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# 2nd IWA Leading-Edge Conference & Exhibition on **Strategic Asset Management**

**Assessing the benefits of rehabilitation programs  
defined with the CARE-W decision support system**

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# Assessing the benefits of rehabilitation programs defined with the CARE-W decision support system

- **Intro: CARE-W\_ARP** (Annual Rehab. Prog.)
- Back to the **formulation of decision criteria**
- **Benefits** of rehabilitation programs  
(Lyon, Reggio Emilia)

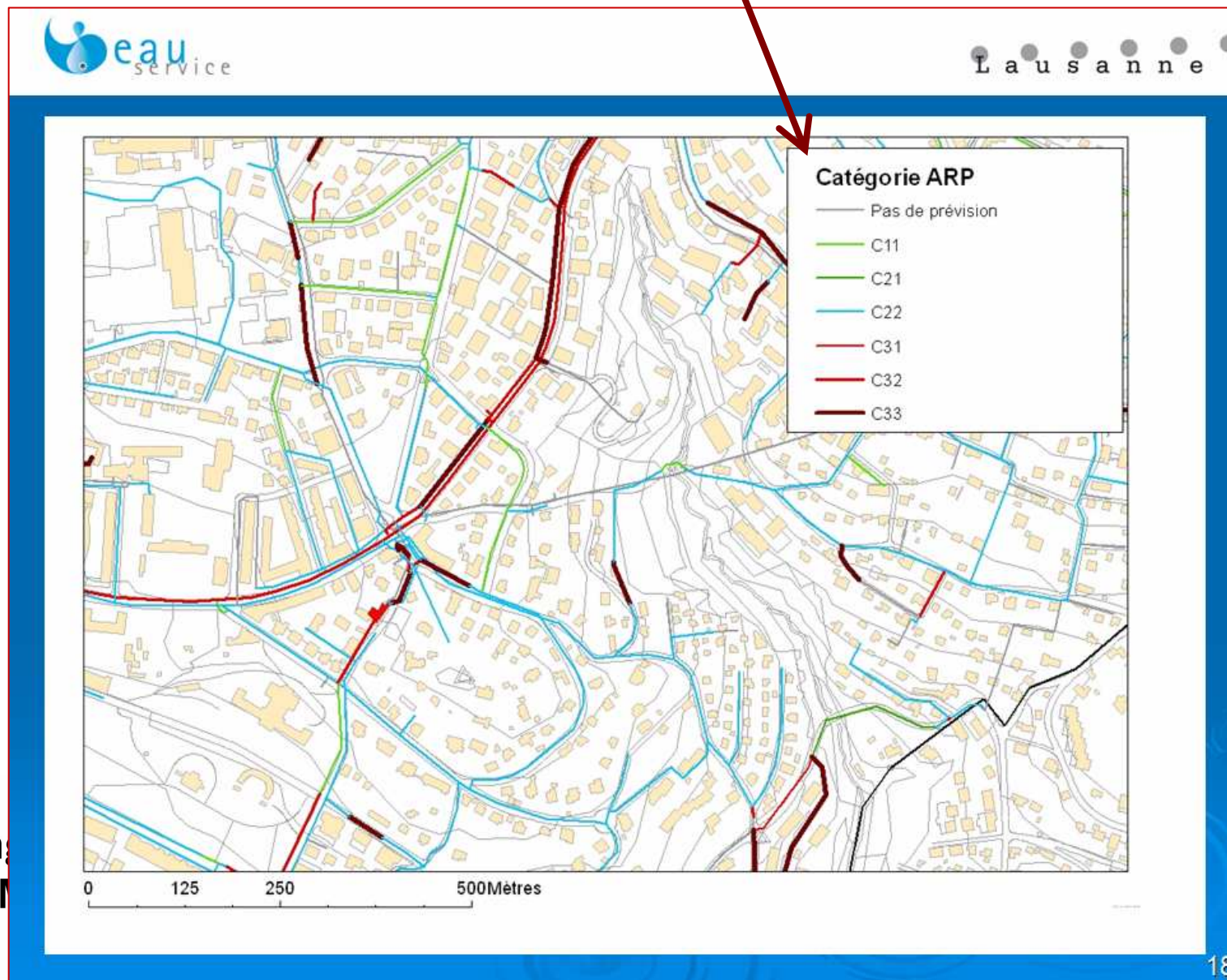


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# 1 - CARE-W\_ARP

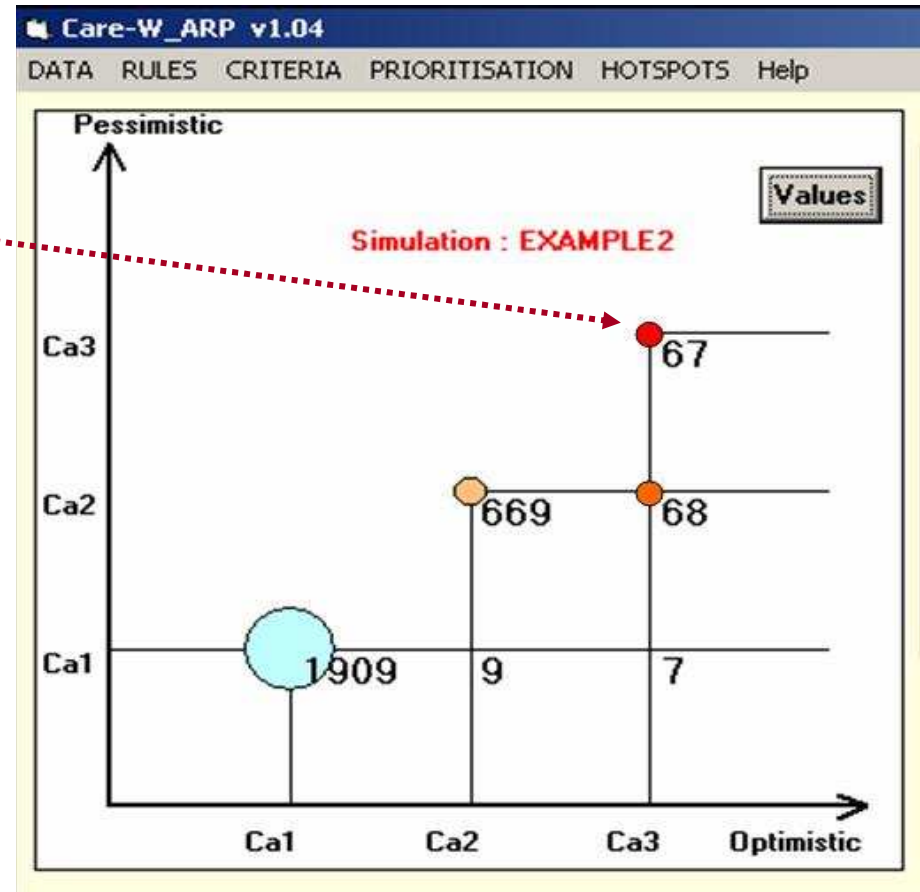
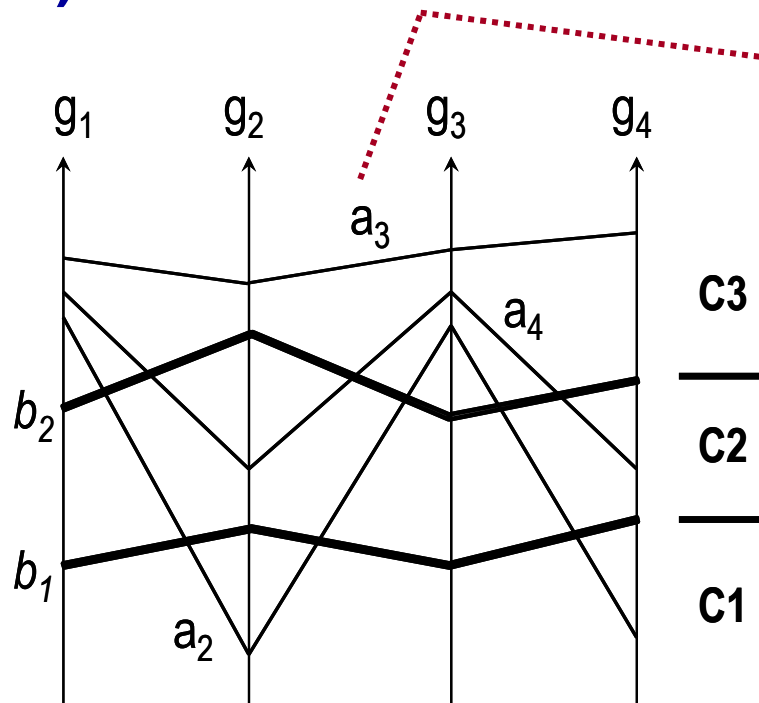
Output: priority level



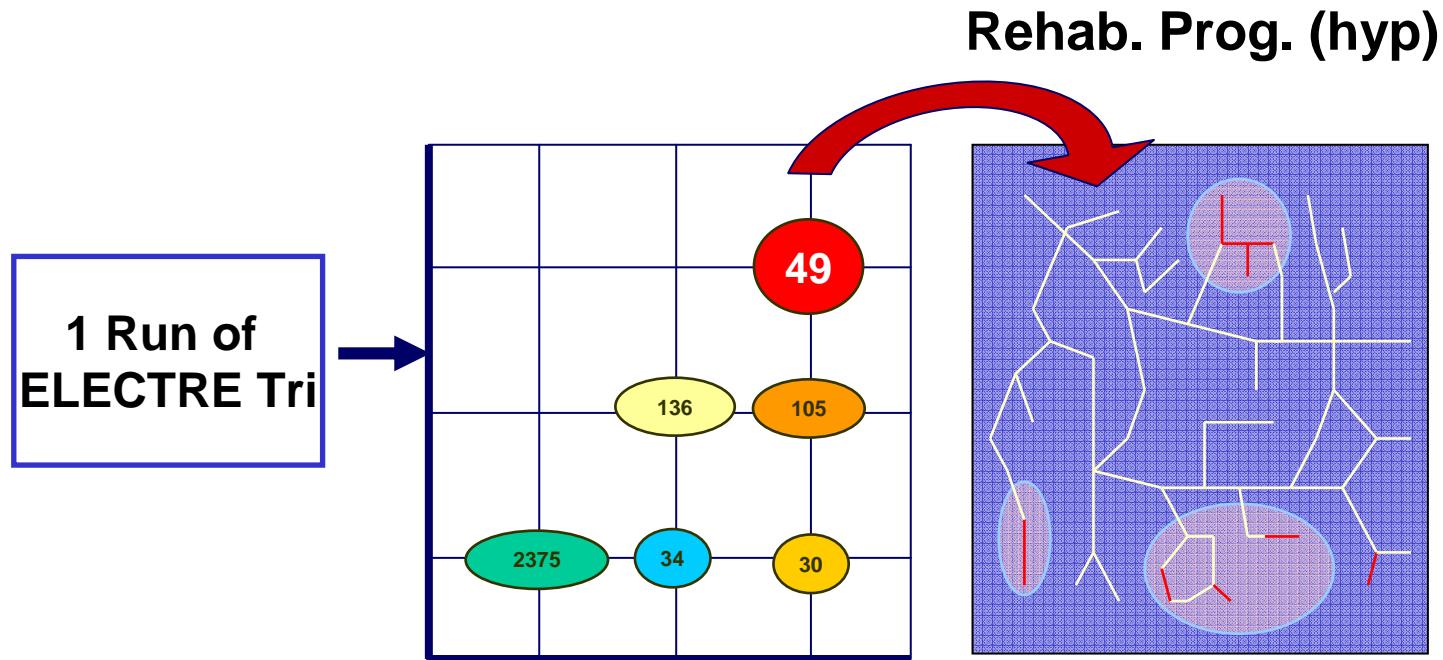
# 1 - CARE-W\_ARP

a) criteria: 1 profile / pipe

b) ELECTRE Tri



# 1 - CARE-W\_ARP



## 2 – Back to the formulation of criteria

- **Two scales:**
  - **Pipes**
  - **Rehabilitation programs**
  
- **Possible formulations:**
  - **Impact of the pipes condition (problems)**
  - **Efficiency of rehab. measures (solutions)**



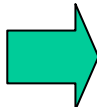
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**Scale: pipe                      Formulation: impact or risk**

**Consequences of pipe failures: Risk-based criteria**

**R = Prob. × Intensity × Vulnerability × Exposed values**

<b>CRITERIA</b>	<b>P</b>	<b>I</b>	<b>V</b>	<b>E</b>
HCI, Hydraulic Criticality	= f (PBR,	EDI,	network	w_node)
 PWI, Water Interruption	PBR	EDI (hours)	/	<b>NPS</b> (persons)
PCWI, Critical Water Interruptions	PBR	EDI	/	<b>SC</b> ∈ [0,1] sensitivity
ARC, Annual Repair cost	PFR	/	/	<b>UCRp</b> (€)
DFH, Damage / Flooding in housing areas	PBR	P.D <sup>2</sup>	<b>IFH</b> ∈ [0,1] intensity	<b>VFH</b> ∈ [0,1] values
DFI, Damage / Flooding in ind. areas	PBR	P.D <sup>2</sup>	<b>IFI</b> ∈ [0,1]	<b>VFI</b> ∈ [0,1]
DSM, Damage / soil movement	PFR	P.D <sup>2</sup>	<b>LS</b> ∈ [0,1] geotech. risk	/
DDI, Damage on other Infra.	PFR	P.D <sup>2</sup>	/	<b>SI</b> ∈ [0,1] sensitive infra.
DT, Disruption on Traffic	PBR	/	/	<b>SR</b> ∈ [0,1] sensitive road

**Scale: pipe**

**Formulation: impact or risk**

$$PWI_k = PBR_k \times EDI_k \times NPS_k$$

**(persons.hours/100m)**



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**Scale: pipe**

**Formulation: impact or risk**

$$PWI_k = PBR_k \times EDI_k \times NPS_k$$

**(persons.hours/100m)**

**Scale: pipe**

**Formulation: efficiency**

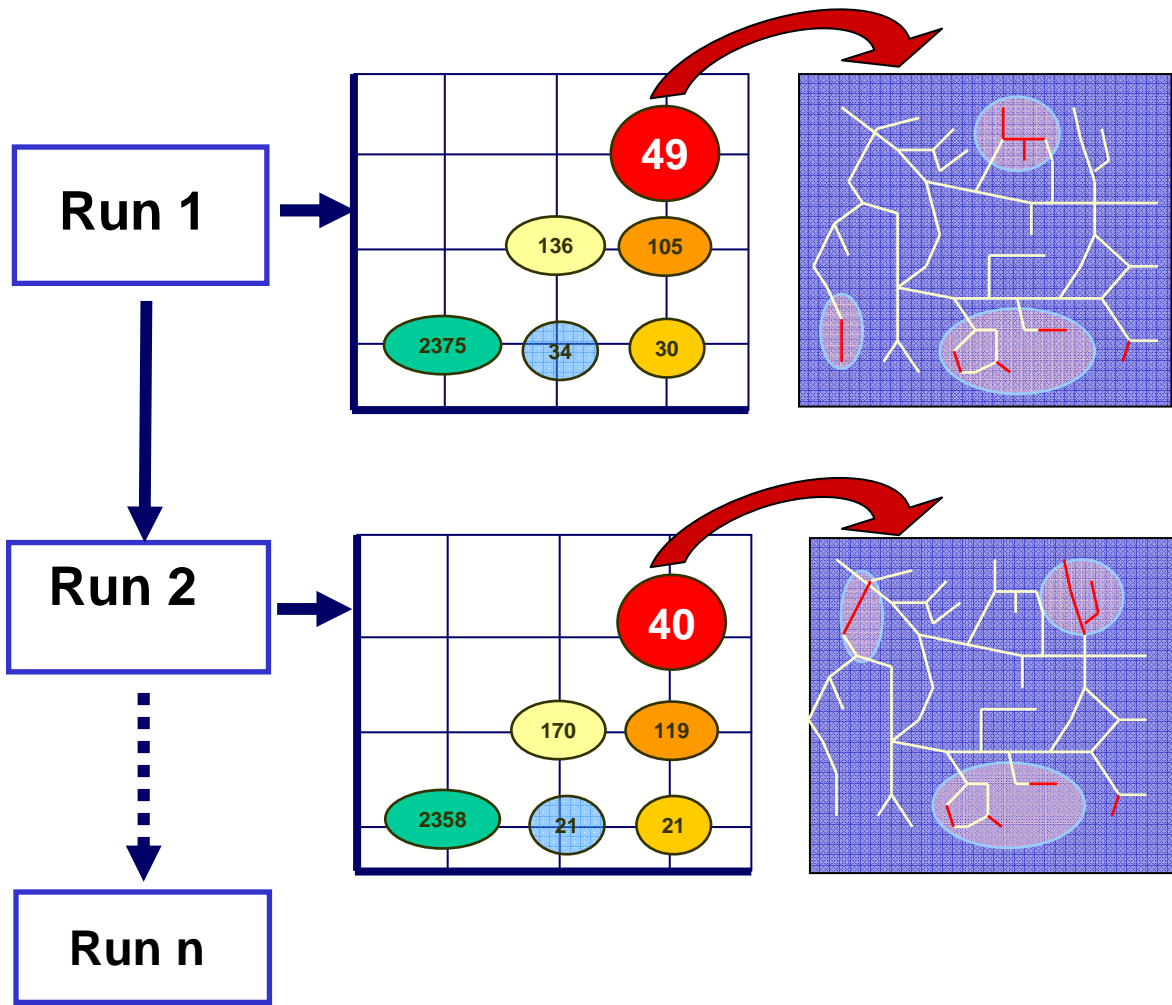
$$PWI_k^* = \frac{PBR_k \times EDI_k \times NPS_k}{UCR_k}$$

**Avoided impacts / k€ dedicated to rehab. (renewal)**

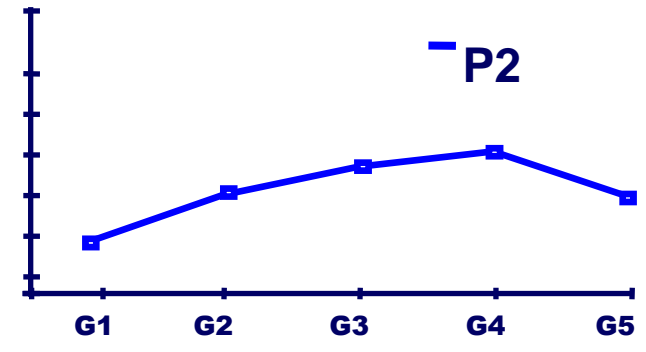
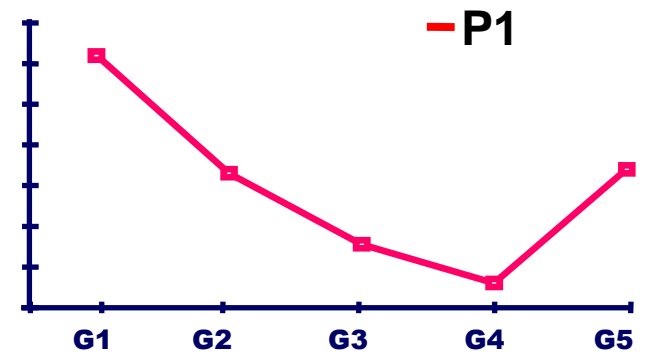


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# Scale: rehabilitation programs



## Scale: Rehab. Prog.



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## Scale: alternative rehabilitation programs

Expected benefits of  $P_j$  regarding criterion  $PWI$

Ratio: 
$$\frac{\textit{Avoided expected impacts}}{\textit{Expected impacts (on the asset stock AS)}}$$

$$EB(P_j, PWI) = \frac{\sum_{k \in P_j} PWI_k \times L_k}{\sum_{k \in AS} PWI_k \times L_k}$$



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# 3 – Benefits of rehabilitation programs

## RB: Real Benefits of fictitious rehabilitation projects!

**Table 6** Real efficiencies of 2 fictitious rehabilitation programs implemented at the end of 1998 and defined by using failure data from 1994 to 1998 in Reggio Emilia (Haidar, 2006)

<i>Real benefits</i> (similar to the expected benefits but calculated with failures observed in 1999-2001)	<i>Rehabilitation program; 2% of the total length of the network selected according to:</i>	
	Pipe failure rates (S1)	CARE-W_ARP (S2)
<i>RB(PWI – Predicted water interruptions)</i>	3.01	21.5
<i>RB(PCWI – Predicted critical water interruptions)</i>	2.47	35.4
<i>RB(ARC – Annual repair costs)</i>	8.40	9.7
<i>RB(DT – Traffic Disruptions)</i>	10.95	16.2

→ efficiency of rehab. programs

→ importance of considering *P & I, V, E*



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# 3 – Benefits of rehabilitation programs

## *Avoided failures, in several contexts:*

**Table 5** Pipe failures avoided in 2002-2004, for 3 fictitious rehabilitation programs, implemented at the end of 2001, and defined by using failure data from 1993 to 2001 in Lyon (Poinard, 2006).

<i>Subsets of pipes</i>	<i>Number of breaks observed during 3 years (2002-2004)</i>			
	No Rehab. Program (S0)	Pipe age (S1)	Pipe failure rate (S2)	CARE-W_ ARP (S3)
Whole asset stock (~ 3000 km)	1138	- 64	- 238	- 183
a) pipes supplying sensitive customers	43	- 0	- 11	- 12
b) pipes in areas prone to landslide	154	-13	- 29	- 52
c) pipes below sensitive roads	627	- 38	- 92	- 114
a) or b) or c)	768	- 46	- 110	- 152

→ PIs have to be in accordance with decision criteria!



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Thank you for your attention!



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## 2 – Back to the formulation of criteria

