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Asset Management

2nd IWA Leading-Edge Conference & Exhibition on

Strategic Asset Management

Scheduling Renewal of Water Supply Distribution Systems – A Case Study in Portugal

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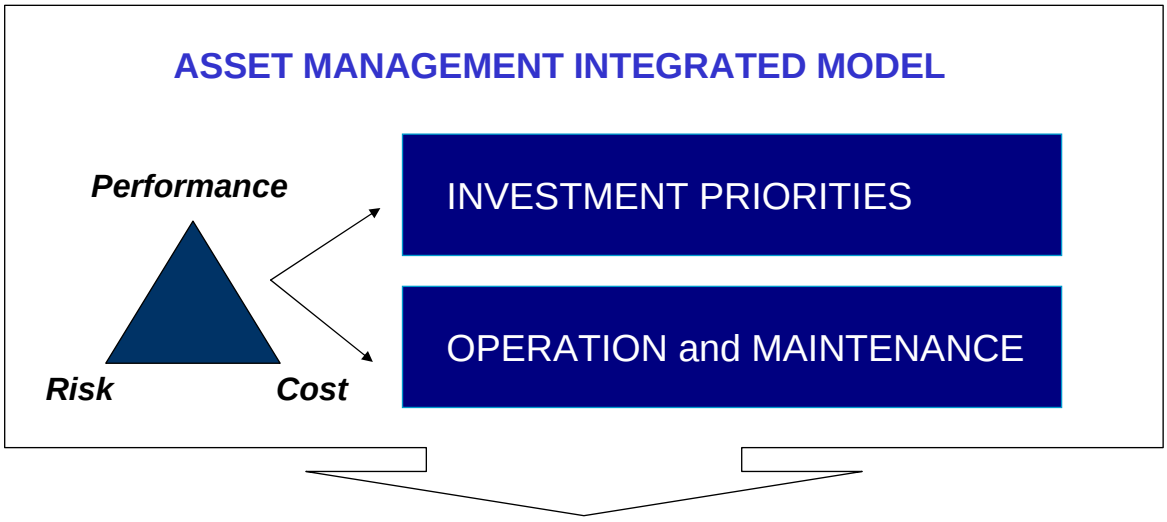
LESAM 2007 – Lisbon 17-19 October 2007

Introduction



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Definition of Rehabilitation Priorities in Lisbon's Water Distribution System

Two different approaches:

- Multi-criteria analysis
- Life Cycle Approach

Multicriteria analysis

Life Cycle Approach

Conclusions

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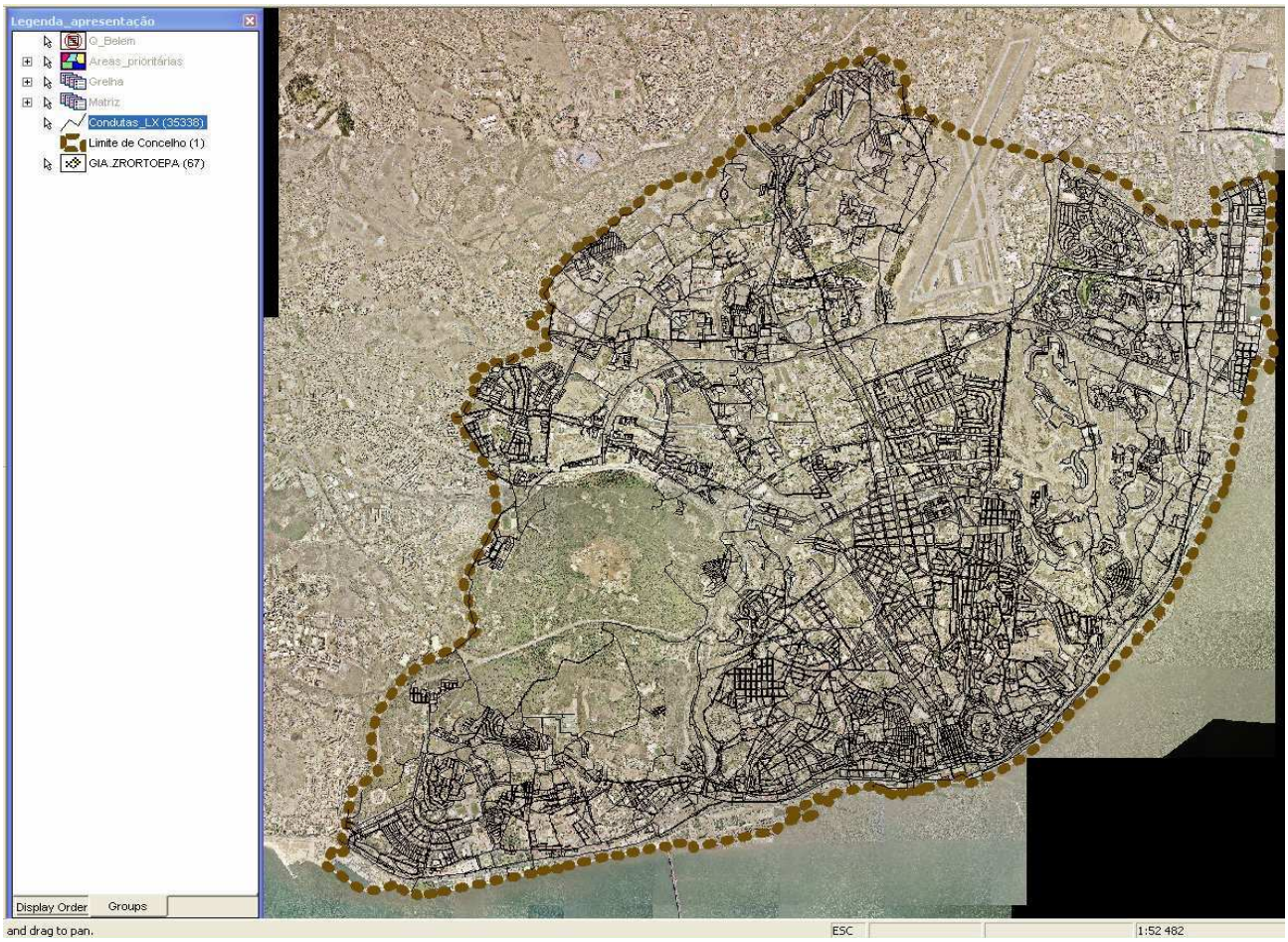
Multicriteria analysis

Point of View	Criteria	Weight	Indicator	Punctuation		Data Sources
Physical Factors	Expected Life	16%	Age (years)	0-20	0	Ginteraqua
				20-30	2	
				30-50	4	
				>50	5	
	Supply Reliability	36%	Nº of Bursts / year / 100 km	0-30	0	Ginteraqua
				30-50	1	
				50-100	3	
				100-150	4	
				>150	5	
	Operational Flexibility	11%	Function	Distribution mains	2	Ginteraqua
				Trunk mains	4	
	Performance	16%	Material	HDPE	0	Ginteraqua
				Ductil Cast Iron	0	
				Europipe Steel	0	
				Steel	1	
				Reinf. Concrete	3	
				Plastic, PRV	3	
				Asbestos	5	
				Rocla Concrete	5	
				Cast Iron	5	
				Unknown, Galvanized Iron	5	
Economic Factors	Investment vs Maintenance Cost	21%	R= Crn/(Ir.L.Cu) (years)	>20	0	Crn - DRA Cu - ADS/MDS Ir - Ginteraqua L - Ginteraqua
				10-20	1	
				5-10	3	
				1-5	4	
				0-1	5	

R = Renewal Cost / [NºFailures/year x Maintenance Cost]

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Matriz
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Condutas_LX by INDICE_R_M
Condutas_LX by REC_AVARI
Roturas em Condutas
Condutas_LX by REC_MATER
Condutas_LX by REC_IDADE
Condutas_LX by REC_FUNCA
4 - Adução (1732)
2 - Distribuição (33606)
Condutas_LX (35338)
Limite de Concelho (1)
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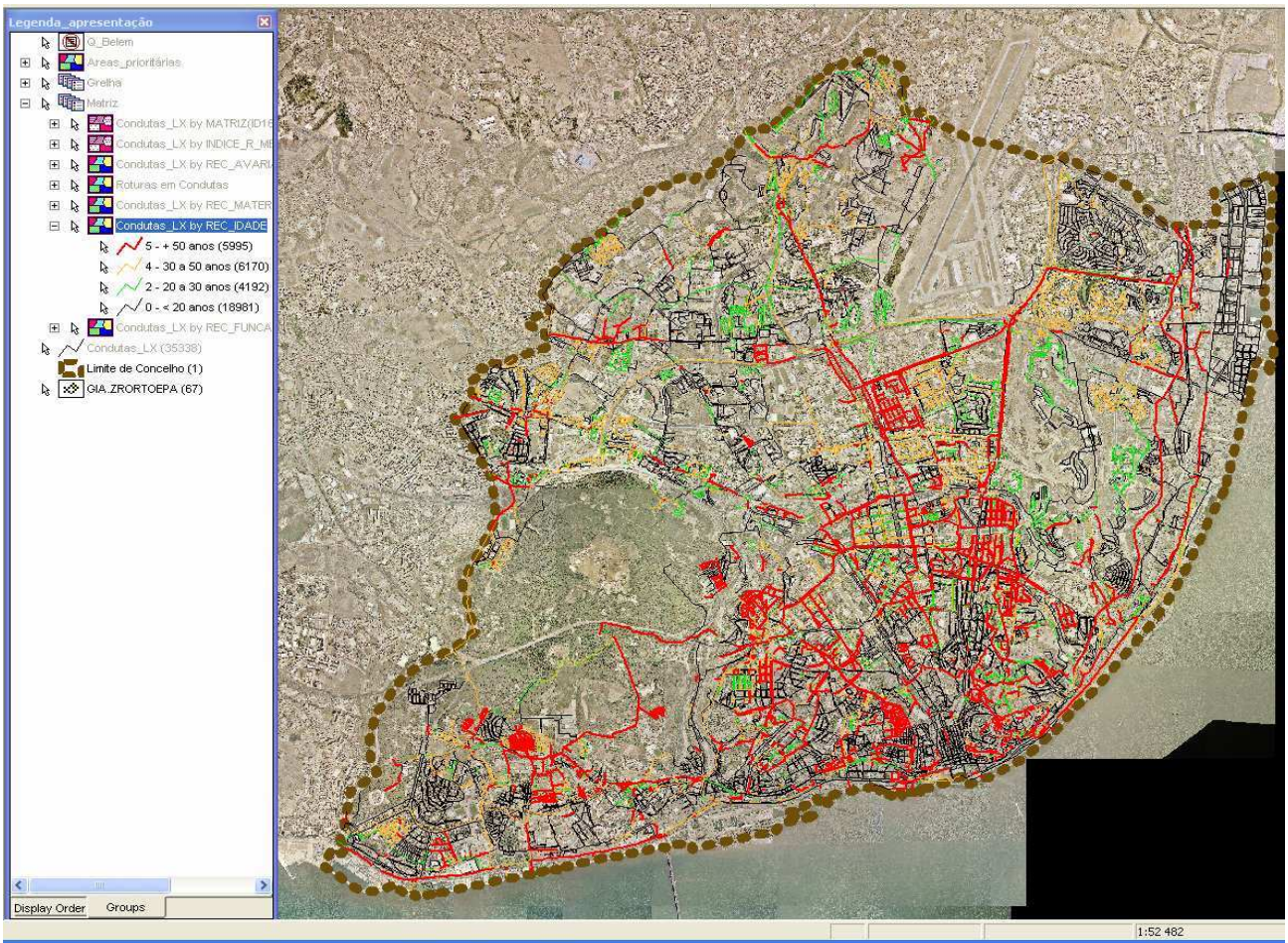
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5 - + 50 anos (5995)
4 - 30 a 50 anos (6170)
2 - 20 a 30 anos (4192)
0 - < 20 anos (18981)
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3 - BA, PL (787)
1 - AC (127)
0 - PEAD, FFD, EUR (17907)
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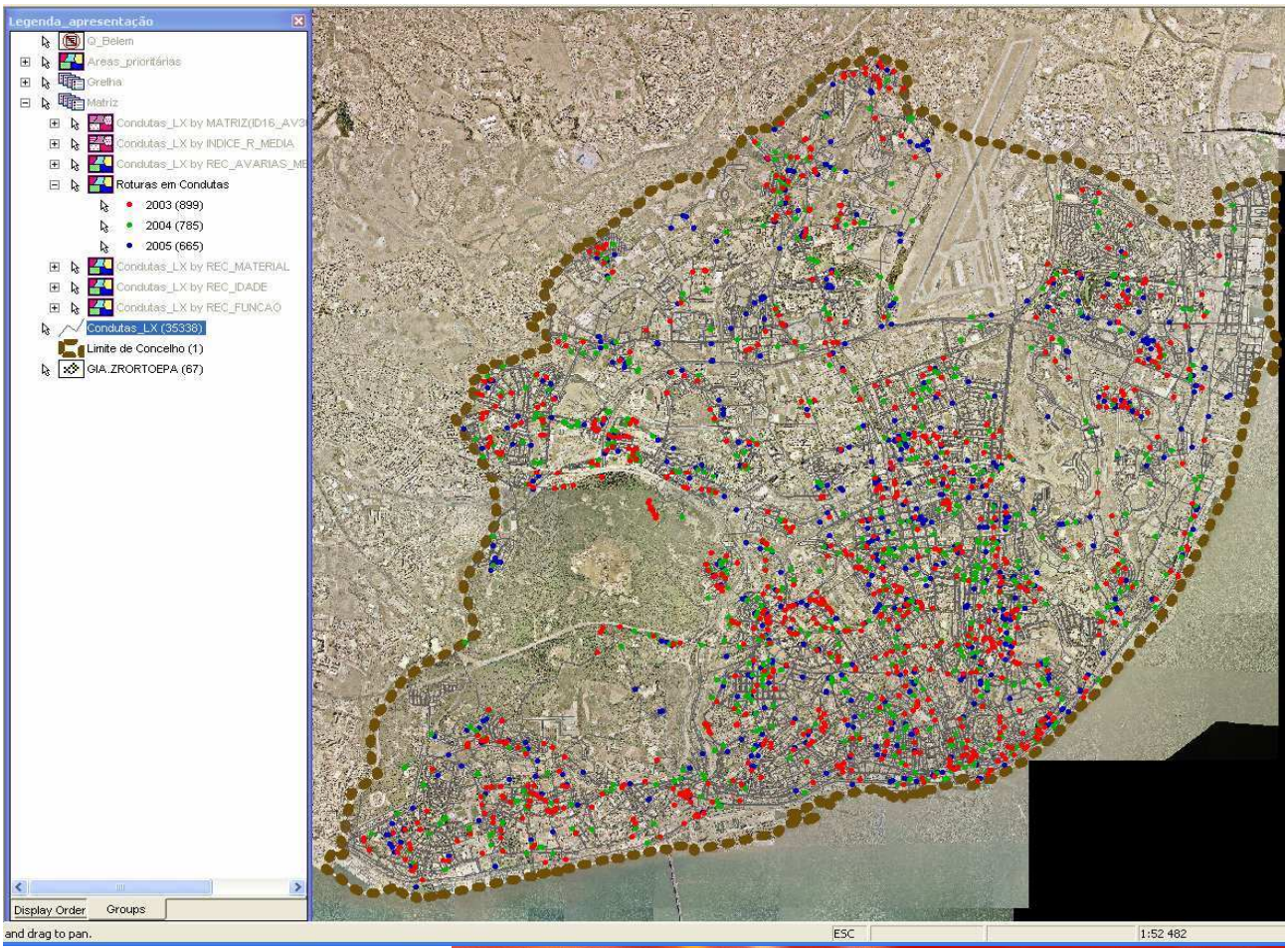
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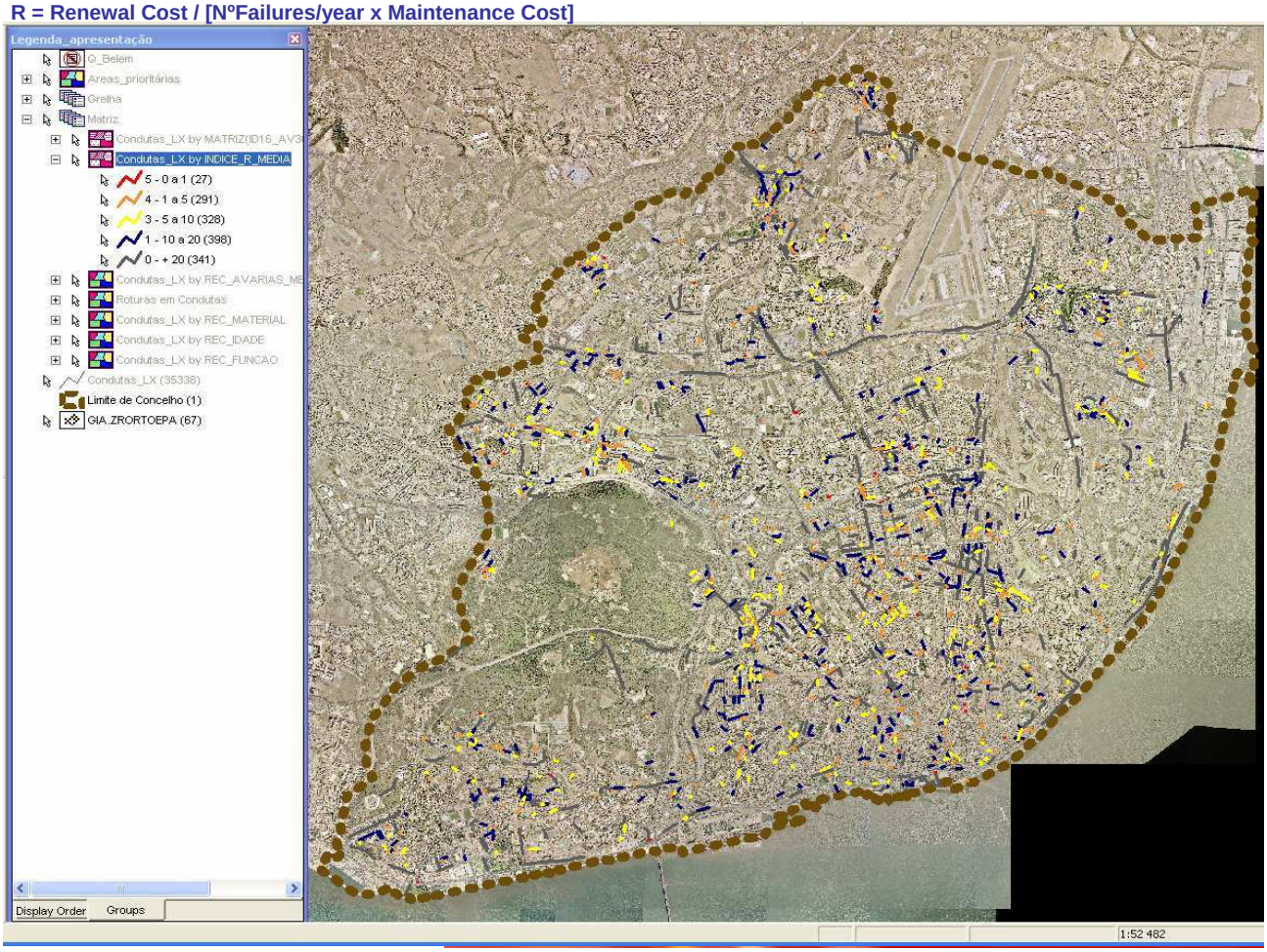
R = Renewal Cost / [NºFailures/year x Maintenance Cost]

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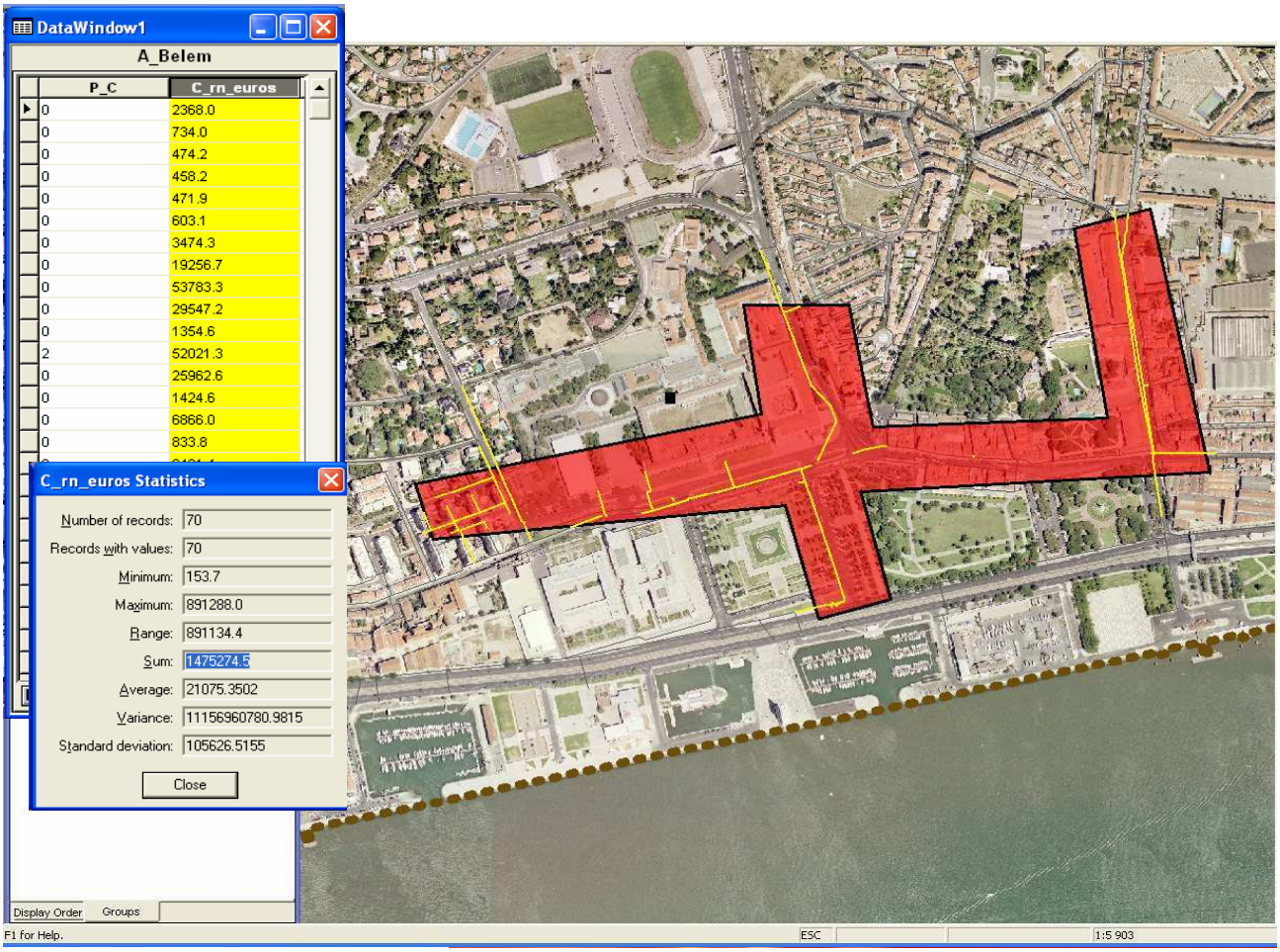


Multicriteria analysis

Life Cycle Approach

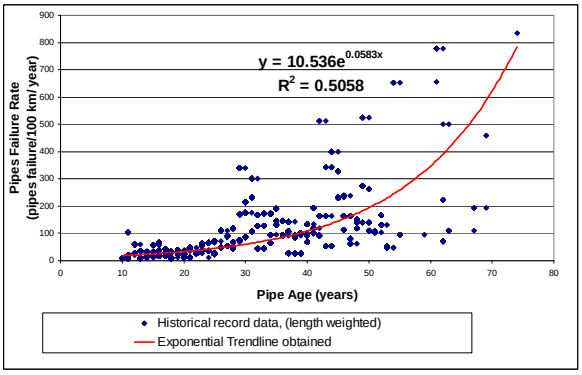
Conclusions

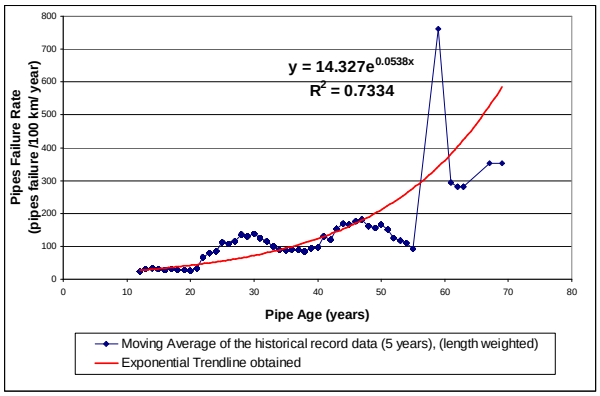
Methodology

1. Pipe failure analysis of two sub-groups — DN<400 / DN>=400
2. Definition of a deterioration model for each sub-group of diameter and pipe material.
3. Each unit area (DMA) was classified according to their behavior age.
4. According to the expected behavior, an evaluation of the pipe whole life cost is made for several life-time periods.
5. Renewal decision based on the use of the residual asset-life time that minimize the total expected costs.

Definition of a Deterioration Model

Failure analysis of Asbestos pipes (DN<400)





Life Cycle Analysis

Costs considered:

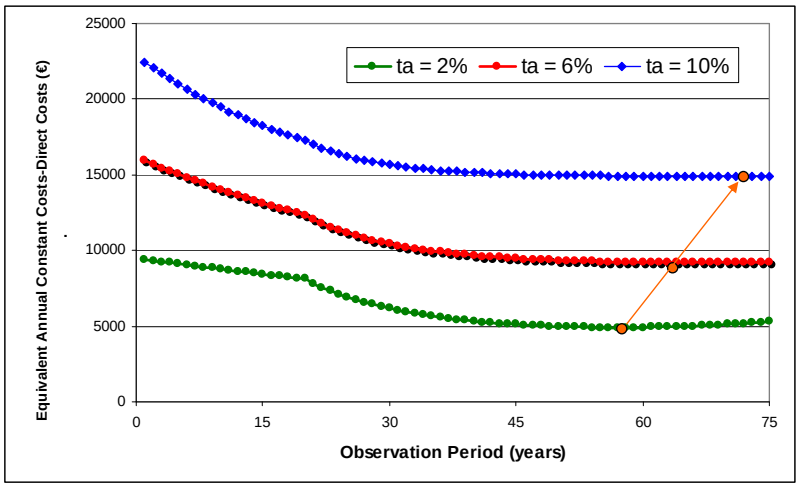
- unplanned emergency intervention for pipe failure repair;
- water loss volume from the pipe burst;
- indirect costs to the client caused by suspension of the water supply;
- risk of direct damages to other entities;
- renewal investment;
- fiscal benefits for the investment annual payment (in Portugal 27,5% of the annual amortization value).

Life Cycle Analysis (Discounted Cash-flows)

Discount Rate (effective, net of inflation) =	**6.5%**		
Fiscal Benefit Rate of annual depreciation =	27.5%		
Break Repair cost =	3 087	€/break	
Water Marginal Cost =	0.0701	€/m3	
Water average sale price =	1.069	€/m3	
Failure social cost/ Cost of affecting clients =	925	€/failure	50% GDP/capita
	163	€/m	
Fiscal depreciation period of the Investment =	20	years	
Lenght of Asbestos Cement (AC) Pipes =	1.00	km	
Lenght of Ductile Iron (DI) Pipes =	0.00	km	
Equivalent Average Age of Asbestos Cement Pipes in the year 0 =		year	
Leakage Volume in year 0 =	19 600	m3	
Number of Critical connections =	50	connections	
Renewal Investment =	163 000	€	
Annual Investment depreciation =	8 150	€	

Year	1	2	3	4	5	6	7	8	9	10	11	12
Pipes Equivalent Average Age	0	1	2	3	4	5	6	7	8	9	10	11
Number of pipe breaks =	0.89	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.09
Leakage Volume / year (10^3 x m3) =	20	1	1	1	1	1	1	2	2	2	2	2
Number of Plomb or Niquel Connections	0	0	0	0	0	0	0	0	0	0	0	0
Operational and Mantainance Costs												
Breaks Repair Costs =	2 755	156	164	173	183	193	204	215	227	239	253	266
Water Sale Income reduction =	15	1	1	1	1	1	1	1	1	1	1	1
Leakage Costs =	1 374	78	82	86	91	96	102	107	113	119	126	133
Other Costs												
Annual Cost of Plomb Connections =	0	0	0	0	0	0	0	0	0	0	0	0
Social Costs =	825	47	49	52	55	58	61	64	68	72	76	80
Investment or Residual Value												
Investment =	163 000											
Annual Depreciation =		8 150	8 150	8 150	8 150	8 150	8 150	8 150	8 150	8 150	8 150	8 150
Residual Value of the Investment =	163 000	154 850	146 700	138 550	130 400	122 250	114 100	105 950	97 800	89 650	81 500	73 350
Annual Fiscal Benefit with depreciation =	0	-2 241	-2 241	-2 241	-2 241	-2 241	-2 241	-2 241	-2 241	-2 241	-2 241	-2 241
Annual Cash Flow - Direct Costs =	163 000	-2 007	-1 994	-1 981	-1 966	-1 951	-1 935	-1 918	-1 900	-1 881	-1 861	-1 840
Annual Cash Flow - with Externalities =	163 000	-1 961	-1 945	-1 929	-1 911	-1 893	-1 874	-1 854	-1 832	-1 810	-1 786	-1 761
Net/ Discounted Annual Cash Flow - Direct Costs =	163 000	-1 885	-1 758	-1 640	-1 528	-1 424	-1 326	-1 234	-1 148	-1 067	-992	-921
Net Annual Cash Flow - with Externalities =	163 000	-1 841	-1 715	-1 597	-1 486	-1 382	-1 284	-1 193	-1 107	-1 027	-951	-881
Net Present Value - Direct Costs =	0	15 716	30 018	43 019	54 826	65 537	75 242	84 025	91 963	99 126	105 580	111 386
Net Present Value - Costs with Externalities =	0	15 760	30 105	43 149	54 999	65 752	75 499	84 323	92 302	99 506	106 001	111 847
Equivalent Annual Constant Payments (Direct Costs)	0	16 738	16 488	16 243	16 004	15 770	15 543	15 320	15 104	14 892	14 687	14 486
Equivalent Annual Constant Payments (Direct Costs	0	16 784	16 535	16 292	16 054	15 822	15 596	15 375	15 159	14 950	14 745	14 546
Increase of the Equiv. Annual Constant Payments (Direct Costs) =		16 738	-250	-245	-239	-233	-228	-222	-217	-211	-206	-200
Increase of the Equiv. Annual Constant Payments (D. Costs + Externalities) =		16 784	-249	-243	-238	-232	-226	-221	-215	-210	-204	-199

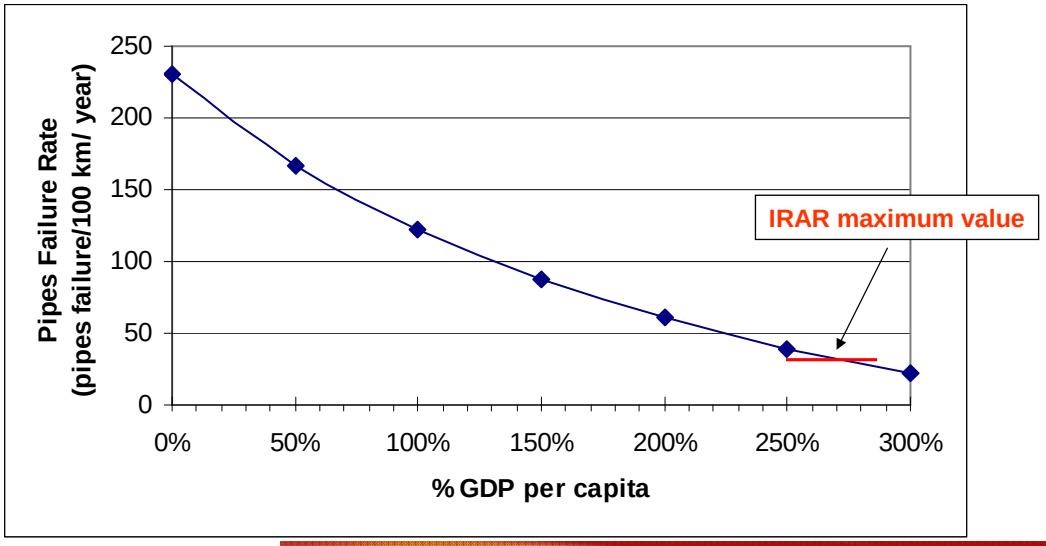
Equivalent Annual Constant Payments for different Observation Periods



Economic Life Cycle

Economic level of Pipe Failure Rate as a function of the Cost to affected Clients

(Ta = 6,5%
Portuguese GDP per capita)



Impact of the Annual Pipes Renewal Effort in Pipe Failure Rate

Annual renewal extension		Accumulated difference in global pipe failure rate indicator (Pipe failure/100 km)	
(%/year)	(km/year)	5 years	10 years
2,0%	28,4	-5,9	-8,4
2,5%	35,5	-8,2	-13,3
3,0%	42,6	-10,5	-16,8
3,5%	49,7	-12,6	-19,7

Regulator target

Economic Annual Pipes Renewal Effort

(Cost of affecting clients = 50% Portuguese GDP of clients affected)

T= 3.5%

AC and GI Pipes Renewal Schedule	Lenght (km)	Investment (€)	Accumulated Difference of the Pipes failure Rate (breaks /100 km/ year)	Accumulated Difference of Number of Critical Connections	Annual Renewal Lenght	
					(km/year)	(%/year)
Years 1 to 5	91.6	14 949 259	-2.5	-2 825	22.9	1.60%
Years 6 to 10	131.0	21 382 189	-4.5	-7 383	26.2	1.84%
Years 11 to 15	165.2	26 967 826	-8.5	-11 821	33.0	2.32%
Total - 15 Years	**387.8**	**63 299 275**		**Annual average value**	**25.9**	**1.81%**

Multicriteria analysis

Life Cycle Approach

Conclusions

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Conclusions

Future developments

- introduction of new criteria in the multicriteria matrix (damage to others, water quality, clients' sensitivity, …)
- accomplishment of a sensitivity analysis to the weights of the criteria
- improvement and updating of the deterioration models
- application of a risk model, considering the factors "probability" and "consequence" of pipe failure
- integration of the two approaches – multicriteria and life cycle analysis

Conclusion

With these two models, EPAL will be able to periodically re-evaluate the requirement for mains renewal in the Lisbon distribution system, within a structured and methodological framework.

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