding the structure condition index and the extent of defects

4.1.3.3 Geotechnical assets

This part includes the description of the geotechnical asset regarding X-ARA tool. The geotechnical asset is evaluated through two attributes:

- Sensitivity against erosion
- Geotechnical condition index

4.1.3.4 Tunnel

This part includes the description of the tunnel asset regarding X-ARA tool. The tunnel asset is evaluated through two attributes:

- Tunnel condition index
- Age of electro-mechanical equipment

4.1.3.5 Road furniture

This part includes the description of the road furniture asset regarding X-ARA tool. The road furniture asset is evaluated through two attributes:

- Road furniture condition index
- Consequence of failure

4.1.3.6 Drainage

This part includes the description of the drainage asset regarding X-ARA tool. The drainage asset is evaluated through two definable attributes:

- drainage condition index
- design category

4.2 Workflow for the X-ARA risk methodology implementation

This part aims at describing the workflow when working with the X-ARA Risk tool. It includes:

- the general workflow, including the different steps of the network, maintenance section and assigned assets definition;
- the workflow of the risk calculation, including the risk calculation per asset, the combination of the asset risk with the maintenance risk per section and the combination of risk per section to provide network risk.

4.3 Risk factors

4.3.1 Risk factors definition and factors sensitivity

This part includes the definition of the risk factors retained for the X-ARA risk analysis.

It includes also the description of the sensitivity factors (economic, environmental, safety, network sensitivity) assigned to sections and the rating of these factors (low, medium, high sensitivity).

4.3.2 Impacts of the influencing factors

This part aims at explaining the impacts of the influencing factors.

The impact could be described in terms of effects as positive, standard or negative. The aim is to be able to evaluate the impact through the sensitivity of some influencing factors.

4.4 Results analysis

4.4.1 Import/Export functionalities

The tool has import/ export functionalities.

The export functionality enables the user to export the data to a CSV file.

The tool allows also CSV import.

An export/import of the data is possible when the user wants to modify some attributes, add on some data or delete some data.

4.4.2 Outputs

This part aims to present the different outputs of the tool: session results, reports, map

5 Practical example

5.1 *Setting the tool*

Prior to running the tool, the key steps for setting the tool will be described in this part. Particular attention will be paid to the requested configuration to manage the tool.

5.2 *Analysis of the results*

Prior to running the tool the trainees will have to analyse some results.

The aim is to be able to understand the results of a cross analysis and to identify the influencing factors and evaluate the consequences.

Results for one specific asset, for a specific section and for a global network will be analysed.

5.3 *Running the X-ARA application through an example*

Through an example of the application, the user can provide a risk analysis running the X-ARA tool.

Some key attributes will be provided to the users.

The application will start with the integration of data coming from a network with X-ARA sections presenting different set of attributes.

Then the users will have to run the tool, provide some results (several forms) taking into account the influencing factors and finally they will provide results through predefined outputs.

6 Acknowledgement

The research presented in deliverable was carried out as part of the CEDR Transnational Road Research Programme Call 2013. The funding for the research was provided by the national road administrations of Denmark, Germany, Ireland, Netherlands, UK and Slovenia.

7 Appendix - Introduction to the demonstration (ppt)

X-ARA

Cross asset risk assessment

CEDR-research project

Presenter / Date



X-ARA Cross-asset risk assessment



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- CEDR-project X-ARA
- Understanding asset management risks
- Risk modelling
 - Maintenance risk
 - High level effects
 - Asset specific risk modelling
 - Combination of risks
- Results and practical approach
- Conclusion



X-ARA Cross-asset risk assessment



CEDR-project X-ARA

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- CEDR research project X-ARA “Cross-Asset-Risk-Assessment”
- Development of a framework for risk assessment within asset management, including:
 - Basic definition of risk within asset management
 - Set of guidelines how to use risk
 - Practical application (software tool X-ARA)



X-ARA Cross-asset risk assessment



Understanding risk (1)

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- Maintenance risk is a part of the asset management decision process
- Risk can be seen from different point of views:
 - Road operator
 - Asset management
 - Perform a non-cost-effective maintenance
 - Provide unsatisfying services to the other stakeholders (users, neighbours, owner, environment, etc.)



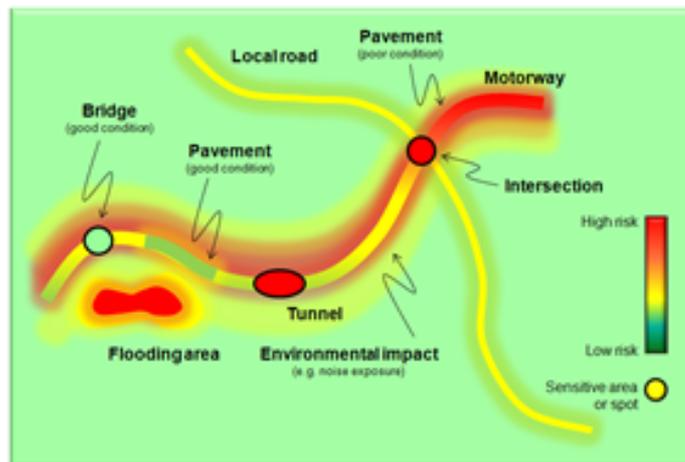
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Understanding risk (2)

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- Holistic overview of risk along the road infrastructure



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Understanding risk (3)

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- Risk definition within asset management (X-ARA)

The maintenance risk is a function of distress probability depending on asset condition or age and the consequences (effects) with respect to the affected stakeholders in the context of asset maintenance management

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$$M_{risk,HLF} = M_{risk} \times F_{HLF}$$

Risk modelling - Basics

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Maintenance risk matrix and risk classification

Condition and/or age (5 classes based on COST354)	1 - very good	20	30	40
	2 - good	30	40	50
	3 - fair	40	50	60
	4 - poor	50	70	80
	5 - very poor	60	80	100
		low	medium	high

Consequences derived from representative indicators

Maintenance risk scale	Maintenance risk categories
[0-60]	Low
[60-90]	Medium
[90-100]	High

High level effects for “what-if-scenarios” in 3 categories for:

- Climate change
- Funding
- Safety regulations

$$F_{HLF} = f(\text{impact}_{HLF}, \text{sensitivity}_{HLF})$$

$$M_{risk,HLF} = M_{risk} \times F_{HLF}$$

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Risk modelling - Assets

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Asset specific risk modelling for:

- Pavements
- Structures (bridges, retaining walls, etc.)
- Road furniture (lighting, safety barriers, etc.)
- Drainage
- Geotechnical assets
- Tunnels (including electro-mechanical equipment)



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Risk modelling - Pavements

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■ Pavements

- Based on COST354 (performance indicators for road pavements)
- Comfort and safety index (CSI)
- Structural condition index (SI)
- Combination of risk based on advanced maximum criteria

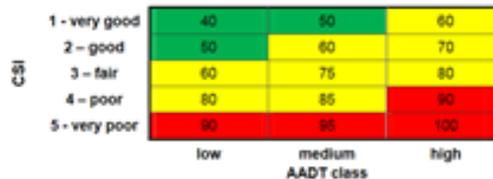


Figure 5: Maintenance risk matrix pavement CSI



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Risk modelling - Structures

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■ Structures

- Based on British standard BE11/94
- Structure condition index (SCI)
- Extent of defects (SED)
- Combination of risk based on maximum criteria

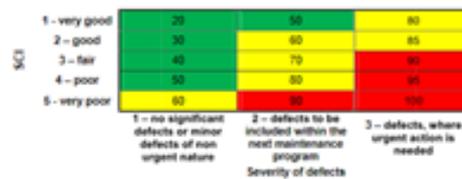


Figure 7: Maintenance risk matrix structures SCI.

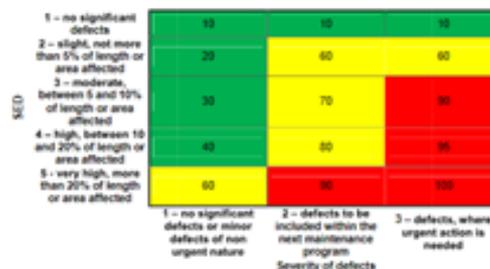


Figure 8: Maintenance risk matrix structures SED.

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Risk modelling – Road furniture

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▪ Road furniture

- Based on COST 354
- Road furniture condition index (RFCI)

RFCI	1 - very good	40	50	70
	2 - good	50	65	80
	3 - fair	60	75	90
	4 - poor	70	90	95
	5 - very poor	80	95	100
		Low	Medium	high
		Consequences of failure		

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Risk modelling – Drainage

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▪ Drainage

- Based on COST 354 / ENR-project EVITA
- Drainage condition index (DCI)
- Design category (over-, well- or under-designed)

DCI	1 - very good	40	50	60
	2 - good	50	60	70
	3 - fair	60	70	80
	4 - poor	70	80	90
	5 - very poor	80	90	100
		o-over	w-well	u-under

X-ARA Cross-asset risk assessment



Risk modelling – Geotechnical assets **13**

▪ **Geotechnical assets**

- refer to all types of earthworks (cuttings and embankments) and ground underlying highway
- Based on COST 354
- Geotechnical condition index (GCI)

GCI	1 - very good	10	20	30
	2 - good	50	50	50
	3 - fair	60	70	80
	4 - poor	70	80	90
	5 - very poor	80	90	100
		Low	Medium	High

Sensitivity against erosion

X-ARA Cross-asset risk assessment

Risk modelling – Tunnel **14**

▪ **Tunnel**

- Based on COST 354
- Tunnel condition index (TCI) to describe the structural condition of the tunnel
- Age of electro-mechanical equipment to describe the condition of the tunnel equipment

TCI	1 - very good	20	50	80
	2 - good	30	60	85
	3 - fair	40	70	90
	4 - poor	50	80	95
	5 - very poor	60	90	100

Severity of defects

1 - no significant defects or minor defects of non-urgent nature

2 - defects to be included within the next maintenance program

3 - defects, where urgent action is needed

Age	1 - new < 2 years	40	50	60
	2 - young, between 2 and 5 years	50	60	70
	3 - medium between 5 and 10 years	60	70	80
	4 - old, between 10 and 15 years	70	80	90
	5 - very old >15 years	80	90	100
		low	medium	high

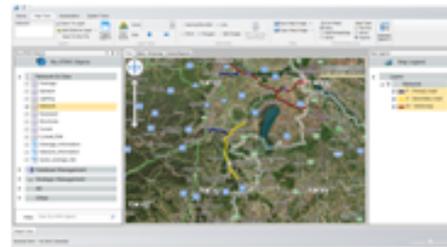
Availability of spare parts

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Risk modelling – Combination of risks **15**

▪ **Combination of asset specific risk to total risk**

- Transformation of asset specific risk onto maintenance sections
- Calculation of total risk on maintenance sections



- Combination of asset specific risk
- Weighting factors subject to significance or importance of assets
- Weighting factors subject to regional situation (urban, mountainous, flat area)

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Risk modelling – Combination of risks **16**

$$M_{risk,total} = \frac{\sum_i M_{risk,i} \times G_i}{\sum_i G_i}$$

with

- $M_{risk,total}$ total (cross asset) maintenance risk
- $M_{risk,i}$ maintenance risk of asset type i
- G_i weight asset type i (see Table 34)

Table 34: Typical weights asset types

Asset type	Regional situation		
	Flat area	Mountain	Urban
Pavement	30	35	35
Drainage	10	5	5
Tunnel	15	15	15
Structures	25	30	35
Road furniture	10	5	5
Geotechnical assets	10	10	5
Sum	100	100	100

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Risk modelling – Network level results **17**

- **Network level assessment**
 - Calculation of average risk over the whole network
 - Comparison of actual situation and what-if-scenarios
 - Including network sensitivity

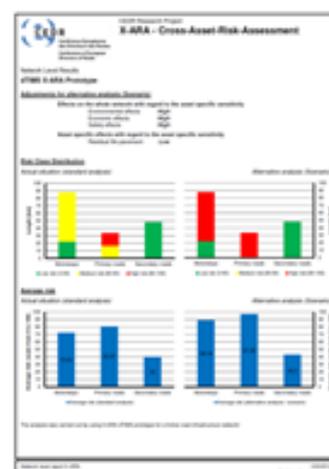
Table 35: Network level weighting factor F_{NL}

Network sensitivity	Regional situation		
	Flat area	Mountain	Urban
L	1.00	1.00	1.00
M	1.10	1.20	1.20
H	1.20	1.40	1.40

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Results **18**

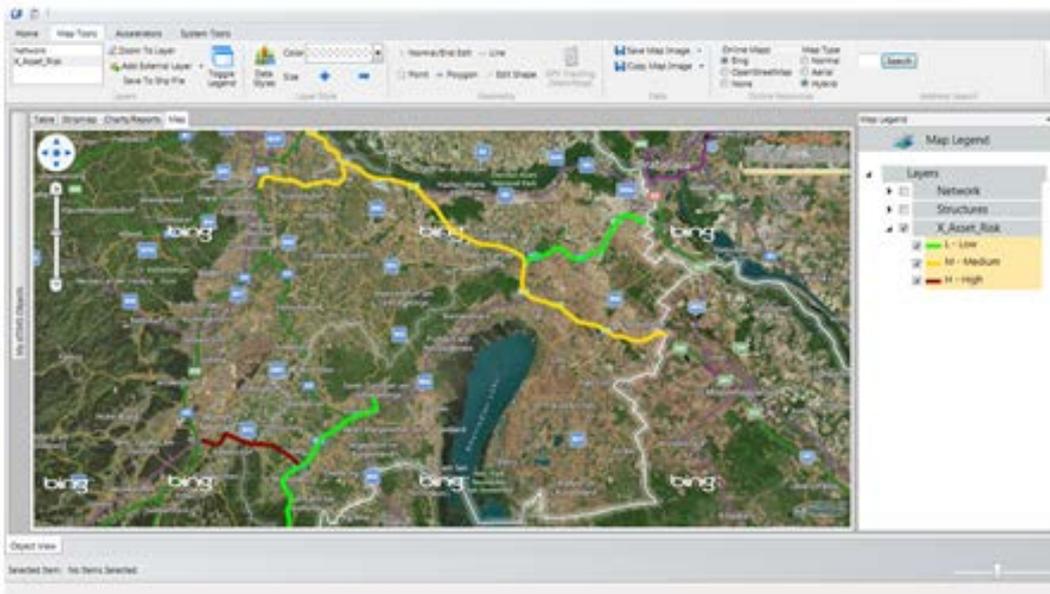
- **Object level and maintenance sections**
 - Risk of single assets
 - Risk for different types of assets
 - Cross asset risk
- **Network level**
 - Average risk and risk distribution for the total risk and for the asset specific risk
 - What-if-scenarios (comparison)



X-ARA Cross-asset risk assessment 

Results – Risk mapping

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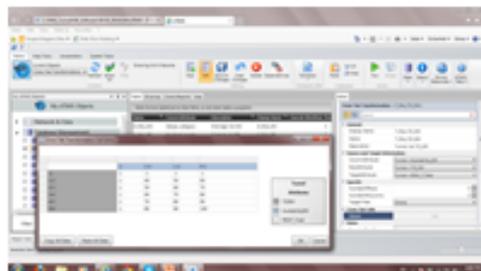
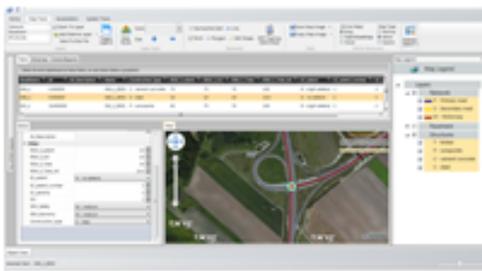
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Practical application and testing

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- X-ARA prototype using dTIMS[®] asset management software tool



- X-ARA software tool
 - Freeware for testing assessment procedure
 - Configuration according to X-ARA results

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Conclusion

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- Risk management as a part of asset management becomes more and more important in the decision processes
- Lack of data and models is a decisive factor
- Risk analysis is a holistic approach in asset management
- Better prognosis of risk against different funding scenarios
- Added value for all stakeholders



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Thank You

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