Krakow, 19 October 2005

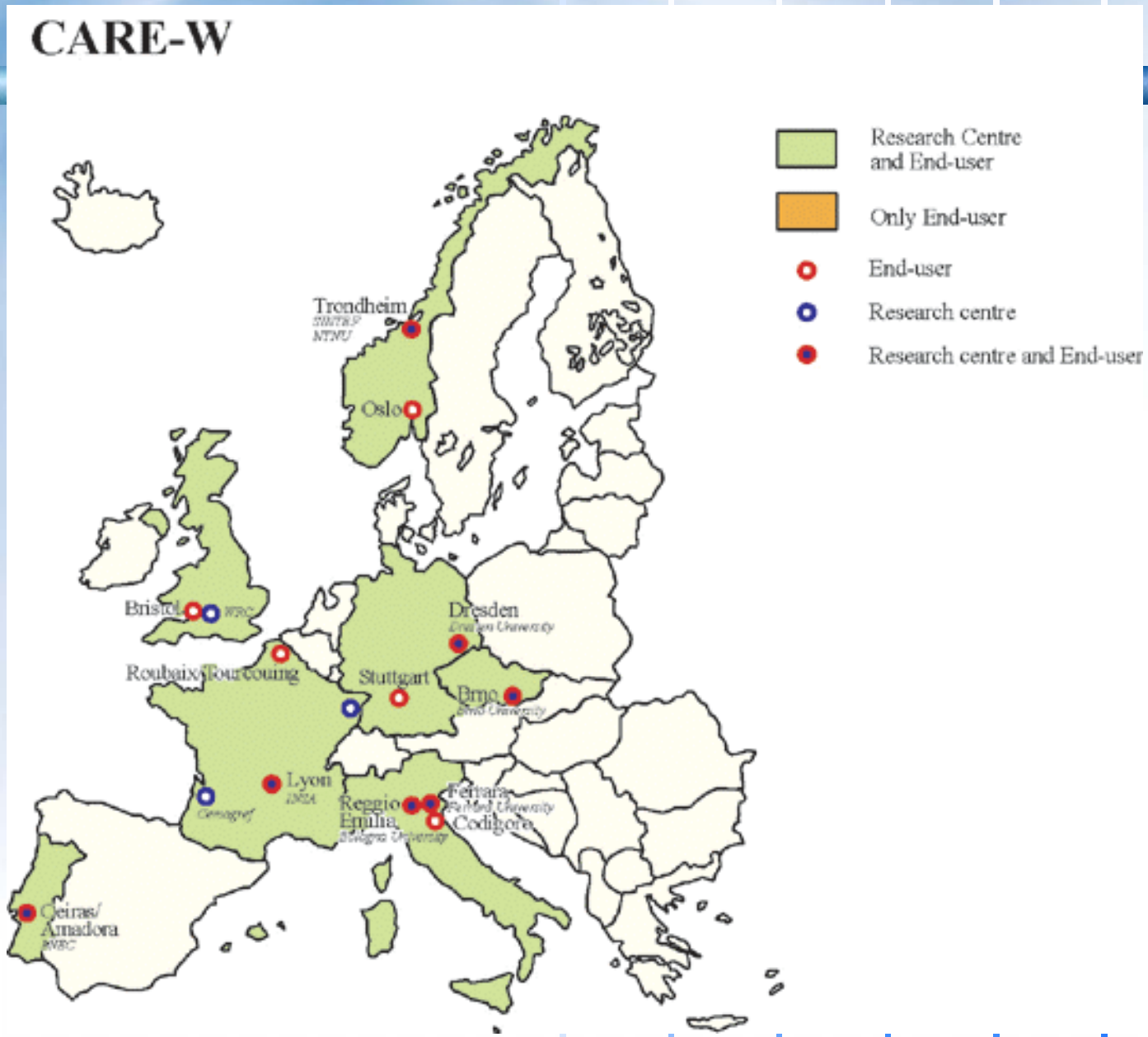
Sveinung Sægrov, SINTEF

Computer Aided REhabilitation of Water networks

What is CARE-W?

- …stands for Computer Aided REhabilitation of Water Networks
- …is a computer based system to support water companies to maintain and upgrade their water networks
- …wa developed by 10 European research groups and 13 cities ("end-users").
- …supported by the European Commission under the 5th Framework Programme for Research and Development.
- …had a budget of 3 mio € (2,1 mio £)

Consortium


CARE-W
Research Centre and End-user
Only End-user
End-user
Research centre
Research centre and End-user
Trondheim
SINTEF
NTNU
Oslo
Bristol
WRC
Dresden
Roubaix/Tourcoing
Stuttgart
Brno
Lyon
Reggio Emilia
Ferrara
Codigoro
Cetras/ Amadora
INRIC

The need for CARE-W

- 1,5 mio miles of water pipes are owned by public or private utilities in Europe. Their age is increasing and the repair budgets limited.
- Annual rehabilitation need is > 0,5%, i.e. 10.000 km/yr at a cost of 5 billion €.
- Efficiency of rehabilitation can be improved by
  - selecting the right projects
  - avoiding consequences of failures, i.e. water supply abruption, flooding, traffic disturbances etc.
- In Europe the economic potential by using CARE-W is in the order 1 billion € annually

CARE-W answers these questions:

- What is the structural condition of a specific pipe - and of the entire network?
- Which are the most vulnerable pipes?
- Will the future failure rate increase or not?
- How should I rank my rehab projects?
- What are the future investment needs?
- What is the optimal management of my water distribution network?

CARE-W Philosophy

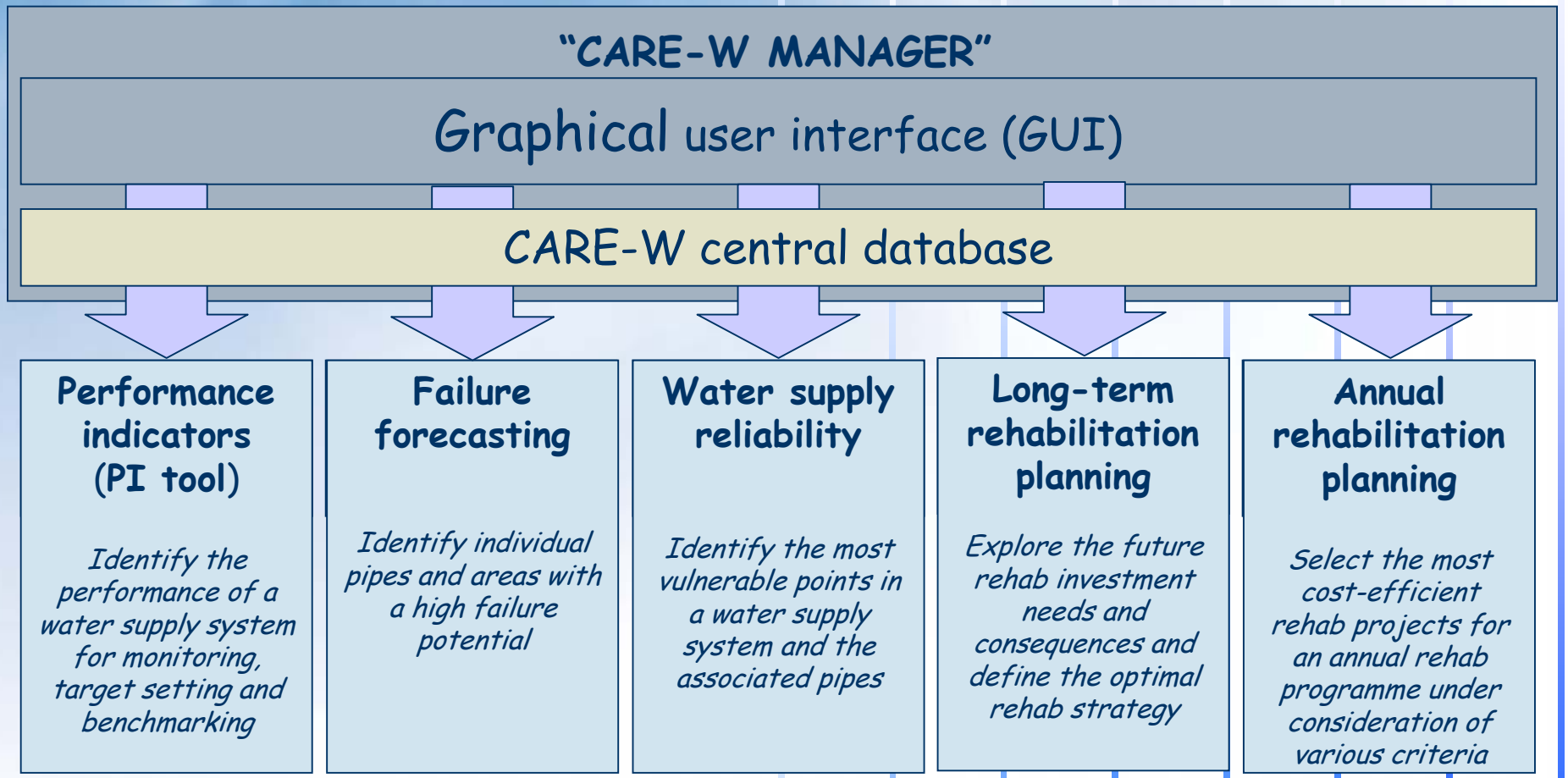
RE-ACTIVE APPROACH

PRO-ACTIVE APPROACH

Our mission: Develop methods and integrated software supporting efficient rehabilitation decisions

CARE-W prototype

WRc, UK



LNEC, Portugal

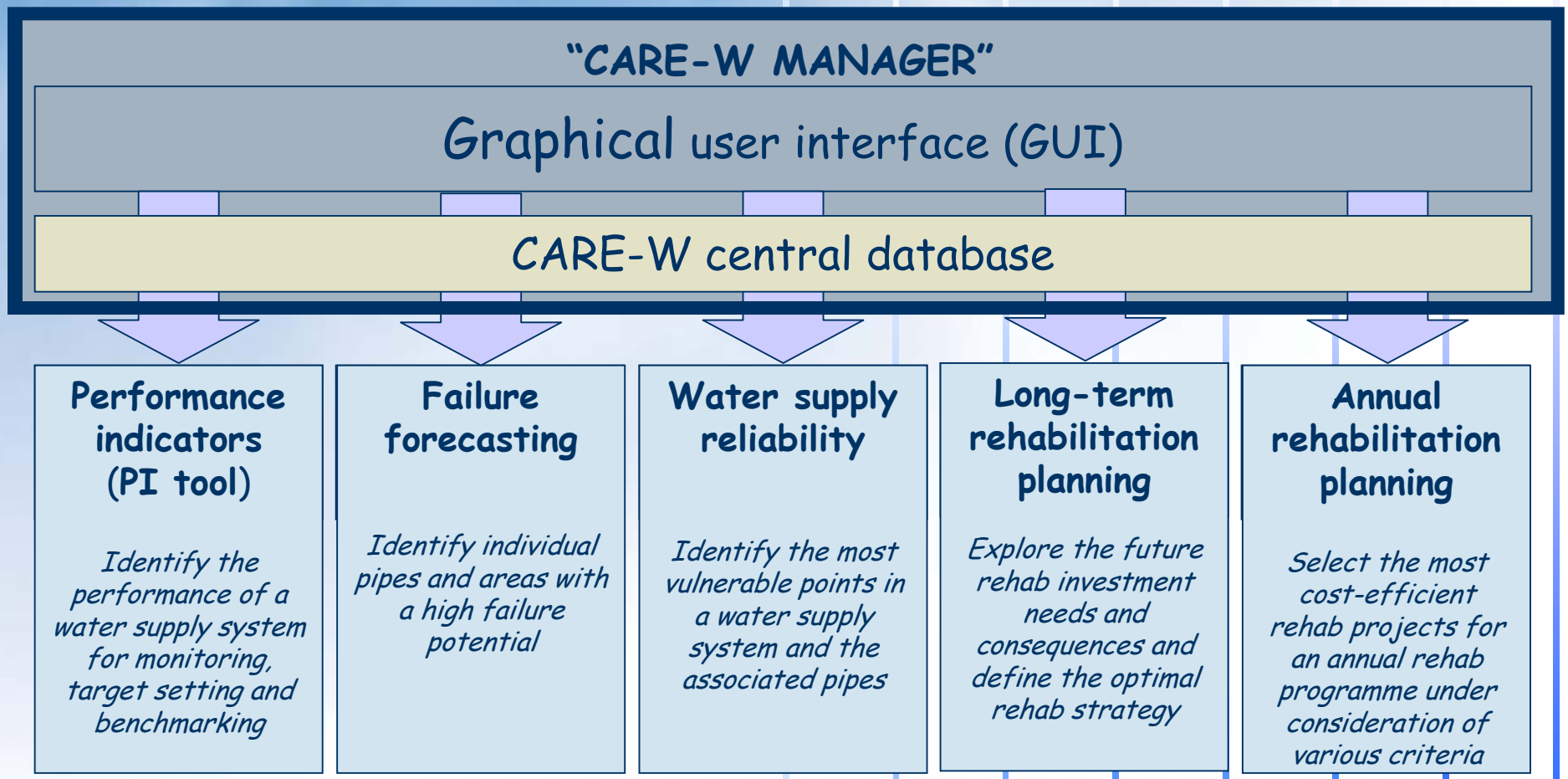
CEMAGREF, France
INSA, France

CEMAGREF, France
SINTEF, Norway
Brno Univ., Czech Rep.

Dresden Univ., Germany

INSA, France

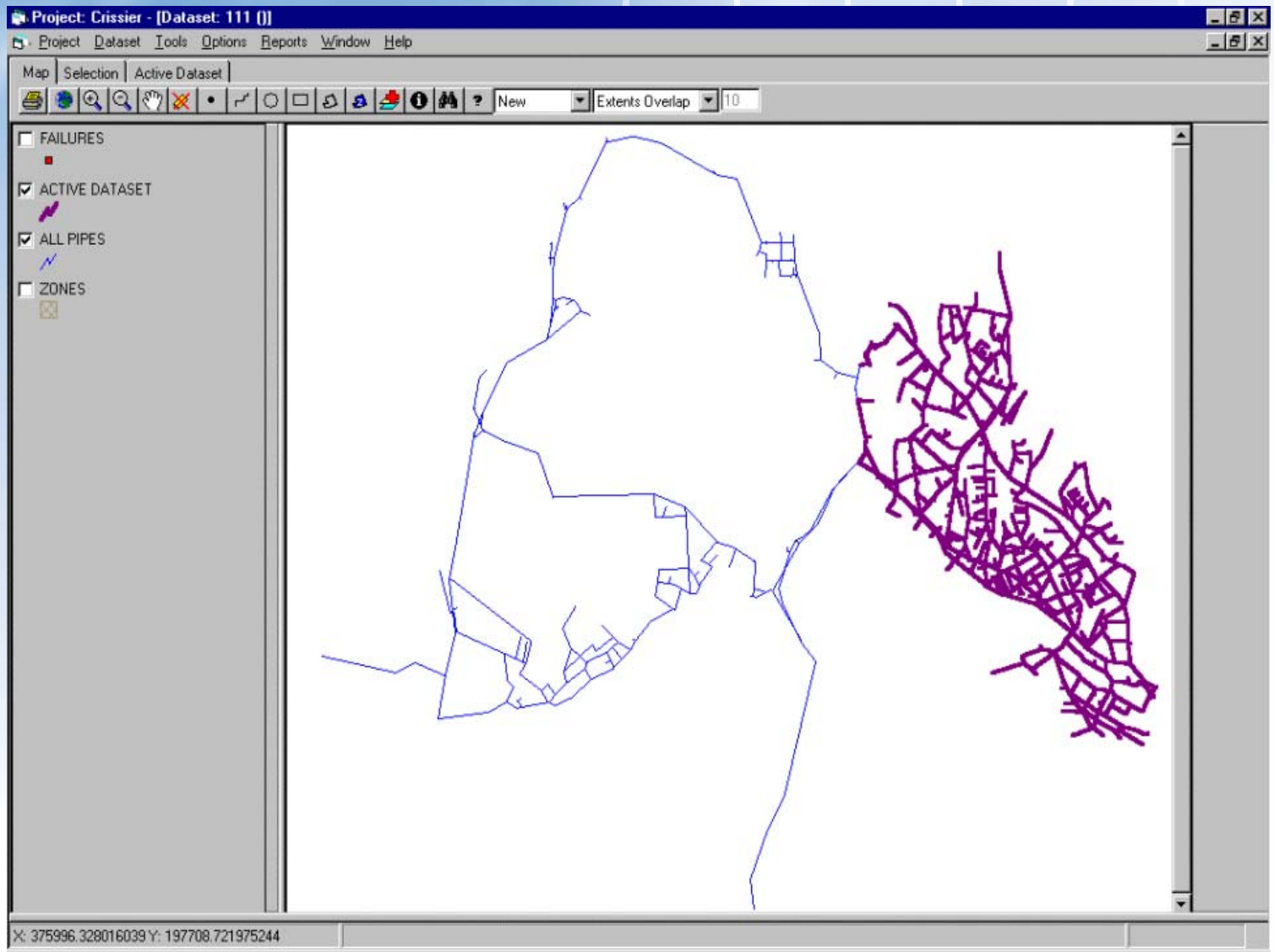
CARE-W prototype



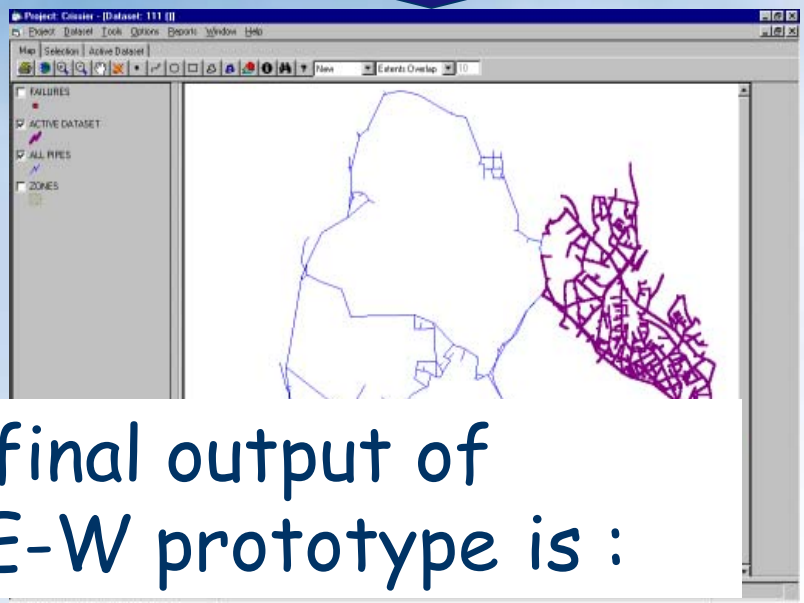
"CARE-W manager"

- Manages a central database
- Contains an imbedded GIS
- Allows for data import/export
- Is an integrating platform for all the individual modules
- Allows to generate the input files and run any of the associated applications
- Allows for graphical data input and results representation.

"CARE-W manager" – example of data selection



INPUT DATA



The final output of CARE-W prototype is :

List of pipes with higher rehabilitation priority

Contributions for the short and long term strategic planning, including some economic analysis

CARE-W TOOLKIT

Input

Results

Performance indicators (PI)

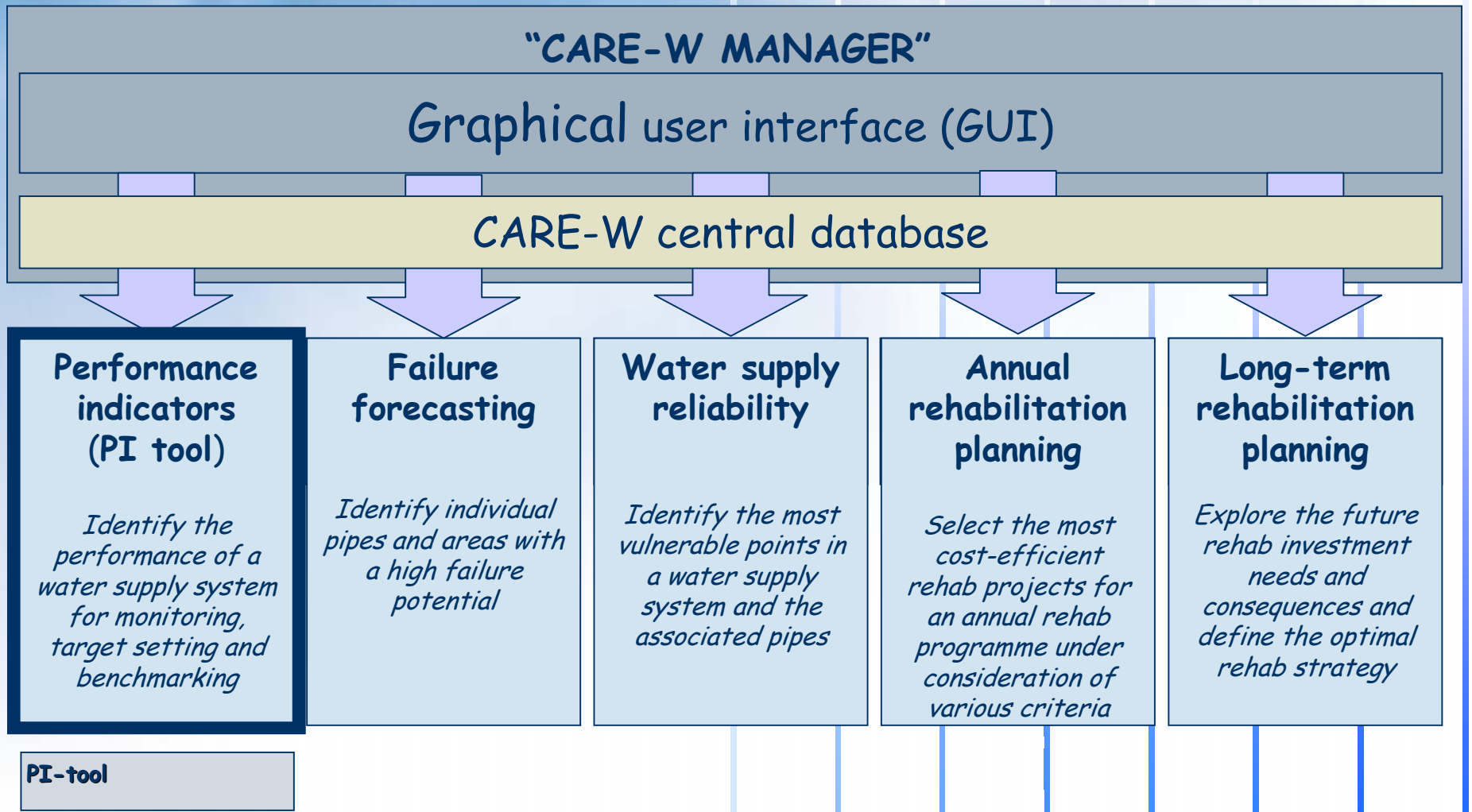
Failure forecasting

Water supply reliability

Long-term rehabilitation planning

Annual rehabilitation planning

CARE-W prototype



Performance indicators (PI)

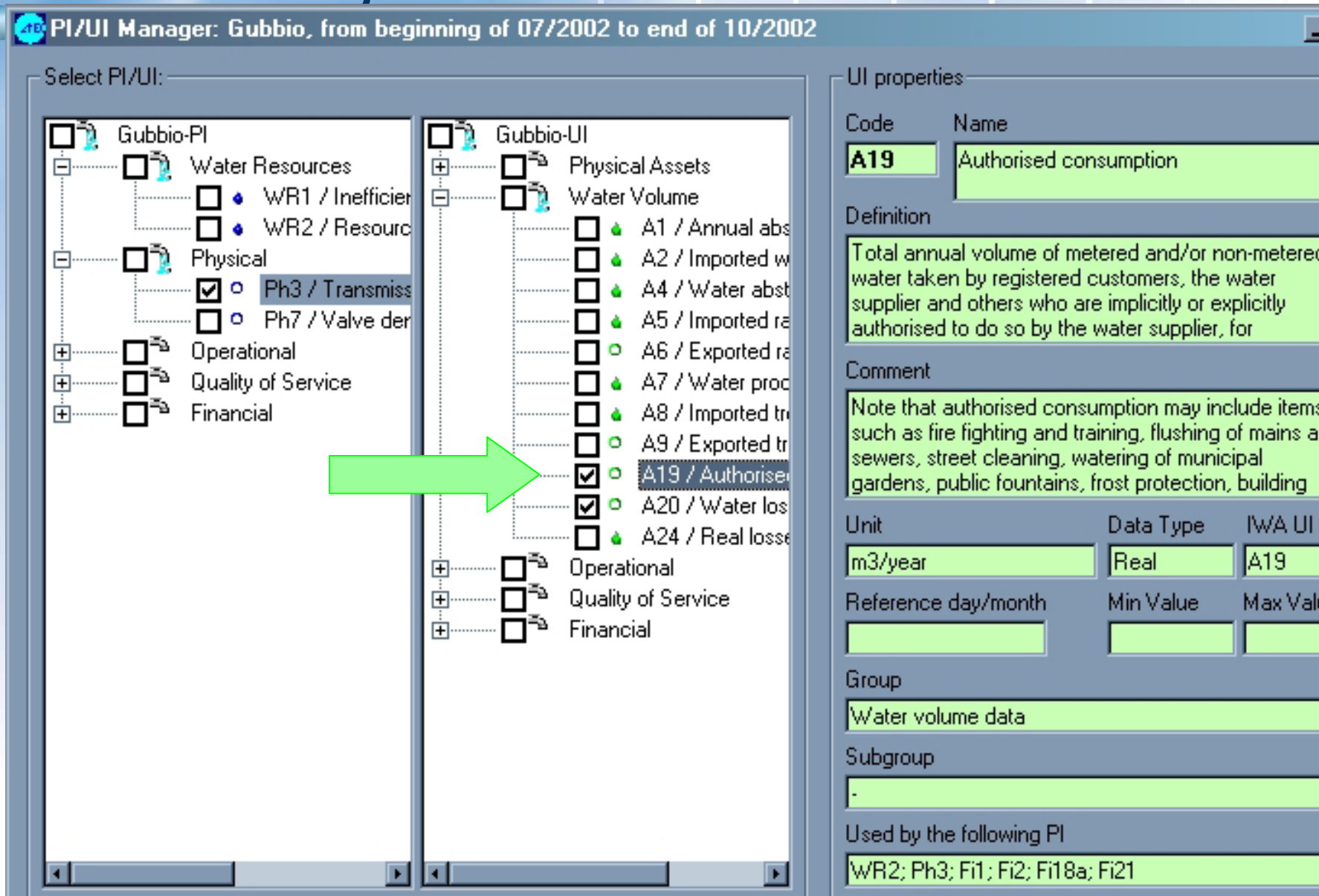
- The CARE-W PI module incorporates a rehabilitation PI system to support network diagnosis
- Is based on the IWA PI system
- PI-Tool allows for:
  - PI and variable selection
  - Import / export
  - Data input and PI assessment
  - Production of tables and graphs with the results

Indicators

- General description of condition
- Compare areas (internal "benchmarking")
- Compare with other cities
- Estimate the benefit of rehab programs

Appropriate for documentation towards policy agencies, investment planners

Example of a PI tool window: PI/UI manager



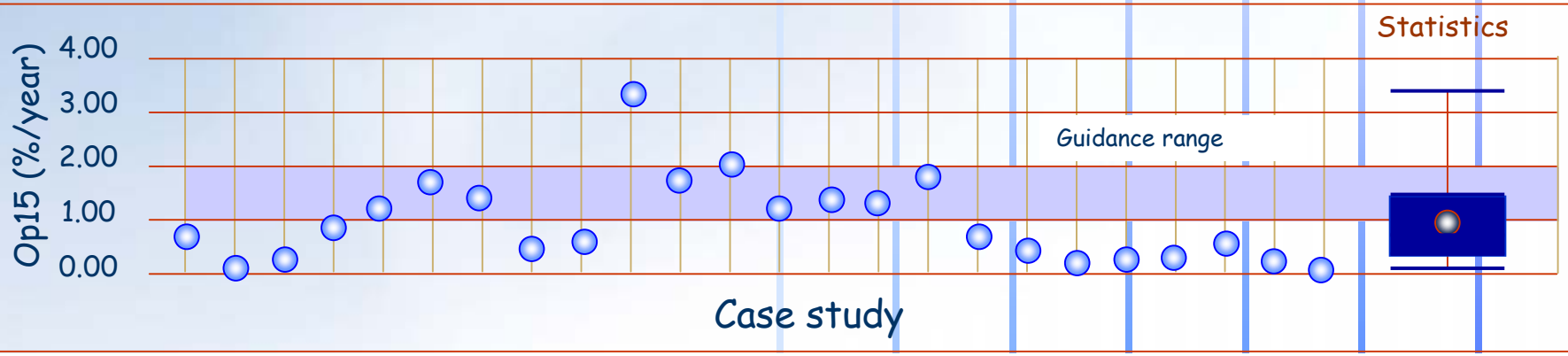
Detailed PI result analysis

Op15 – MAINS REHABILITATION (%/year)

Concept: Length of transmition and distribution mains rehabilitated during the year / total mains length x 100

Processing rule: Op15 = D18/C6 x 100

Variables: D18 – Mains rehabilitation (km/year)
C6 – Mains length (km)



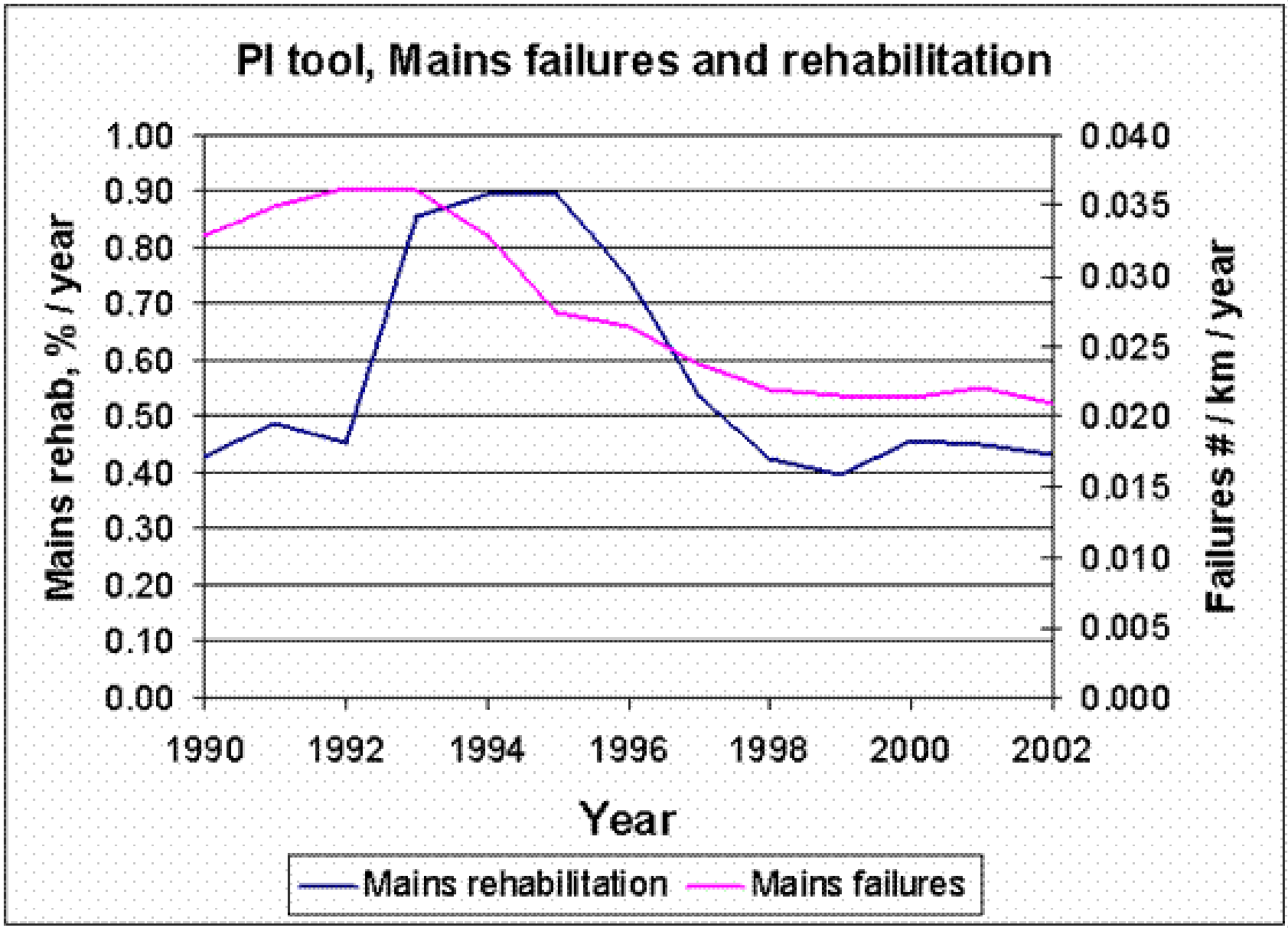
Comments: The mean value of the results collected is 0.91% of mains rehabilitated per year and 50% of the case studies are situated in the range from 0.25 to 1.3% of mains rehabilitated per year. As it might be expected, a significant number of case studies present relatively low rehabilitation rates, corresponding in average to a mains lifetime of 110 years.

Difficulties: A few end-users had difficulties with D18 (Mains rehabilitation). This difficulty seems to be due to the lack of record, not to the complexity of the variable itself, and nobody recommended abandoning this PI due to assessment difficulties.

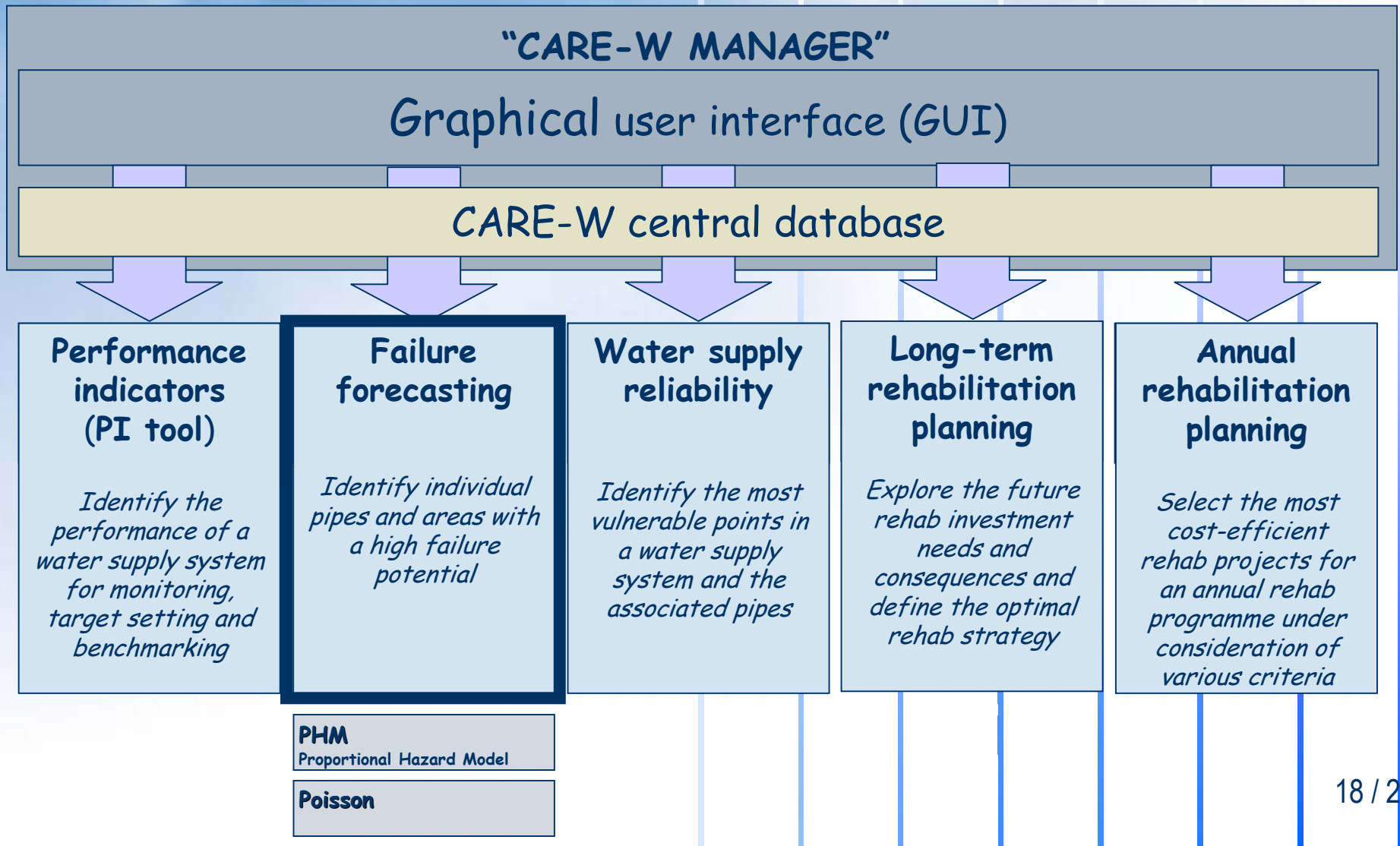
Relevance: This PI is considered essential or important by all end-users.

PI guidance range: At this stage, a tentative recommended threshold seems to be 1.0-2.0% of mains rehabilitated per year, representing a global network renovation within a period of 50 to 100 years.

Indicators, example



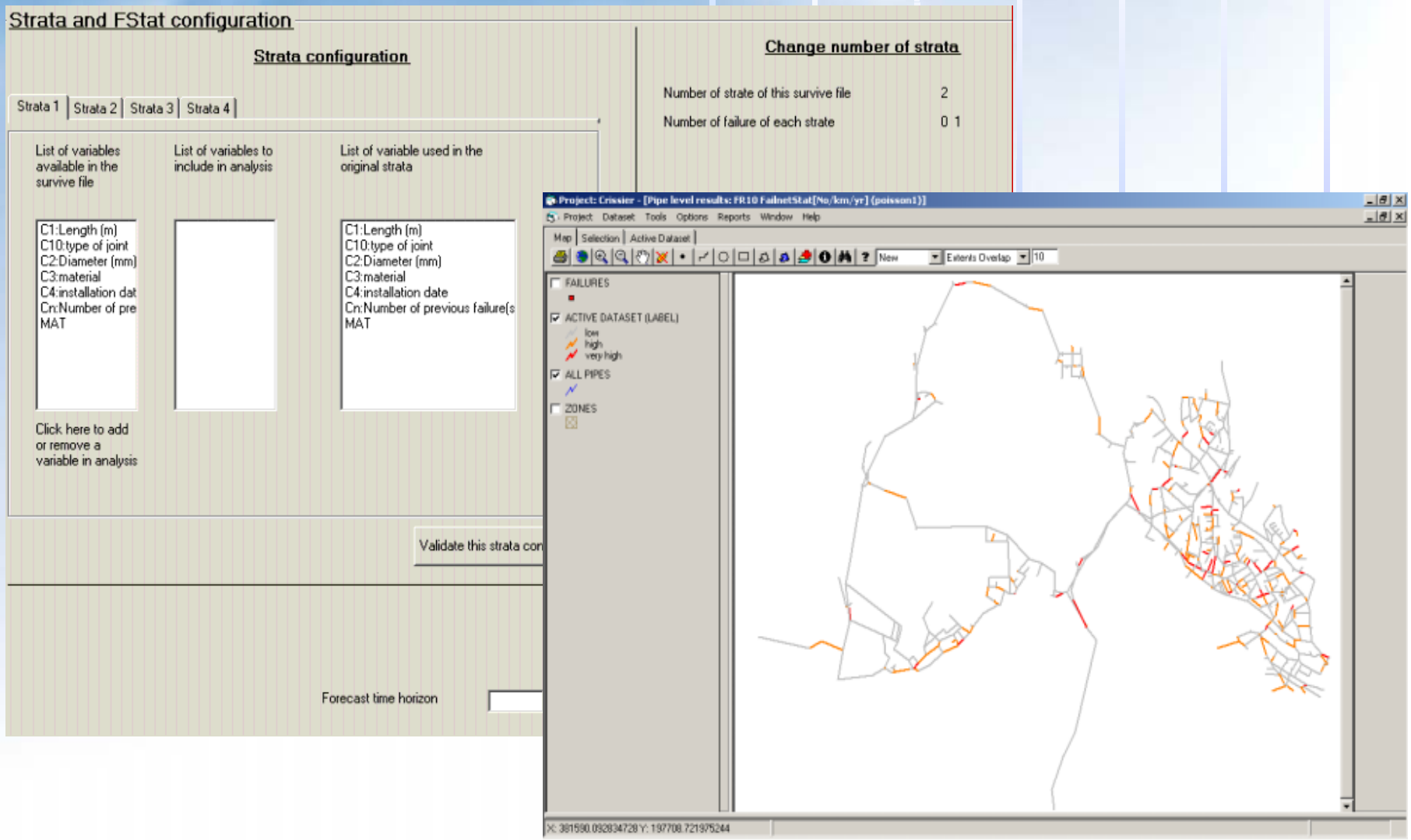
CARE-W prototype



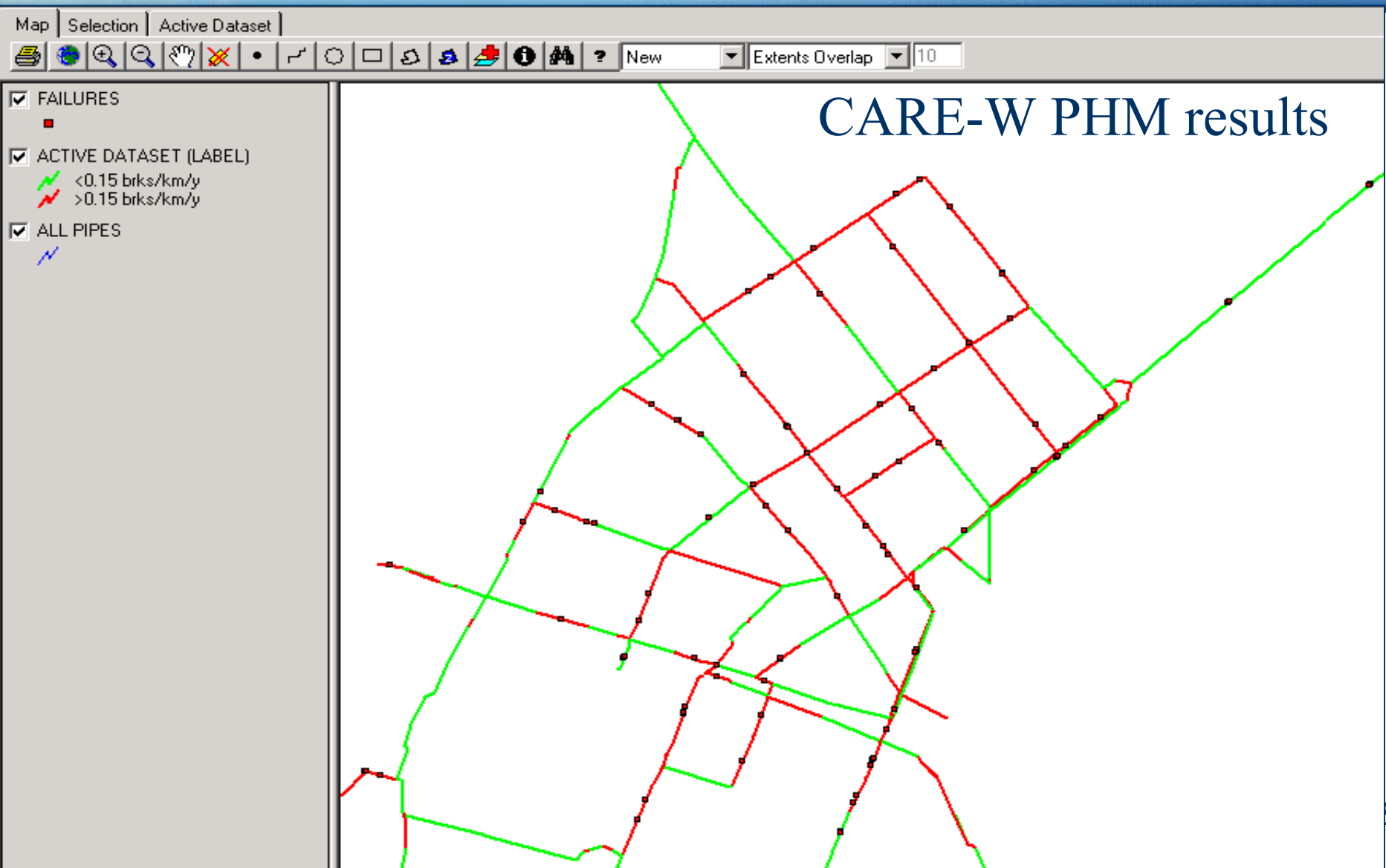
Failure forecasting module

- Predicts the probability of pipe failures
- Pipes are grouped in clusters of similar behaviour
- In general 5 years of data are sufficient to get useful results
- Tests showed that it is more important to have **good data** than <u>many</u> data

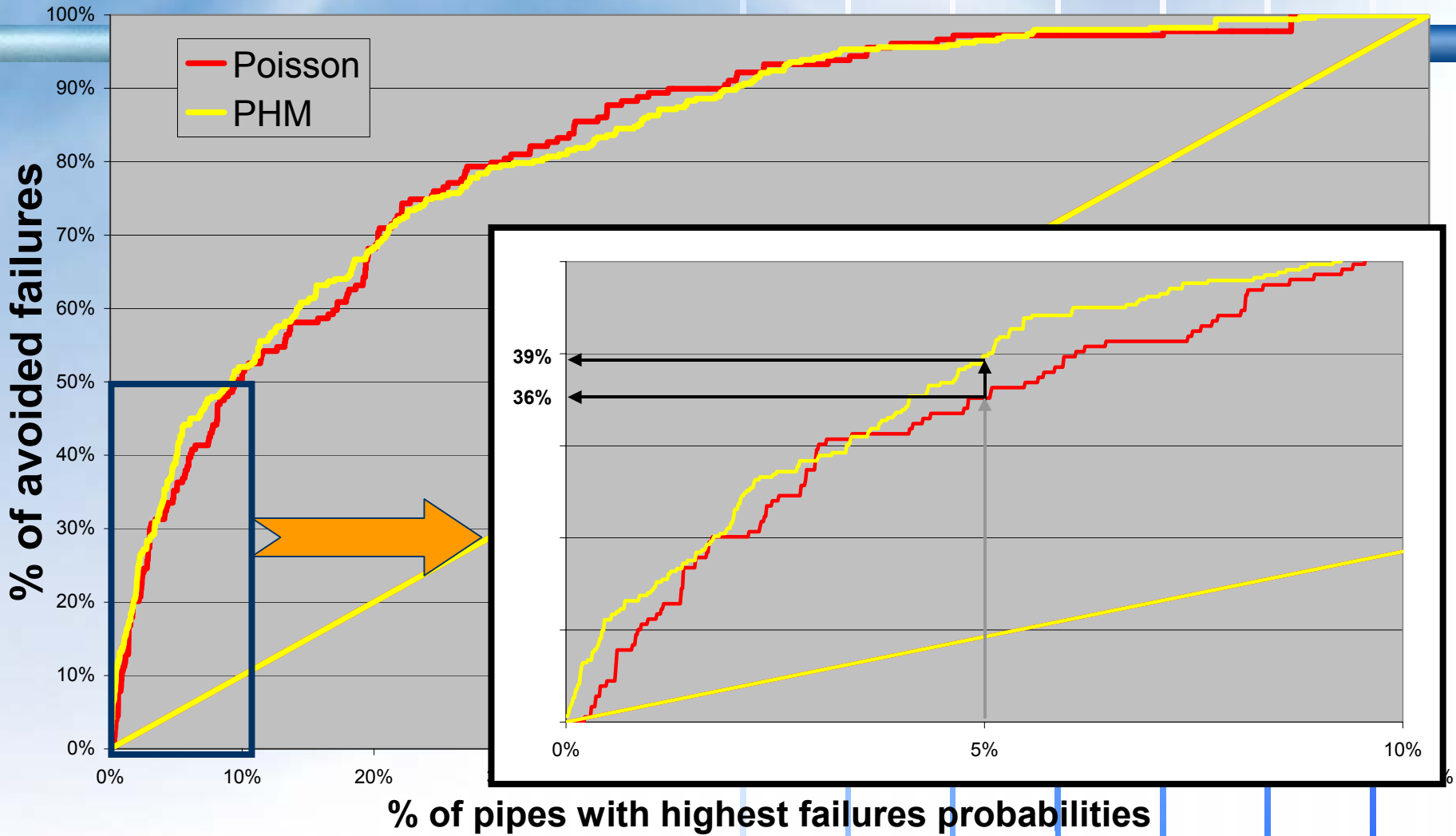
Example of a PHM window



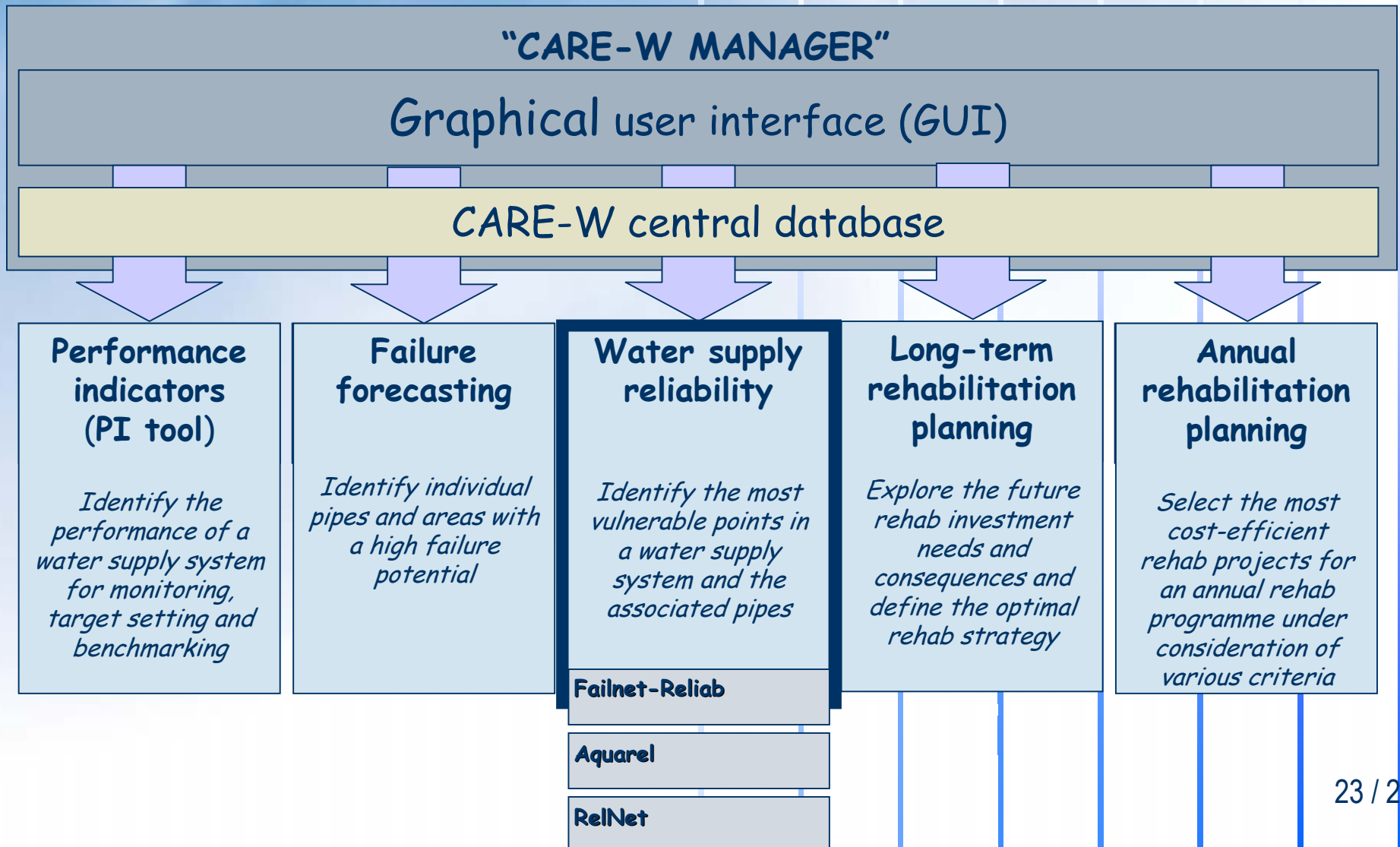
Example of a PHM window



Benefit of using these tools



CARE-W prototype



Reliability analysis

- Assesses the relative importance of each pipe in terms of hydraulic reliability
- Is based on the input data file of a hydraulic simulation model

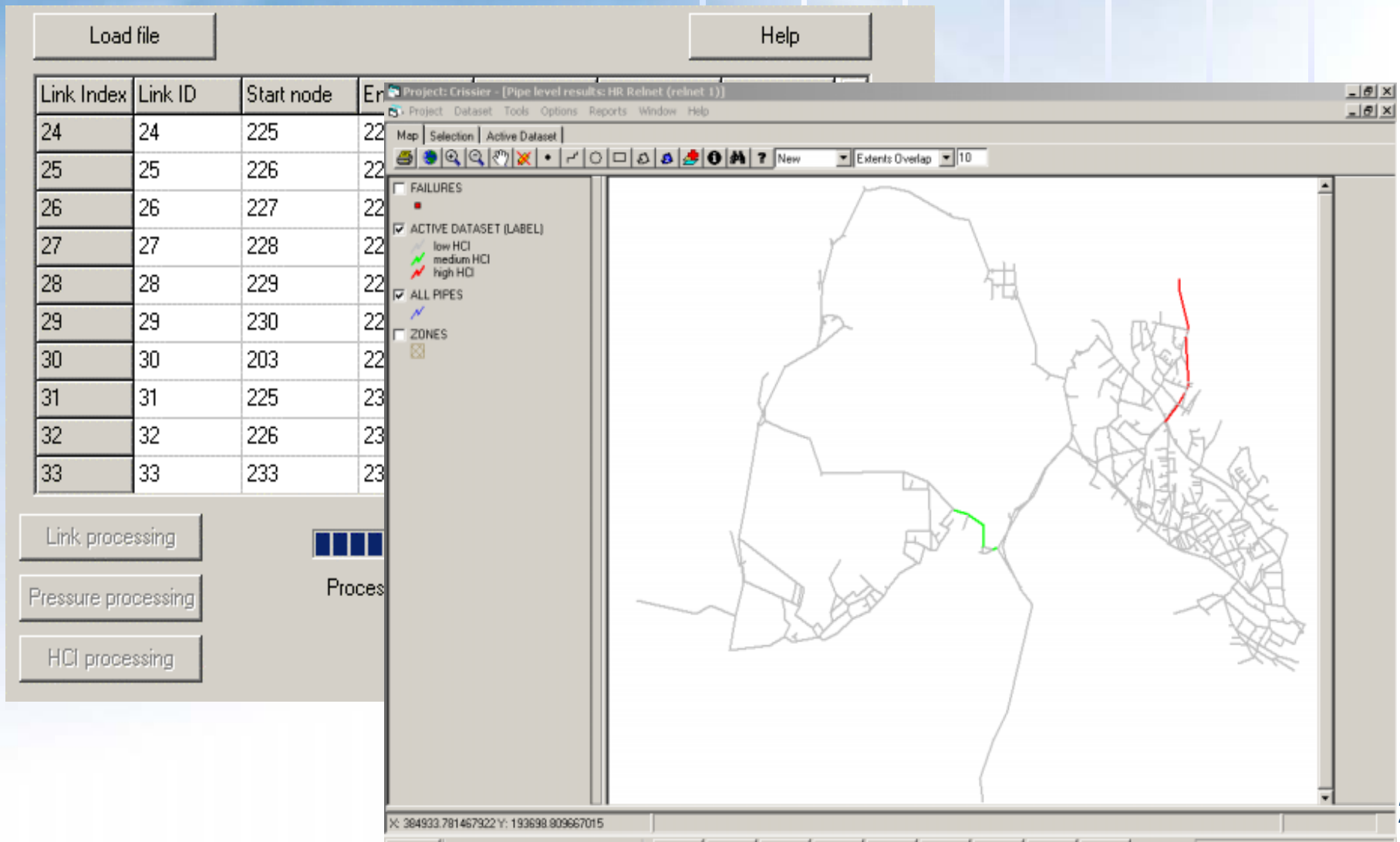
Reliability analysis

- Assesses the relative importance of each pipe in terms of hydraulic reliability (MTTF, MTTR, consequence)
- Is based on the input data file of a hydraulic simulation model (e.g. epanet)

CARE-W REL tools

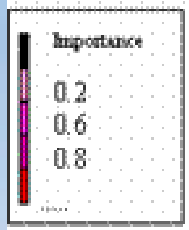
Feature	Hydraulic model	Equipment integration	Failure rate	Indices
Aquarel	Classical model (EPANET) on 24h, considering tank water levels	Yes	Yes	One index (0-1)
Failnet-Reliab	Head dependent demand model (based on "Porteau" Model)	In progress	Yes	2 indices (0-1 and non-supplied water volume)
Relnet	Classical model (EPANET)	Yes	No	One index (0-1)

Example of a Relnet window



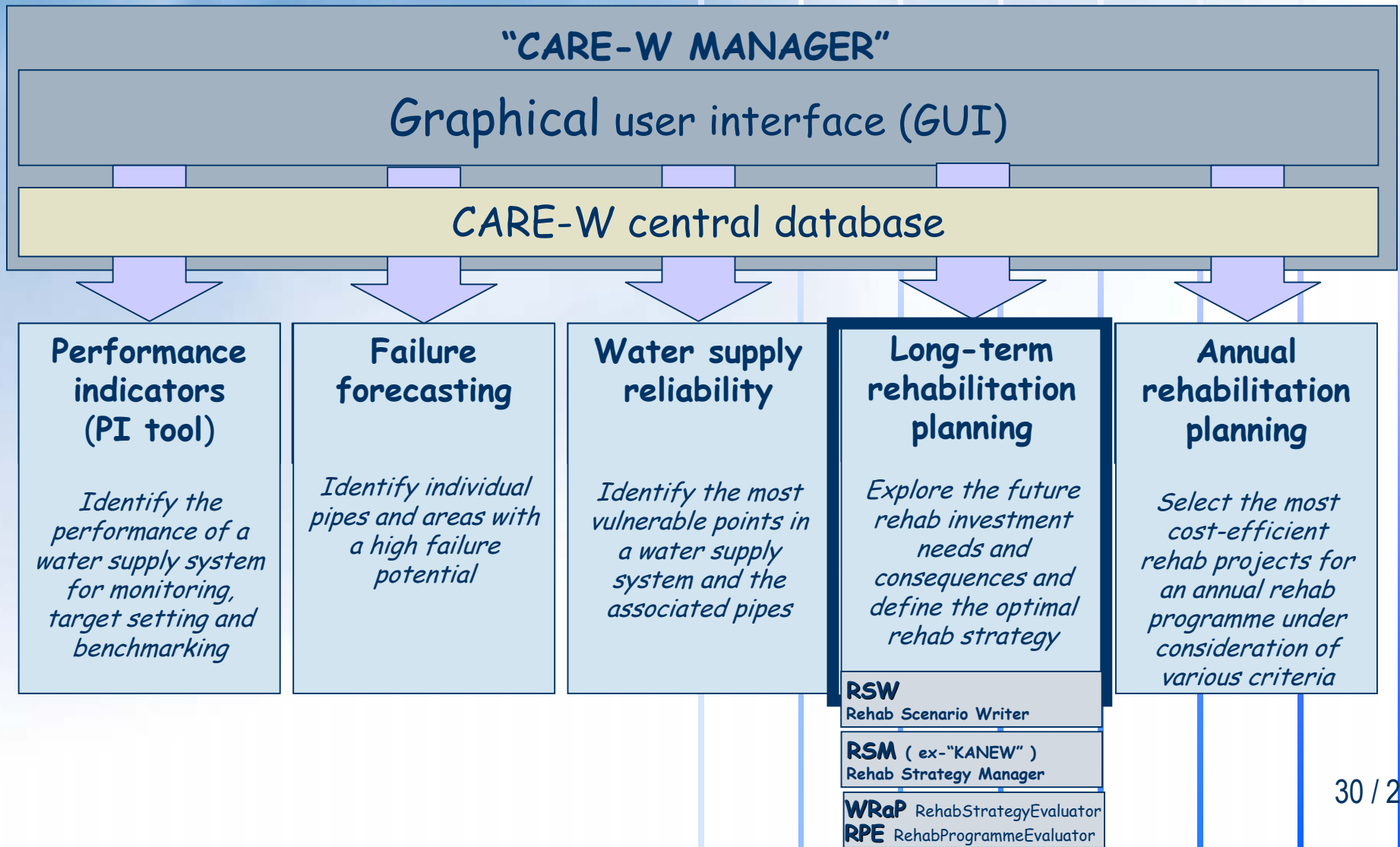
Example of a Relnet window

Example result from Aquarel



Importance	
Pipe ID	HCI
167703	0.9
187468	0.88
167690	0.6
167659	0.4
181459	0.3
181447	0.1
181450	0.1
186040	0.1
167474	0.1
167486	0.1

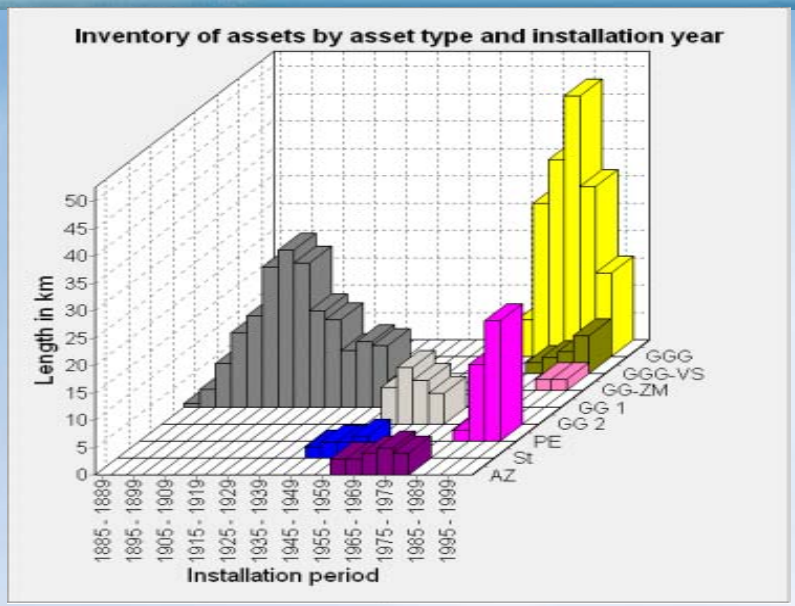
CARE-W prototype

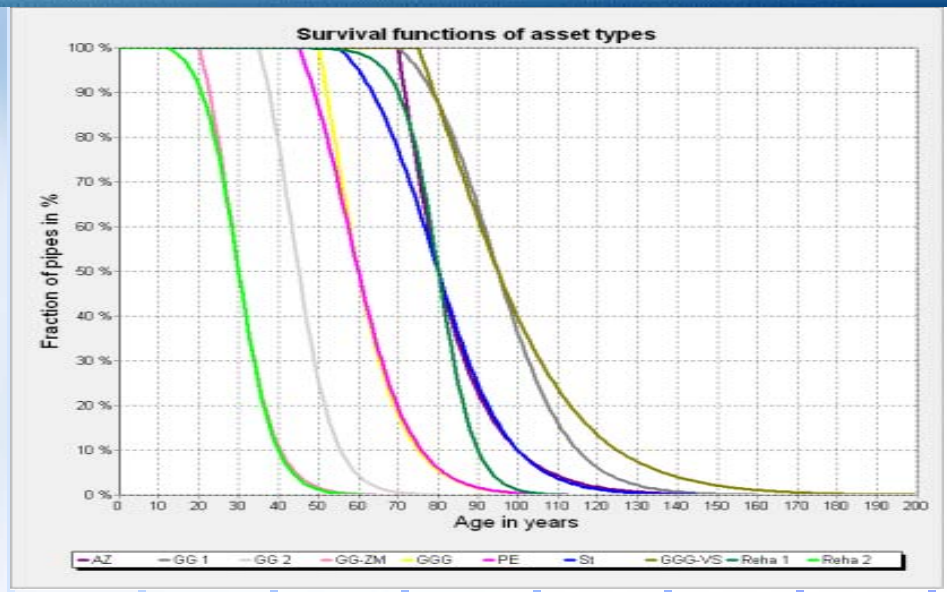


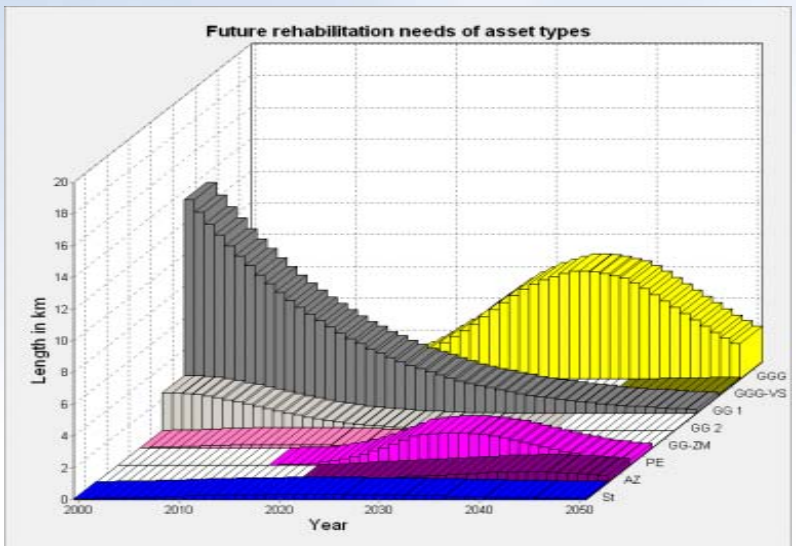
Long term rehabilitation planning (LRP)

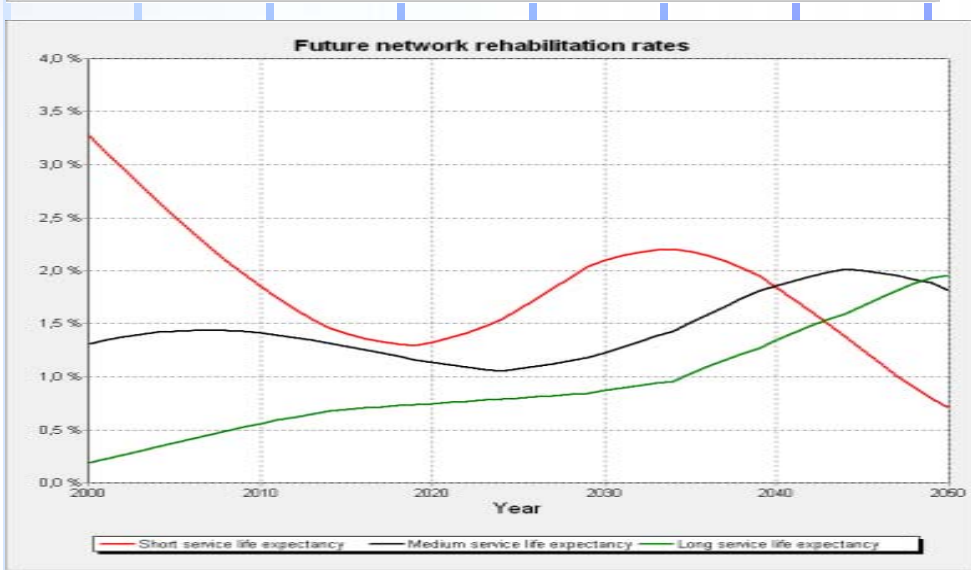
- Allows to predict the long term network behaviour for pre-defined rehabilitation scenarios
- Is based on the life expectation distribution for each group of materials
- Provides a global budget to support the strategic rehabilitation plan

Example of LRP results

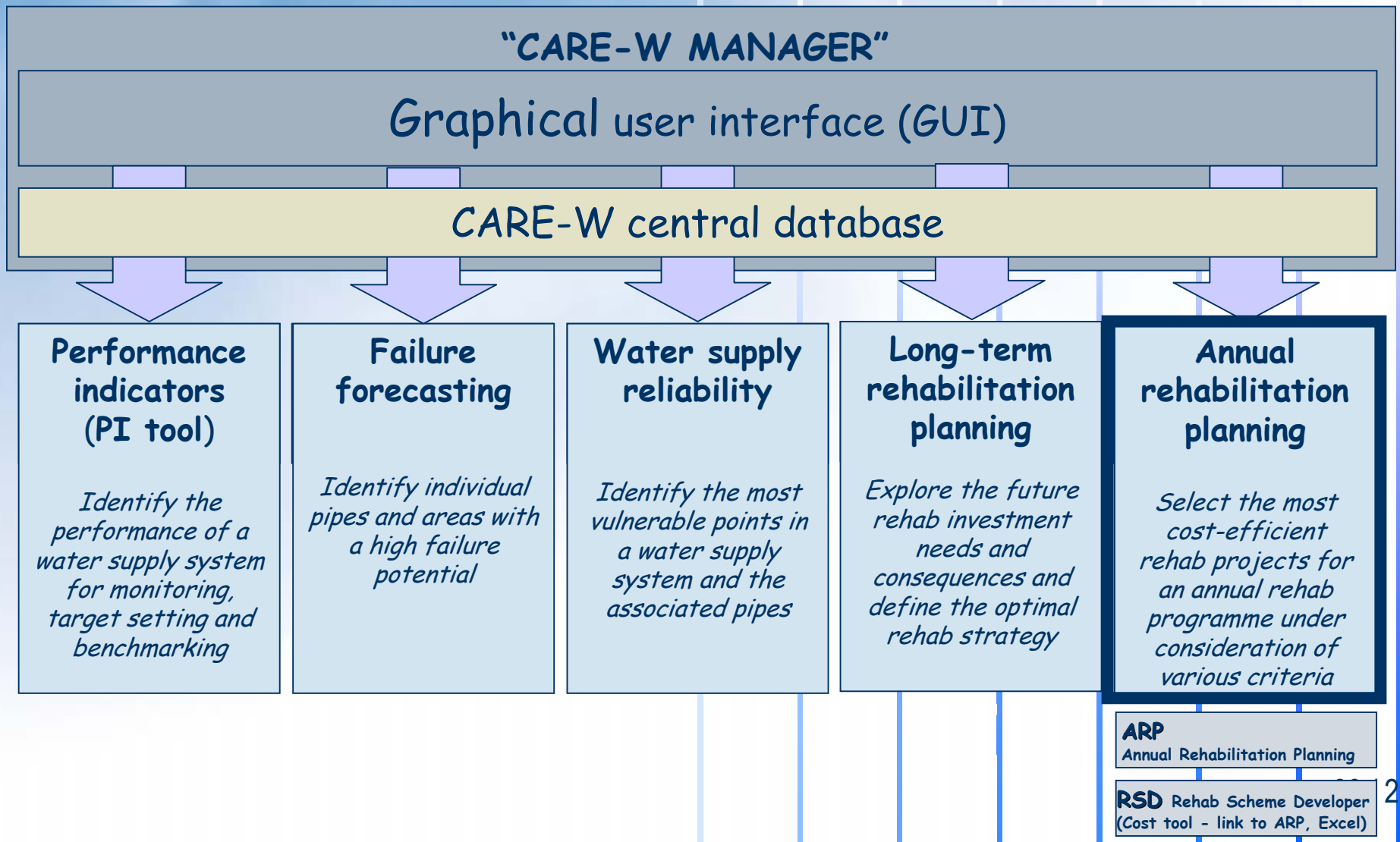








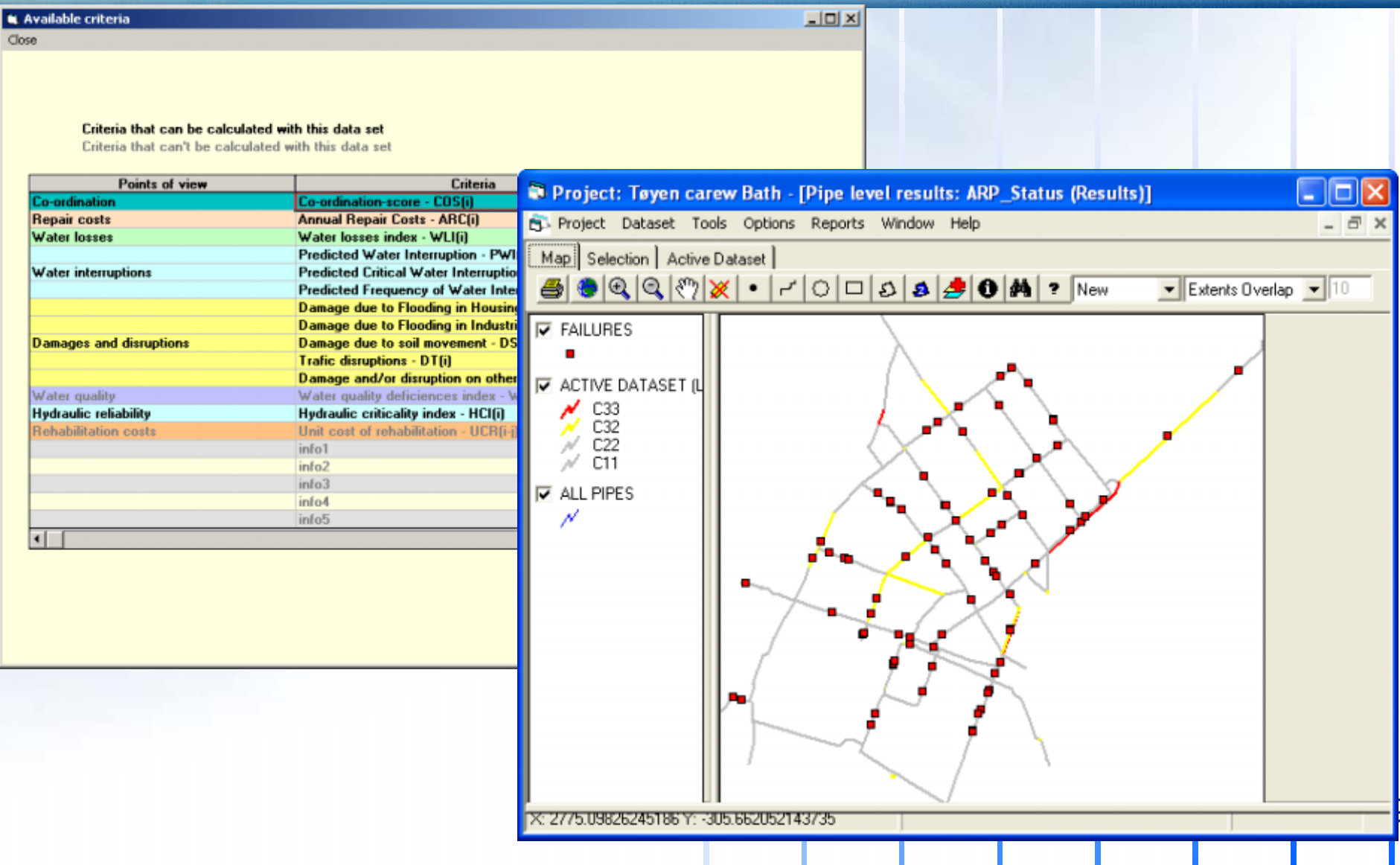
CARE-W prototype



Annual rehabilitation planning (ARP)

- ARP is a multi-criterium decision-support tool
- Helps selecting the pipes with higher priorization to be rehabilitated
- The user selects and customises the criteria to be adopted (results from other tools Fail, Rel etc)
- ARP allows for the comparison of results from different scenarios

Example of an ARP window



Using the CARE-W Rehab. Manager

- Importing data
  - Define specification for user GIS/CSV files
  - Use pre-existing tool formats (e.g. Poisson, Relnet)
- Viewing project data
  - Integral GIS viewer
  - Some limited tabular views
- Working with data(sets)
  - Search/selection facilities on project database
    - GIS selection tools
    - Expression Builder
- Reporting results
  - Tabular
  - Geospatial

Workload in CARE-W

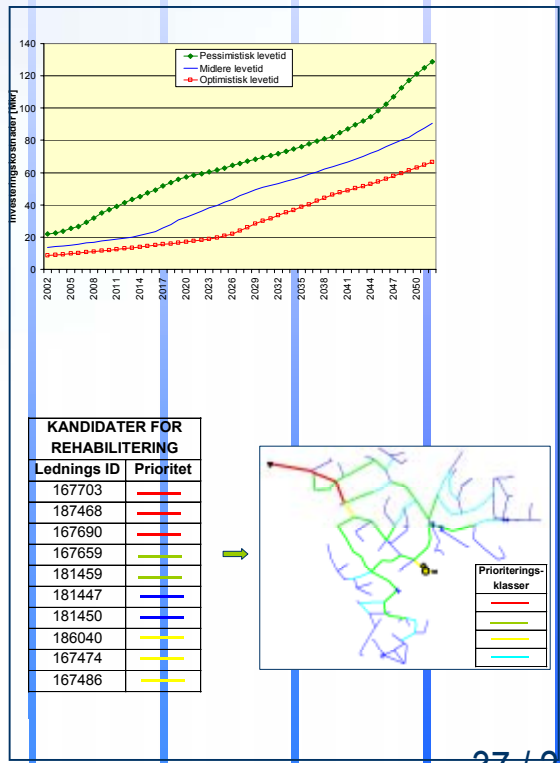
75%

25%

Data preparation

Analyses

Raw-data



Examples of data errors

- Missing pipe data (e.g. material, year, length or diameter are missing).
- Illogical combinations of pipe material, diameter and installation year (e.g. 150 mm PVC laid in 1930).
- Failure date pre-dates year of installation.
- Multiple breaks at the same pipe in the same day.
- Rehabilitation date pre-dates year of installation.
- Breaks not linked to pipes

Concluding remarks

- Some of the CARE-W tools are more data hungry than others.
- End-users appreciate CARE-W approach, although the prototype still needs further consolidation.
- The "hands-on" experience is necessary to make the CARE-W tools most useful.
- CARE-W is currently available as prototype.

Acknowledgments

Co-authors :

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- Wolfgang Schilling
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