LEADING-EDGE

International Water Association

Leading-Edge
Asset Management

2nd IWA Leading-Edge Conference & Exhibition on

Strategic Asset Management

Planning maintenance strategies for Italian urban drainage systems applying CARE-S

Ugarelli Rita, Pacchioli M. & Di Federico V.

LESAM 2007 – Lisbon 17-19 October 2007

Agenda

- Brief introduction of CARE-S project
- CARE-S: case study
- The project
- Results
- Discussion

CARE-S

Project Number EVK1-CT-2002-00106

- CARE-S : Computer Aided RE-habilitation of Sewer networks computer based system designed for sewer networks rehabilitation planning.

- CARE-S provides
  - State of the art, condition of sewer assets, risk of failures
  - Investment needs
  - Project prioritisation and technology recommendations

Behind CARE-S is European Commission and a number of forefront water research institutes of Europe and Australia

CARE-S TOOLKIT

- Predictable performance indicators
- Sewer condition classification and assessment tools
- Deterioration process tools
- Hydraulic performance tools
- Tools for socio-economic assessment
- Rehab multi-criterion decision-making tool

CARE-S manager to integrate the tools

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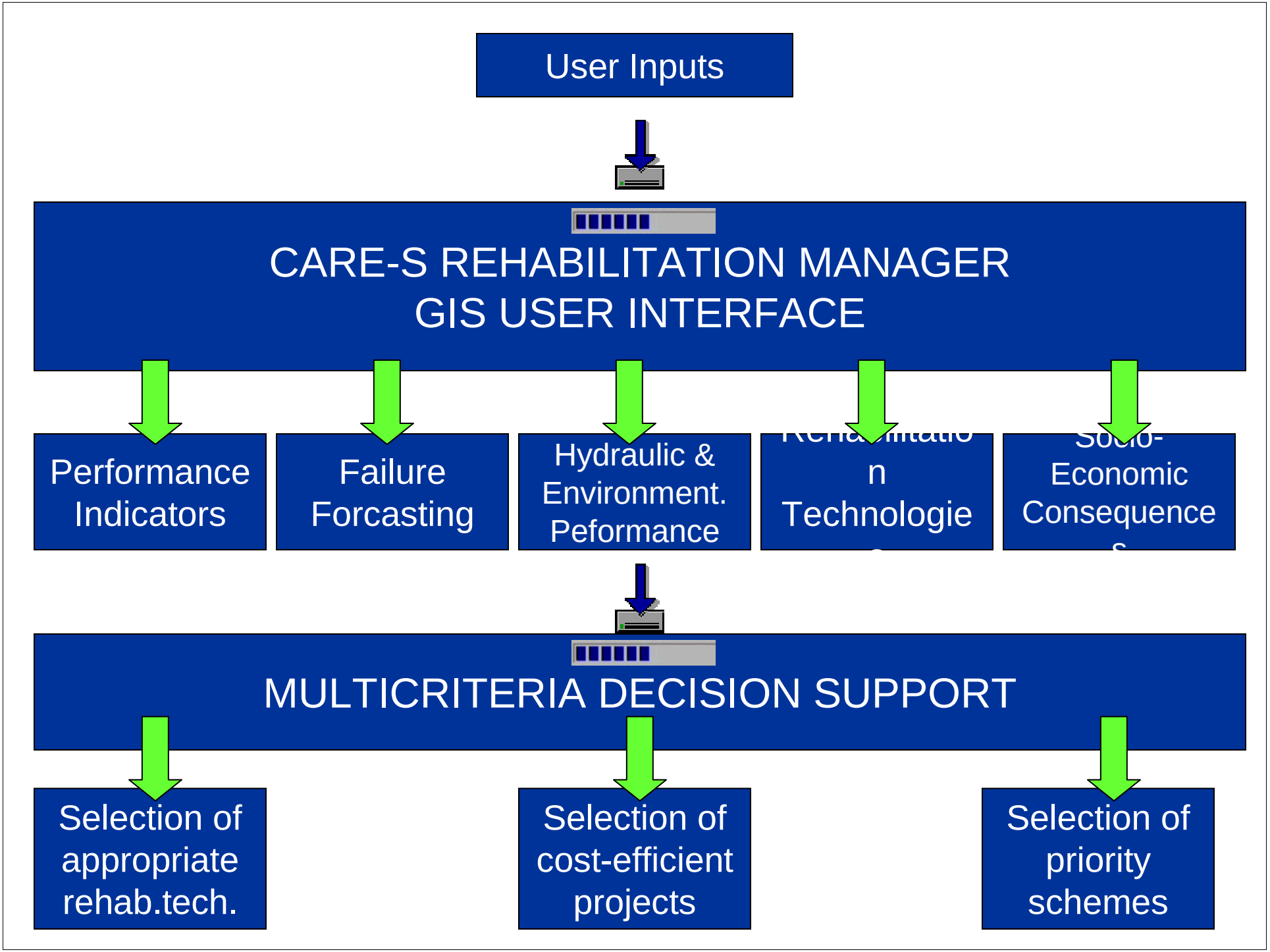
User Inputs
CARE-S REHABILITATION MANAGER
GIS USER INTERFACE
Performance Indicators
Failure Forcasting
Hydraulic & Environment. Peformance
n Technologie
Economic Consequence
MULTICRITERIA DECISION SUPPORT
Selection of appropriate rehab.tech.
Selection of cost-efficient projects
Selection of priority schemes

Area: Reggio Emilia hystoric centre

Utility: ENIA s.p.a – Reggio Emilia – Italy;
very recently doubled its service area;
merging with other companies to form a larger company

950 pipes 918 nodes
Network Length:30,161 km
30000 inhabitants

Project

Duration: April 2006 – October 2007

Data collection

Blockage

Load model

Ext Corr Tool

Vulnerability of GW to exfiltration

CCTV Planning

First 11 months of work

NO Hydraulic simulation

Deterioration tool

Following 7 months of work

Socio Failure

Socio Works

Rehabilitation Planning

Rehab Technology Database

projects

Short term

Long term

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Project – Data Collection

-Shape files including Pipes characteristics:

- Pipe ID;
- US Node ID;
- DS Node ID;
- Material;
- Shape;
- Width;
- Height;
- Length;
- System Type;
- US Invert level;
- DS Invert level.

Project – Data Collection

- Wall Thickness → 557/950 pipes with wall thickness known- from literature –new pipes
- Soil → Only Silt and Medium sand
- Groundwater Level → Maps (5,5 metres)
- Traffic Data →
  - number of lines for each road;
  - road type;
  - traffic flow
- Basements → 190 files analysed

Project – Data Collection

- Installation Year (627/950 pipes) → Only on paper sheet format

Steps:

1. Find the projects of wastewater (from 1930);

Project – Data Collection

- Installation Year (627/950 pipes) → Only on paper sheet format

Steps:

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2007

Project – Data Collection

- Installation Year (627/950 pipes) → Only on paper sheet format

Steps:

1. Find the projects of wastewater (from 1930);

2. Analyse project referred to the hystoric centre;

Project – Data Collection

- Installation Year (627/950 pipes) → Only on paper sheet format

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2. Analyse pro storic centre;

Project – Data Collection

- Installation Year (627/950 pipes) → Only on paper sheet format

Steps:

1. Find the projects of wastewater (from 1930);

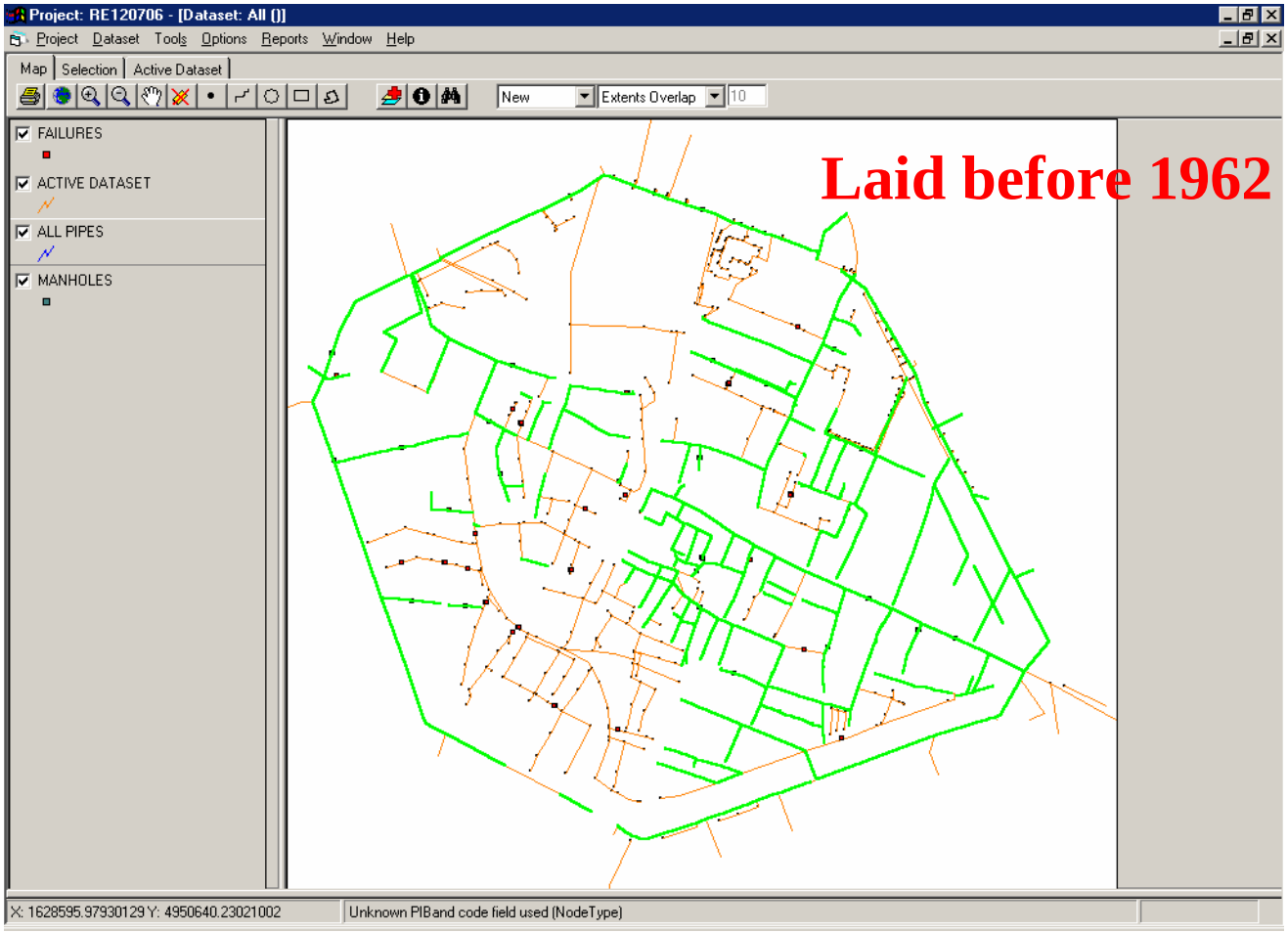
2. Analyse project referred to the hystoric centre;

3. Project are referred to the streets, need of associating each project the correct Pipes ID manually.

↓

History of pipe installation

Project – Data Collection



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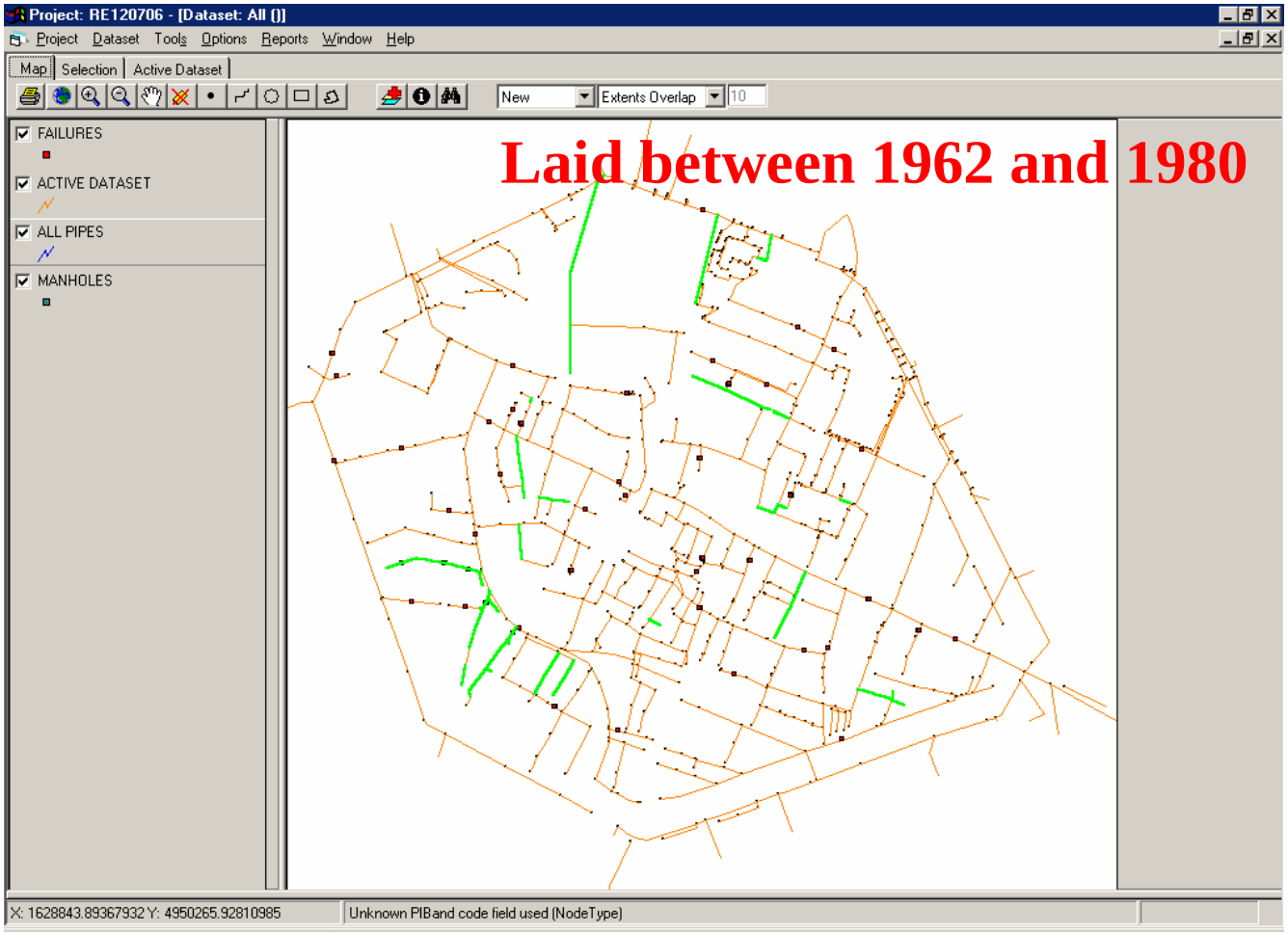
Project – Data Collection



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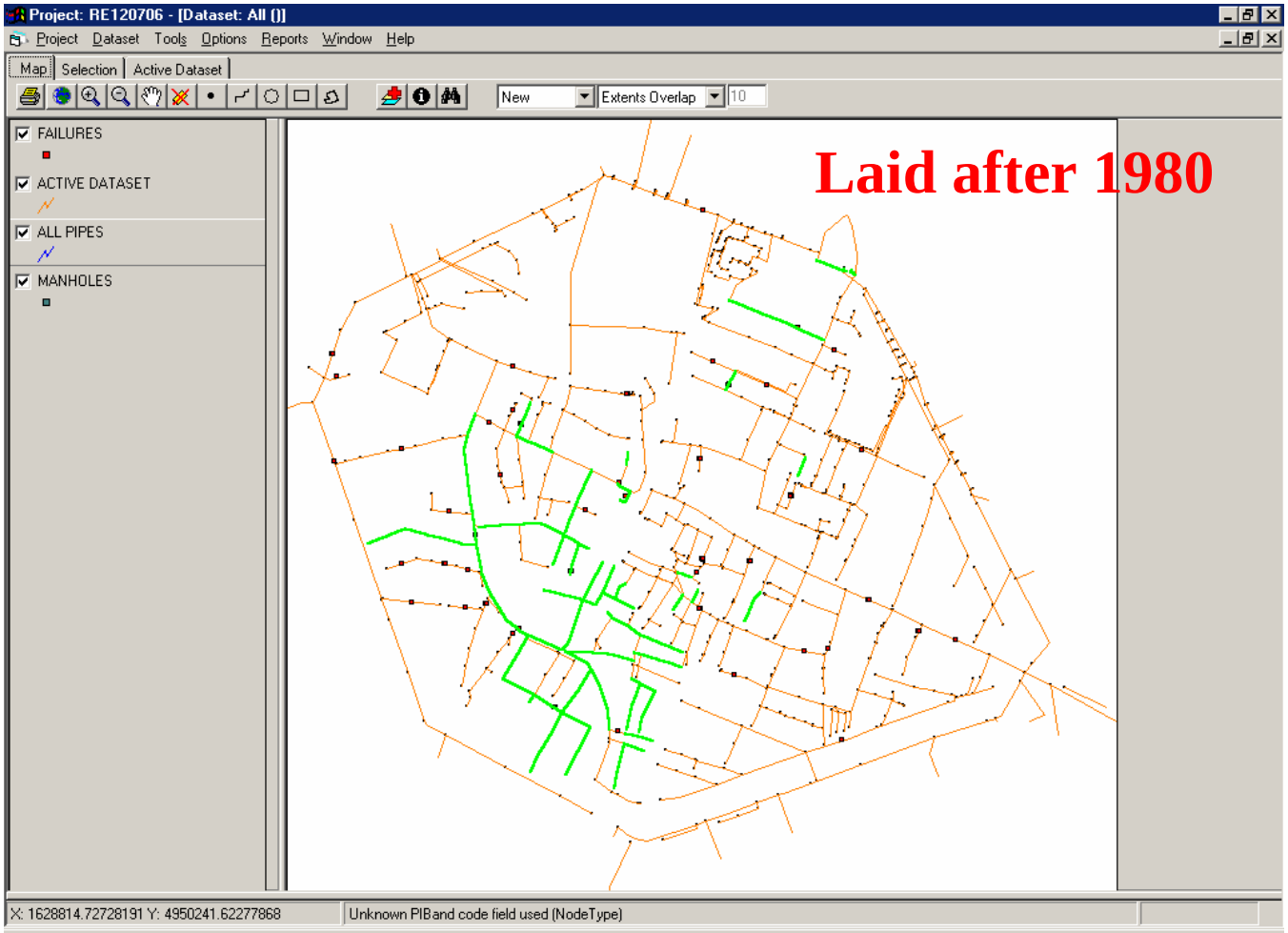
Project – Data Collection



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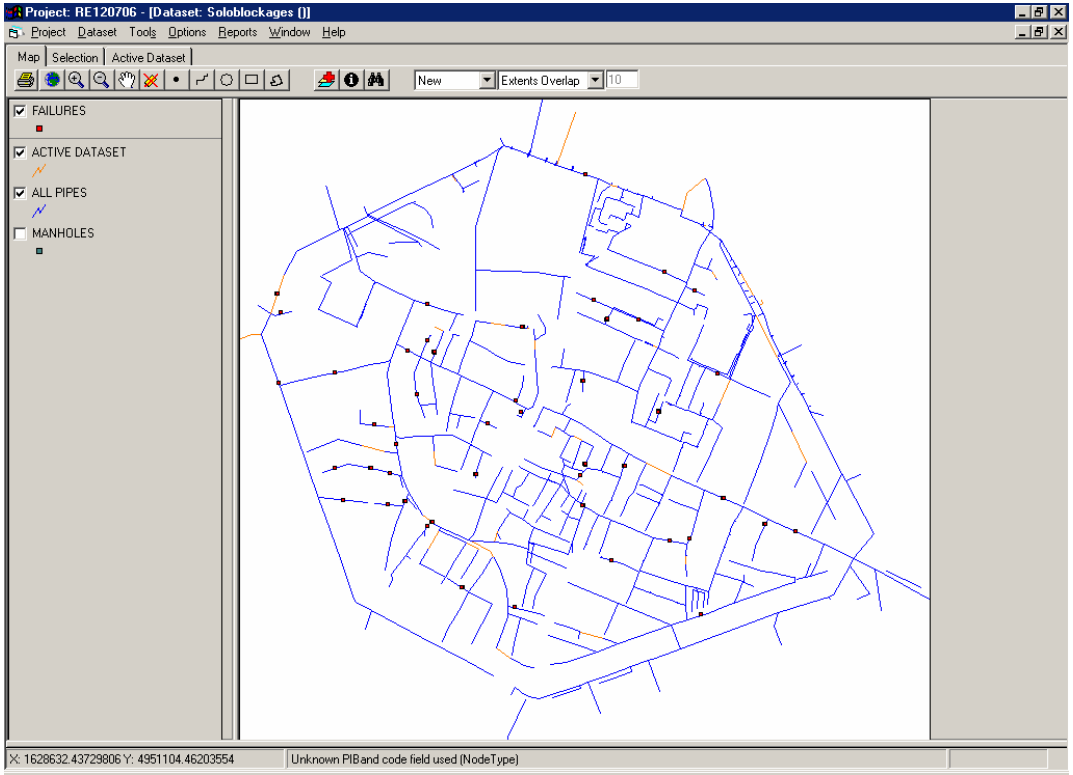
Project – Data Collection

- Failure data
(January 2003-March 2006)

Repair: 10 events
Other: 60 events
Blockage: 35 events

Not referred to pipes ID but to streets



Association to Pipes ID made manually

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Project – Data Collection

39 Pipes inspected → Defect Code registered manually

↓

"Score" and "Current Condition Grade" computed manually

CCTVID	PipeID	A	B	C	D	E	I	G	Mate	Score
1	218	BAB	B		0	0	14	12		10
1	272	BAG			10	0	11	02		0
1	272	BAG			10	0	12	12		0
1	272	BAG			20	0	14	10		0
1	272	BAJ	B		0	0	48	1001		40
1	272	BCA			0	0	11	02		0
1	272	BCA			0	0	12	12		0
1	272	BCA			0	0	14	10		0
1	298	BCC	B		0	0	51.3			0
1	364	BBB	A		0	0	1	0507		0
1	417	BBB	A			0	21	0507		0
1	438	BAB	B			0	3.5	12		10
1	447	BCC	A		0	0	52.9			0
1	551	BAG			10	0	21.9	01		0
1	551	BAG			50	0	31.9	12		0
1	551	BCA			0	0	21.9	01		0
1	551	BCA			0	0	31.9	12		0
1	643	BBB	A		0	0	1	0507		0
1	731	BAJ	B		0	0	10	1002		40
1	767	BAJ	B		0	0	36.8	1212		40
1	790	BAC	A		0	0	50	12		80
1	790	BAG			20	0	60	12		0
1	790	BCA	A	A	0	0	60	12		0
0	0				0	0				0

FT	Fine Del tubo	BCE-A
GLD	Giunto leggermente disossato	**BAJ-B**
FPT	Foro nella parete del tubo	**BAB-B**
AMS	Allacciamento mediamente sporgente	BAG
CDD	Cambio di direzione verso destra	BCC-B
CDS	Cambio di direzione verso sinistra	BCC-A
OST	Ostacolo	BBE
MDGT		**BAJ-A**
MRDL		BBB-A
TIM		BDC
FSNR	[illegible]	BDC
ALS	Allacciamento leggermente sporgente	BAG
LST	Leggera scrostatura parete del tubo	BBB-A
LRPT	Leggera rottura parete del tubo	**BAC-A**
MAF		**BAJ-C**
LDGT		**BAJ-A**
LDT		**BAF-J**
MIRA	Media infiltrazione di radici	BBA-A
GPG	Grave protuberanza materiale della giunzione	**BAI-A**
MPG	Media protuberanza materiale della giunzione	**BAI-A**
MRG	Media rottura della giunzione	**BAC-A**
AME	Allacciamento non correttamente eseguito	BAH + BC
GFDD	Grossa formazione di depositi duri nella giunzione	BBB-A
MRT	Media riduzione dello spessore della tubazione	**BAF-J**

Operators codes

EN 13508 codes

ASPI

ASSOCIAZIONE NAZIONALE MANUTENZIONE
E SPURGO DELLE RETI FOGNARIE E IDRICHE

Ente Nazionale Italiano di Unificazione

Rita Ugarelli

18th of April'07 EN13508 translated and adapted to italian reality:

Uni-ASPI Standard

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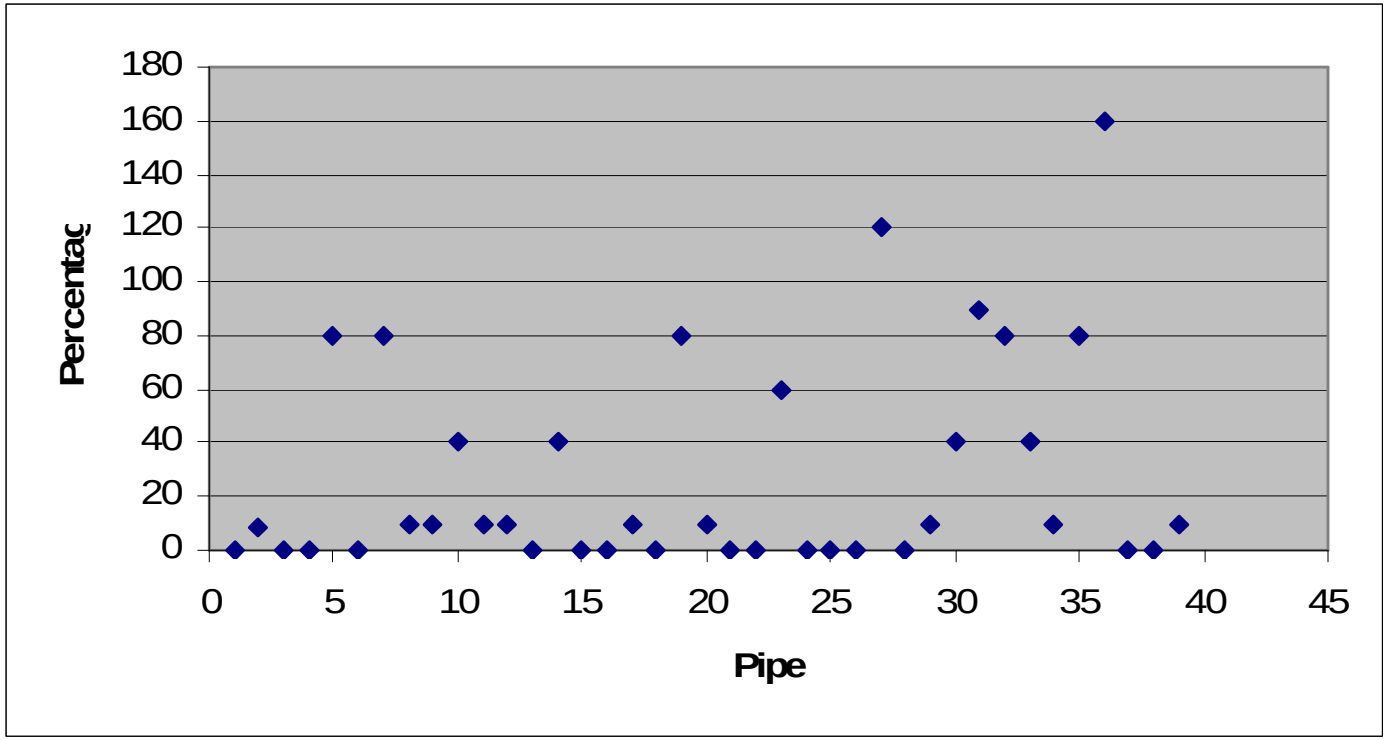
Project – Data Collection

Condition grade	"Percentage"
5	220
4	170
3	80
2	10
1	0



26/39 pipes in c.g. 1-2

Project – Data Collection

Pipes Burial Conditions

- In order to run the 'load model' it was necessary to review projects from 1937 to understand pipes burial practice:
  - 1937-1950: pipes laid on reinforced concrete;
  - 1950's: main pipes laid on concrete with reinforcement in concrete for 2/3 of height and 10 cm of insole at the bottom; same for secondary pipes but without reinforcement;
  - 1980's: reinforced concrete turbo- centrifuged with a 20 cm insole and ¼ of Height reinforcement;
  - … 1980's PVC appeared, filling material: compacted sand.

Project – tools application

Current External Corrosion Rate (644 / 950 pipes analysed)

Selected water-cement ratio looking at different cement quality in time:

Parameter a (external corrosion in mm/year)

moisture grade	soil type: non corrosive	medium corrosive	high corrosive
dry	0.01	0.1	0.3
medium	0.05	0.2	0.5
wet	0.01	0.5	0.7

Parameter b (pipe quality, water-cement ratio)

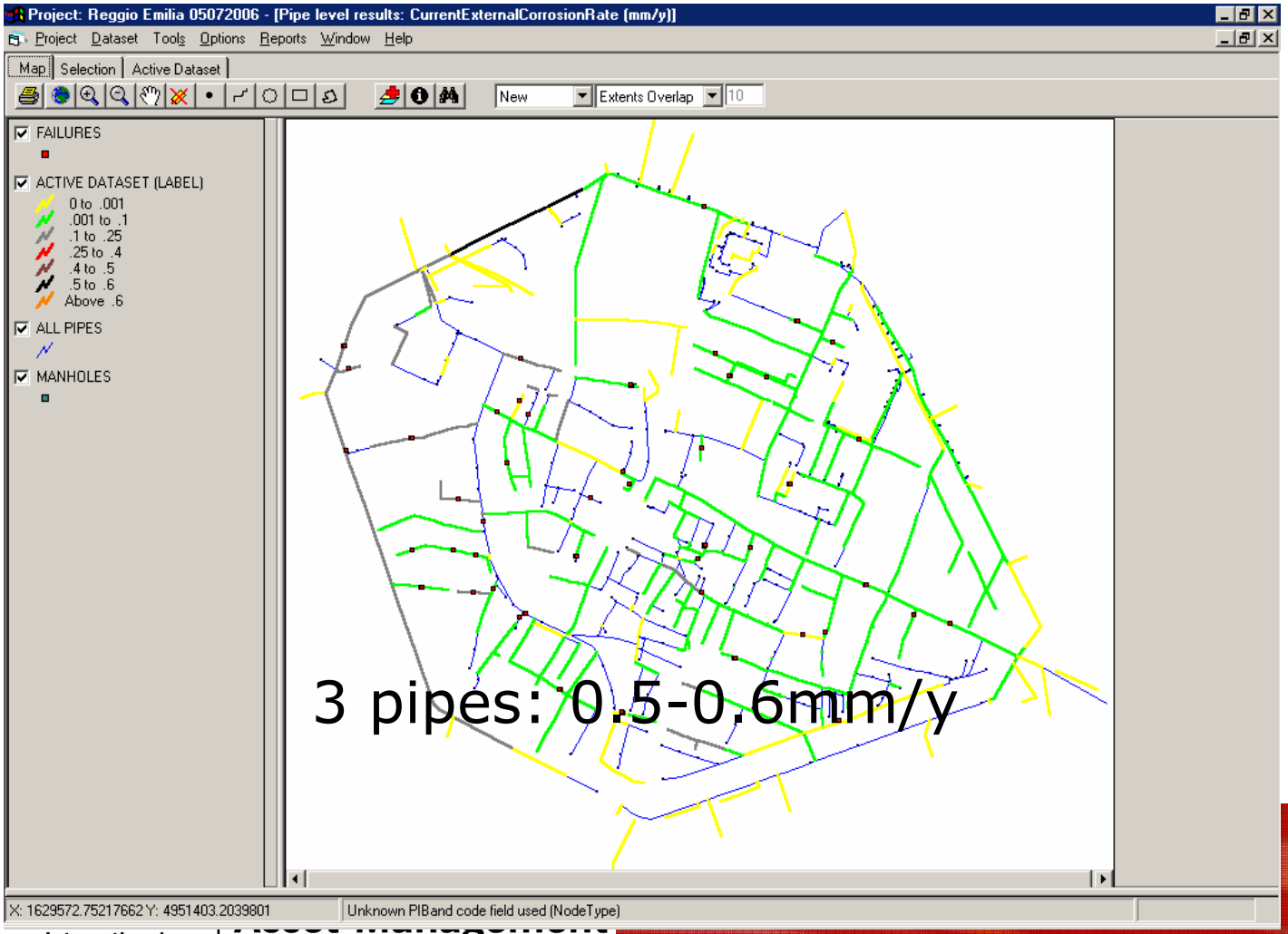
water-cement ratio	resistance grade: good < 0,30	medium < 0,45	poor >=0,45
b	0.3	0.7	1

Quality of concret pipe (water-cement ratio)

	ratio		year
poor	>=0,45	including	1960
medium	< 0,45	including	1975
good	< 0,30	from	1976

Project – tools application

Current External Corrosion Rate (644 / 950 pipes analysed)



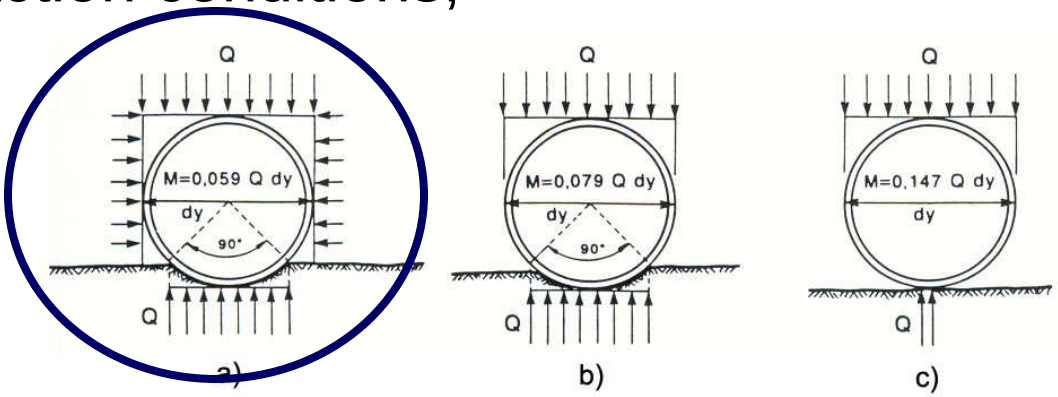
Network:

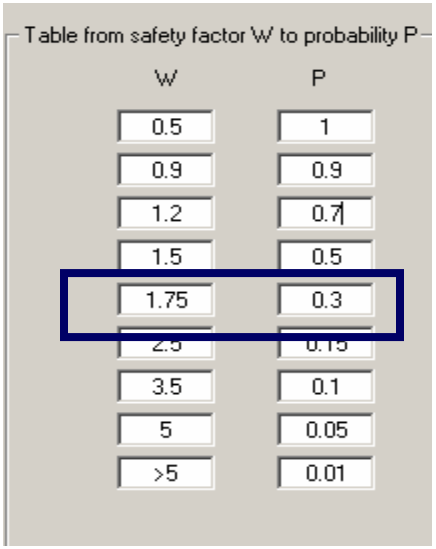
[0.001-0.1mm/y]

Project – tools application

Predicted Probability of Collapse (301 / 950 pipes analysed)

- Selection of pipes under high traffic load;
- Import results from Extcorrosion tool;
- Imported info on different construction practices in time and compaction conditions;

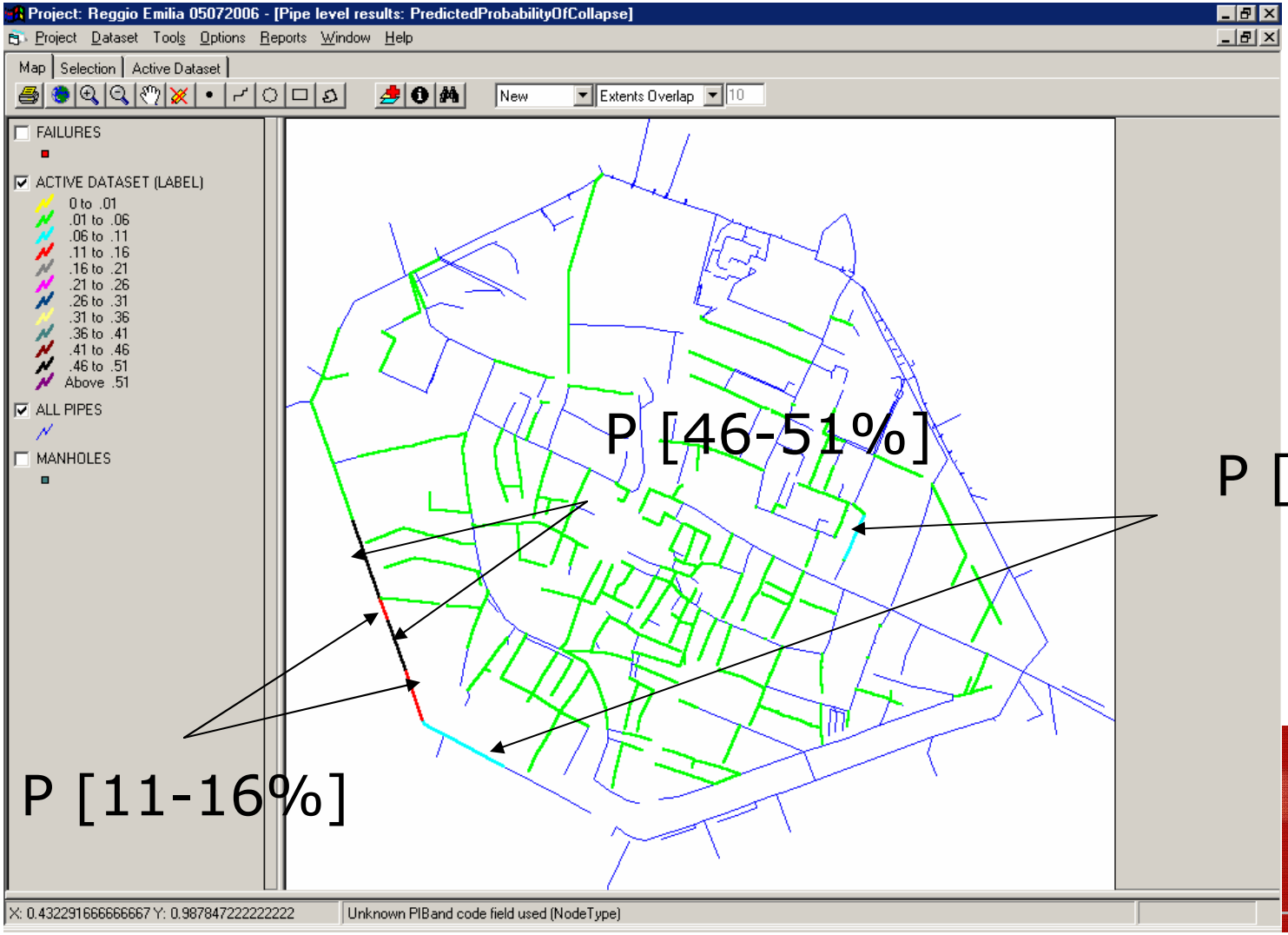




- Definition of pipe design strength.
- Calibration of safety factor/probability

Project – tools application

Predicted Probability of Collapse (301 / 950 pipes analysed)



Project – tools application

Current Probability of Blockage

-groups and classes defined:

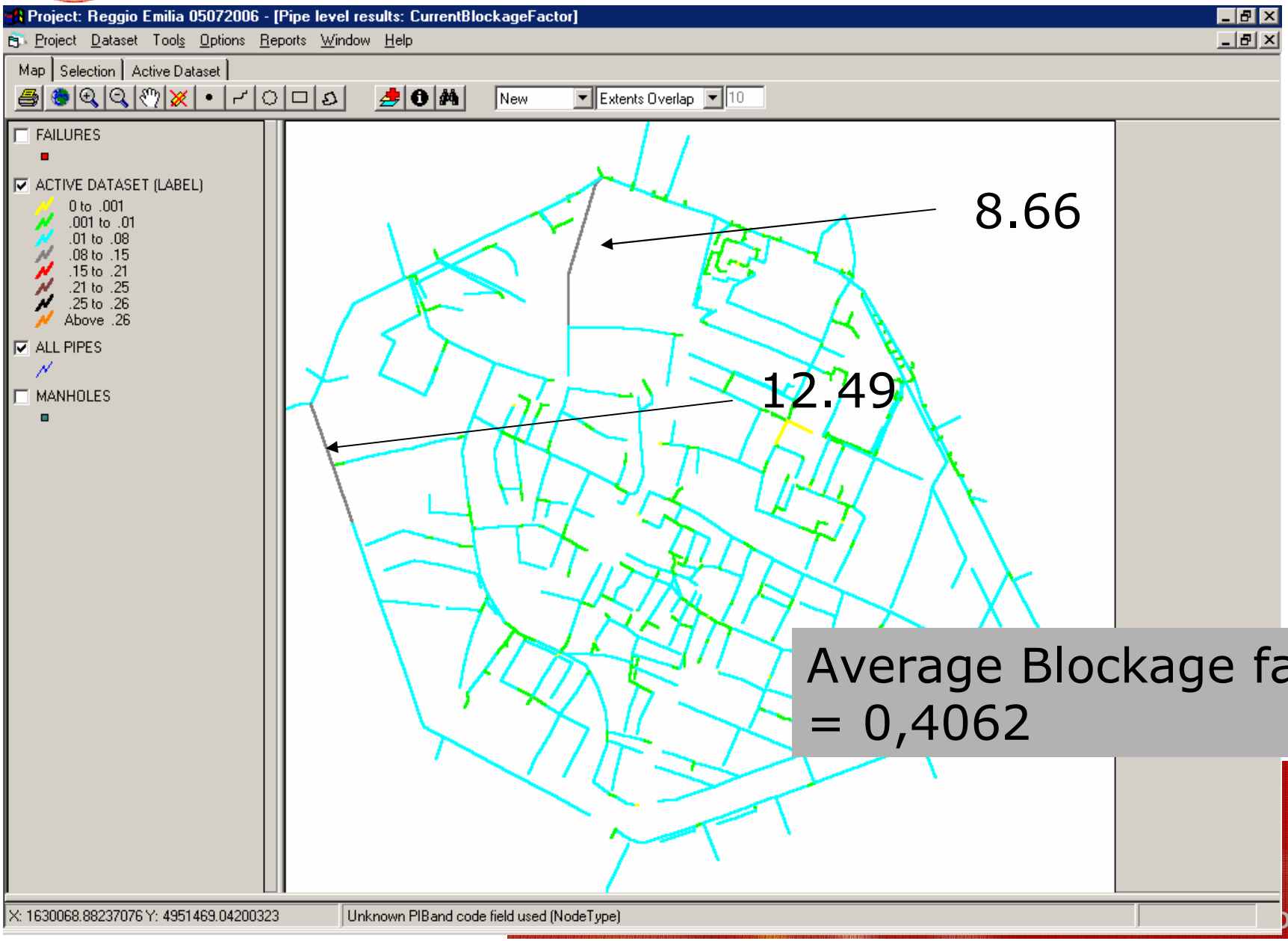
-Material
- -Steel
- -Others
- -Cement
- -Concrete
- -Reinforced concrete
- -Fiber concrete
- -PVC

-System type
- -Separated
- -Combined

-Soil type:
- -Sand
- -silt

Installation year:
-1930-1970
-1970-2006

Project – tools application



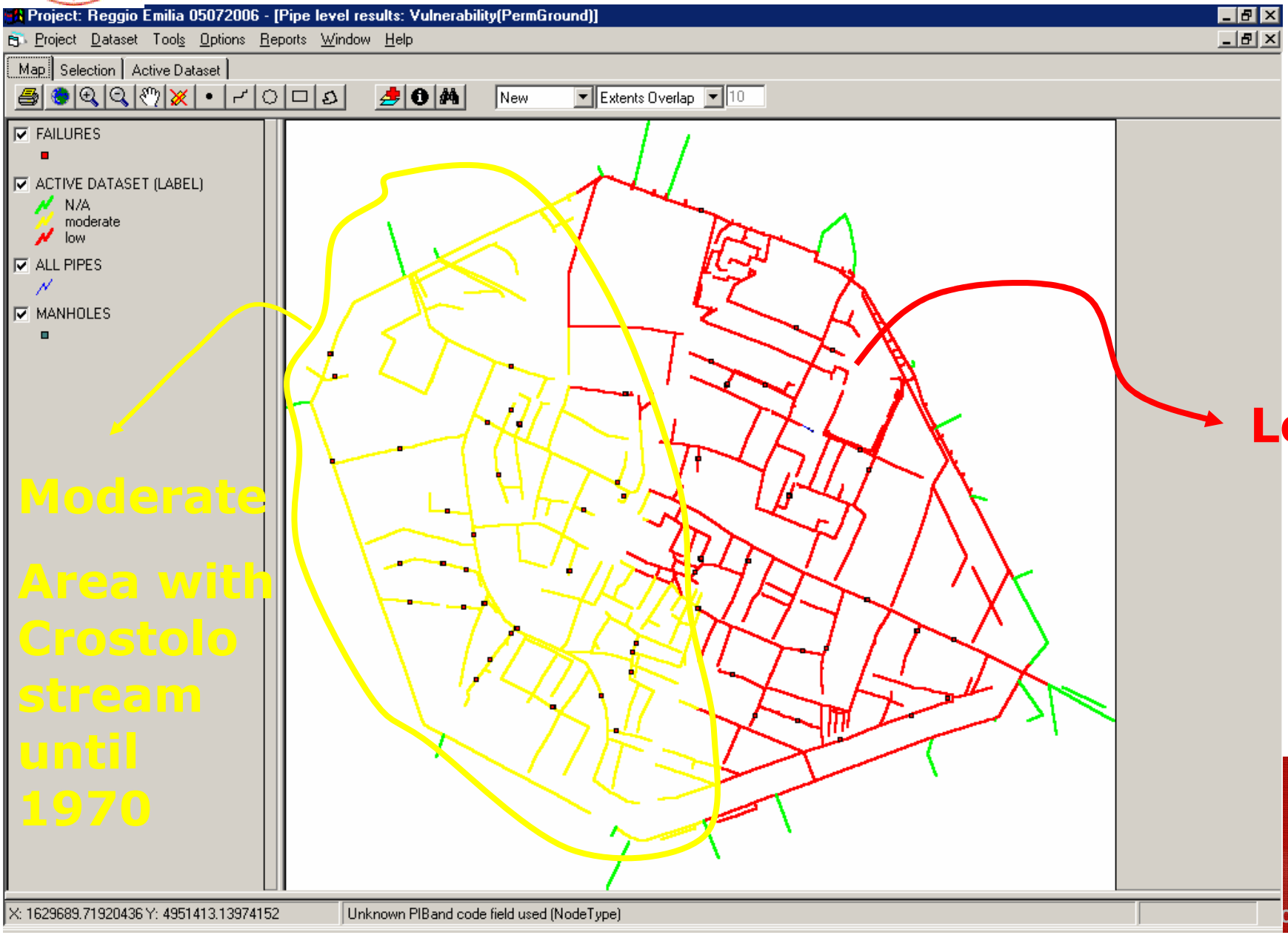
Average Blockage factor = 0,4062

Project – tools application

Groundwater vulnerability

Since no hydraulic simulations available we applied the Perm-Ground method.

Project – tools application



Project

CCTV PLANNING

CCTV PLAN BASED ON DIFFERENT CRITERIA:

1. LOAD, BLOCKAGE, EXTCORR AND GAT results;
2. Past rehabilitation and renovation projects (i.e. pipes with higher rehabilitation rate);
3. Traffic type and load (i.e. streets with bus)
4. CCTV data (i.e. from previous CCTV pipes with fissures to be checked);
5. Material and burial conditions (i.e. select PVC pipes under high traffic load, or deeper depth (heavy load).

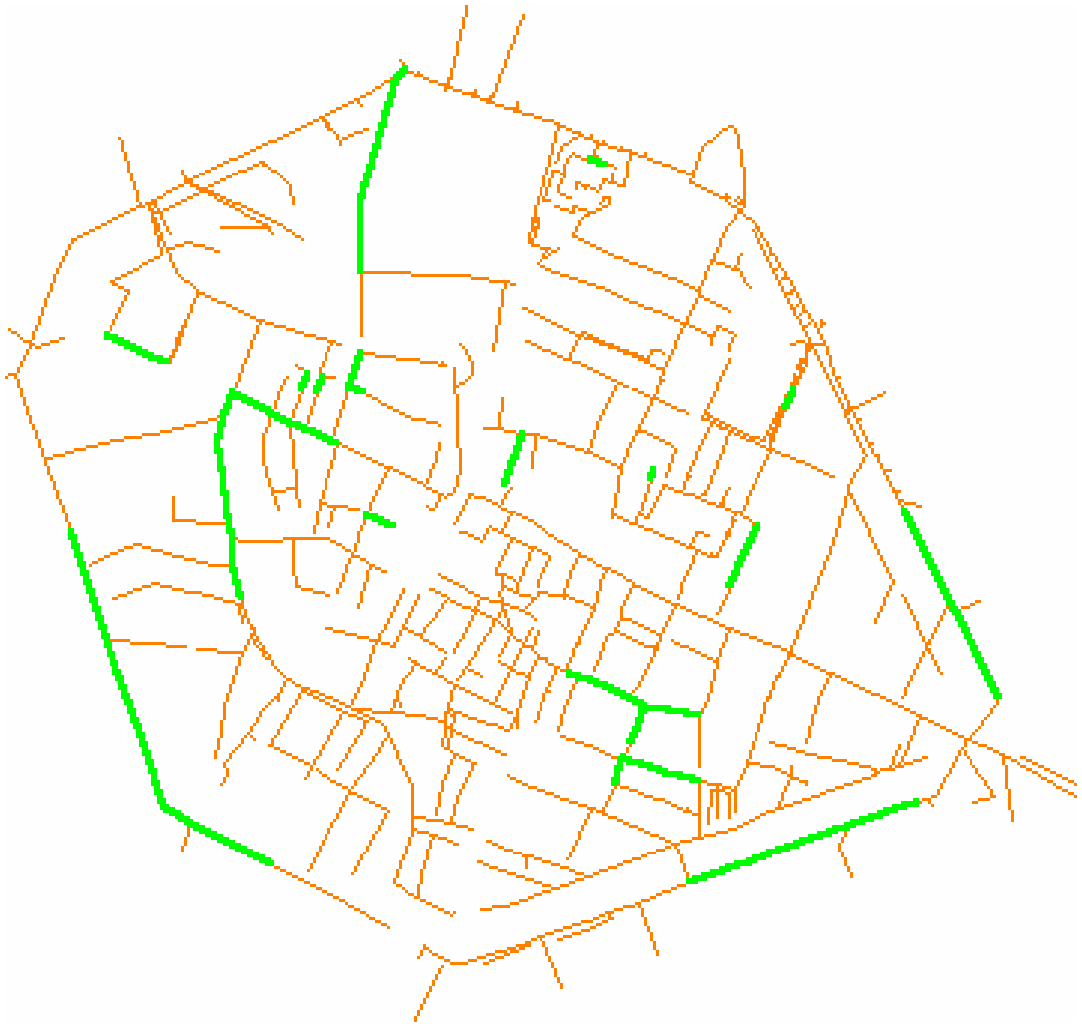
Project

CCTV PLANNING

CCTV plans for single criteria or combining criteria have been suggested.

Including ALL the criteria 2986km (51 pipes) have to be inspected.

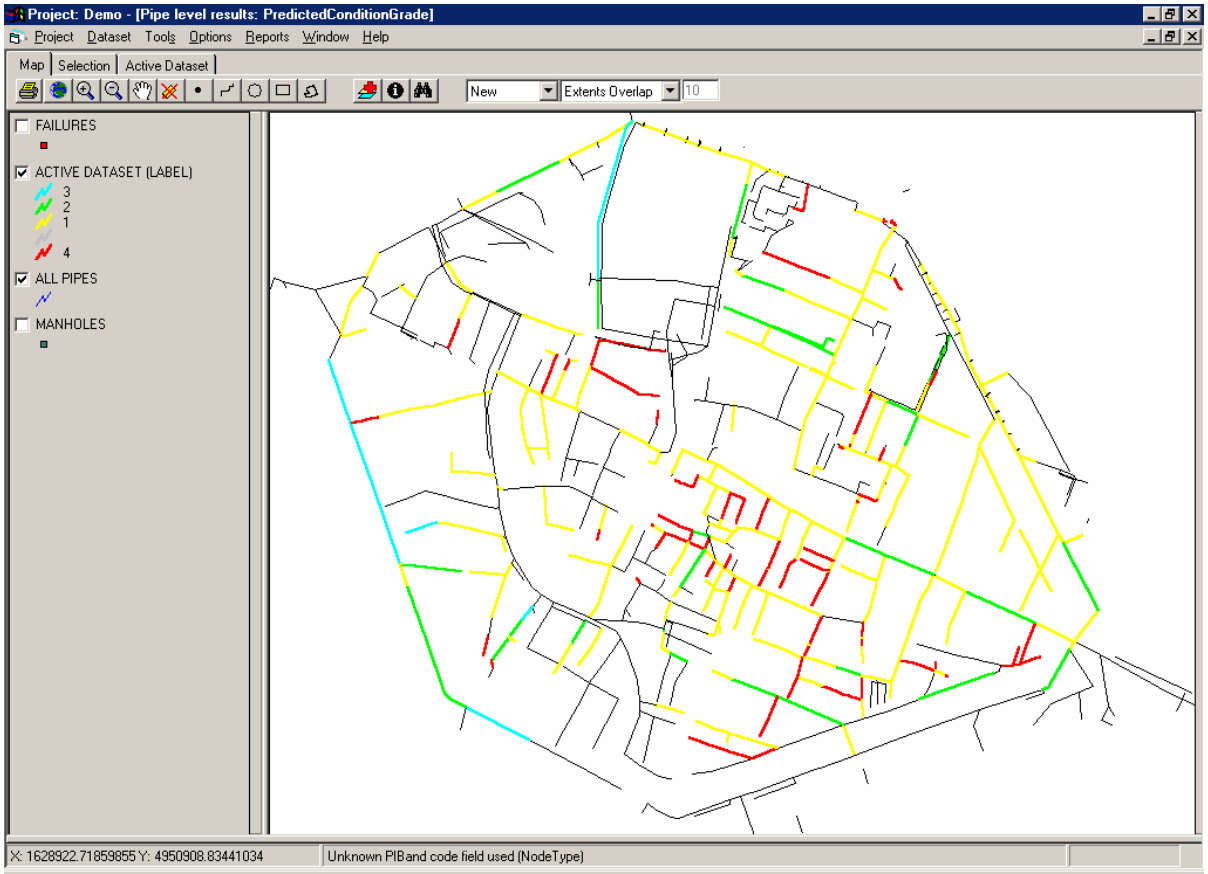
ENIA completed the inspections as outsourcing projects



Project

Predicted Condition Grade (CG) at 2011

For the 483 pipes of the analysis, 330/483 pipes in CC1, best case, 30/483 in CC2, 6/483 in CC3 and 117/483 in CC4, the worst case.



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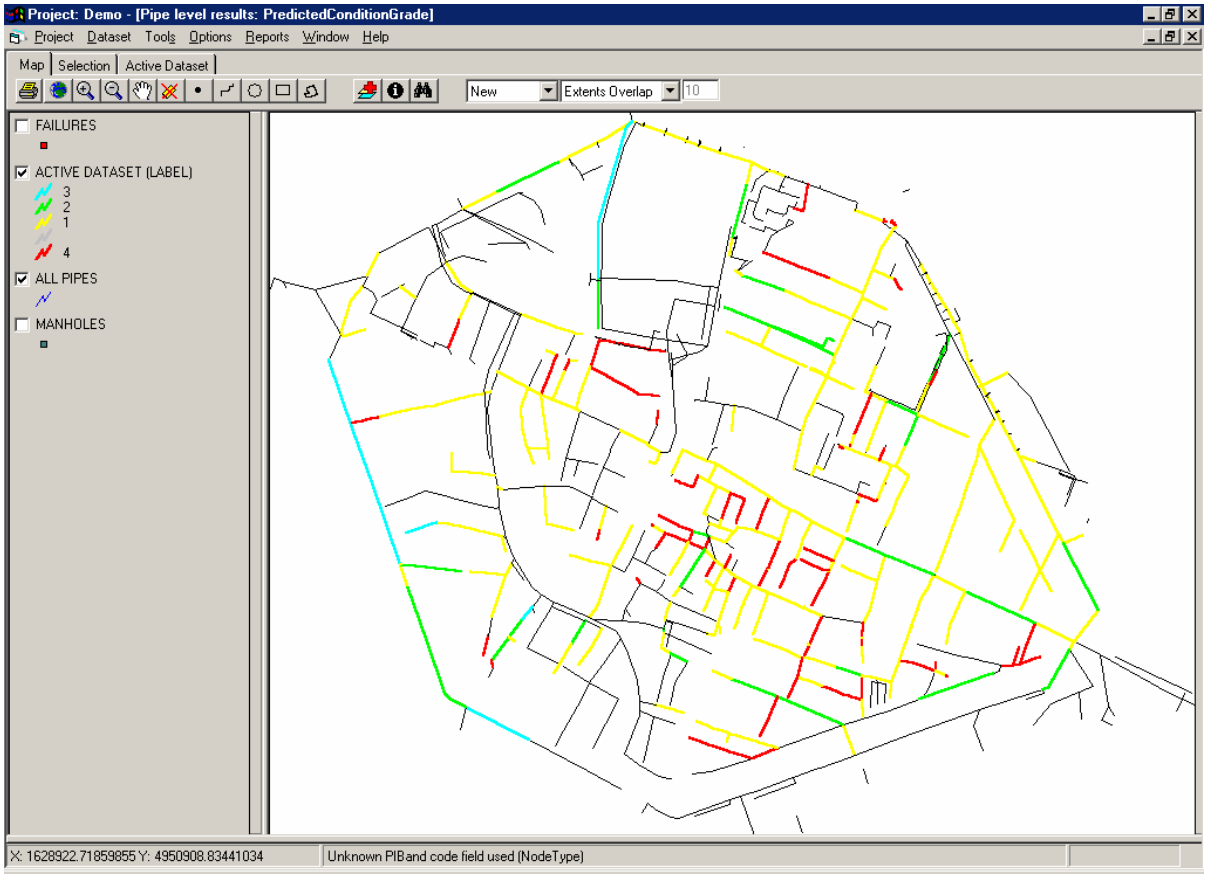
Project

Predicted Condition Grade (CG) at 2011

Looking at the worst case (CC4), the most representative material is Gres (64 pipes - 1759 metres) then PVC (52 pipes - 1026 metres) and Concrete (1 pipe - 52 metres).



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Project – investment strategy

Time horizont: 2040

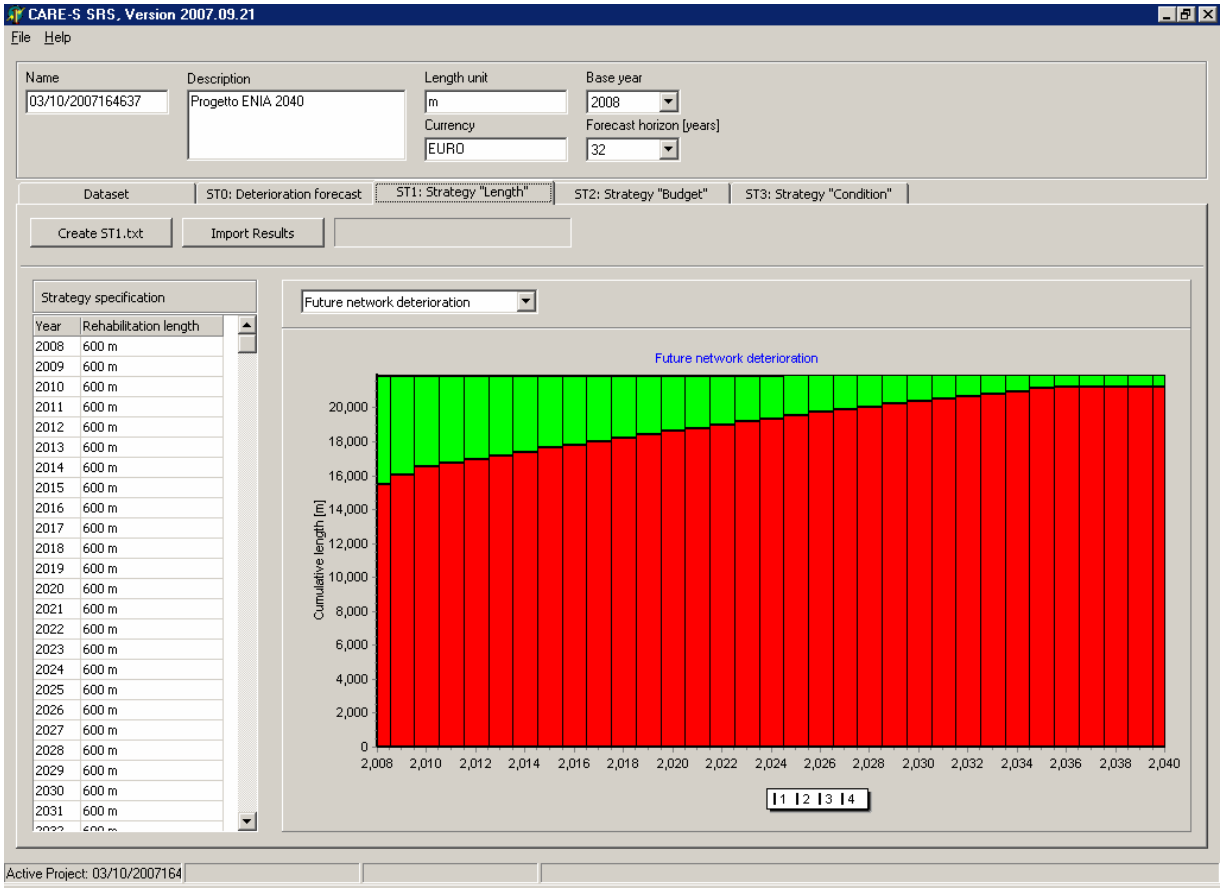
Long term analysis (SRS tool):
2 strategies have been compared

1. **Strategy length**
2. **Strategy budget**

Project – Strategy 1 : Length

Testing hypothesis:
Strategy: 600m/year
Cost: 600€/m

Future network deterioration



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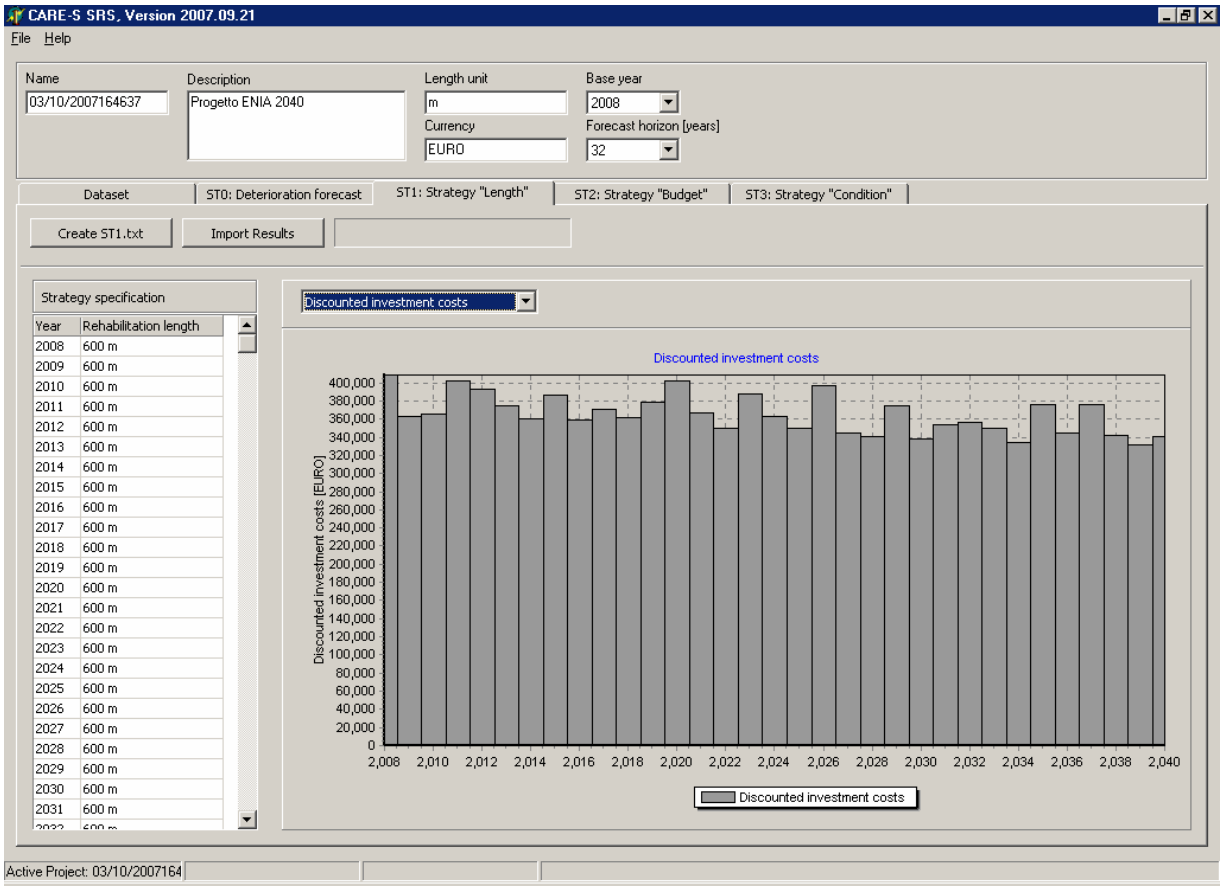
Project – Strategy 1 : Length

Testing hypothesis:
Strategy: 600m/year
Cost: 600€/m

Discounted investment costs



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Project – Strategy 1 : Length

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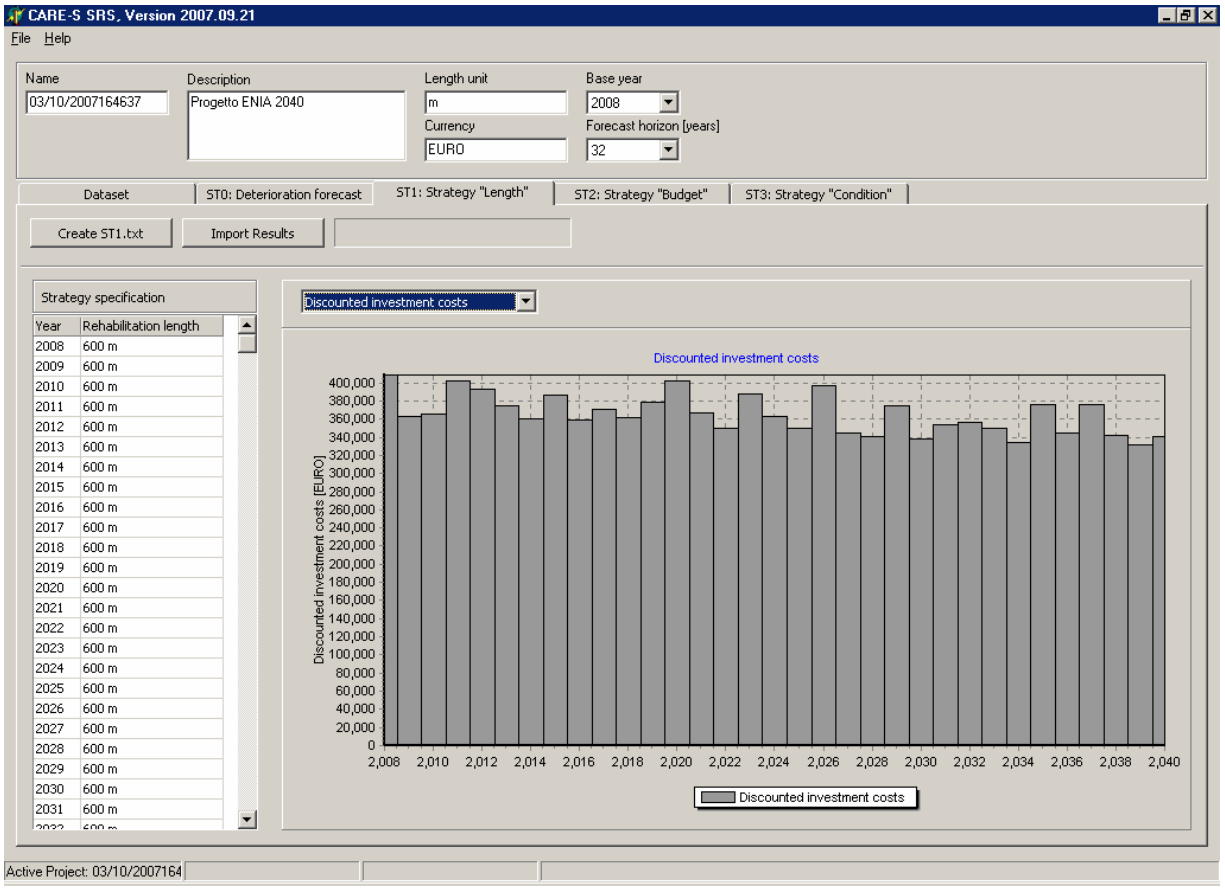

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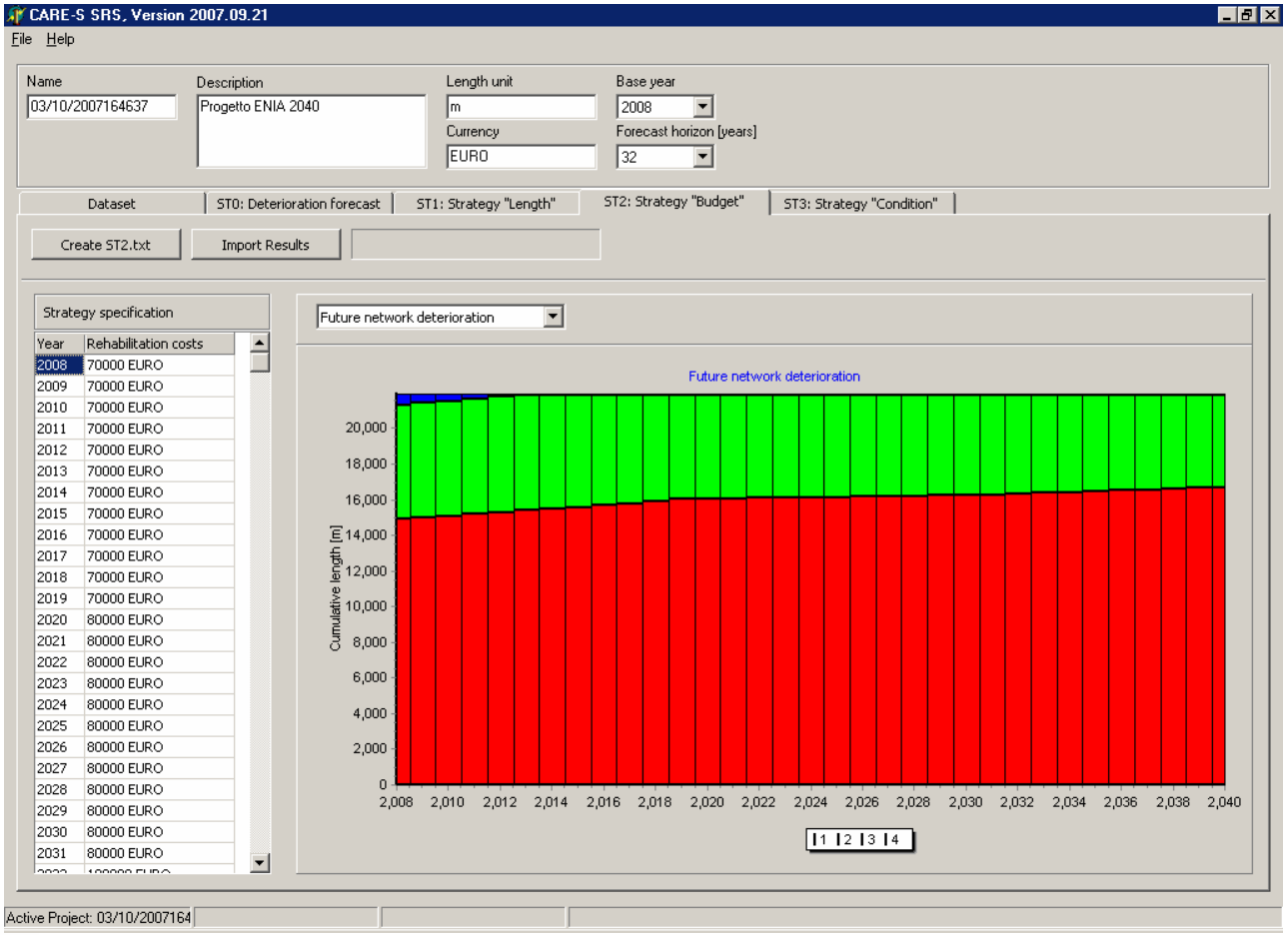
Project – Strategy 2: Budget

Strategy:
70000€/y until 2019
80000€/y until 2031
100000€/y until 2040

Future network deterioration



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Project – Strategy 2: Budget

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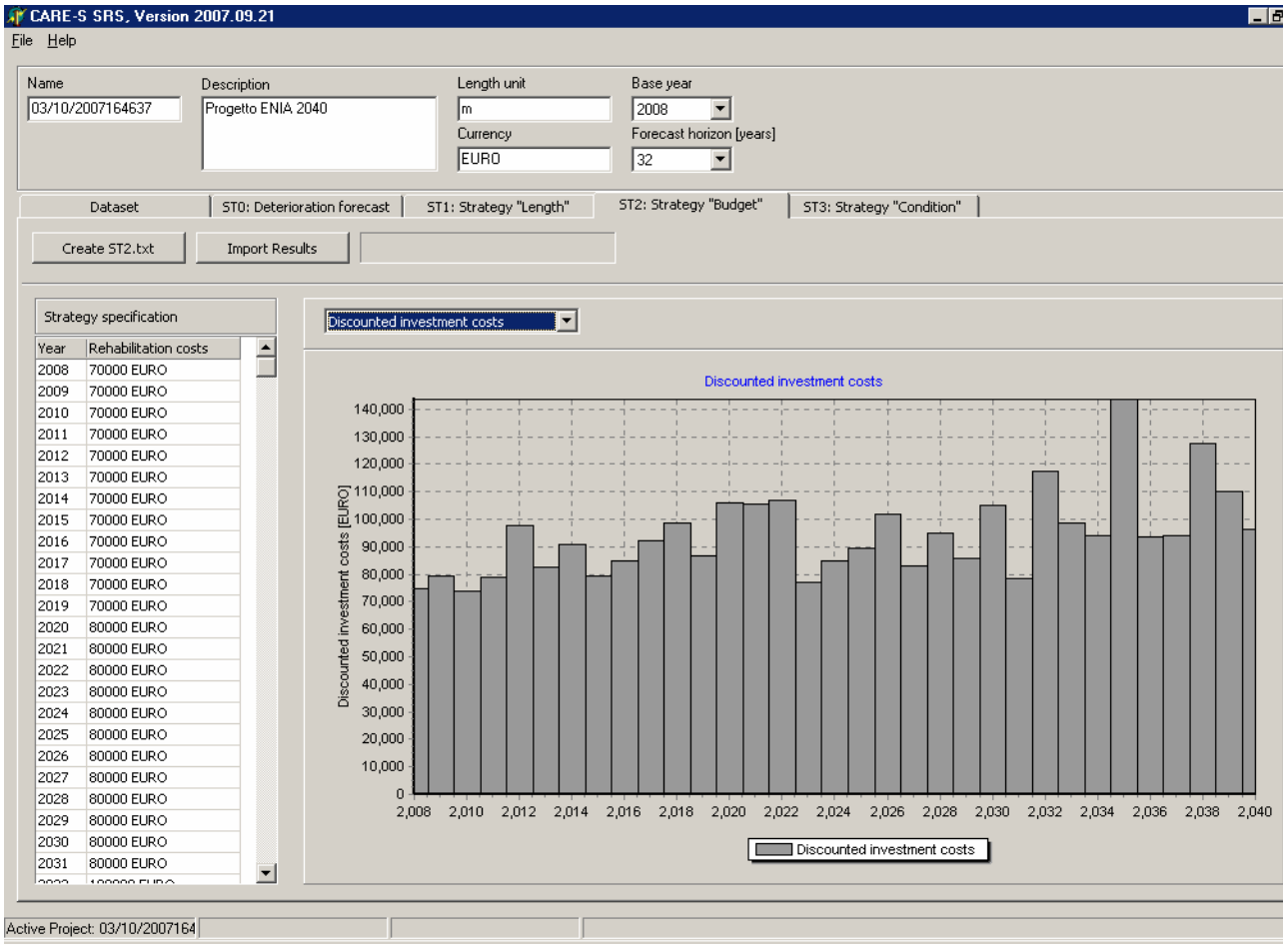

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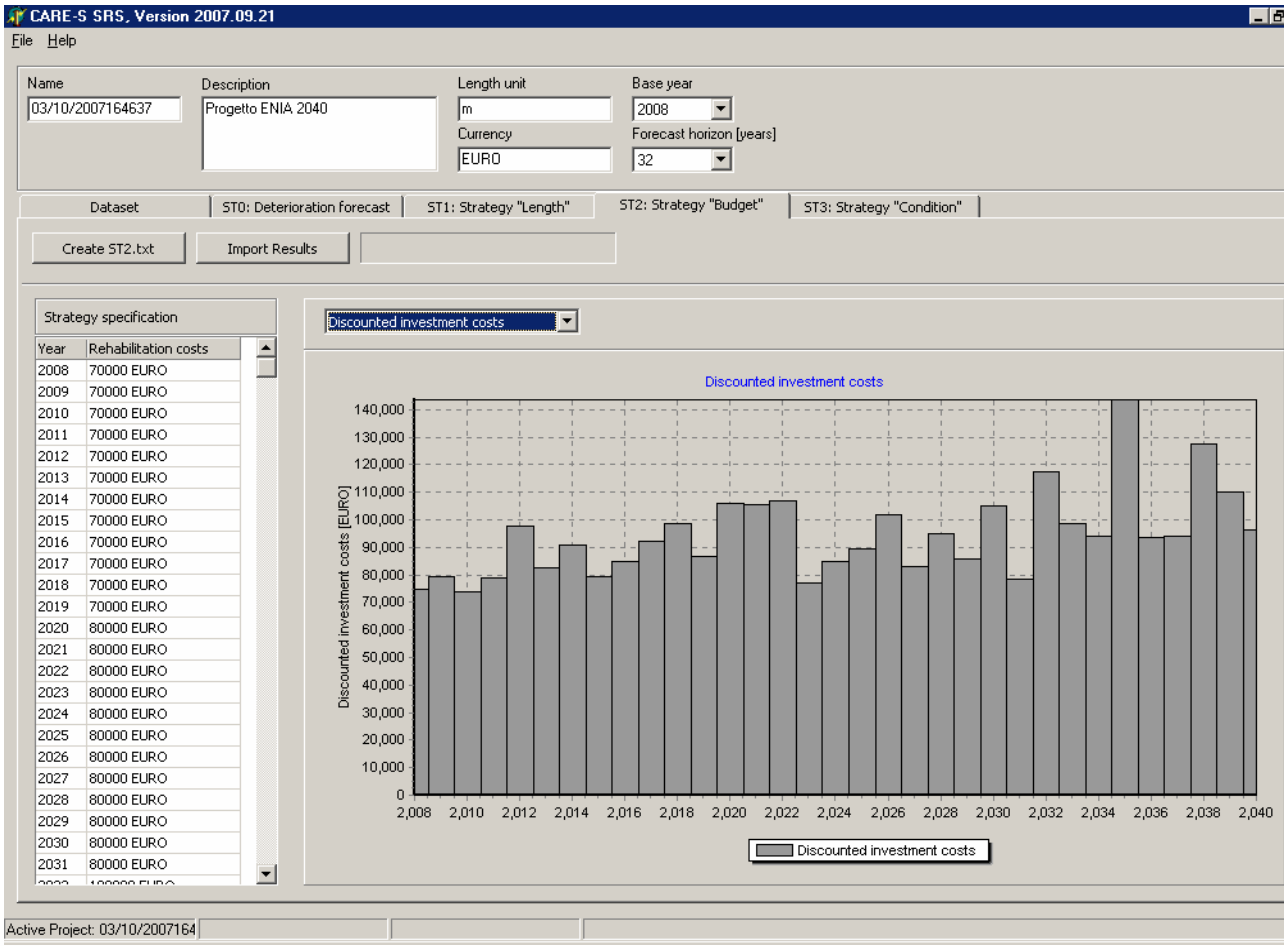

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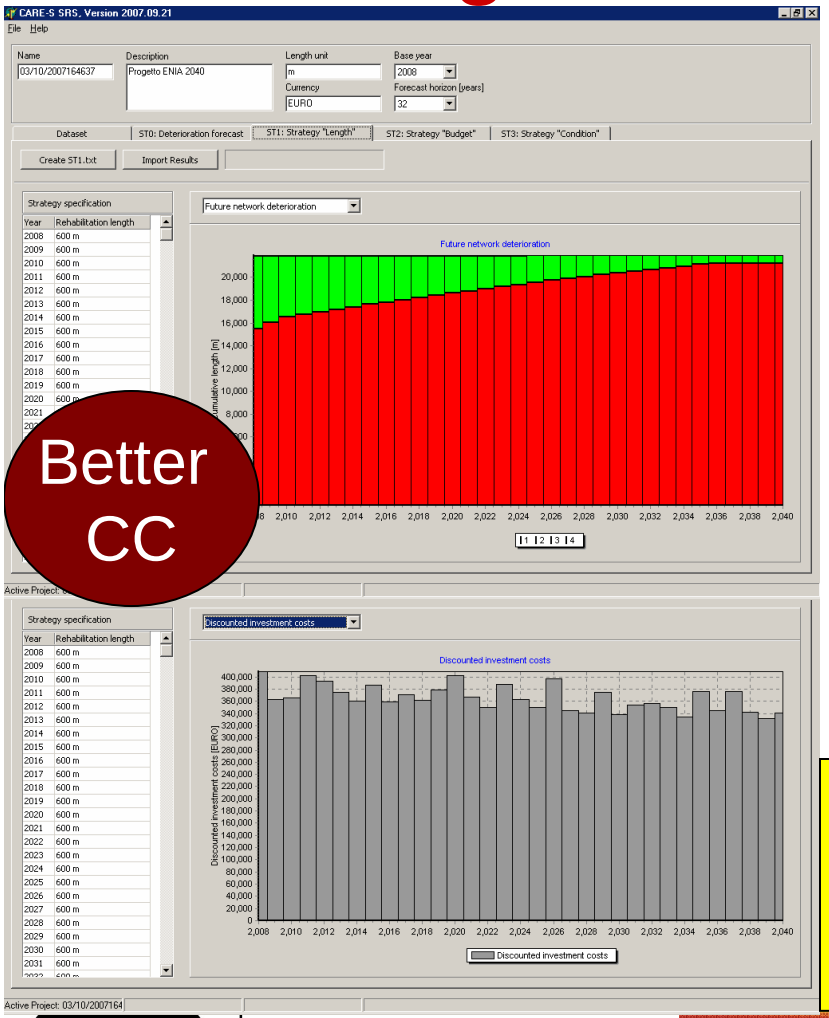
Project – Strategy 1vs 2

1: length

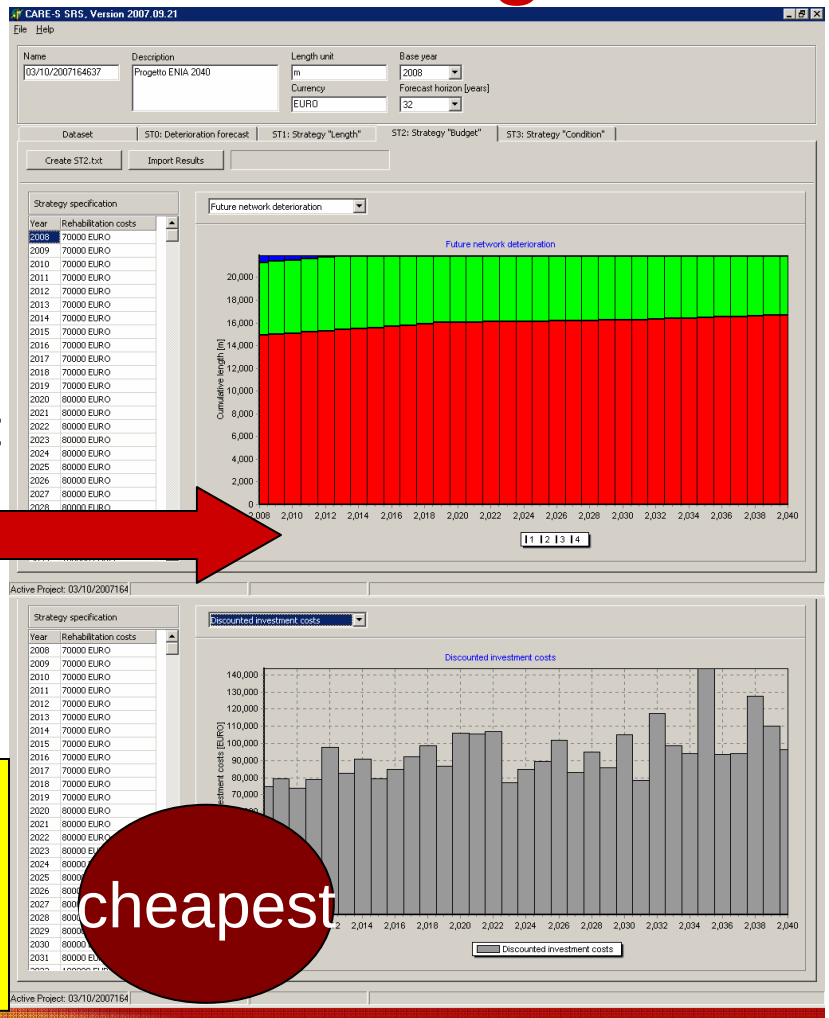


Better CC

Strategy 2 is cheaper and does not predict much worse deteriorati on: WINNER

Fix to invest 300000€ in 4 years

2: budget



cheapest

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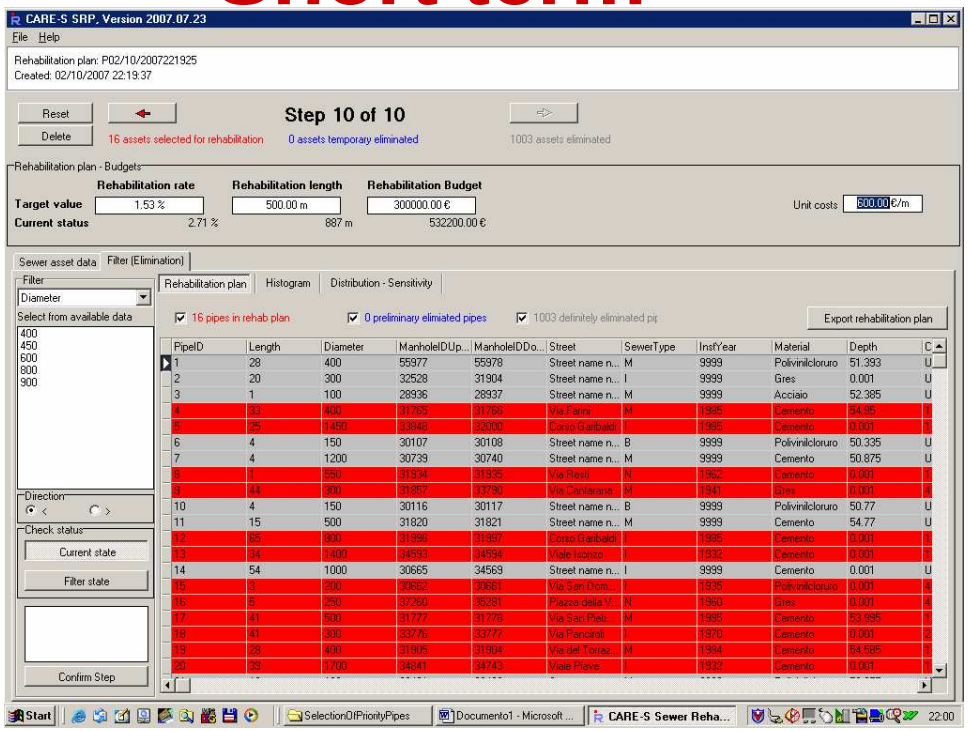
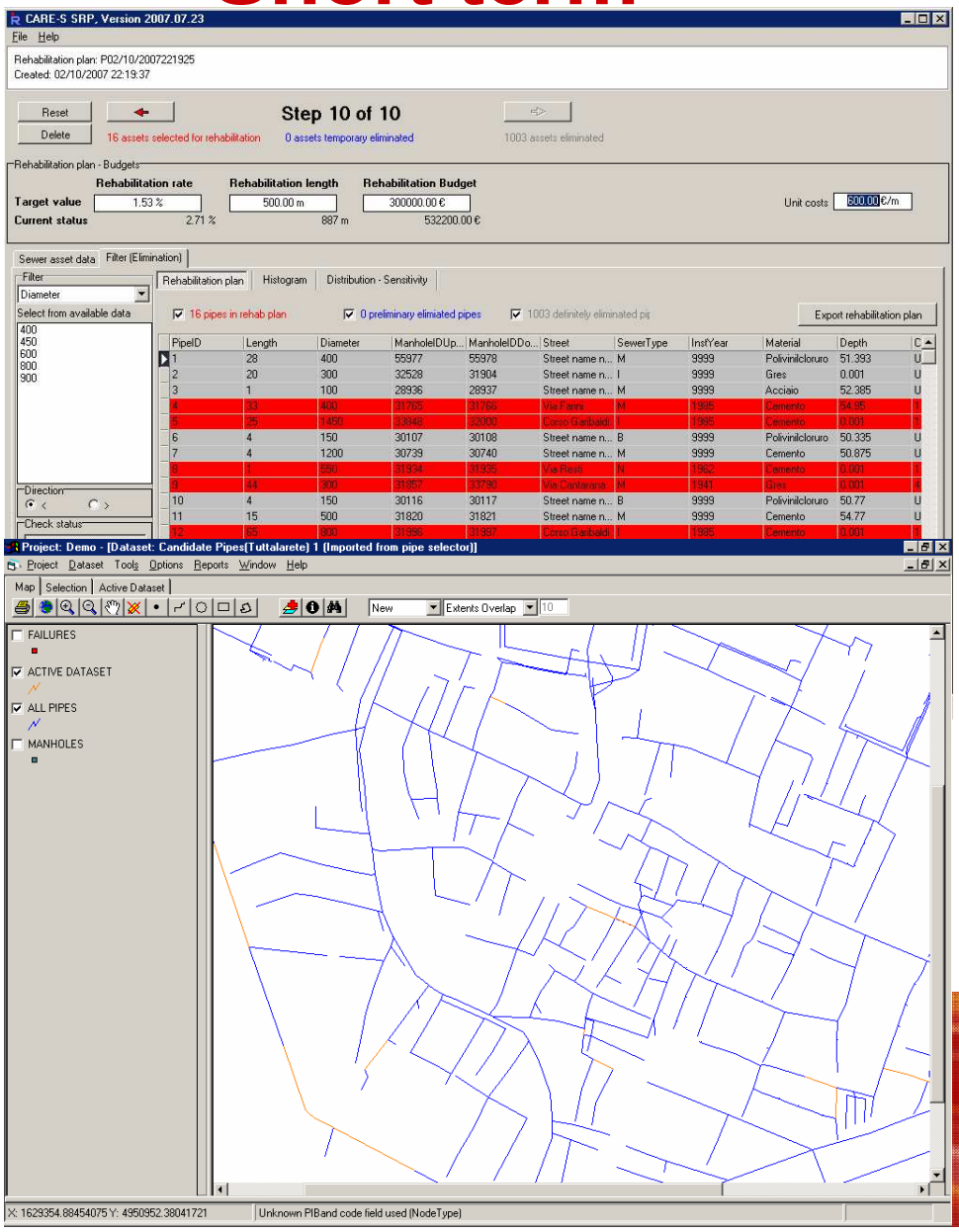
Project – Selection of priority pipes
Short term



Filters :

- CC = U; CC = 1; CC = 2
- Diameter < 400mm
- Diameter > 900mm
- Sewer type & material “unknown”
- ExtCorr < 0.07mm/y
- Probability of collpse < 0.3

Project – Selection of priority pipes Short term



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Priority of rehabilitation for: 16 pipes = 887 metres = 2,71% of net

Estimated cost (600€/m):

€ 532200 >>€300000

Project – Selection of priority pipes Short term

Comparison of Rehabilitation technologies:

- CIPP: € 328000
- Trench: € 407000

Note: the hypothesis of 600€/m was too high since the computed investment (532200€) >> fixed budget (300000€)

Instead of reducing the number of pipes with priority of rehabilitation (16) a cheaper rehabilitation technology can be chosen, CIPP.

Project – impact of failure on society

Sociofails (impact of failures on customers/inhabitants) has been applied to the 16 pipes for 3 criteria (to start):

ICF service interruption

ICF wastewater dry weather flooding on street

ICF odours, rodents insects

	PipeID	ICF service interruption	ICF wastewater dry weather flooding on street	ICF odours, rodents insects
	62	0.146166602	0.031321415	0.033682635
→	64	0.096917548	0.030279795	0.258097166
	114	0.032684072	0.013927872	0.180899296
	167	0.103719755	0.01983675	0.104051297
→	173	0.133160348	0.044288364	0.485054348
	180	0.003076254	0	0.049227799
	265	0.025281176	0.013946952	0.211342647
	379	0.062001968	0.006992703	0.013047483
	433	0.035888193	0.015973973	0.213576858
	443	not calculed	not calculed	not calculed
→	505	0.484834389	0.044035821	0.066230106
→	545	0.128895939	0.03933752	0.064867157
	625	0.046843447	0.006928138	0.005674232
	899	not calculed	not calculed	not calculed
	918	0.088796363	0.038991377	0.086328125
	1015	not calculed	not calculed	not calculed

For 2008 we prioritize 4 pipes = 307 m

Project – impact of works on society

Socioworks (impact of works/intervenitions on customers/inhabitants) has been applied to the 1 of the 4 pipes selected (for example)

EX: pipe 505 = 165 m

Impact of 3 technologies compared

Technology ID	Rehabilitation Technique	Day or night work	Duration value (days)	ICW noise	ICW dust	ICW pollution of ground water	ICW service interruption	ICW road traffic disturbance	ICW loss of trade
16	in situ repair	d	110.10	0.00	0.00	0	0.00	817,492.50	1,998.32
16	in situ repair	n	110.10	0.00	0.00	0	0.00	245,247.75	599.49
38	CIPP hot water cure	d	2.06	0.00	0.00	0	0.01	16,060.28	49.35
38	CIPP hot water cure	n	2.06	0.00	0.00	0	0.00	4,818.08	14.81
42	conventional trench	d	33.03	0.17	0.17	0	0.17	33,814,462.50	458,211.98
42	conventional trench	n	33.03	1.72	0.09	0	0.04	10,144,338.75	137,463.59

CIPP has the lower impact and quicker, in addition we are working in the historical centre of Reggio Emilia (historical pavement)

Further work

- Complete the analysis of different possible strategies in long and short period comparing investment needs, impact of failures and interventions on customers, improvement or deterioration of the network following different rehabilitation criteria and
- Provide the Utility with alternative solutions…

Conclusion

- The Reggio Emilia case study has been presented: first italian complete application of CARE-S;

- Applying Asset Management practice in reality is a challenge due to the need to re-build utilities databases and rehabilitation philosophy before being able to start the application of AM.

- The Utility ENIA took advantages from this experience recognising the need of improving the data collection practice, in defining areas and/or priority components and in comparing their usual practice with alternatives.

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Thank you

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