LESAM 2017
NTNU, Trondheim, Norway

Presentations

Openning session

Norwegian University of Science and Technology

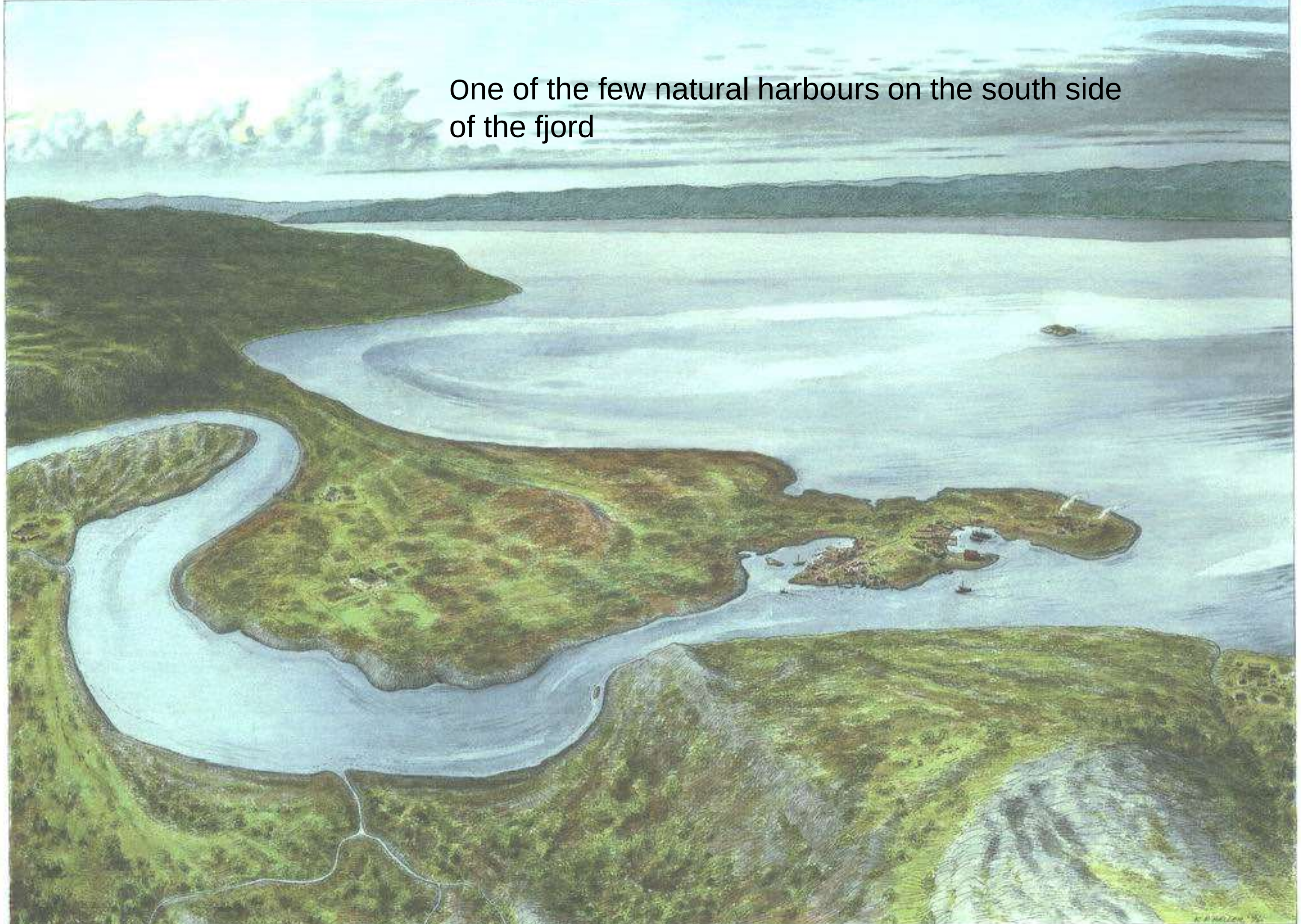
Opening by lead officers of NTNU and Trondheim municipality

Welcome to Trondheim

A modern city based on history

History – Timeline

- From The Saga (the year 997):
- ”King Olav Tryggvason went with his army to Nidaros. He ordered the building of houses by the river Nid and decided there should be a market town”



One of the few natural harbours on the south side of the fjord

In the 990s Olav Tryggvason (968 - 1000) built his Royal Residence here. The city expanded throughout the Middle Ages

King Olav Haraldson was killed at the battle of Stiklestad in 1030

The king became a Saint after his death

The Church

- Construction of a church began in 1070 on the site of St. Olav’s grave
- Workers and experts from all over Europe contributed

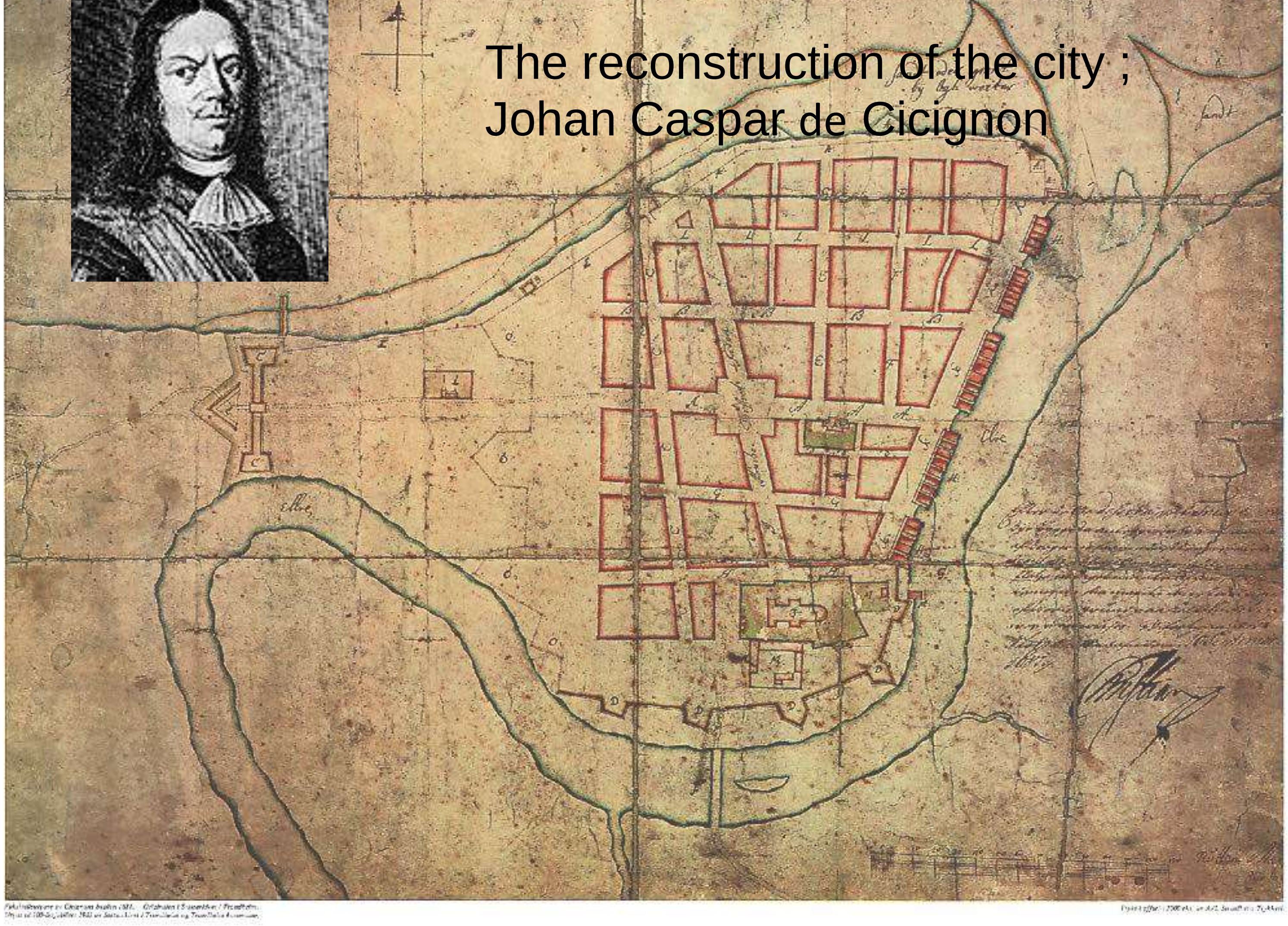
Nidaros Cathedral

- 1531 The cathedral was destroyed by fire
- 1689 The spire collapses in storm
- 1708 New fire – the cathedral burns down
- 1869 restoration – lasting 100 years, ”completed” 1969

The night of 16. April 1681

- People went to bed as normal
- The fire started around midnight
- Strong winds throwing sparks over wooden houses
- The citizens had no chance of controlling the flames.
- Only a few buildings and the Cathedral survived

The reconstruction of the city ; Johan Caspar de Cicignon



The cityplan still exists

Trade, industry and science

- Trondheims position as a trading town was consolidated in the 16th century (fish, timber and ore from copper mines)
- From 1900: science and technology

FACTS AND FIGURES

Area: 342,2 km²

Population: 191 000 (1.4.2017)
Students: 31 000 (2013)
Foreign nationals: 10,7 % (2013)
Households: 83 000 (2013)

Expected lifespan men: 78.2 years
Expected life span women: 82.7 years

Trondheim is an attrac**tive city**:

- Highly rated internationally
- Attractive for living, studying and work
- Population growth



Vision: Big little Trondheim

Main challenge: Securing sustainable growth

1. Climate challenge
2. Public health
3. Social economics

Densification

- Limit landuse and securing the cultivated land
- Better exploite the existing infrastructure
- Reduce the need for tranportations
- Better the public transport offerings

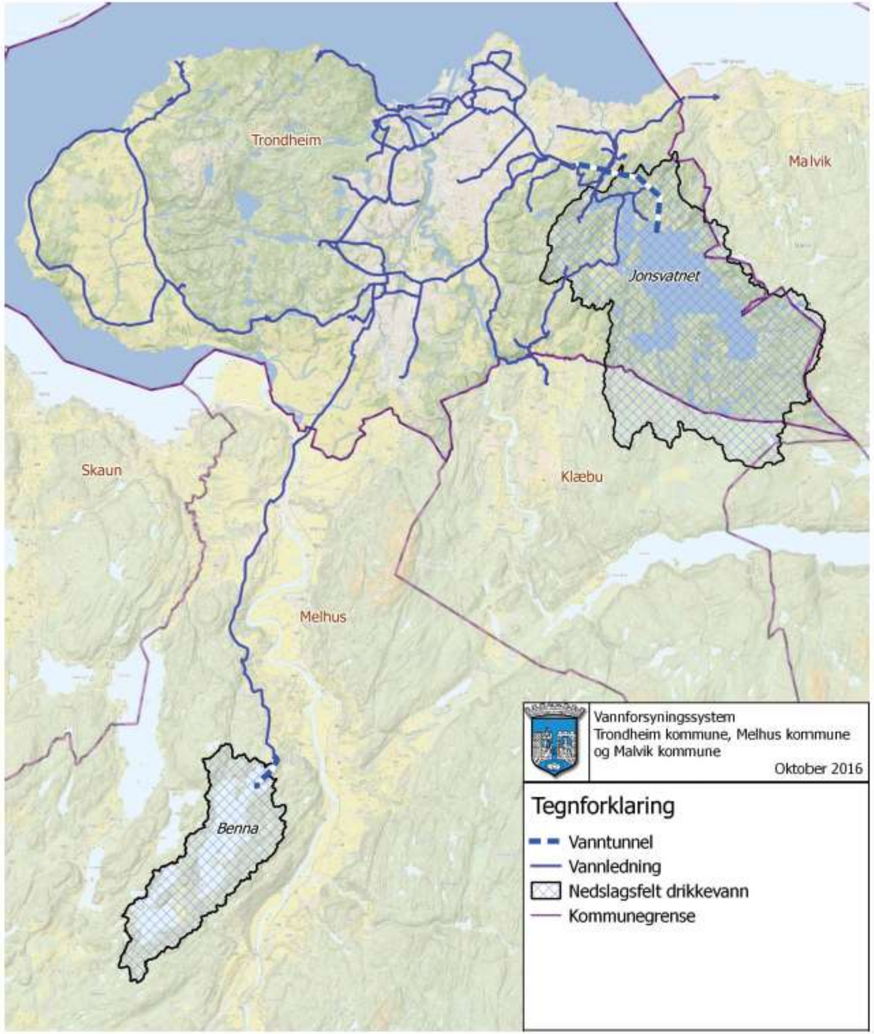

Cycling….


Walking


Snarvei

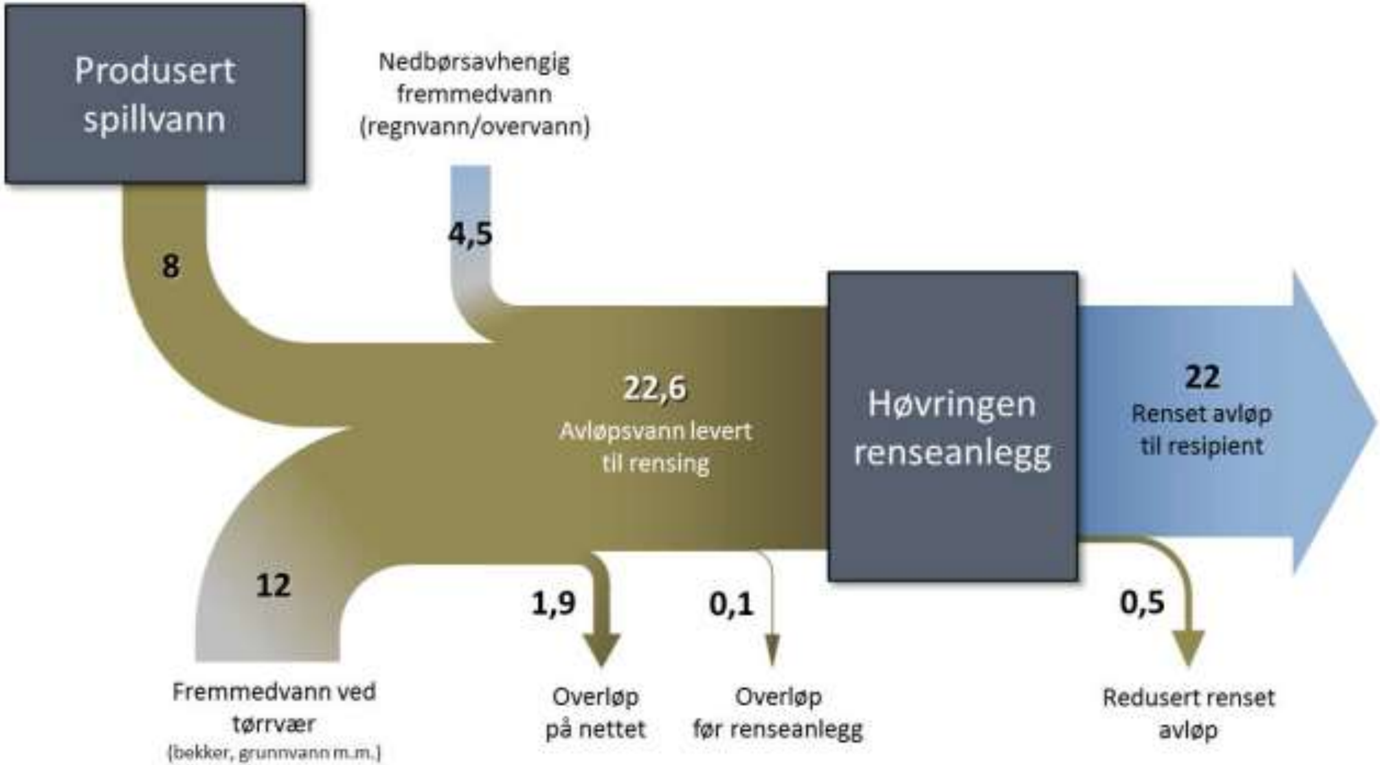
Urban spaces,
green lungs
and meeting places

Trondheim kommune



Vannbalanse 2009-2011 [millioner m³/år]

Høvringen rensedistrikt, Trondheim



Education and science

Introduction by the Chair of the Strategic Asset Management Specialist Group Helena Alegre

Opening address:
From San Francisco to Trondheim

Helena Alegre

Chair of the IWA Strategic Asset Management Specialist Group

Senior Researcher at LNEC, Portugal (www.lnec.pt)

Vision and key objectives…

… of the IWA Strategic Asset Management Specialist Group

- LESAMs are part of the tactics

Vision

- Be THE international network of IAM water professionals

Key objectives

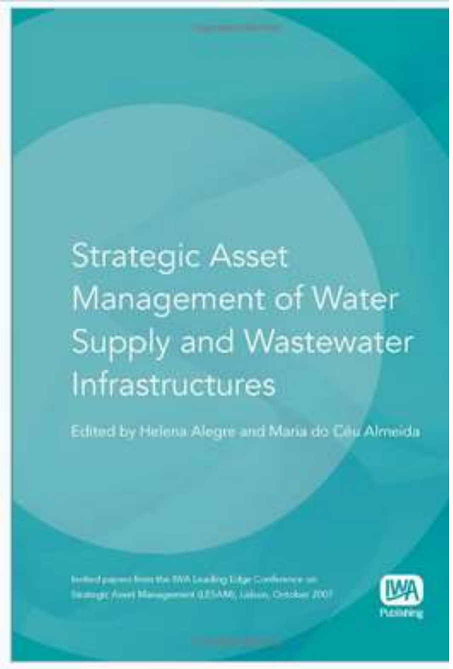
- Create awareness
- Leverage leading edge science and practice
- Help consolidating key general principles
- Be a pleasant and effective group to work with


1st LESAM
San Francisco,
USA, 2004
LESAM 2017
Trondheim, Norway
IWA+NTNU
Germany
LESAM 2015
Yokohama, Japan

Legacy from previous LESAMs

- Proceedings
- One book
- Many publications in IWA journals
- Network of professionals – “**LESAMers**”
- Share of experience between all group of stakeholders involved in infrastructure management

- LESAM: a **safe value**, a **brand** → a big responsibility on OUR shoulders

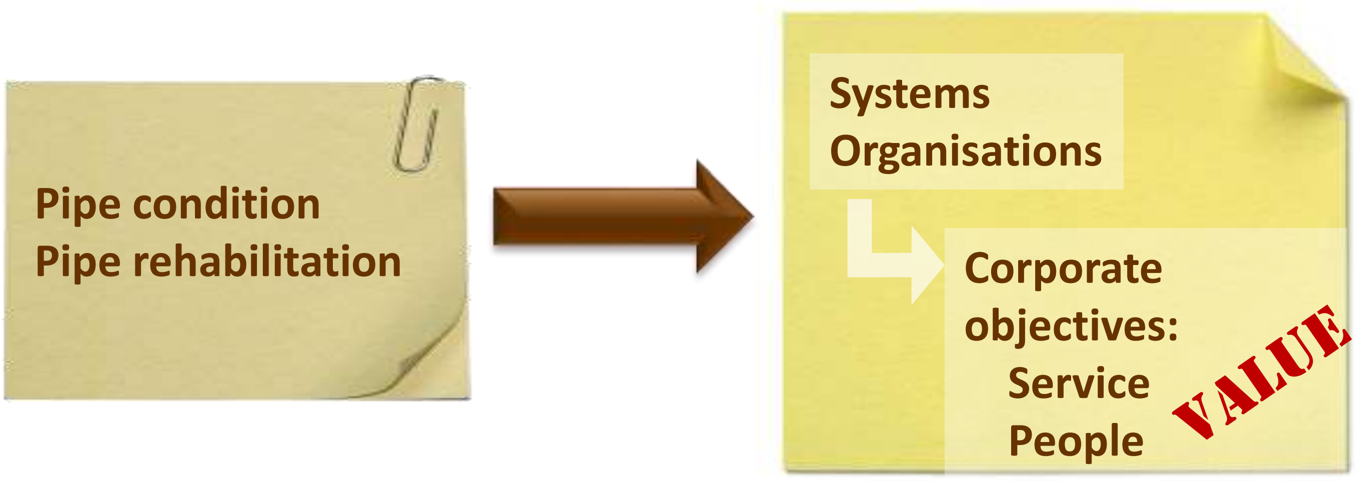


BUT ALSO…

Consolidation of key IAM principles

- Added **awareness** and **recognision** of the **importance of IAM**
- **Value**-oriented IAM
- **Objective-oriente**d IAM
- Balancing **performance, risk and cost**
- Taking the most of **sound assessment systems**
- **System approaches**

From San Francisco **to** Trondheim



From San Francisco **to** Trondheim

Engineering

Other disciplines

- natural sciences
- economy
- communication
- business management
- statistics and data analytics
- …

Multidisciplinary approaches

From San Francisco **to** Trondheim

Engineering

→

Integrated organization management processes

From San Francisco **to** Trondheim

Like-for-like rehabilitation

Rehab towards

- **Global efficiency and effectiveness**
- **Adaptation to climate change**
- **circular economy**
- **green solutions**

From San Francisco to Trondheim

Wishes from LESAM 2015 to LESAM 2017: topics that should be explored

- Utilities – policy-makers – researchers / academics
  - An essential triangle

    Good examples from Australia (e.g. WSAA), Portugal (LNEC's National Initiatives), the Netherlands
- "Still an existing gap between strategic and operational AM",

    but good examples exist (e.g. Portugal; Sendai City, pioneer certified ISO 55001)
- Internal and external communication: an issue and an opportunity

    (a good example from the Netherlands)


Take home messages from Yokohama


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

ISO 55 X: A great
portunity

Key messages from the chair (Rhys Davies):

- Vertical and cross-cutting alignment
- Transparency
- Risk-based decisions from understanding our business
- Long-term views

HOW TO BETTER INVEST OUR LAST ¥2000 BILL?

My *apriori* view of LESAM 2017

STRATEGY – STRATEGY – STRATEGY

Increased focus on:

- **Global frameworks, strategic planning, integrated and long terms approaches**.
- **Data-related technological innovations**
- More and more **consolidated practices**
- **Financing** and **communication**: growing, but still room for an increased share in LESAM sessions.

TO FINALISE…

Are you already a LESAMER?

Key requirements:

- Understand that strategic asset management is essential for the survival of societies
- Participation in, at least, one LESAM

Are you a LESAMER?

Other key requirements:

- Passionate
- Have a vision
- Enjoy sharing
- Enjoy life

But also…

- Be an active participant and do your homework during LESAMs

But also…

- Be an active participant, do your homework during LESAMs
- Do not forget that your performance will be

Now: TIME FOR LESAM 2017!

With a big word of gratitude and appreciation to or hosts!

Invitation to the SAM SG meeting

IWA STRATEGIC ASSET MANAGEMENT SPECIALIST GROUP MEETING

- Open meeting: everybody is welcome, members and non-members
- Tomorrow, **21 june, 13:00-14:00**

Contact

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Keynote:

Building a framework for national management of water services /Jaime Melo Baptista, LNEC

LESAM 2017
The Leading Edge Sustainable Asset Management of Water and Wastewater Infrastructure Conference
Trondheim, Norway, 20-22 June 2017

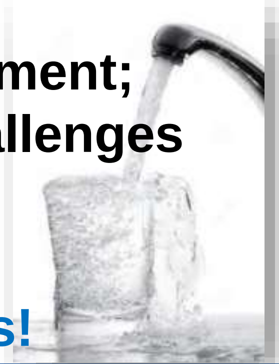
Building a framework for national management of water services

Jaime Melo Baptista
Principal Researcher at LNEC, Portugal
President of the Strategic Council of Portuguese Water Partnership
Responsible for the Lisbon International Centre on Water
Former Chairman of the Portuguese Water Regulator (ERSAR) 2003-15
Portuguese Commissioner for the 8th World Water Forum 2018 in Brazil

What is the situation on water services around the world?

The situation on water services

- **In emerging & developing countries (75%):**
  - **Very poor public services, when existing;**
  - **Lack of continuity and quality;**
  - **Negative impact on health, economy and environment;**
  - **Nonexistence of national framework.**
- **In developed countries (25%):**
  - **Suitable public services;**
  - **Continuity and good quality in general;**
  - **Positive impact on health, economy and environment;**
  - **But increasing aged infrastructures and new challenges to face;**
  - **Need of updated national framework.**
- **We need better national management frameworks!**



What do we face at the international level on water?

What do we face on water?

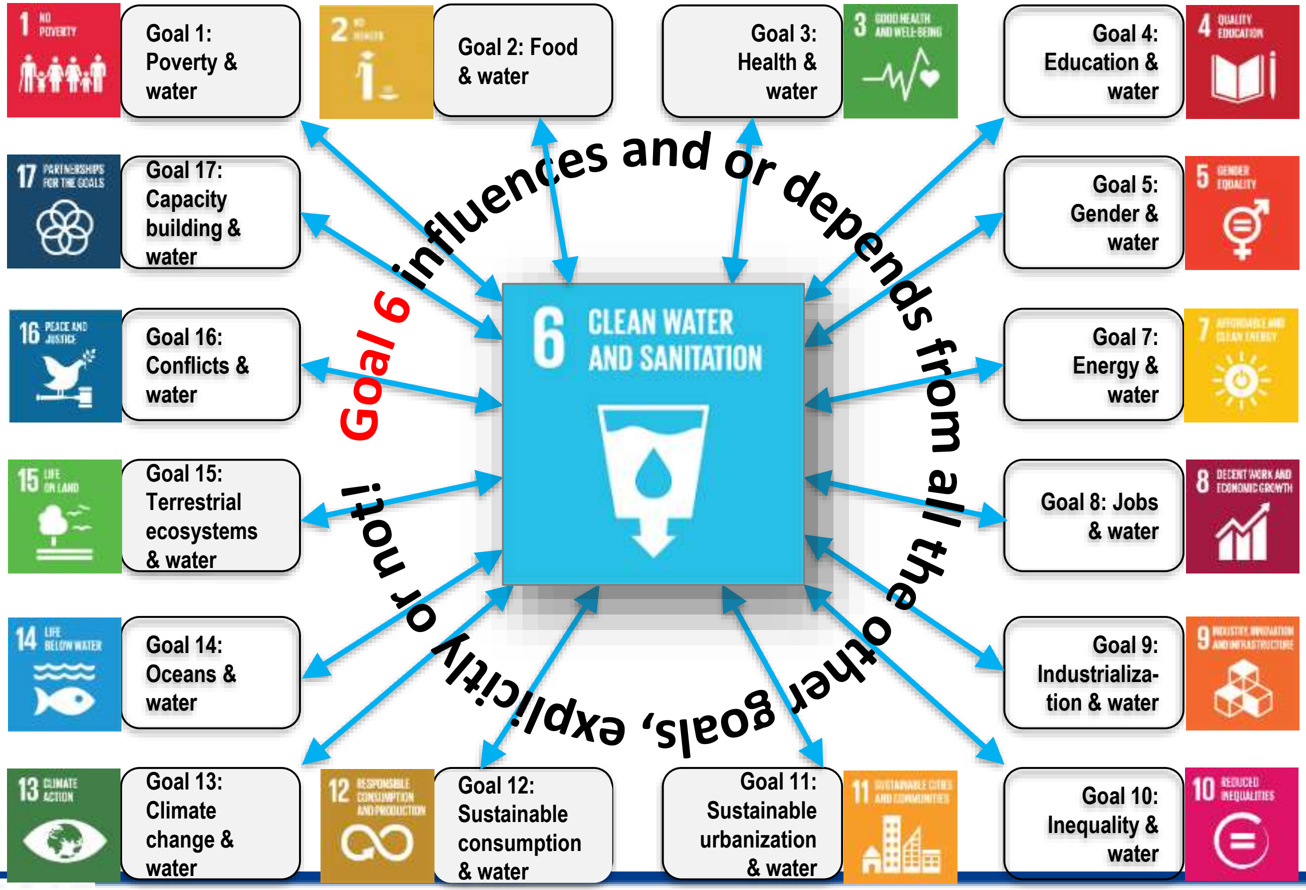
- **UN Sustainable Development Goals 2016-2030:**
  - **Constitute the new agenda of action until 2030, to:**
    - **end poverty;**
    - **promote prosperity and well-being;**
    - **protect the environment;**
    - **fight climate change.**
  - **All countries come to share a common vision of the challenges of water.**
  - **Applicable to developed & developing countries, but not legally binding.**
  - **Monitored annually through indicators.**

What do we face on water?

Goal 6: Ensure availability and sustainable management of water and sanitation for all, with the following targets:

Targets	Category
6.1: Drinking water 6.2: Sanitation and hygiene	WASH
6.3: Water quality 6.4: Water-use efficiency 6.5: Integrated water resources management 6.6: Water-related ecosystems	IWRM
6.a: International cooperation and capacity-building 6.b: Participation of local communities	Gover- nance

What do we face on water?



Goal 6+: SDG encourage inter-sectorial links!

What do we face on water?

- **Other international references:**
  - **Access to safe drinking water and sanitation as essential human rights, United Nations 2010.**
  - **Paris Agreement under the United Nations Framework Convention on Climate Change, United Nations 2015.**
  - **Twelve principles of water governance, OECD 2015.**
  - **IWA Lisbon Charter for Public Policy & Regulation of Water Services, 2015.**

What do we face on water?

IWA decided to approve the Lisbon Charter 2015:

- **With the principles for sound public policy and effective regulation of water services;**
- **Declaring the respective rights, duties and responsibilities of the:**
  - **Governments**
  - **Regulatory authorities**
  - **Public administration**
  - **Water utilities**
  - **Users.**

How to implement better national management framework on water services?

Better national framework

- **National management framework for water must in general include different components:**
  - **Strategic plans.**
  - **Legislative framework.**
  - **Institutional framework.**
  - **Governance models.**
  - **Service access targets.**
  - **Quality of service goals.**
  - **Tariff policy.**
  - **Tax policy.**

National framework as a set of different components

Better national framework

- **Financial resources.**
- **Construction & renovation of infrastructures.**
- **Structural and operational efficiency.**
- **Capacity building.**
- **Research and innovation.**
- **Entrepreneurship.**
- **Competition.**
- **Users protection, awareness and involvement.**
- **Data and information.**

- **Holistic approach is essential for success of a national management framework!**

Better national framework

- **Adoption of strategic plans for the sector:**
  - Formulation of national strategies with stable implementation.
  - Definition of goals & measures.
  - Annual monitoring and reporting of execution.

- **Definition of legislative framework:**
  - Approving legislation (for services and regulation, tariffs, quality of service, water quality, etc.).
  - Clarification of rules governing the sector.
  - Issuing sound recommendations for the sector.

- **Definition of institutional framework:**
  - Clear responsibilities of authorities on services, environment, water resources, public health, etc.
  - Clear responsibilities of service owner and operator.

Better national framework

- **Definition of the governance of the services:**
  - Public, private or public-private governance and rules.
  - Direct management, delegation and concession.
  - Healthy competition between models.
  - Political decisions must be based on sound studies.

- **Definition of quality of service targets:**
  - Quality of service based on performance indicators.
  - Annual assessment of the quality of service.
  - Annual benchmarking between operators.
  - Assessment of the evolution for each indicator.

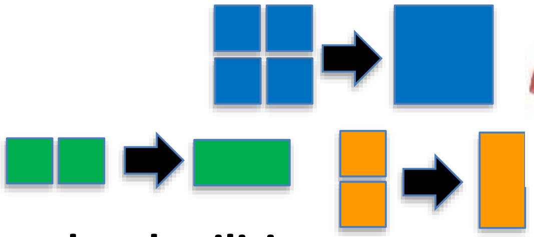
- **Promoting water quality for human consumption**
  - Monitoring compliance in real time.
  - Annual assessment of the water quality operator.
  - Annual benchmarking between operators.
  - Assessment of the evolution of the water quality.

Better national framework

- **Definition of the tariff and tax policy:**
  - Promoting (a trend toward) full cost recovery.
  - Promotion of efficient & affordable tariffs.
  - Assessment of economic performance of operators.
  - Annual benchmarking between operators.
  - Assessment of the evolution of the performance.
- **Management of the financial resources:**
  - Large investment in water infrastructures.
  - Management of important financial resources.
- **Construction and renovation of the infrastructures:**
  - Planning, design, financing & construction.
  - Use of appropriate technologies.
  - Infrastructures asset management.

Better national framework

- Improving the structural efficiency:
  - Search for:
    - Scale economies;
    - Scope economies;
    - Process economies.
  - Current trend to aggregate those local utilities (smaller number of larger and integrated utilities).



- Improving the operational efficiency:
  - Improve of efficiency by the utilities (commercial & physical water losses, energy efficiency, etc.).

- Human resources capacity building:
  - Skilled human resources.
  - Experience on planning, design, financing, construction and operation.

Better national framework

- **Promotion of research and development:**
  - Activity on research and development with increasing links between university and industry.
  - Increasing participation in international R&D projects.

- **Development of entrepreneurship:**
  - Improving the development of the water economy.
  - Generating new activities with employment creation.

- **Introduction of competition:**
  - Competition encourages innovation and progress.
  - In the case of natural or legal monopolies, promote virtual competition, ex. through benchmarking.
  - In the case of private involvement, competition in the market (tender procedures for the allocation of delegations, concessions and the provision of services).

Better national framework

- **Users protection, awareness and involvement:**
  - **Assessment of the economic accessibility to the service based on an indicator of affordability.**
  - **Creation of tools to protect consumers in general:**
    - **Right to be served when the public system is available.**
    - **Right to be served within few days of subscription request.**
    - **Right to have a 24h x 365 days of service.**
  - **Creation of tools to protect poor consumers:**
    - **Right to benefit from a social tariff (poor families).**
    - **Right to benefit from a family tariff (large families).**

- **Provision of information:**
  - **Providing rigorous & comprehensive information.**
  - **Disseminate information at public level.**
  - **Guaranteeing ease-of-use by consumers.**

Better national framework

- The implementation of one or a subset of these components is not sufficient to ensure the sustainability of the sector.
- This does not achieve the results expected in a long-lasting manner.
- The success of a national framework depends on the ability to manage the implementation of its components, with a effective global and integrated approach.

What is the role of regulation of water services?

Role of regulation of water services

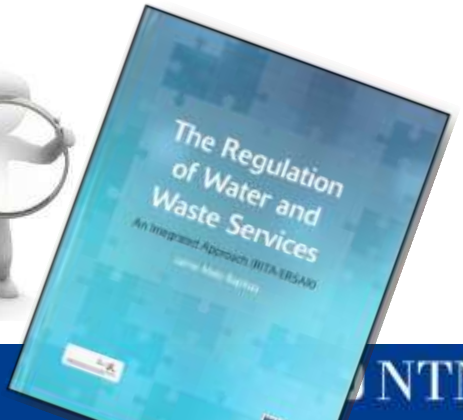
▪ The importance of regulation:

- Regulation should be seen as one component of the national framework on water, out various.
- But it has a very important role given the fact that it promotes and or controls the remaining components.
- Effective regulation is essential.
- Different models can be used according country context.

National framework as a set of different components

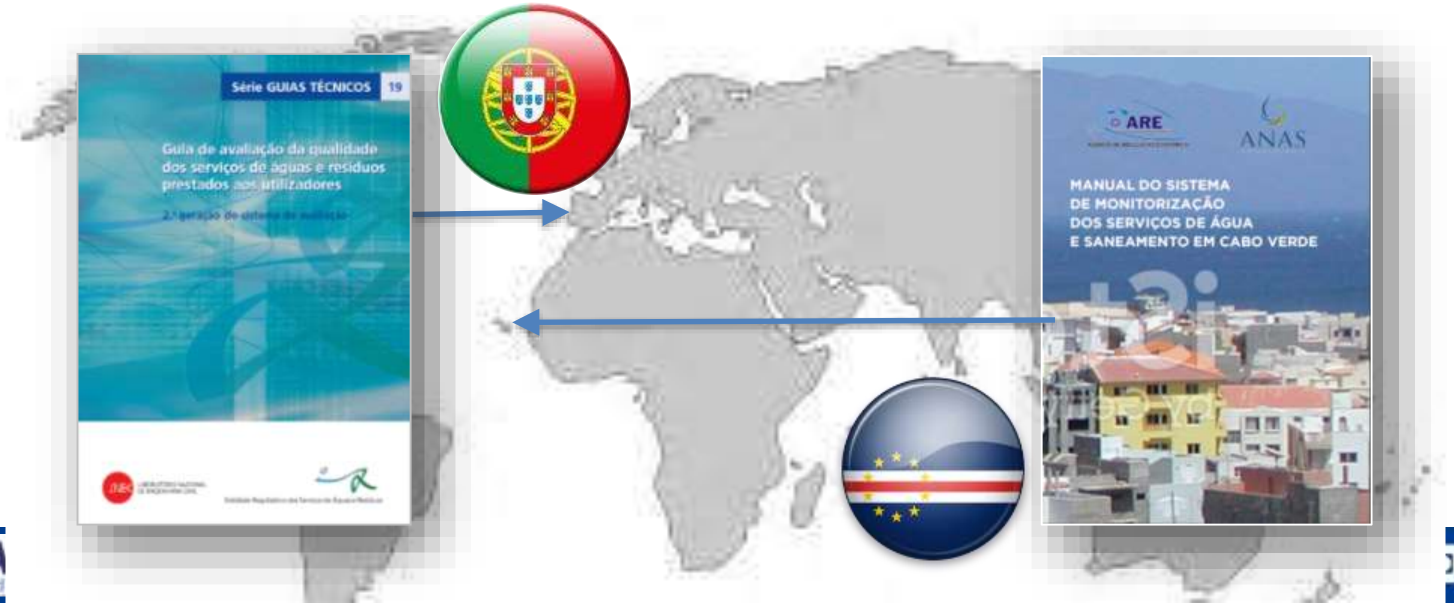
Role of regulation of water services

- **Regulatory model:**
  - Structural regulation of the sector:
    - Contribution to the organisation of the sector.
    - Contribution to the legislation of the sector.
    - Contribution to the information of the sector.
    - Contribution to the capacity building of the secto
  - Behavioural regulation of the utilities:
    - Legal and contractual regulation.
    - Economic regulation.
    - Quality of service regulation.
    - Drinking water quality regulation.
    - Consumers interface regulation.



Role of regulation of water services

- **Regulatory instrument must be adapted to the context of the country.**
  - **Examples of different KPI systems for quality of service regulation:**



Role of regulation of water services

- **Regulators have become an important element of modern governance of water.**
- **For this reason, a growing number of regulators have been created in recent years (170?):**
  - **28 regulators in Europe.**
  - **45 regulators in North America.**
  - **62 regulators in South & Central America.**
  - **6 regulators in Asia.**
  - **14 regulators in Africa.**
  - **12 regulators in Oceania.**

Role of regulation of water services

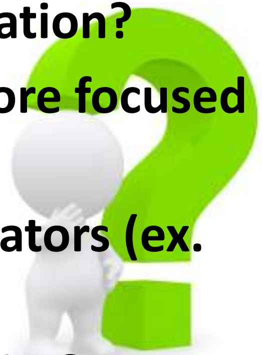
- **Positive impacts of (independent) regulation:**
  - **It is a powerful tool for an effective national framework.**
  - **It promotes/controls its components.**
  - **It promotes short / medium / long term technical approach, instead of short term politic approach.**
  - **It “decreases” political influence in the sector.**
  - **It promotes stability across time (long term).**
  - **It promotes more harmonization in the sector (ex. levels of service and tariff structures).**
  - **It promotes more transparency in the sector.**
  - **It promotes more citizens’ involvement and responsible participation.**

Role of regulation of water services

- It introduces optimization of the efficiency and effectiveness, sustainability and social sensitivity.
- It promotes that public services will respond to the strategy objectives.
- It promotes a better balance of different powers.
- It contributes to legal certainty of the stakeholders involved in the sector.
- It introduces effective accountability tools.
- It promotes better public perception of water tariffs, and water governance.
- It promotes future investment to maintain aging infrastructure.
- It address increased resilience issues ex. building new infrastructure to face future threats.

Role of regulation of water services

- **Some question to be raised about regulation:**
  - **Regulation must be independent or not? What that means? What level of independence?**
  - **Regulation must be sectorial or multisector?**
  - **Operate at national, regional or local level?**
  - **Regulate all the utilities, or only the privates utilities?**
  - **Adopt a hard regulation or a pedagogic regulation?**
  - **Adopt an integrated (holistic) approach or more focused on some aspects (ex. economics)?**
  - **How to link with other related sectorial regulators (ex. competition, environment, health)?**
  - **How to promote innovation, not being a barrier?**



What have been the results of the public policy and regulation for water services in Portugal?

Example of Portugal

- **Portugal is an good "case study":**
  - A new and sound public policy was implemented in the last two decades (1993-2016).
  - One regulator (ERSAR) was created (2000).
  - 16,000 professionals have been involved.
  - Many successes have been achieved.
  - Some mistakes was made.

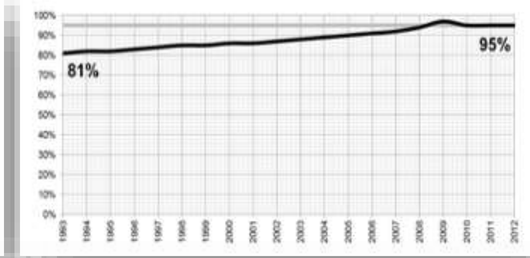
Portugal
Area: 92,000 km²
Population: 10,000,000

Example of Portugal

- **With this water reform Portugal:**
  - **Mobilized large investments (10 000 M €) on water services in the last 22 years.**
  - **Planned to invest more 3 700 M€ until 2020.**
  - **Spend 2 000 M€ annually with management, operation & maintenance of the services.**
  - **Currently has valuable public infrastructure assets, complex and demanding in terms of management, operation & maintenance.**
  - **But a significant part is becoming degraded and requires a sound management.**

Example of Portugal

The Portuguese public policy (1993-2015) was successful for citizens, economy, public health & environment:



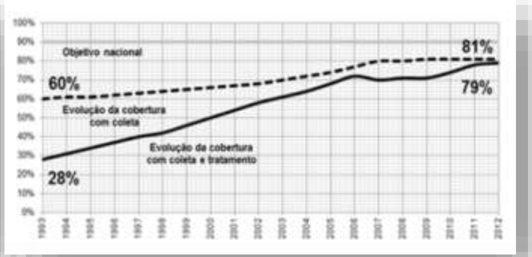
Water supply:
81% ⇨ 95%

Water quality:
50% ⇨ 98,2%

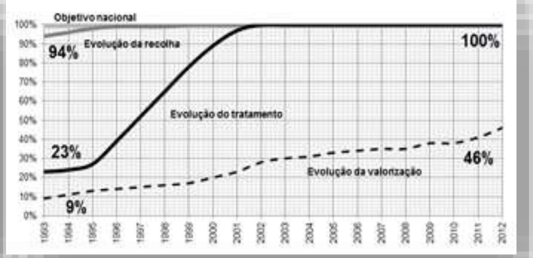
Hepatitis A:
630 ⇨ 8

Example of Portugal

The Portuguese public policy (1993-2015) was successful for citizens, economy, public health & en



Wastewater:
28% ➪ 79%

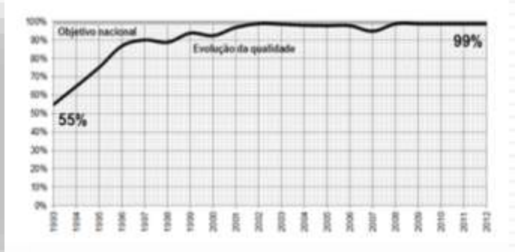


Solid waste:
22% ➪ 100%

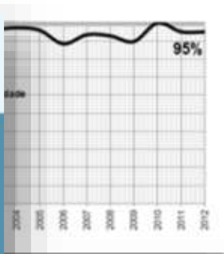
Water resources:
28% ➪ 78%

Example of Portugal

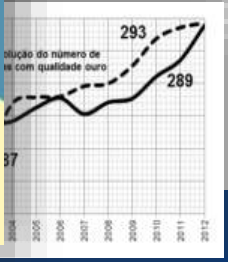
The Portuguese public policy (1993-2015) was successful for citizens, economy, public health & er



Costal beaches
55% ➩ 99%



River beaches:
17% ➩ 95%



Blue flags:
89 ➩ 289

Gold beaches:
87 ➩ 293

Example of Portugal

- **Example of information available: Information available in the smartphone (App ERSAR):**

How to share this experience with other developed and developing countries?

LIS-Water

- **Former United Nations Secretary-General Ban Ki-Moon sent an appeal (2016):**

  Ensuring water and sanitation for all is crucial for reducing poverty and achieving other Sustainable Development Goals.
  I urge all partners to mobilize behind SDG 6 with political, financial and technological support.

- **We accept to face this appeal and contribute for the compliance of the UN SDG 6+ "Water".**

- **With that objective we recently created a new centre of excellence, LIS-Water.**

European Commission | Horizon 2020 European Union funding for Research & Innovation

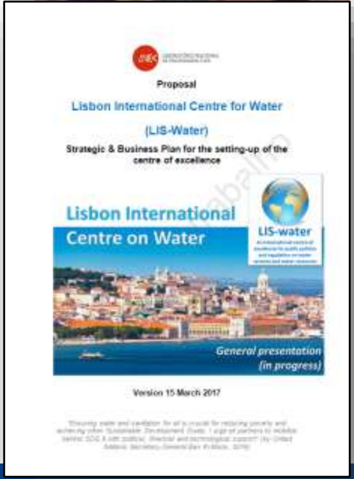
Lisbon International Centre for Water

LIS-Water

International centre on public policies, regulation and management for water services and water resources

LIS-Water

- LIS-Water is a non-profit centre of excellence focused on public policies, regulation and management on water services and water resources.
- Promoted by the National Laboratory for Civil Engineering (LNEC) ...
- … with a effective partnership with many internationally recognised Portuguese, non-Portuguese and international organisations.
- LIS-Water will be an inclusive project, all the stakeholders are welcome!


Proposal

Lisbon International Centre for Water

(LIS-Water)

Strategic & Business Plan for the setting-up of the centre of excellence

Version 15 March 2017

LIS-Water

- **In a glance:**

LIS-Water will focus on these 1+4 aspects and on new instruments to an better linkage between them

LIS-Water

- **LIS-Water is a centre fully dedicated to the public policy, regulation and management of water services and water resources.**
- **LIS-Water will contribute to solutions for global water problems.**
- **LIS-Water will help countries on complying with international resolutions like the Agenda 2015-2030 for Sustainable Development from United Nations (SDG6+).**
- **LIS-Water will support: water policy makers, executives, high level**

LIS-Water

- **LIS-Water has the support of all the type of stakeholders (about 40):**
  - **Central Government**
  - **Regional Government**
  - **Local Government**
  - **Public administration and regulators**
  - **Universities and R&D centres**
  - **Water utilities**
  - **Industry in general**
  - **Technical associations on water**
  - **International organisations**
  - **Multilateral development banks**
  - **Cooperation organisations**
  - **Civil society associations**
  - **Media partners**
- **A “water campus” will be**

LIS-Water

- **Portugal as hosting country, a universal country, full of global history.**
- **Portugal, the heart of Lusophony (267 million Portuguese speaking people).**
- **Lisbon as hosting city for this Centre, a beautiful place to live, work, study and visit.**
- **LNEC as hosting organisation, with a large campus and many skills.**




LIS-Water

- **Good facilities:**

  Office spaces
  2 auditoriums
  6 class rooms
  1 large library
  Several working spaces
  30 laboratories (several certified)
  Videoconference rooms
  Video/broadcasting centre
  Students accommodation
  Coffee and lunchrooms
  Access to medical care
  Access to a kinder garden
  Outdoor exercise facilities.


Lunchroom


Congress centre


Research facilities


Accommodation


Main auditorium


Laboratories


Medical care


Class rooms


Videoconference


Kinder garden


Library


Broadcasting

Videoconference


Outdoor facilities

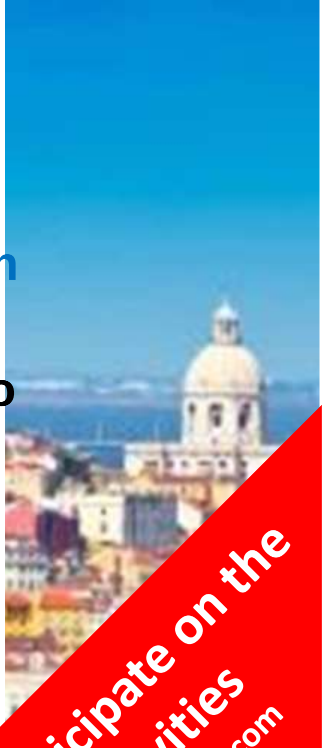
LIS-Water

- **LIS-Water got funding from:**
  - **European Union trough DGResearch (2017)**
  - **Program: Horizon 2020 (2016-2017)**
  - **Pillar: Spreading excellence and widening participation**
  - **Schedule: 1 September 2017 till 31 August 2018**

European Commission

Horizon 2020
European Union funding
for Research & Innovation

LIS-Water



- In summary, LIS-Water will boost research and innovation on public policies, regulation and management.
- Will promote think-tank & strategic advice to assist decision makers.
- Will promote education, training & capacity building for water professionals.
- Will support business, incubation of start-ups & acceleration.
- Will support the social engagement on water.
- LIS-Water will strongly support count compliance with SDG6+.

You can also participate on the LIS-Water activities

Contact: rita.amaral@live.com

The need to face new water challenges

8th World Water Forum 2018 in Brazil

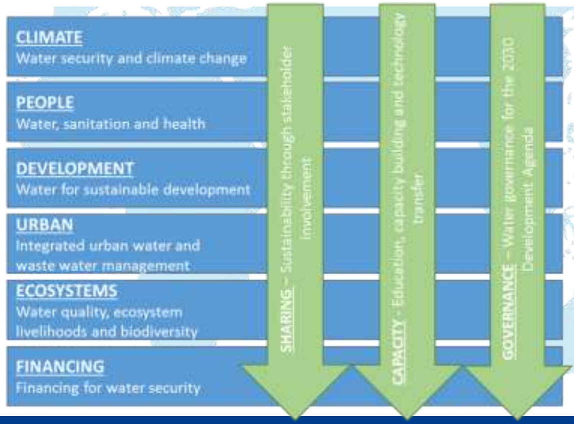
European Regional Process

WORLD WATER COUNCIL

The European Regional Process

- **8th World Water Forum 2018 in Brazil:**

- **Thematic matrix, covering the main Water challenges:**



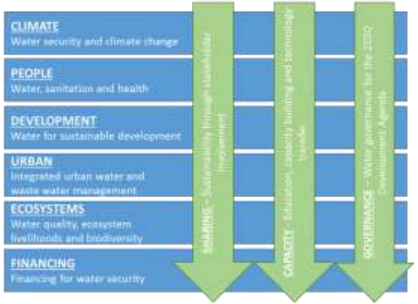
The European Regional Process

- Methodology used for European Regional Process:
  - Preparation of a survey sent out to all the European countries.
  - Identification the contact points for each European country.
  - Contact with international organisations (e.g. EC, OECD, EEA).
  - Collection, processing and interpretation of answers.
  - Selection of good case studies.
  - Kick off meeting in The Hague, May 2017.
  - Design of the sessions of the European Regional Process.
  - Contribution to the design of inter-regional sessions.
  - Preparation of the 1st draft of European Report.
  - Workshop at Stockholm World Water Week, Au
  - Wrap-up meeting in Porto, Portugal, 26 Sept
  - Conclusion of the European Report, Marc

You are invited to participate
on the next meetings!
(free registration)

The European Regional Process

- **Methodology used for European Regional Process:**
  - **Mailing to 51 Countries / more than 200 Organisations:**
    - Water resources administration
    - Water services administration
    - Water industry
    - European CSOs/ NGOs on water
    - European regional water networks
    - International organisations



  - **For each topic the questions are always the same:**
    - What is the relevance of this topic in Europe?
    - What is the relevance of this topic in your country?
    - What is the public perception of this topic in your country?
    - What is the current performance of your country on this topic?
    - What is the level of engagement of your country on this topic?
    - To what extent can you identify a case study in your country?
  - 95 replies received (40%) so far.

The European Regional Process

8th World Water Forum Brasilia-Brazil 2018 Sharing water

https://pt.surveymonkey.com/r/WWF8_EUR

- **Based on:**
  - The results of the survey to all the 51 European (UNECE) countries;
  - Outcomes of the 2nd Stakeholder meeting in April in Brasilia;
  - Outcomes of the kick off meeting in May in The Hague.
- **Priorities for discussion in the WWF seems to be:**
  - Theme CLIMATE - Water security and climate change
    - 1st: Water and adaptation to climate change
    - 2nd: Managing risk and uncertainty for resilience and disaster preparedness
    - 3rd: Climate science and water management priority: the communication between science and decision/policy making
    - 4th: Water and climate change mitigation
  - Theme PEOPLE: Water, sanitation and health
    - 1st: Water and public health
    - 2nd: Integrated sanitation for all + Enough safe water for all

The European Regional Process

https://pt.surveymonkey.com/r/WWF8_EUR

- Theme DEVELOPMENT: Water for sustainable development
  - 1st: Efficient use of surface water and groundwater - urban and rural
  - 2nd: Water, energy and food security nexus
  - 3rd: Inclusive and sustainable growth, water stewardship and industry
  - 4th: Infrastructure for sustainable water resource management and services
- Theme URBAN: Integrated urban water and waste management
  - 1st : The circular economy - reduce, reuse, recycle
  - 2nd: Treatment and reuse technologies
  - 3rd: Water and cities
- Theme ECOSYSTEMS: Water quality, ecosystem livelihoods and biodiversity
  - 1st: Managing and restoring ecosystems for water services and biodiversity
  - 2nd: Water and land use
  - 3rd: Ensuring water quality from ridge to reef
  - 4th: Natural and engineered hydrological systems
- Theme FINANCING: Financing for water security
  - 1st: Economics and financing for innovative investments
  - 2nd: Financing implementation of water-related SDGs & adaptation to climate change
  - 3rd: Finance for sustainable development - supporting water-friendly business

The European Regional Process

▪ Prioritisation of 21 topics:

- What is the relevance in your country?

- What are the top 5?

1. The circular economy - reduce, reuse, recycle
2. Managing and restoring ecosystems for water services and b
3. Water and adaptation to climate change
4. Treatment and reuse technologies Mediterranean
5. Managing risk and uncertainty for resilience and dis

You can still participate in this survey till 23 June
Contact: rita.amaral@live.com

Lisbon International Centre on Water

LIS-water

An international centre of excellence for public policies and regulation on water services and water resources

jmbaptista@lnec.pt

LESAM 2017
NTNU, Trondheim, Norway

Keynote:

Digitalisation trends and opportunities/ Bård Benum, CEO Powel

DIGITALIZATION TRENDS AND OPPORTUNITIES

BÅRD BENUM, CEO POWEL

TOPICS

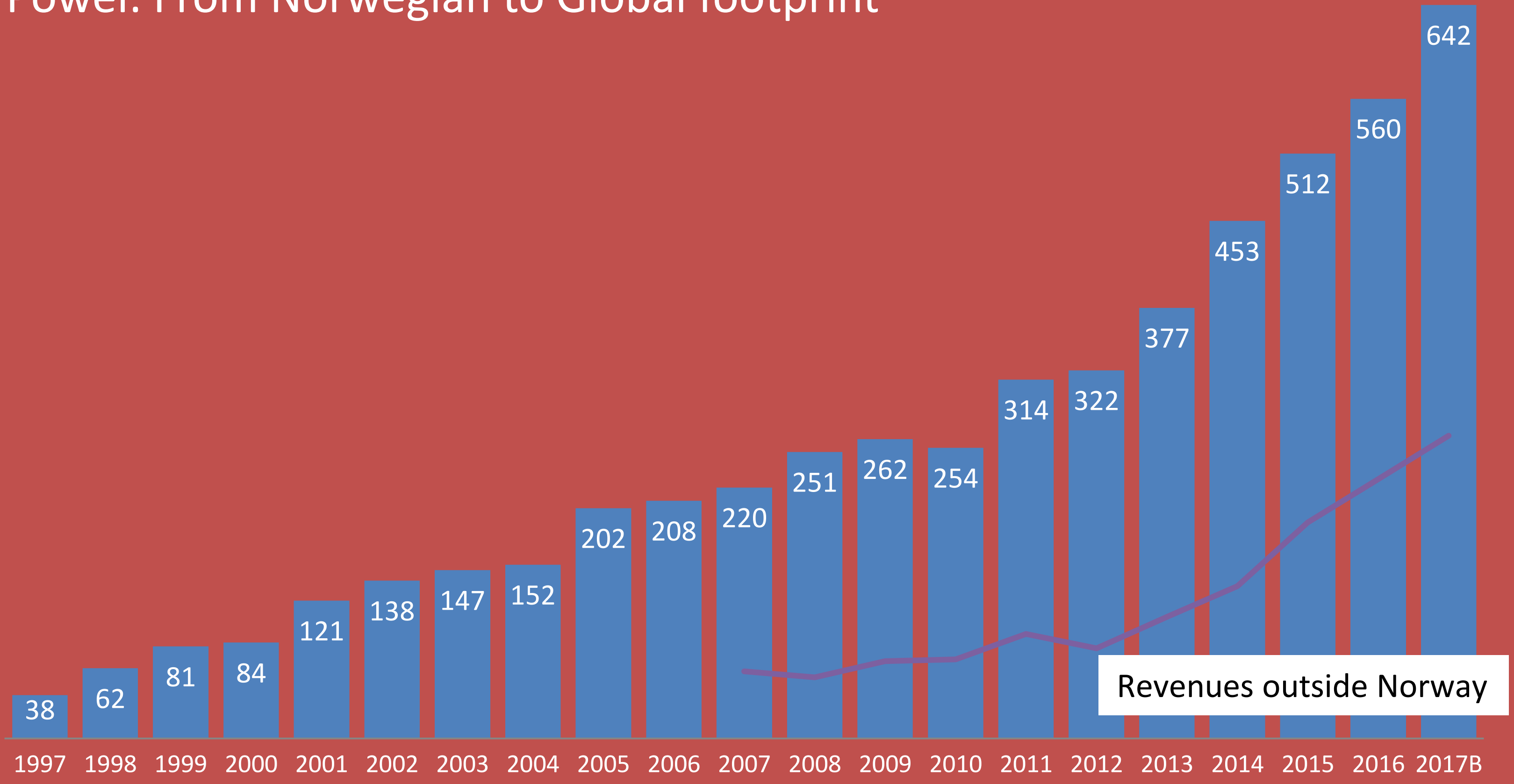
- Powel in short
- Technology changes last 30 years
- How to digitalize?
- Digital solutions, most promising areas

POWEL

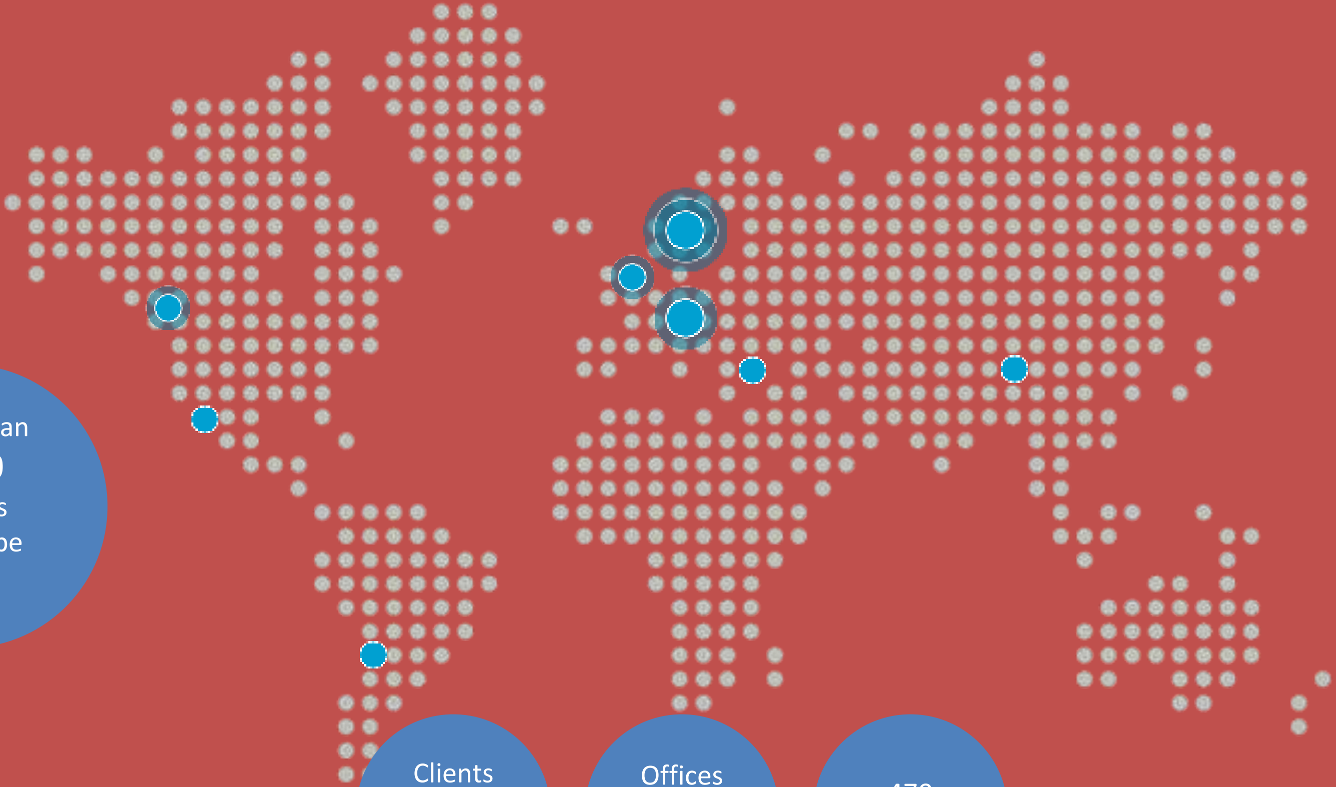
Digitalization with sustainability

(Renewable) Energy | Water | Infrastructure

Powel: From Norwegian to Global footprint



Powel : From Norwegian to Global footprint



More than
1300
clients
in Europe

Clients
in 19
Countries

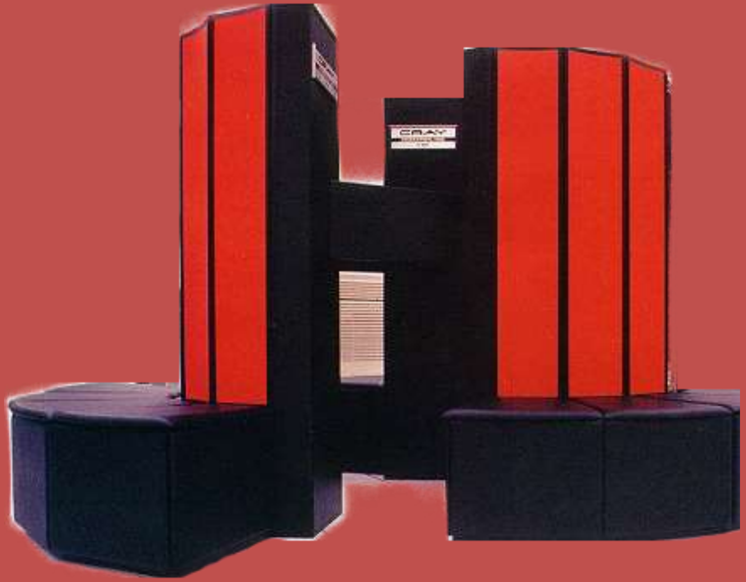
Offices
in 7
Countries

470
Employees

Technology changes last 30 years

Technology changes last 30 years

1986



Cray X-MP – 17 mill (2017) €

2016

Iphone 6S – 300X faster

Technology changes last 30 years

1993

World Wide Web

Free to anyone

2017

3,636,711,203

Internet Users in the world

Technology changes last 30 years

2004

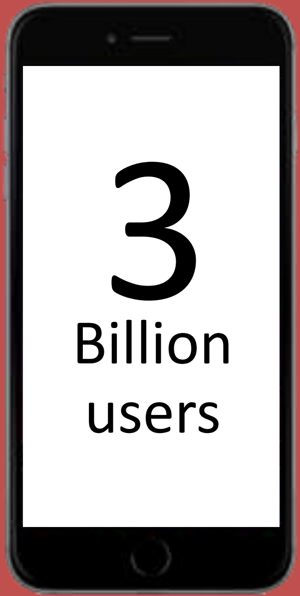
facebook

2017

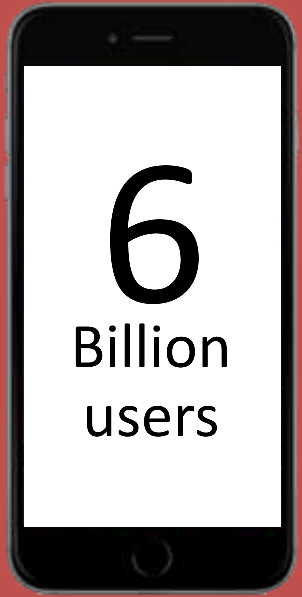
Facebook is closing in on 2 billion monthly users

First real smartphone

2007



2016



2020

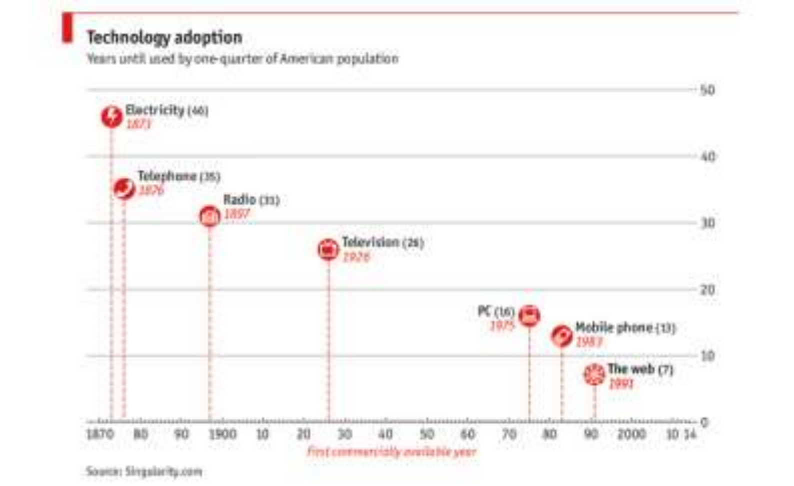
RADICAL CHANGES

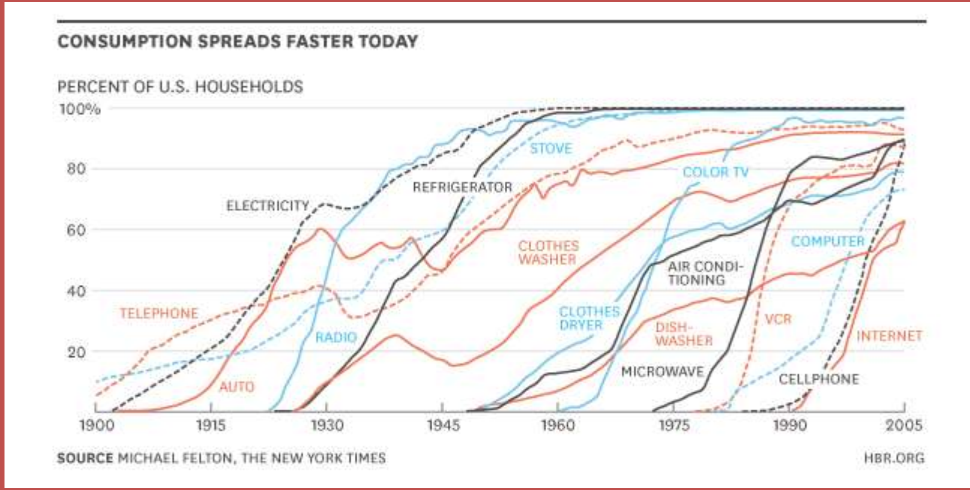
- Data power
- Network
- Data & information sharing
- Mobility

INNOVATION

The Pace of Technology Adoption is Speeding Up

by Rita McGrath





We need shorter time to market within digitalization…..

How to digitalize?

New innovation ->

Shorter time to market….

INNOVATION

”Everything should be made as simple as possible, but not simpler”

Albert Einstein

Fear of failure

&

Lowest possible cost

⬇

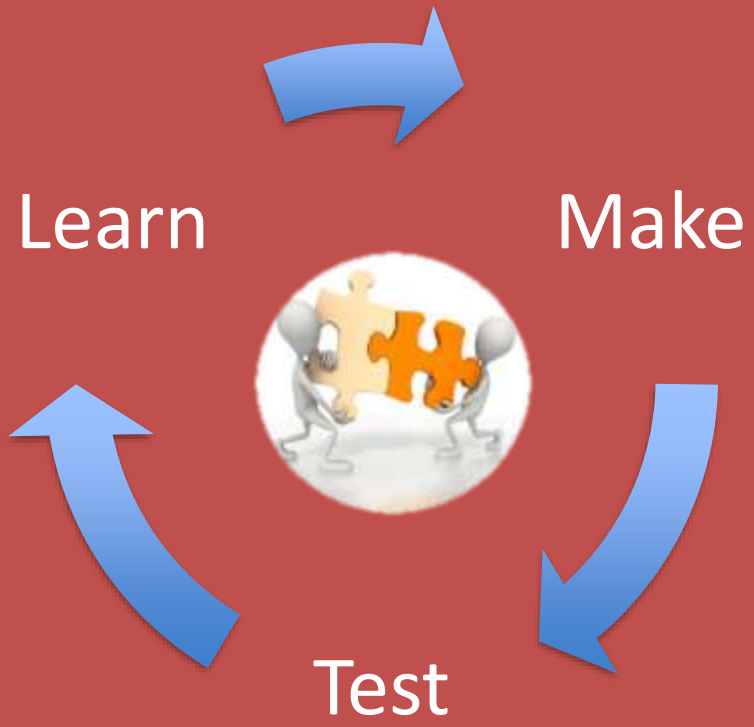
No innovation

Amy
Edmondson
HARVARD
BUSINESS
PUBLISHING
Microsoft
esri
Know How &
Recruitment
Learning
Organization
Co-Creation
define
ideate
learn
DESIGN
THINKING
prototype
implement
choose
Global
Partners
Design
Thinking
Innovation
Labs

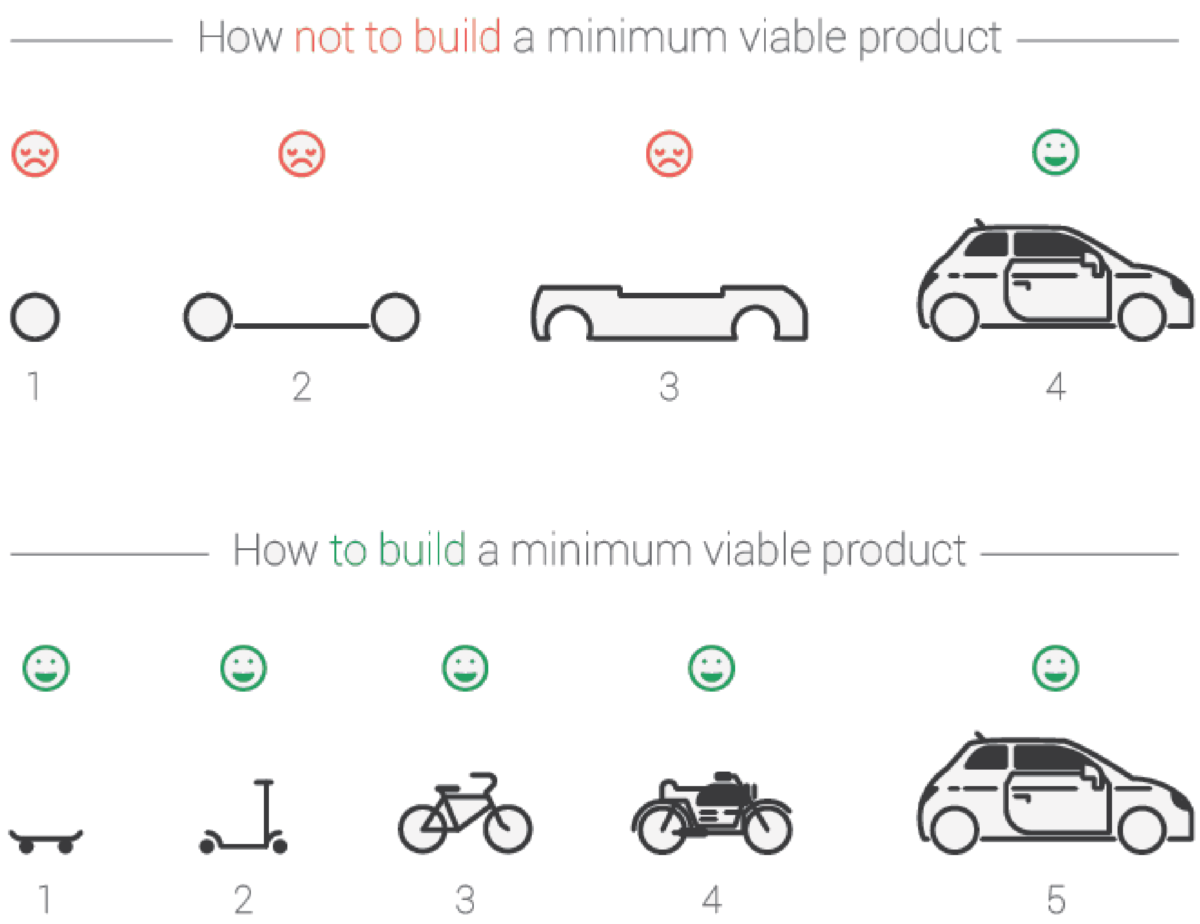
Bergen Municipality

Digitalisation through Co-creation

LEAN STARTUP & CO-CREATION



MVP



How not to build a minimum viable product
1
2
3
4
How to build a minimum viable product
1
2
3
4
5

Digital solutions, most promising areas

New opportunities faster than ever

It´s all about data…

IT IS ALL ABOUT DATA….

Digital transformation

Big Data

Machine learning

Analytics

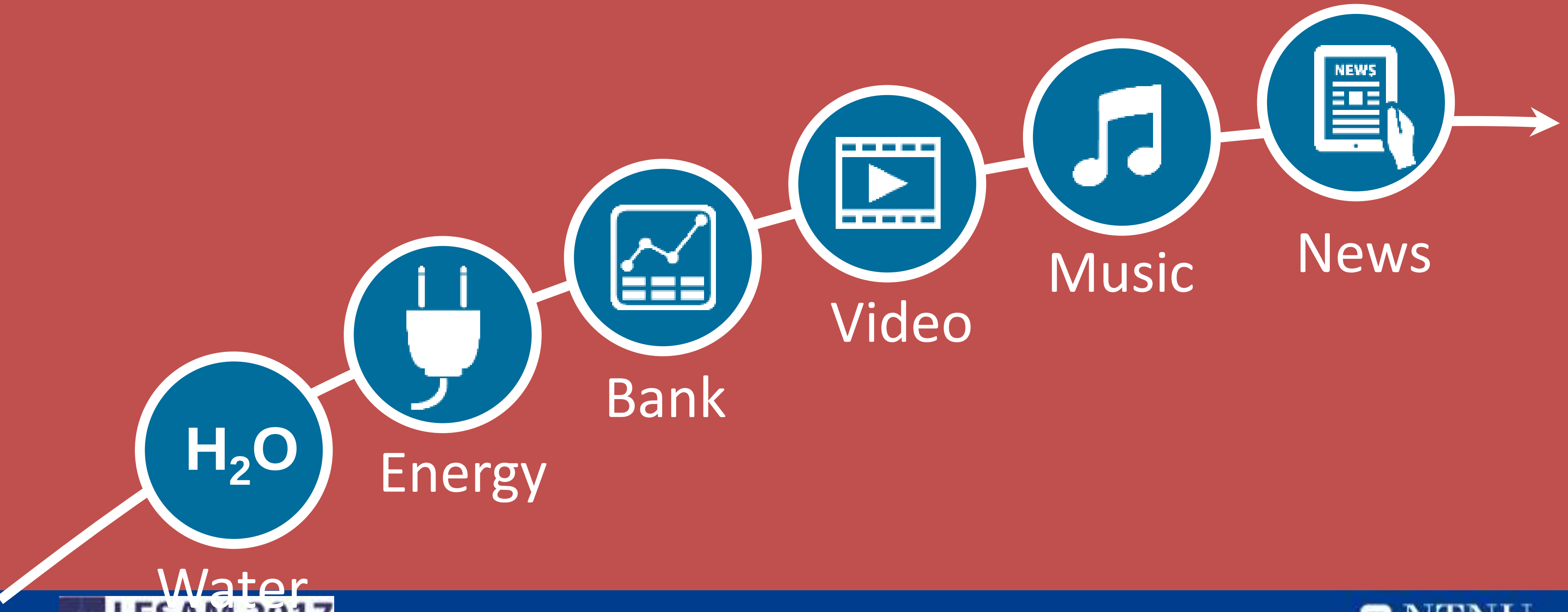
Robotics

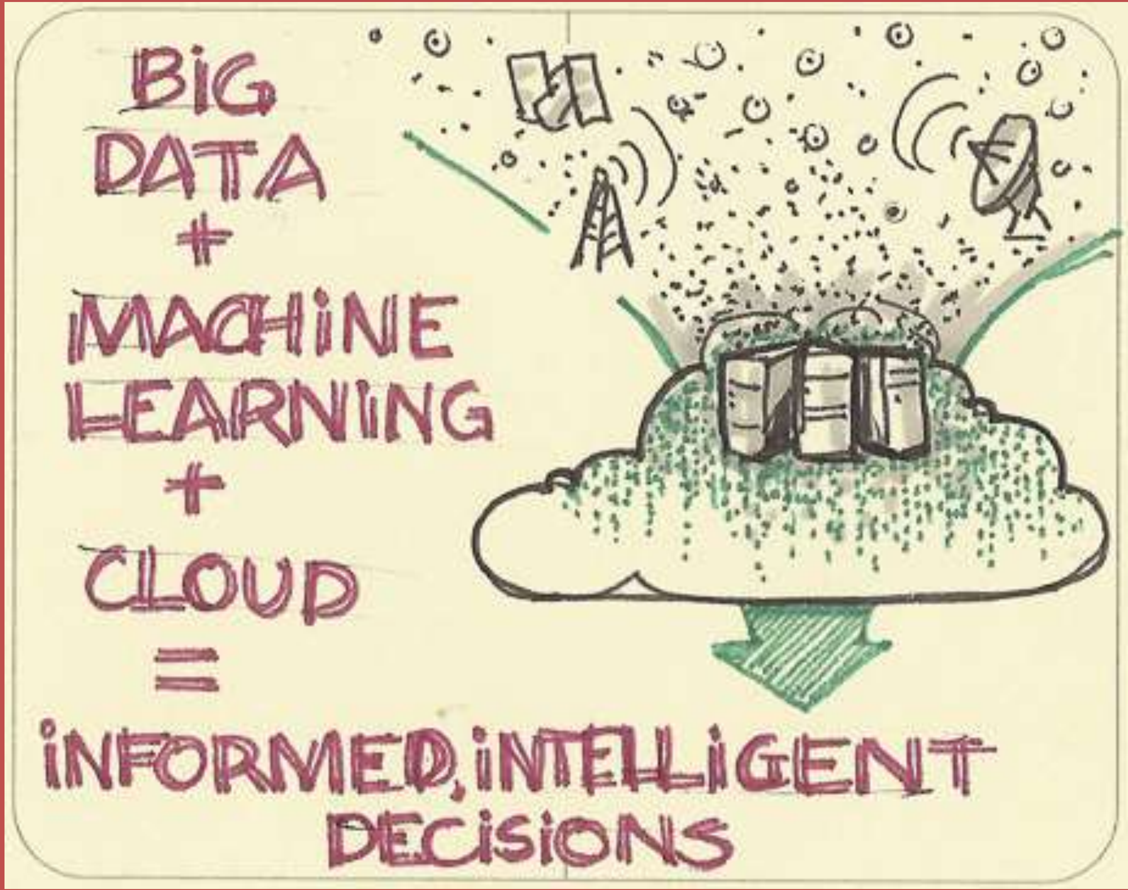
IoT

Sensors

Mobile solutions

DIGITALIZATION - RADICAL CHANGES




BIG
DATA
+
MACHINE
LEARNING
+
CLOUD
=
INFORMED, INTELLIGENT
DECISIONS

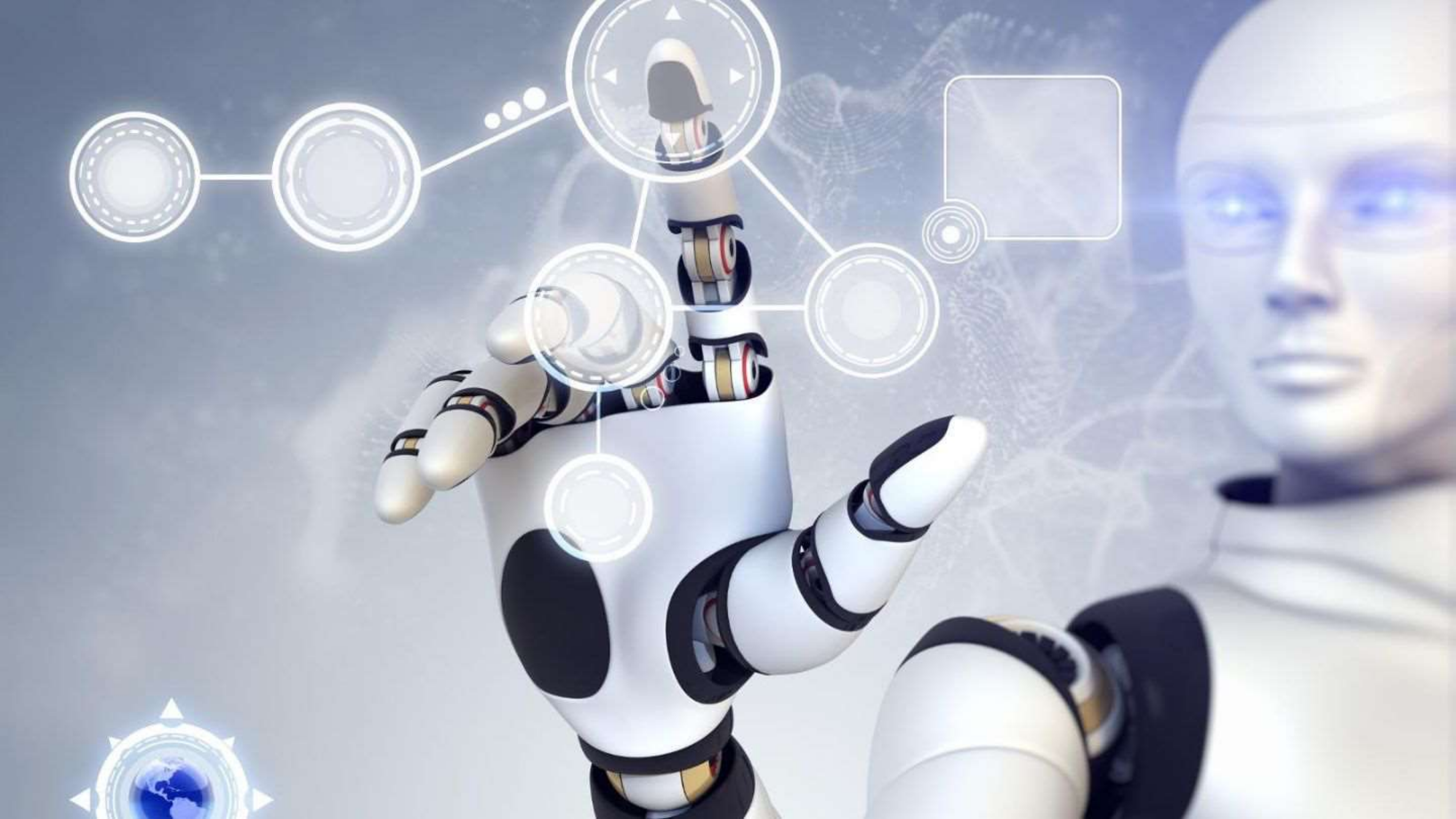
IT´S ALL ABOUT DATA

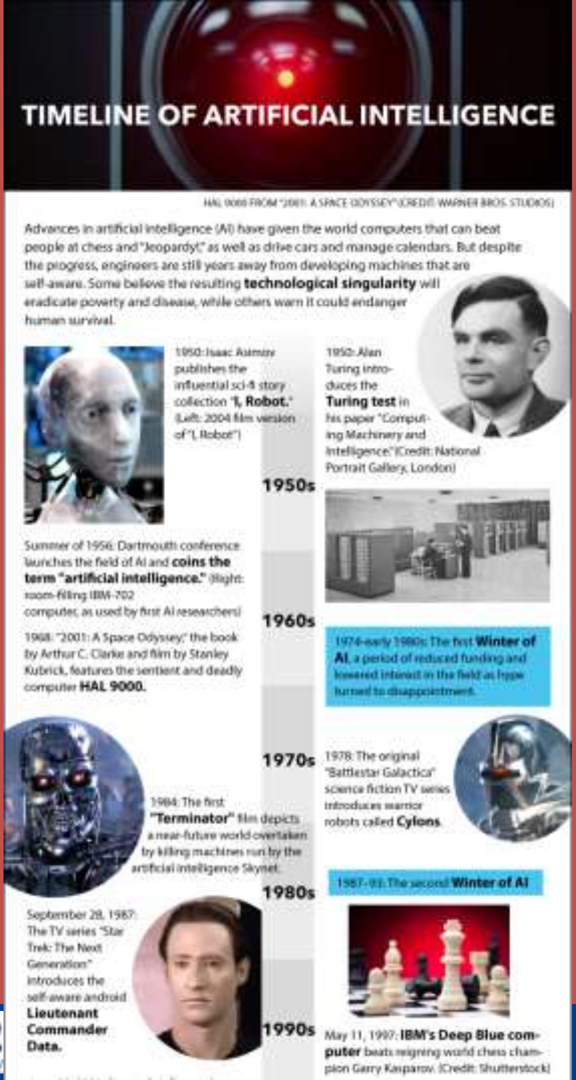
- What do we know today?
- What do we know, but do not know?
- What will we be able to know?

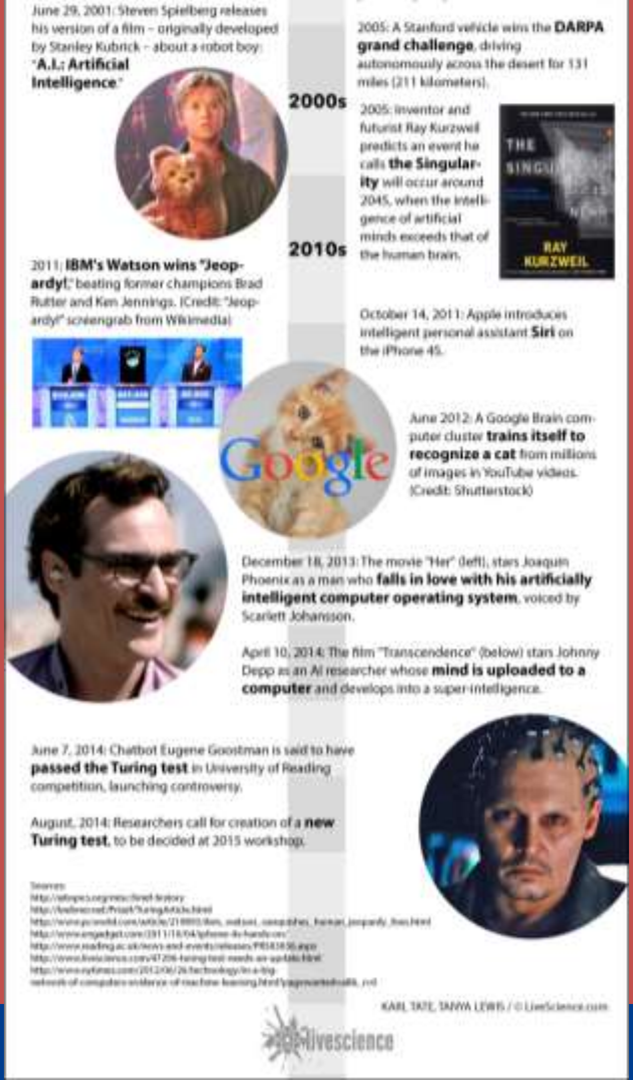
The Future

or

opportunities today?



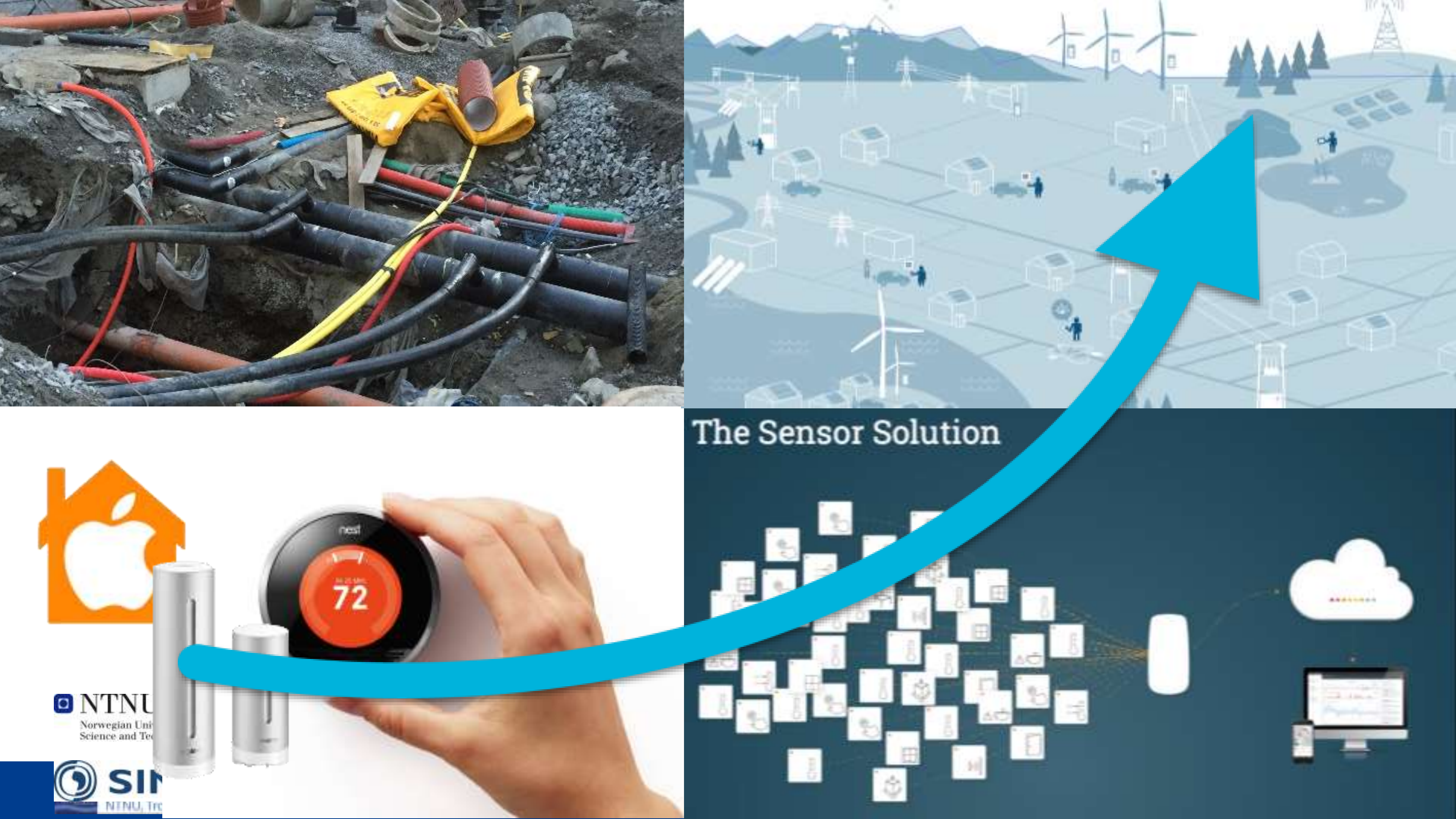

TIMELINE OF ARTIFICIAL INTELLIGENCE
HAL 9000 FROM "2001: A SPACE ODYSSEY" (CREDIT: WARNER BROS. STUDIOS)
Advances in artificial intelligence (AI) have given the world computers that can beat people at chess and "Jeopardy!," as well as drive cars and manage calendars. But despite the progress, engineers are still years away from developing machines that are self-aware. Some believe the resulting technological singularity will eradicate poverty and disease, while others warn it could endanger human survival.
1950: Isaac Asimov publishes the influential sci-fi story collection "I, Robot." (Left: 2004 film version of "I, Robot")
1950: Alan Turing introduces the Turing test in his paper "Computing Machinery and Intelligence." (Credit: National Portrait Gallery, London)
1950s
Summer of 1956: Dartmouth conference launches the field of AI and coins the term "artificial intelligence." (Right: room-filling IBM-702 computer, as used by first AI researchers)
1960s
1968: "2001: A Space Odyssey," the book by Arthur C. Clarke and film by Stanley Kubrick, features the sentient and deadly computer HAL 9000.
1974-early 1980s: The first Winter of AI, a period of reduced funding and lowered interest in the field as hype turned to disappointment.
1970s
1978: The original "Battlestar Galactica" science fiction TV series introduces warrior robots called Cylons.
1984: The first "Terminator" film depicts a near-future world overtaken by killing machines run by the artificial intelligence Skynet.
1980s
1987–93: The second Winter of AI
September 28, 1987: The TV series "Star Trek: The Next Generation" introduces the self-aware android Lieutenant Commander Data.
1990s
May 11, 1997: IBM's Deep Blue computer beats reigning world chess champion Garry Kasparov. (Credit: Shutterstock)


June 29, 2001: Steven Spielberg releases his version of a film – originally developed by Stanley Kubrick – about a robot boy: "A.I.: Artificial Intelligence."
2000s
2005: A Stanford vehicle wins the DARPA grand challenge, driving autonomously across the desert for 131 miles (211 kilometers).
2005: Inventor and futurist Ray Kurzweil predicts an event he calls the Singularity will occur around 2045, when the intelligence of artificial minds exceeds that of the human brain.
RAY KURZWEIL
2010s
2011: IBM's Watson wins "Jeopardy!," beating former champions Brad Rutter and Ken Jennings. (Credit: "Jeopardy!" screengrab from Wikimedia)
October 14, 2011: Apple introduces intelligent personal assistant Siri on the iPhone 4S.
Google
June 2012: A Google Brain computer cluster trains itself to recognize a cat from millions of images in YouTube videos. (Credit: Shutterstock)
December 18, 2013: The movie "Her" (left), stars Joaquin Phoenix as a man who falls in love with his artificially intelligent computer operating system, voiced by Scarlett Johansson.
April 10, 2014: The film "Transcendence" (below) stars Johnny Depp as an AI researcher whose mind is uploaded to a computer and develops into a super-intelligence.
June 7, 2014: Chatbot Eugene Goostman is said to have passed the Turing test in University of Reading competition, launching controversy.
August, 2014: Researchers call for creation of a new Turing test, to be decided at 2015 workshop.
Sources:
KARL TATE, TANYA LEWIS / © LiveScience.com
livescience

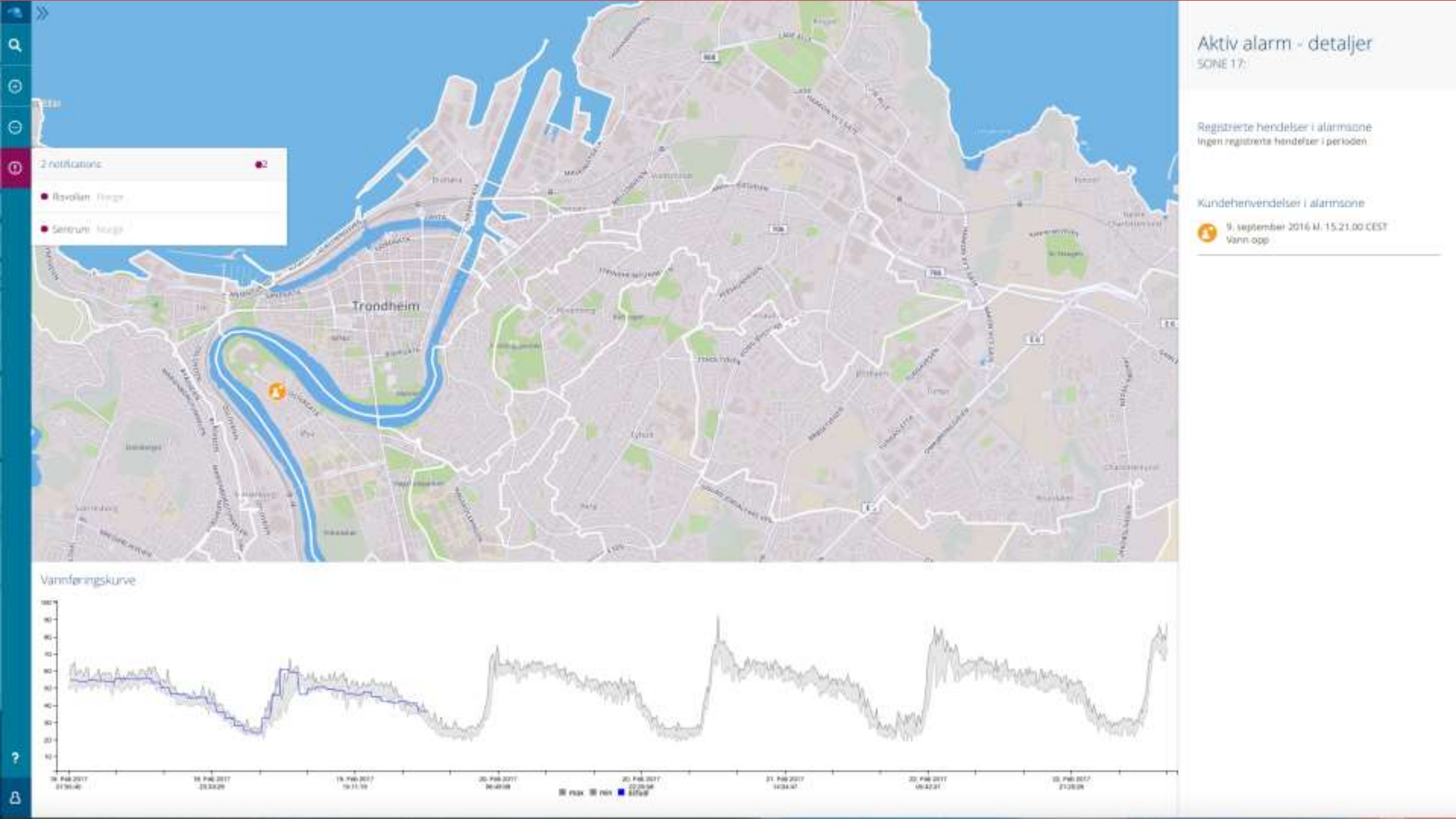
SO, THIS IS NOT NEW, BUT SOMETHING IS NEW..

- Data Power –> Yes we have
- Available Data –> Yes we have
- Ability to share data –> Yes we have


VIVA TECHNOLOGY
bpifrance
bpifrance



The Sensor Solution
nest
72
NTNU

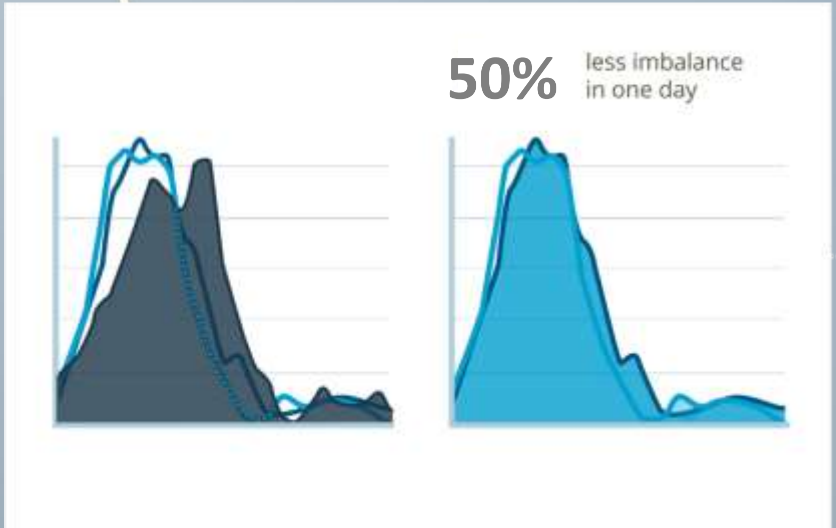


Aktiv alarm - detaljer
SONE 17:
Registrerte hendelser i alarmsone
Ingen registrerte hendelser i perioden
Kundehenvendelser i alarmsone
9. september 2016 kl. 15.21.00 CEST
Vann opp
2 notifications
Rovollan
Sentrum
Trondheim
Vannføringskurve


3402
Temperatur ute
Temperatur inne
Dør


HØYSPENNING
LIVSFARE
TRAFO
0089
Trondheim Energi
13:46:57
Eklesvegen
Bratsbergvegen
Plassen
Håpet
Solstua
Bakkeland
Eklesbakke
Amundsdalvegen
Eklehaugen
Haugstad
Folla
3402
Temperatur ute
Temperatur inne
Dør

WIND POWER FORECASTING



DIGITALIZATION CHALLENGES

- Data Quality
- Culture & Change
- Data Security

WRAP IT UP

- Digital technology is moving faster than ever
- It is all about data
- Lean start-up, fail & learn fast, change
- The AI future is here

INNOVATION IS A STATE OF MIND

Keynote:

From research to practice - the Baseform case / Sergio Coelho, Baseform, Portugal

baseform

From R&D to practice: the Baseform case

Sergio T. Coelho

LESAM 2017 - June 20-22 Trondheim - Norway

AWARE-P
A collaborative, system-based IAM planning software

Leading Edge Strategic Asset Management
September 29, 2011

Sérgio Coelho [LNEC] | Diogo Vitorino [Addition]

AWARE-P Advanced Water Asset Rehabilitation Portugal

1. Baseform
2. technology
3. vision for water infrastructure software
4. R&D to market
5. challenges

about Baseform

Baseform

Baseform is a Software-as-a-Service (SaaS) for water utilities, providing actionable analytics to assist in key business outcomes.

It builds on the utility's existing data, sensorization and IT systems, and leverages cloud technology, enhanced 3D, demographics and deep domain knowledge.

- Founded Jan 2015 (Lisbon, Portugal).
- US-based since Jan 2017
- Currently in 20 cities in Europe, USA, South America (~ 5M pop served)
- 20,000 km in real-time monitored networks; 300 daily utility users

Key features

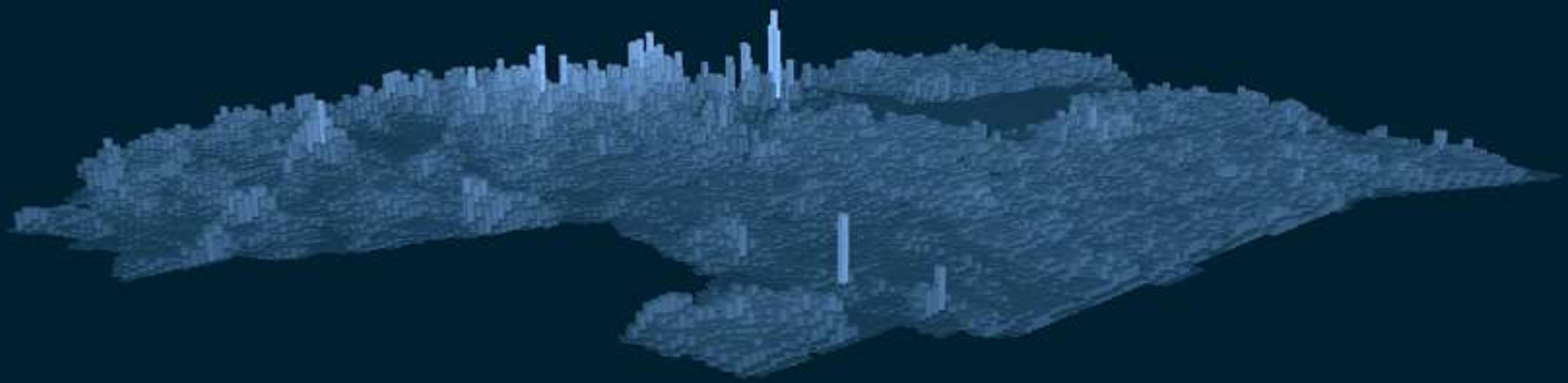
A software designed specifically for decisional processes in the water utility, with the flexibility to easily connect to all relevant data sources for each purpose.

A measurable ROI: drinking water & energy losses, wastewater infiltration & inflow, service performance and risk, CAPEX optimization, asset management prioritization.

- Unlimited users, unlimited data.
- Cloud-based: no IT migration or integration drama.
- A streamlined, next-gen 3D technology.
- A single price point, no hidden costs of any sort (set-up, configuration, support or other)

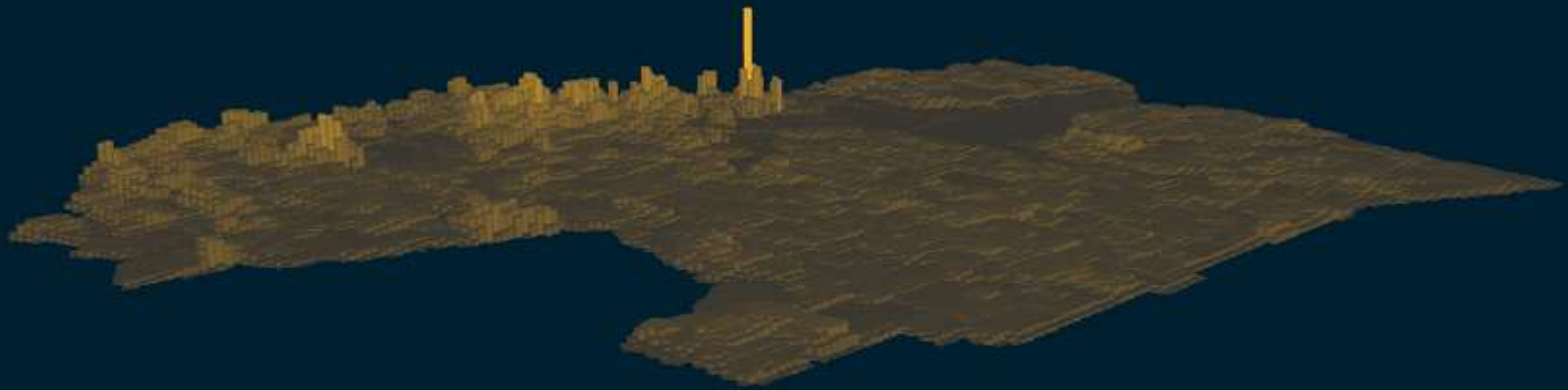
our vision for
water infrastructure
software

1. It's about delivering a service to cities



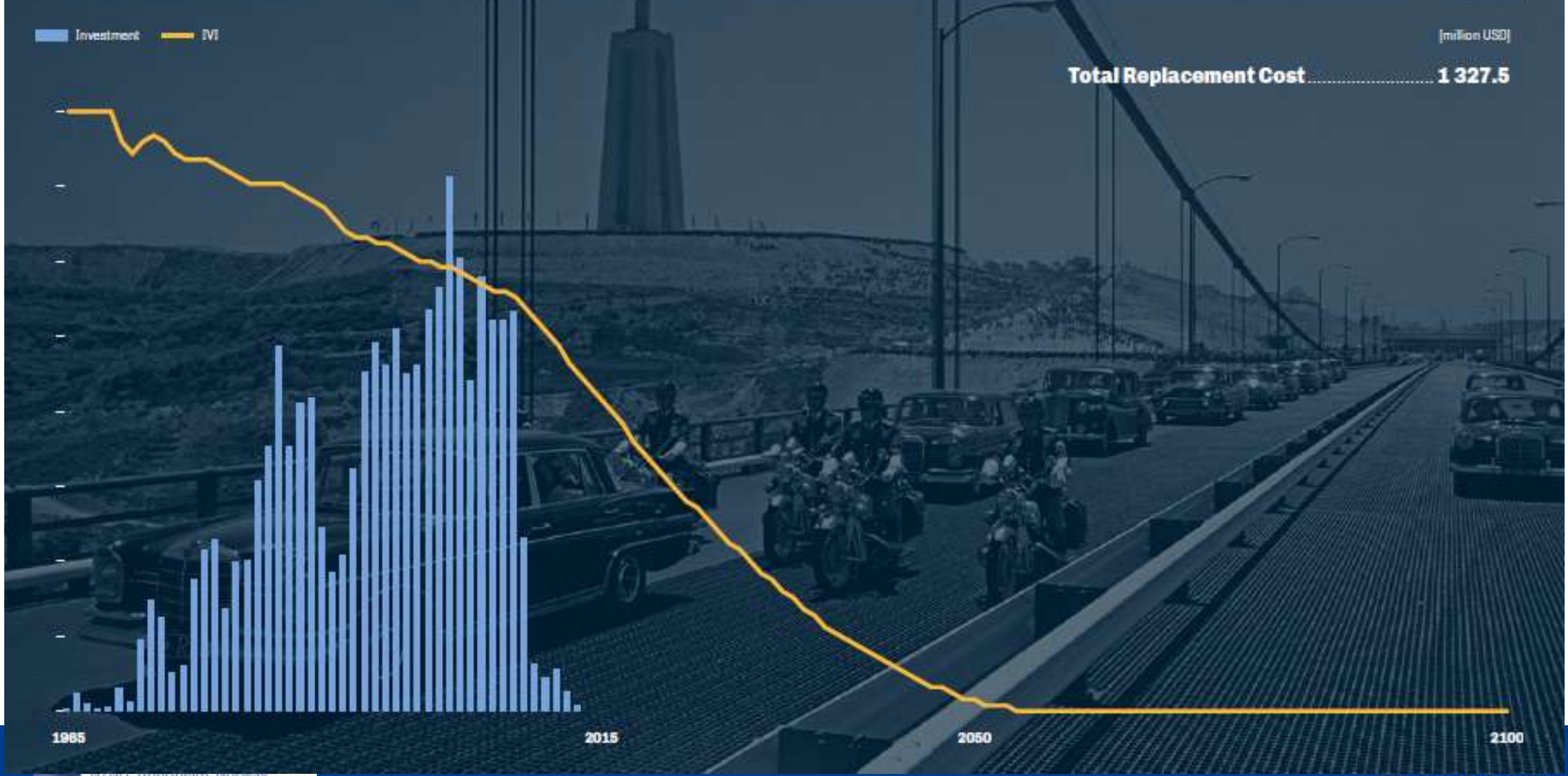
1. It's about delivering a service to cities

baseform



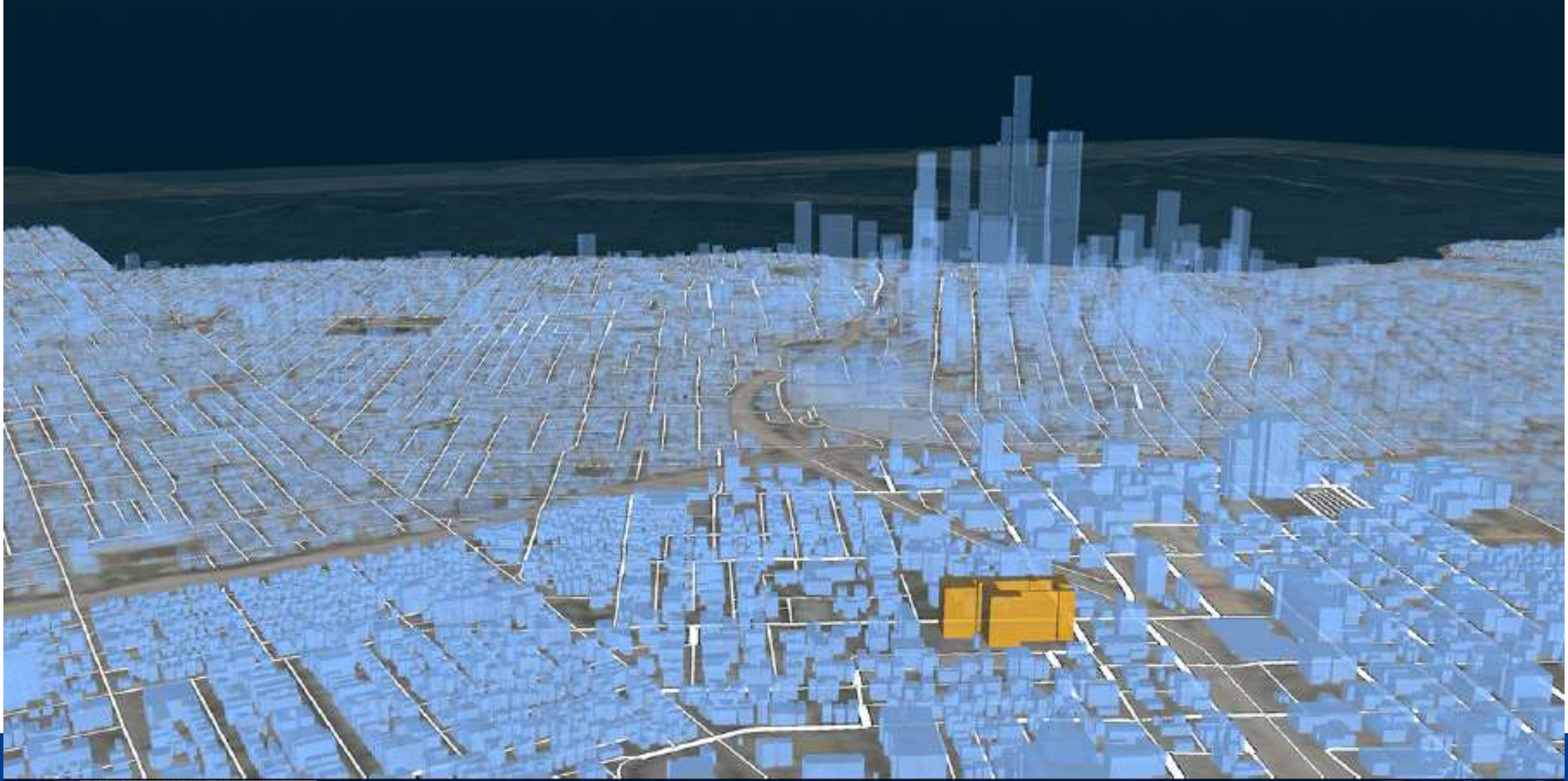
2. Infrastructure

2. Infrastructure

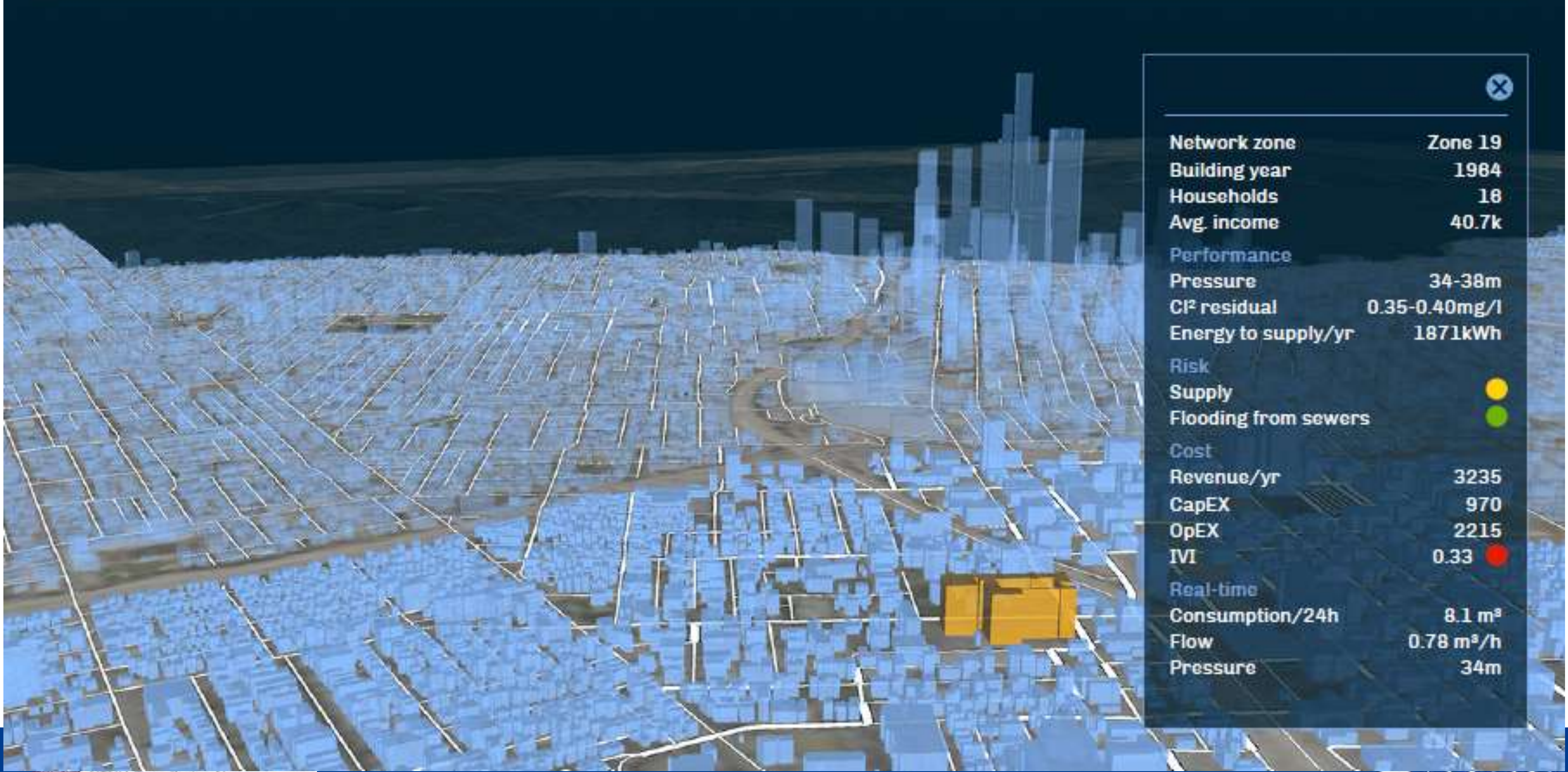


2. Infrastructure

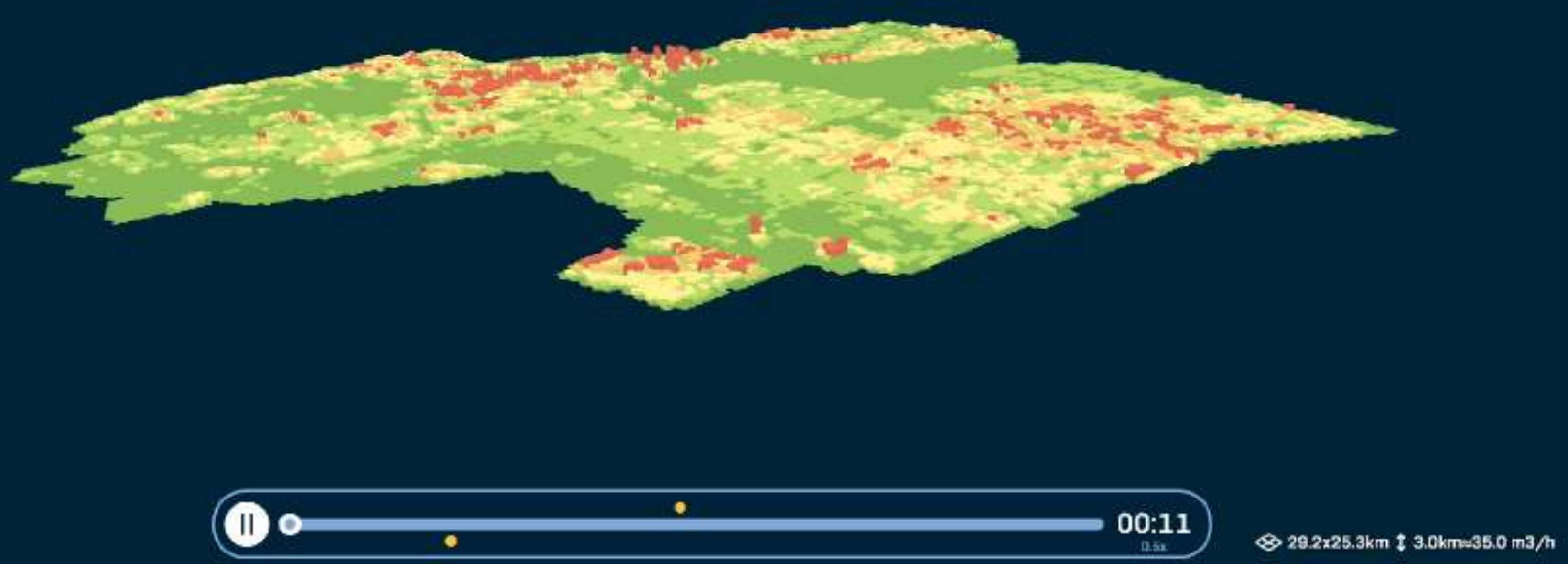
3. Sensorization



3. Sensorization



3. Sensorization



technology

Tech options from the outset

baseform

- Client-server, fully cloud-based
- Runs on the browser
- 3D mapping interface
- Simplicity in automating data upload
- A social management paradigm: unlimited users, unlimited data

WS/WW infrastructure asset management

Non-revenue water (NRW) Water & Energy Losses

Wastewater Infiltration & Inflow (I&I)

Utility data

SCADA, metering, AMI/AMR, billing, GIS, work orders, etc

WS/WW infrastructure asset management

Non-revenue water (NRW) Water & Energy Losses

Wastewater Infiltration & Inflow (I&I)

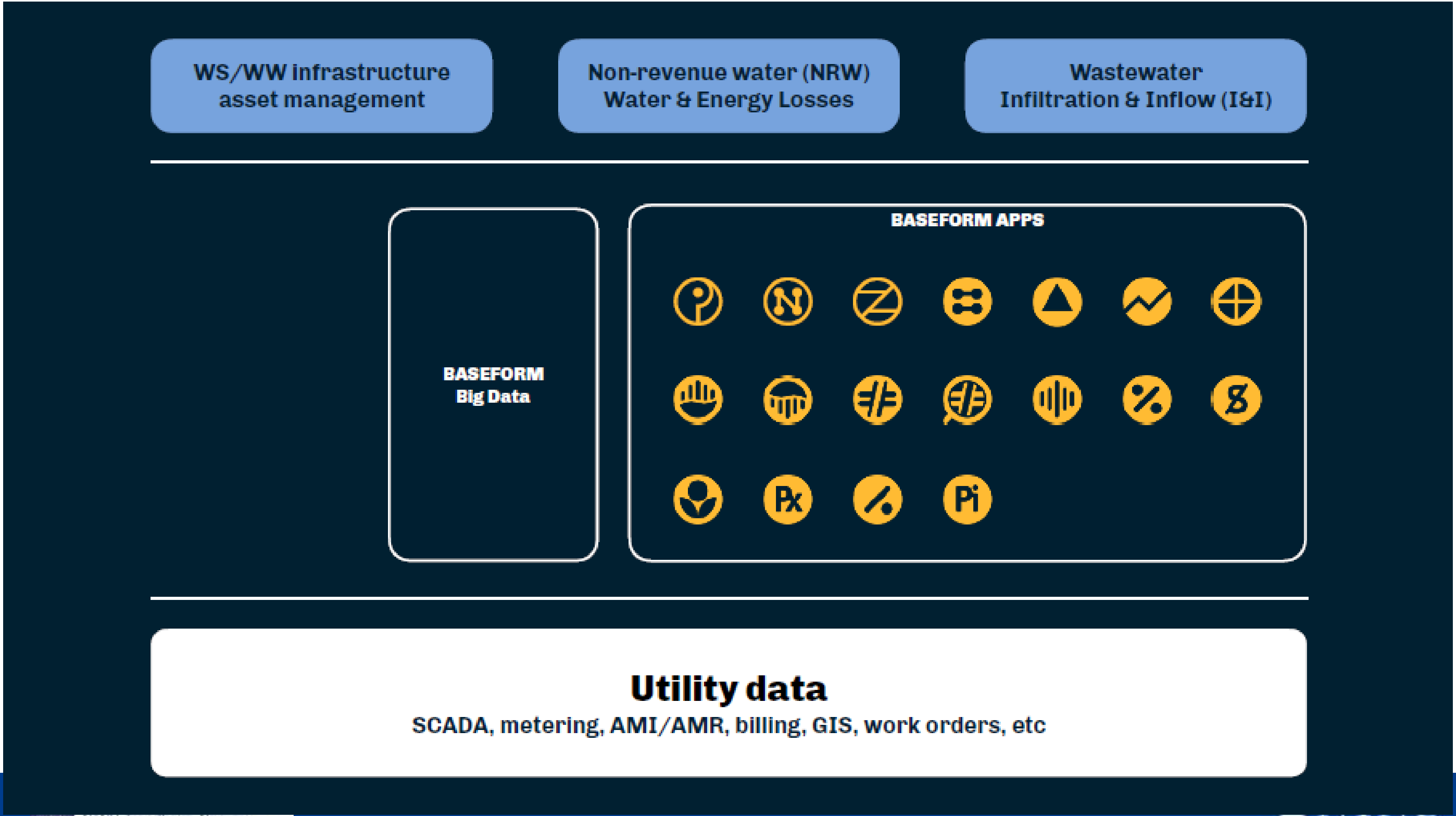
BASEFORM APPS

Px

Pi

Utility data

SCADA, metering, AMI/AMR, billing, GIS, work orders, etc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BASEFORM Big Data
BASEFORM APPS
Utility data
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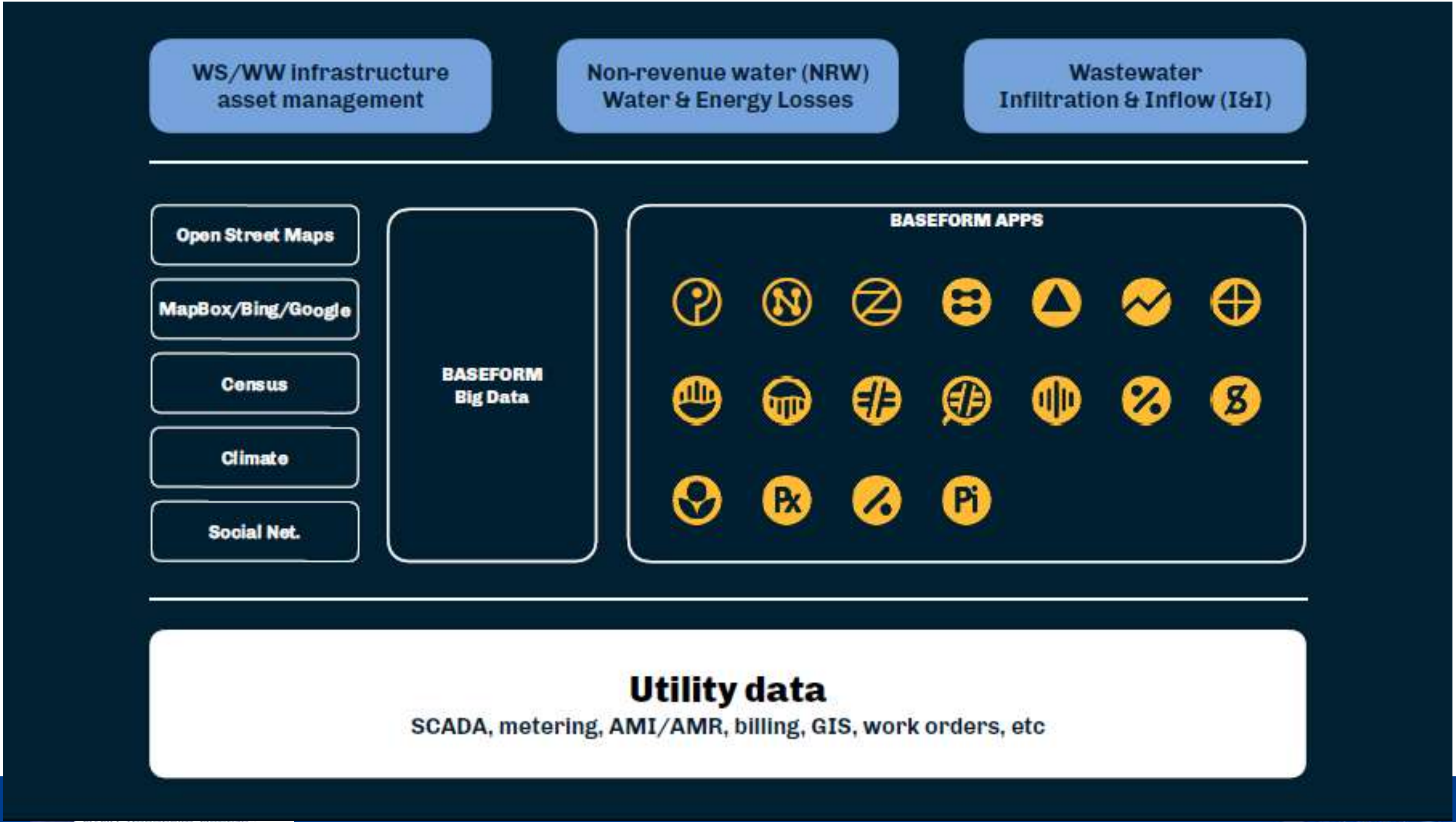
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MapBox/Bing/Google
Census
Climate
Social Net.
BASEFORM Big Data
BASEFORM APPS
Px
Pi
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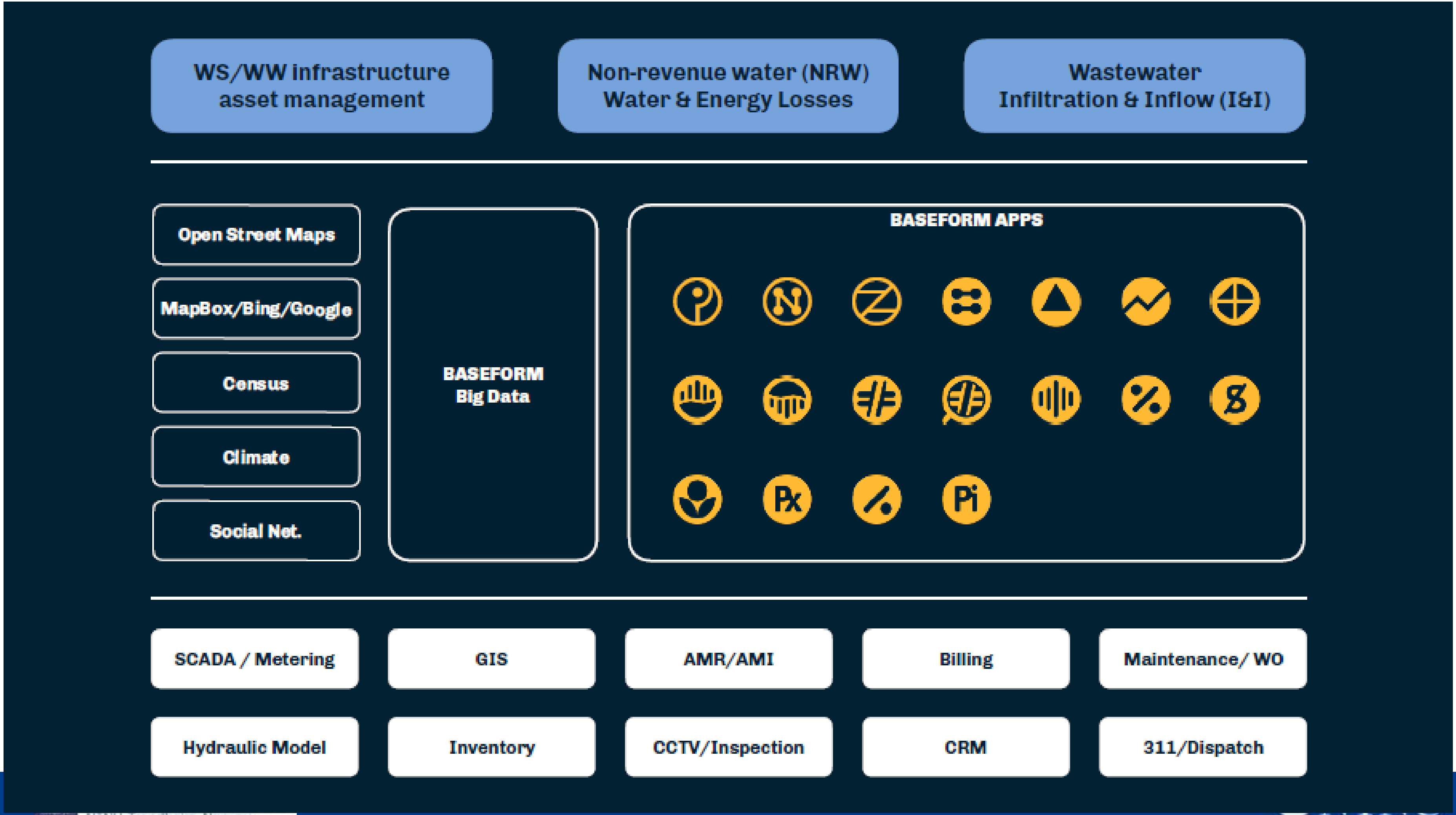
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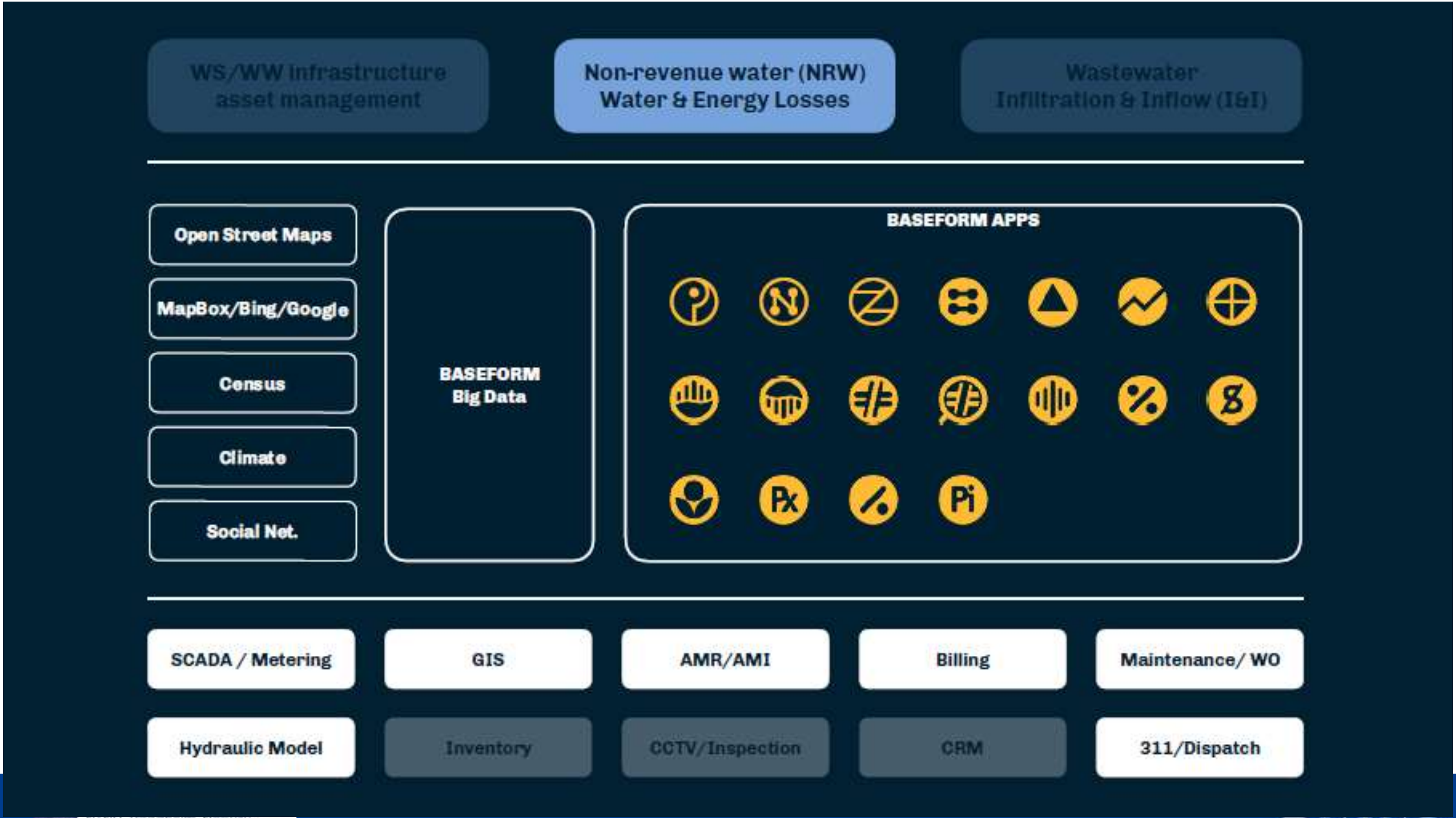
SCADA / Metering
GIS
AMR/AMI
Billing
Maintenance/ WO
Hydraulic Model
Inventory
CCTV/Inspection
CRM
311/Dispatch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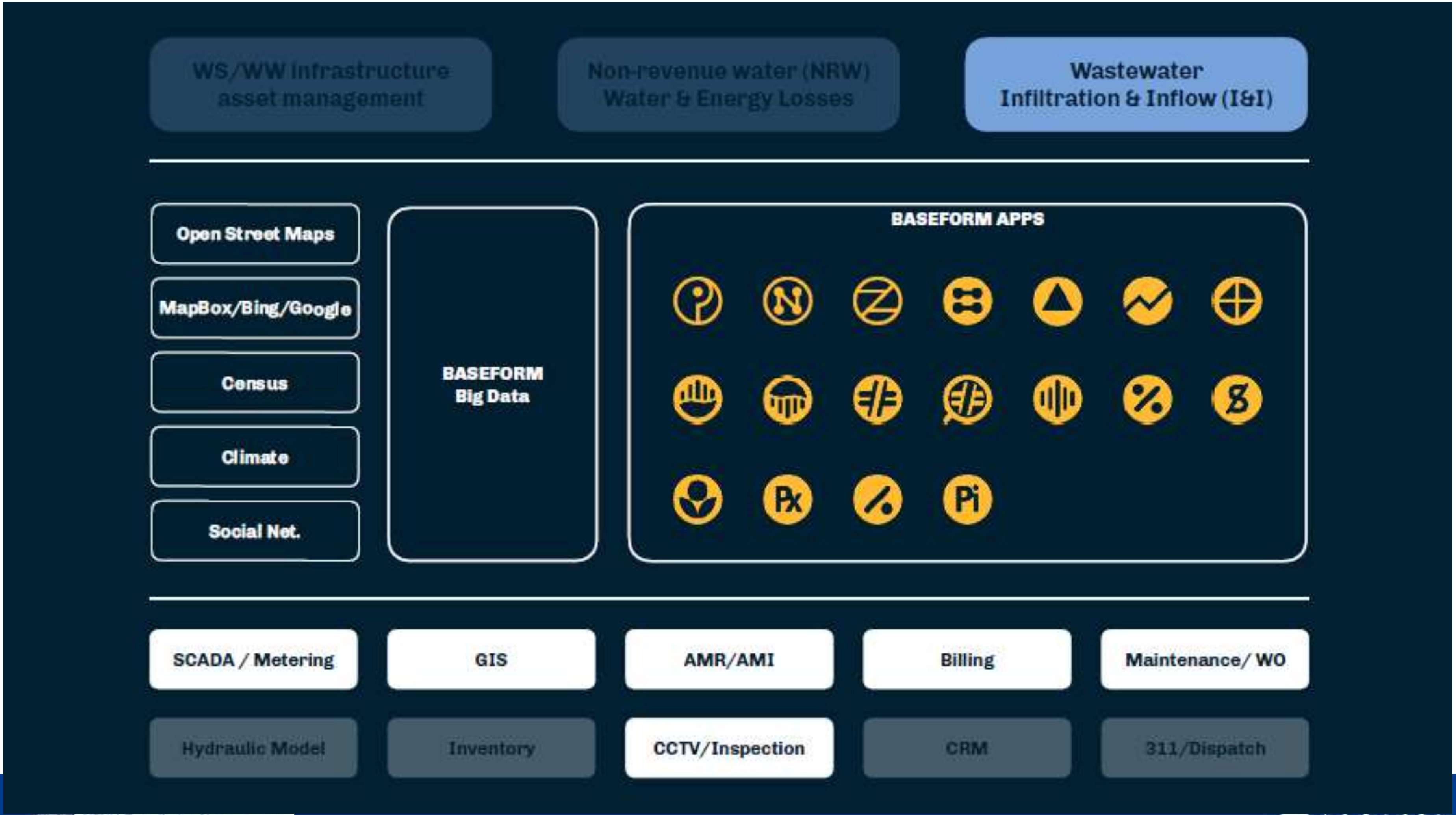
311/Dispatch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Wastewater Infiltration & Inflow (I&I)
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BASEFORM Big Data
BASEFORM APPS
Px
Pi
SCADA / Metering
GIS
AMR/AMI
Billing
Maintenance/ WO
Hydraulic Model
Inventory
CCTV/Inspection
CRM
311/Dispatch

baseform

from R&D to market

Research & development

baseform

- Research generates a great number of useable, useful methods and tools
- Often concentrates on conceptual problems and derives conceptual solutions
- Some programs have been helping bridge the gap
- Impact of R&D on the utilities limited by ability in fitting conceptual solutions to the utility's context:
  - organisational structure
  - strategic, tactical drivers

MWA
Muelheim Water Award
Winner 2014

IWA the international water association
Project Innovation Awards
Winner 2014 Planning

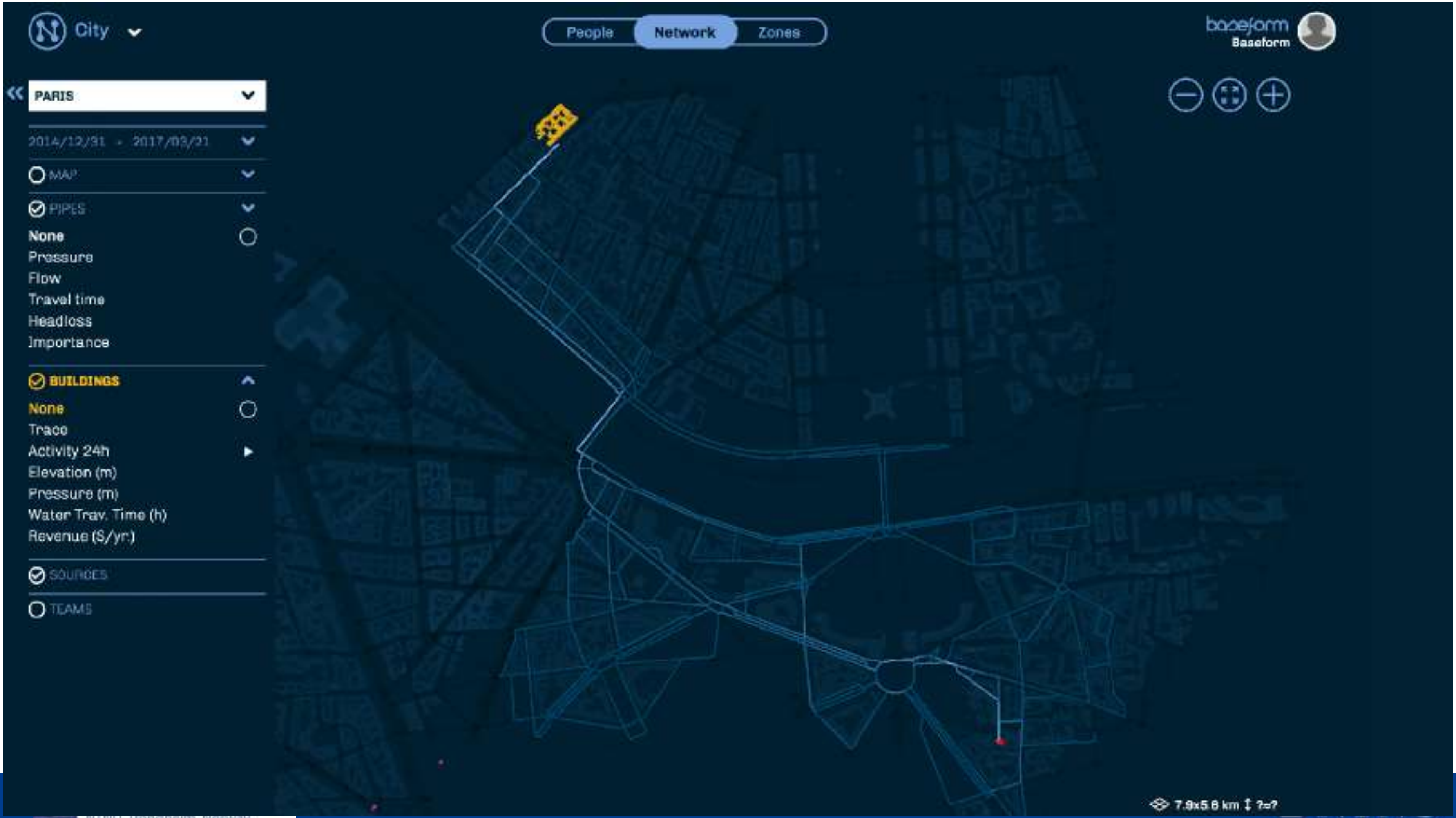
Going to market: message and fit

baseform

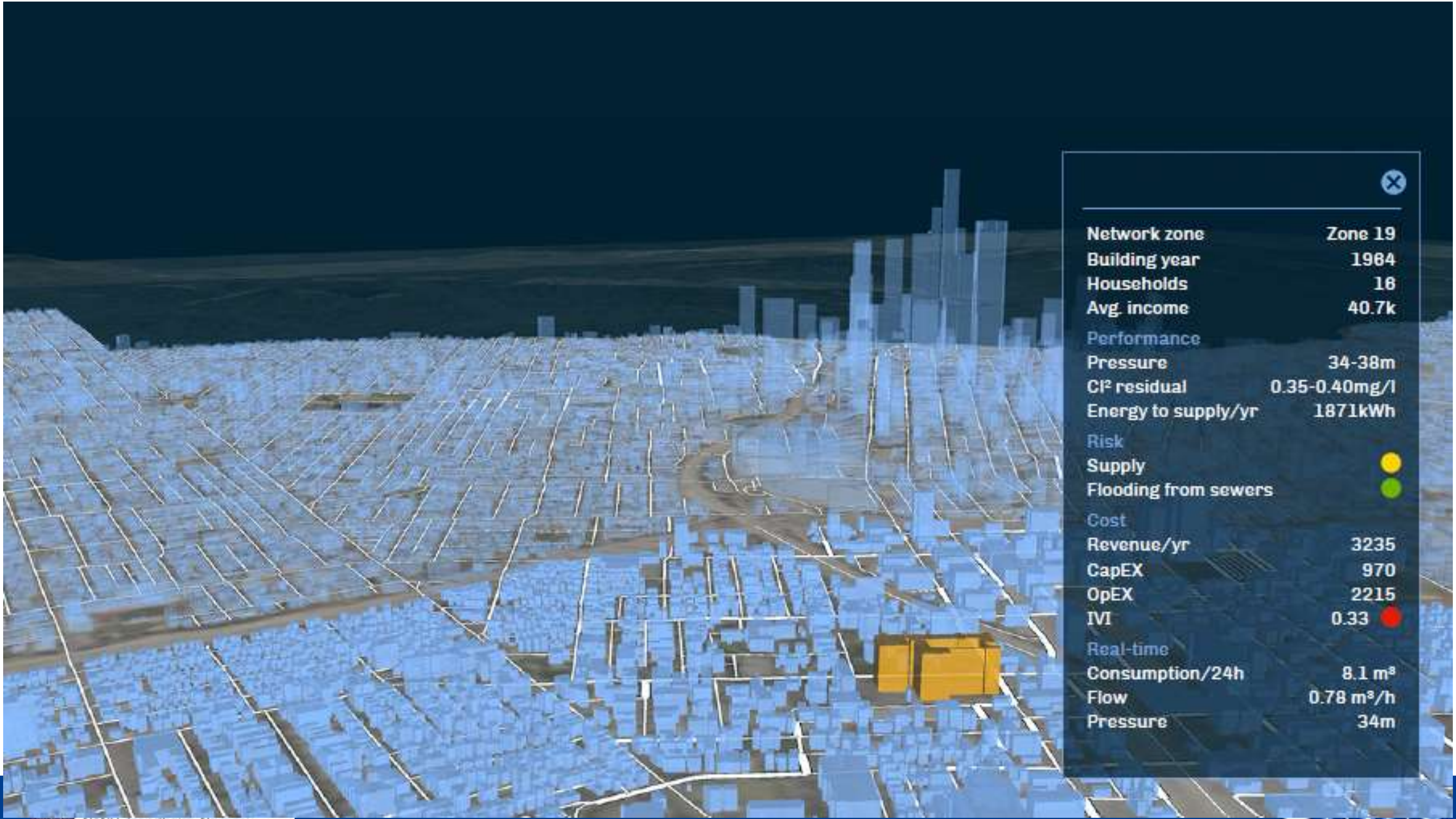
- *A technology looking for a problem:* avoiding a common trap
- Understanding how the audience sees the world
- Learn to listen: solving expressed needs, before working up to the vision
- *'Great software; lousy salespeople'*

R&D is still crucial

- R&D is never done
- An R&D network is a great asset: fosters innovation and provides validation
- Working with our network has been yielding good results for us
- (a good example is on the right)



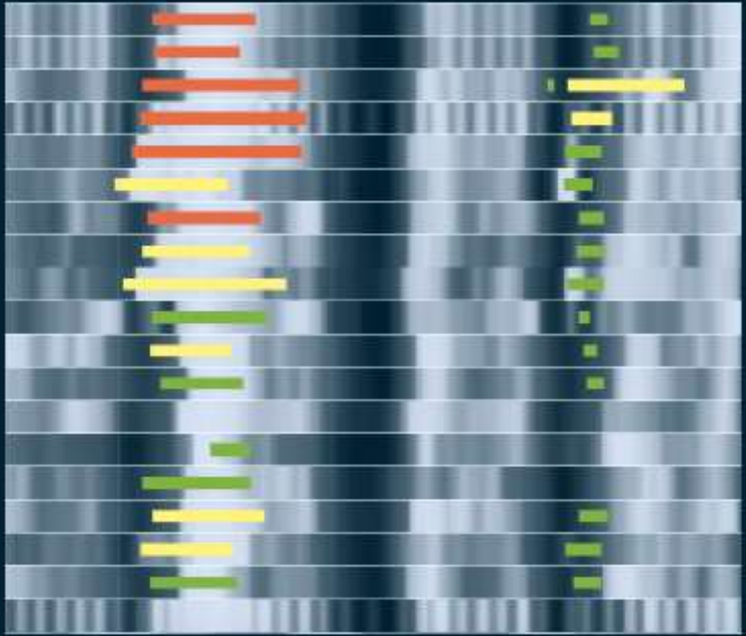
NTNU, Trondheim, Norway


Network zone Zone 19
Building year 1984
Households 18
Avg. income 40.7k
Performance
Pressure 34-38m
Cl^2 residual 0.35-0.40mg/l
Energy to supply/yr 1871kWh
Risk
Supply
Flooding from sewers
Cost
Revenue/yr 3235
CapEX 970
OpEX 2215
IVI 0.33
Real-time
Consumption/24h 8.1 m^3
Flow 0.78 m^3/h
Pressure 34m

Reality

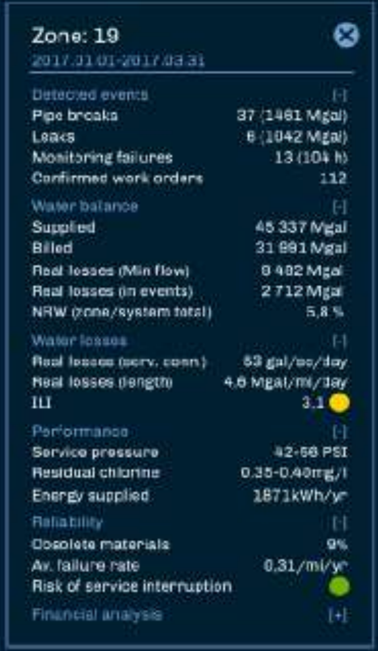
baseform

- Utilities are conservative by nature and structured around organizational models that have been established for quite some time.
- In our experience of tracking the industry internationally, we see common objectives, identical bottlenecks and mostly similar difficulties in determining the key metrics.



Innovation

- If we are going to conceive a path from R&D to market based on improving existing steps of a sometimes archaic process, there is a high risk of very limited returns and smaller chances of innovating.
- It has been crucial for us to rely on a vision of how the processes can significantly evolve…
- …while achieving verifiable and more immediate gains in some areas with direct ROI: service monitoring, prioritization metrics.



A word on human resources

‘Pre-millennials’

‘Millennials’

A word on human resources

baseform

'Pre-millennials'

Software is something you install

Pay per seat and all that

Migration is traumatic

Integration does not really exist

'Millennials'

Spotify, Instagram, Facebook

Integration? Migration? DropBox?

forthcoming challenges

Challenges

baseform

- Sensorization and the cloud are making data cheaper and ubiquitous.

Challenges

- Sensorization and the cloud are making data cheaper and ubiquitous.
- But: there is already a lot of data. Utilities have been intensive collectors of data for many years.

Challenges

- Sensorization and the cloud are making data cheaper and ubiquitous.
- But: there is already a lot of data. Utilities have been intensive collectors of data for many years.
- Data only seems to make a difference when we know what we want to use it for. And when we know what we want.

Challenges

- Sensorization and the cloud are making data cheaper and ubiquitous.
- But: there is already a lot of data. Utilities have been intensive collectors of data for many years.
- Data only seems to make a difference when we know what we want to use it for. And when we know what we want.
- People, their digital habits and the tech they use, are changing fast. The organisations must adapt.

baseform

thank you

Keynote:

Trade-off between Total Cost and Reliability, / Gunnar Mosevoll, Norway

«Trade-off between total costs and reliability»

Dr. Ing. Gunnar Mosevoll, Skien, Norway

Lesam 2017_Gunnar Mosevoll_22 juni 2017_GM_2017-1.pptx

1. «Trade-off between total costs and reliability»

- Some definitions
- Setting the goals for reliability and planning of the needed measures
- Situations of reduced reliability
  - ► Example a: Resource costs (water shortage – opportunity costs of water use)
  - ► Example b: Social costs (insufficient water treatment combined with internal corrosion in distribution an service pipes)
- Using the water supply and sewerage utilities as taxation objects:
  Does high taxes reduce the total reliability of the water supply and sewerage services ?
- During the last 40 years the pipe materials are improved:
  How to record information on increased reliability ?
- A small error repeated many times:
  How to prevent errors like that ?

Reliability and risk: Some definitions

Reliability: The ability of a system or component to perform its required functions under stated conditions

Risk: The risk is quantifying the potential loss of a specified event or condition

Risk = Probability x Consequence

Consequence: A large consequence can be:

- one large and severe event or condition (example: a severe water shortage) or
- a large number of the same and minor event (example: an systematic error repeated many times)

Producing water and sewerage services:
Balancing performance, risk and costs

When balancing the performance, risk and costs we need to describe:

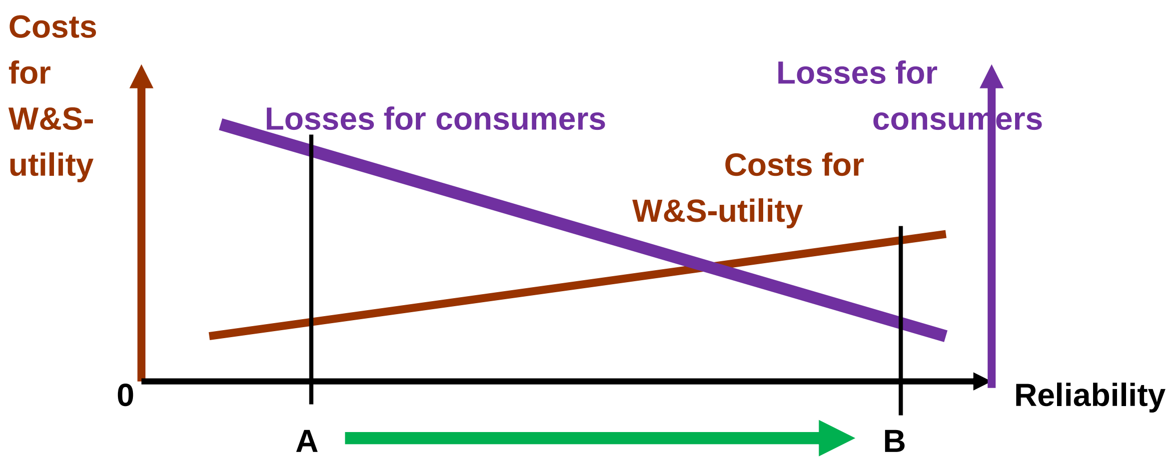
- Water and sewerage services: Extent and quality
- Costs: Category
- Treatment plants and water transportation network: Capacity and useful lifetime
- Financing: Category
- Price: Price policy and indirect effects
- Natural monopoly: How to produce the services in a sustainable way and to low costs,

Reliability is used in the description of the quality of the water and sewerage services.

Categories of costs

- Operations and maintenance costs
- Capital costs
  - Interest and principal payments
  - Real interest rate / opportunity interest rate
  - Depreciation
- Resource costs (opportunity costs of water use):
  - Present situation
  - Future situation (impact of climate changes ?)
- Environmental damage costs: Degradation and depletion by water extraction and by emission of pollutants:
  - Present situation
  - Future situation (climate changes ?)
- Social costs: Example: Incidents with not safe water
- Long run marginal costs: Extension of capacity, water extraction

2. Trade-off between total costs and reliability: Setting the goals and planning of the needed measures



The losses for the consumers include both tangible and intangible losses

A is the present condition. B is the goal.

How to go from condition A to condition B ?

3. Situations of reduced reliability

Example a: The water resources are insufficient and the water consumption has to be reduced

It may be difficult to imagine and weigh the many consequences of a severe water shortage.

Reduction of the leakage loss in the water distribution network is a usual measure against such vulnerability.

When weighing resource costs and the risk of reduced quality of the water services it is useful (necessary ?) to study experiences from similar cases. Hard measures may be needed.

Some water utilities may benefit from the experiences in Sao Paulo in Brazil 2014 – 2015.

Some water crisis are more worse than this; others are less worse. However, the Sao Paulo crisis is worth to study.

The water shortage in São Paulo, Brazil 2014 – 2015: A large water crisis I

The British newspaper the guardian had
a series reports from the water crisis in Sao Paulo:

theguardian

www.theguardian.com

5 Sept 2014: **Brazil drought crisis leads to rationing and tensions:**

Water rationed in 19 cities in southeast and central regions after usual abundant supplies run dry.

11 Febr 2015: **Brazil drought: Water rationing alone won't save Sao Paulo:**

The solutions to the severe drought in Brazil must go deeper than water rationing and pressure changes, says the Alliance for Water network.

Sao Paulo city:	12 million inhabitants
Sao Paulo city + the areas surrounding Sao Paulo:	20 million inhabitants

The water shortage in São Paulo, Brazil 2014 – 2015: A large water crisis il

Report from the British newspaper the guardian :

25 Febr 2015: **São Paulo – anatomy of a failing megacity: residents struggle as water taps run dry :**

Many «paulistanos» are hoarding water in their apartments – and some are even drilling homemade wells – as they prepare for possible rationing.

- In part a result of badly stored water, instants of dengue fever spread by mosquitos almost tripled in January, compared with the previous year.

Graphic designer Isabella Sacramento, 33, lives in at neat, well maintained apartment complex i the neighbourhood of Saúde. South-central São Paulo:

- On the third day without water, residents set out rows of plastic chairs in the communal area and held emergency meeting to discuss the problem. But to Berger's dismay, the meeting quickly descended into furious argument:

  «I'd always imagined people would try and help each other out in a crisis situation,» she says. «But it's not what happened at all.»

4 days withou twater supply

The water shortage in São Paulo, Brazil 2014 – 2015: A large water crisis III

Report from the British newspaper the guardian :

15 April 2015: **São Paulo's water crisis: in the Favela do Moinho, 2 500 residents rely on one impossible thin blue pipe:**

How water shortages are affecting the city's poorest residents in central São Paulo's last remaining slum.

- **Many, including most Favela do Moinho residents, don't have water tanks, making it all the more difficult to cope when the taps run dry – as they do, daily, for millions in the city, any time from 2 pm onwards.**

http://www.theguardian.com/cities/2015/feb/25/sao-paulo-brazil-failing-megacity-water-crisis-rationing
http://www.theguardian.com/cities/2015/apr/15/sao-paulo-water-crisis-favela-shortages-poorest
http://www.theguardian.com/cities/2015/feb/25/sao-paulo-brazil-failing-megacity-water-crisis-rationing

If the water resources are insufficient and the water consumption has to be reduced: ***«The Danish method» may be a solution ?***

It is normally necessary to reduce both

- the private water consumption and
- the leakage loss.

There are several different incentives to reduce the total water consumption.

Denmark has done it in a very effective way:

Charging a high tax on both the private water consumption and the leakage loss.

Both are strongly reduced; especially the leakage loss.

The hard work has lasted for many started many years ago. Few countries has now a lower leakage loss than Denmark.

In 2017 the water tax in Denmark is DKK 6,25 /m3 + added value tax.
The water tax is about 40 % of the total water price.
(Denmark has a similar tax on wastewater. This is a pollution tax, and it is much lower than the water resource tax.)

3. Situations of reduced reliability

Example b: A catastrophe with high *social costs*:

What can we learn from that ?

When the «incomprehensible» happens: Example Flint, Michigan, USA 2014 - 2017

Wikipedia has this summary of the case: (May 2017)

Flint water crisis	
Time	April 2014; 3 years ago (April 2014) – present
Duration	Ongoing
Location	Flint, Michigan, United States
Type	•Water contamination: •Coliform bacteria •THMs •Lead •Possible Legionnaires' disease outbreak
Participants	Residents of Flint, Michigan
Outcome	•6,000–12,000 children exposed to lead[1] •Public health state of emergency •Several lawsuits •Several investigations •Four resignations •Four firings •Five suspensions •Thirteen criminal indictments
Deaths	14
Non-fatal injuries	6,000-12,000

https://en.wikipedia.org/wiki/Flint_water_crisis

The city of Flint is now under way with major improvements

The city of Flint have now improved the water quality.

Flint has also started the replacement of service pipes of lead.

How long time will ittake before the consumers again trust the water utility?

Pipes at 1,139 Homes Replaced So Far through Mayor's FAST Start Initiative

FLINT, Mich. — Lead-tainted service lines at 253 homes have been replaced so far in Phase 4 of Mayor Karen …

Read More

May 23, 2017 / Home Page, Mayor's Office, News And Events, Press Releases, Updates on FAST Start, Water & Utilities

A catastrophe with high social costs: What can we learn from that ?

Possible preventative measures in the water supply utility?

► More basic knowledge to degradation processes in the water supply network

.

► Good routines for internal warning

► Good risk analysis for events with serious consequences.

4. Using the water supply and sewerage utilities as taxation objects

Does high taxes reduce the total reliability of the water supply and sewerage services ?

Denmark: Is the high taxes to the government, especially on drinking water, still necessary to keep the leakage loss low ?
Does the high tax lead to reduced investments and reduced reliability ?

Berlin, Germany: In 1999 the city of Berlin sold 49,9 % of the shares in the water supply and sewerage utility to private companies.
The city of Berlin needed the money for other purposes.
In 2013 the city of Berlin bought it back.
The utility had to pay high interest rates for the private capital.
Was the normal investment in the utility influenced by the costs of the private investment ?

Greece: EU is forcing Greece to sell off water and sewerage companies to pay the Greece debt. Is increased water prices the best way to pay for the debt of a country ?

5. During the last 40 years the pipe materials are improved: How much have the reliability increased ?

● During the last 40 years the pipe materials are improved:
How to record information on increased reliability ?

The quality of pipes of ductile iron, PVC-U and PE improved significantly.
The expected lifetime has increased.

The estimates of "useful time" and "survival function" have to be revised for these improvements.

How to record:

- The changes in the quality of pipe materials
- The failure / leaks (location, type and size)

An important feedback in innovation work for better pipes !

6. A small mistake which is repeated many times:
How to prevent systematic mistakes like that ?

Example x:

The electro fusion socket was not properly supported during the fusion.

This fusion joint will therefore not stand for 100 year (probably less than 50 years).

Example y:

We may not know enough about the long term strength a rubber sealed joint.

Will the useful lifetime reach 100 years ?

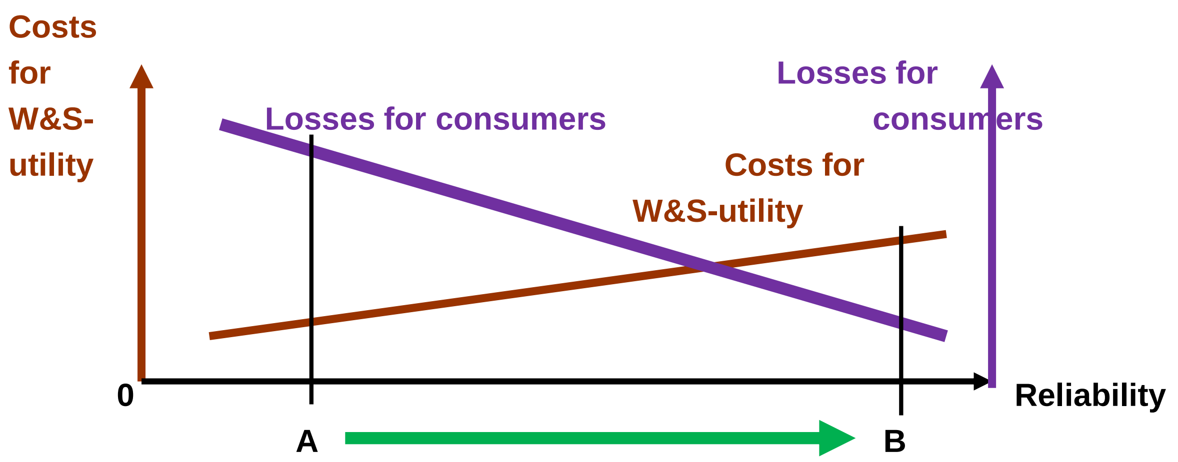
A report from Swedish water:

«Life-time prediction of rubber sealed joints for water and sewer pipes»

Kristian Thørnblom Jan Henrik Sallstrom Gunnar Bergstrøm

http://vav.griffel.net/filer/SVU-rapport_2014-04.pdf

7. Final remarks



The losses for the consumers include both tangible and intangible losses

A is the present condition. B is the goal.

How to go from condition A to condition B ?

Closing messages:

The Chair of the Strategic Asset Management Specialist Group Helena Alegre

Closing session:
What have we learnt? Where to go now?

Helena Alegre

Chair of the IWA Strategic Asset Management Specialist Group , IWA Fellow, IWA Strategic Council Member

Head of the Hydraulics and Environment Department, LNEC, Portugal (www.lnec.pt)


1st LESAM
San Francisco,
USA, 2004
LESAM 2017
Trondheim, Norway
IWA+NTNU
Germany
LESAM 2015
Yokohama, Japan

Some statistics

LESAM 2015 (Yokohama, Japan)

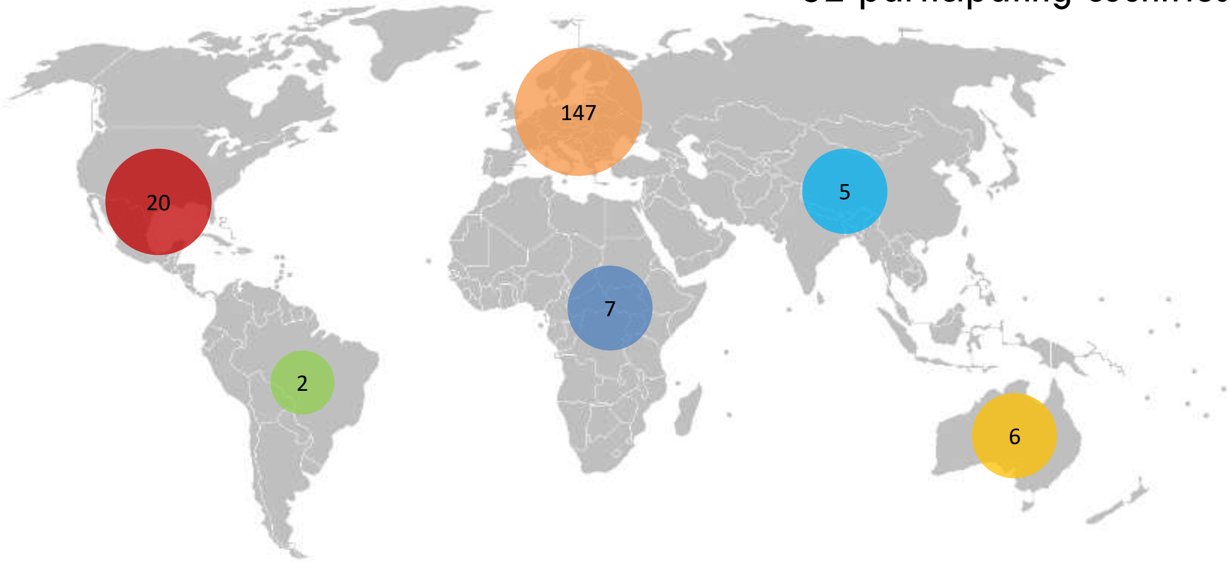
- **222 delegates**
- **23 countries**
- **173 from Asia**
  - 133 from Japan
  - 18 from Korea
  - 9 from Philippines
  - 4 from Indonesia
  - 3 from China
  - 2 from Taiwan
  - 2 from Viet Nam
  - 1 from Malaysia
  - 1 from Singapore
- **34 from Europe**
- **9 from Australia & NZ**
- **3 from North America**
- **2 from South America**
- **1 from Middle East**

LESAM 2017 (Trondheim, Norway)

- **149 delegates**
- **28 countries**
- **14 from East Asia**
- **90 from Northen Europe**
  - **53 - Norway**
  - **11 Netherlands**
- **25 from Southern Europe**
  - **10 Portugal**
- **6 from Africa**
- **1 from Australia**
- **2 from North America**
- **1 from South America**
- **8 from Middle East**

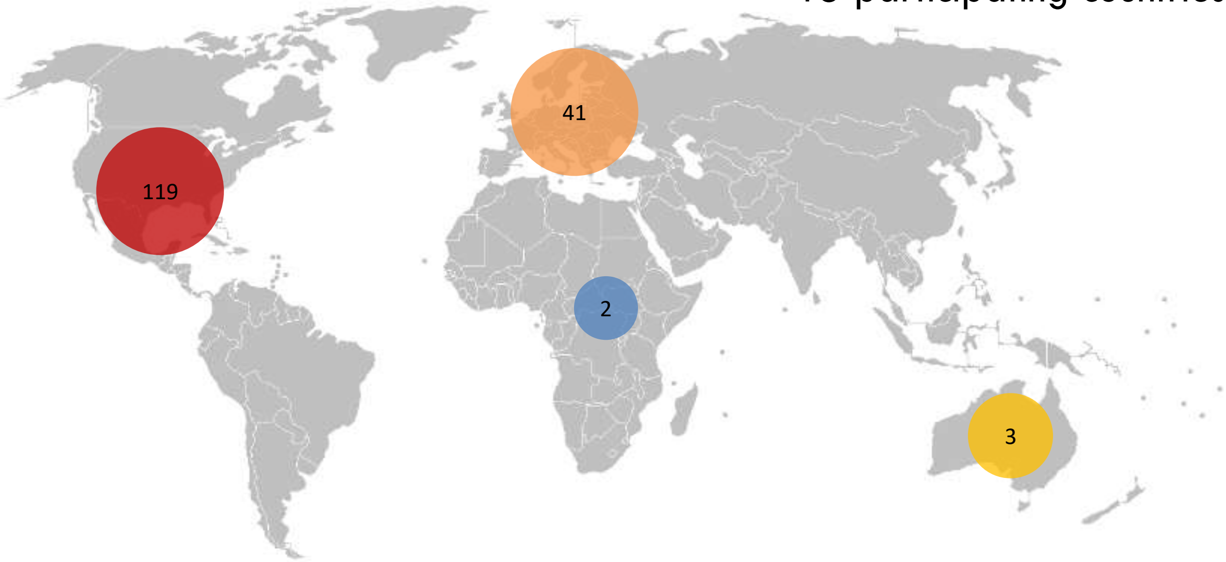
LESAM 2007, Lisbon

32 participating countries



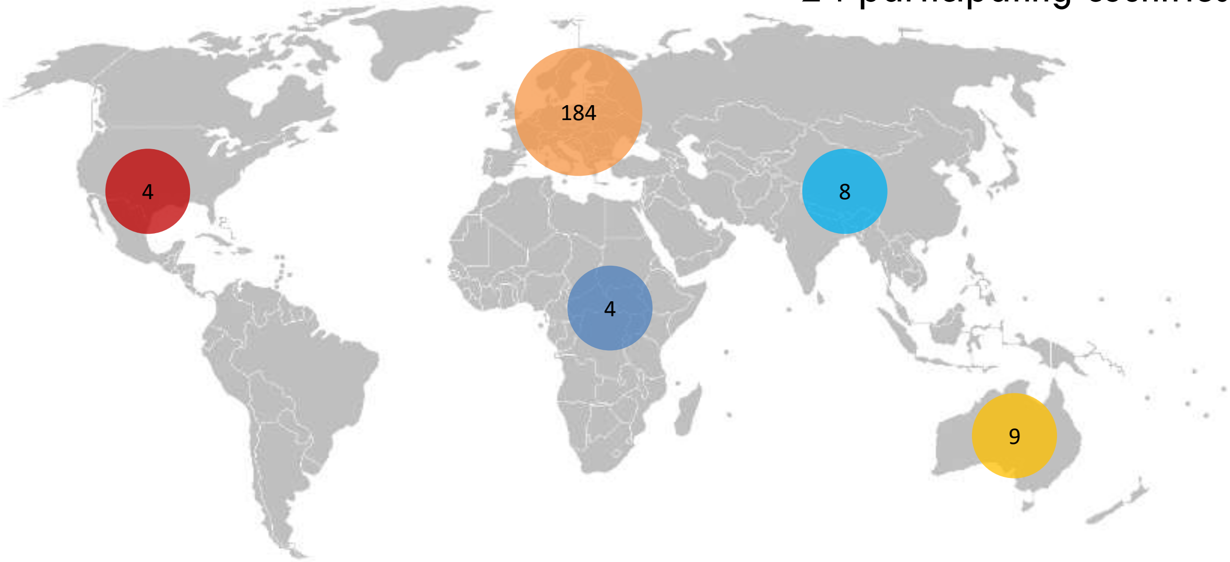
LESAM 2009, Miami

15 participating countries



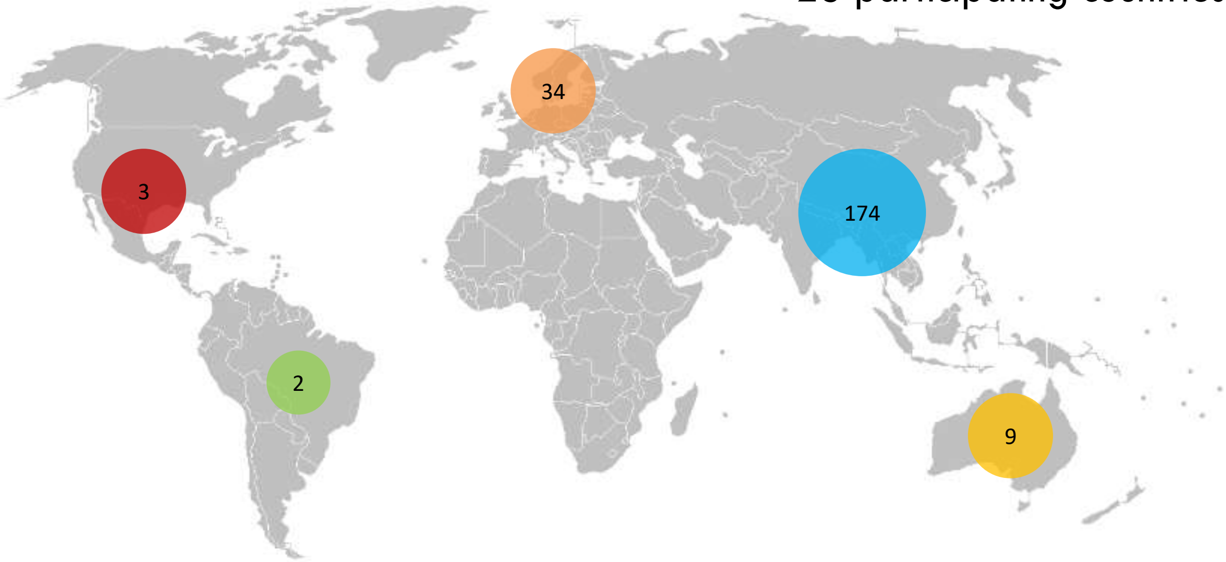
LESAM 2011, Muelheim

24 participating countries



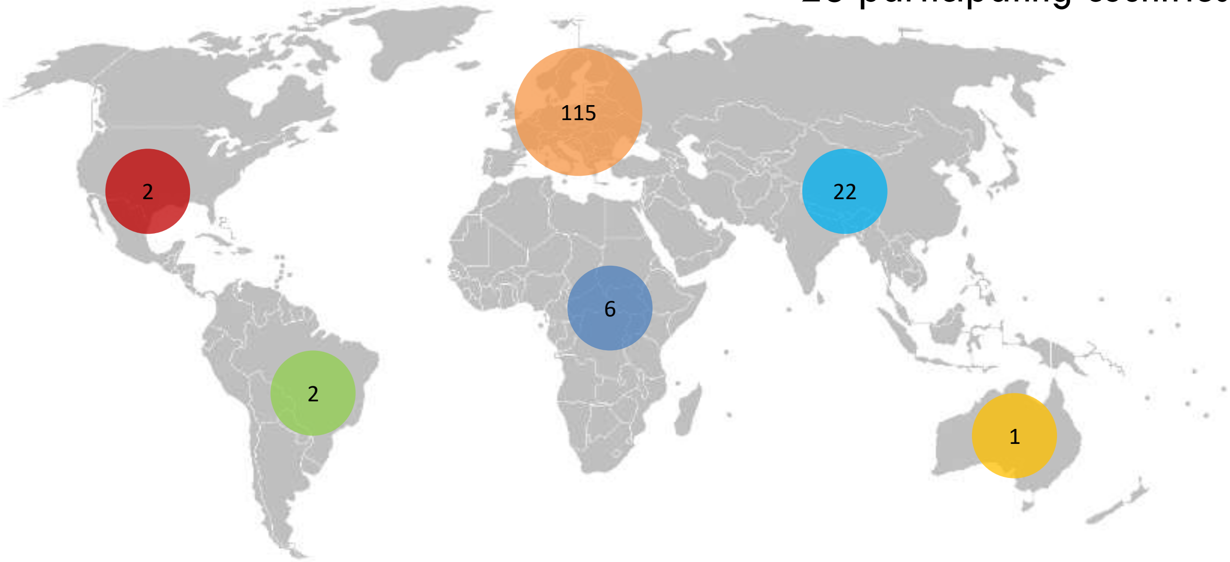
LESAM 2015, Yokohama

23 participating countries

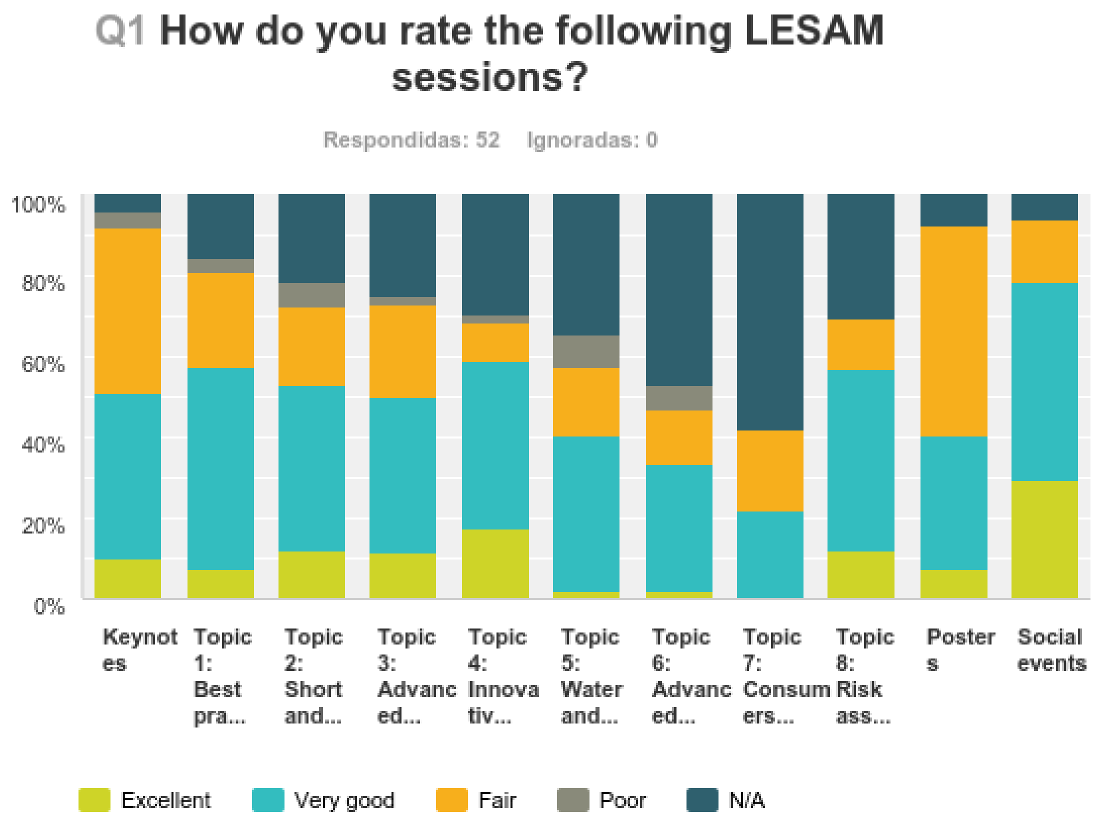


LESAM 2017, Trondheim

28 participating countries



General comments



Take home messages

- Positive move from **assets** to **value, organization, policies, governance** – but not forgetting the assets…
- The **feasibility of aligning strategic views and objectives with the day-to-day actions**
- **The importance of adopting a system's approach**
- Positive move from **engineering** to **interdisciplinary** approaches
- Positive move from "**silo**" views to **integrated management processes** and **integrated views**
- The power and potential of **new technologies**
- The importance of **PEOPLE-PEOPLE-PEOPLE**

App, presentations and papers

- The LESAM App, a novelty of LESAM 2017
- Presentations (keynotes, SAM SG plenary meeting, papers): to be made available
- Papers: available for a very limited time
- Paper publication: selection process to be carried out soon

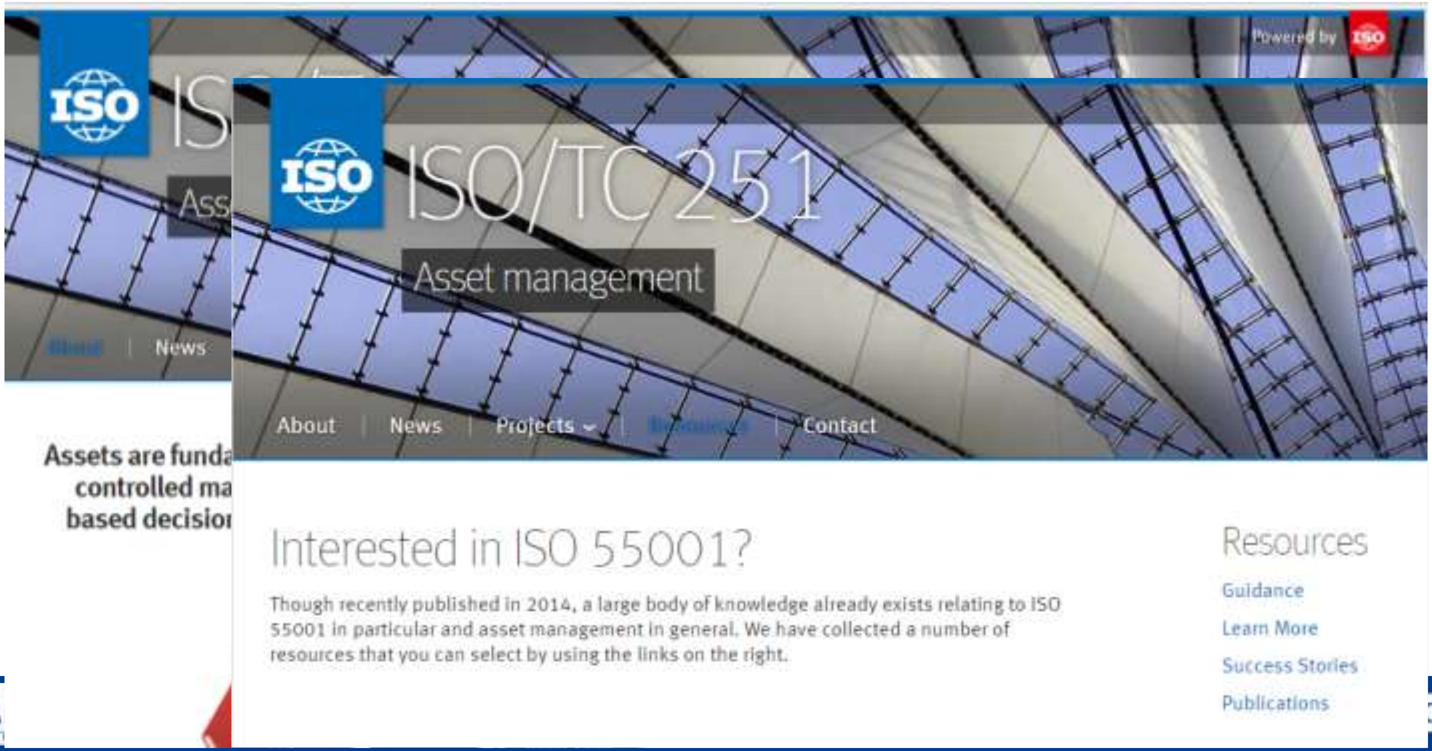
KEEP POSTED

ISO/TC 251: Asset management

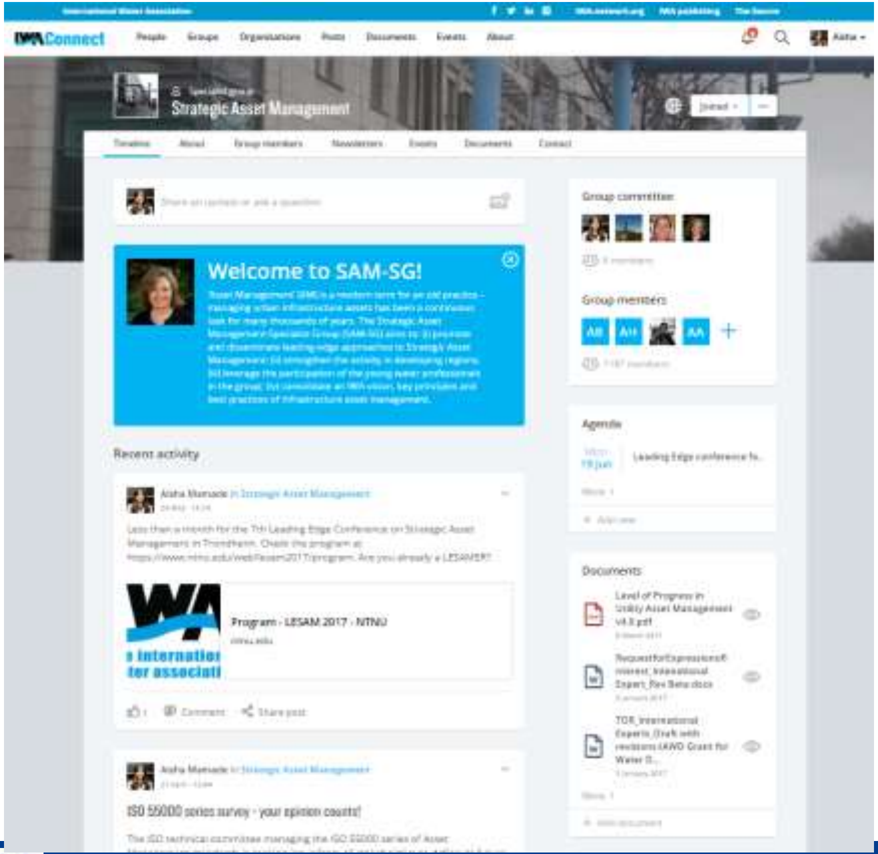
committee.iso.org/home/tc251

ISO/TC 251: Asset management

committee.iso.org/home/tc251



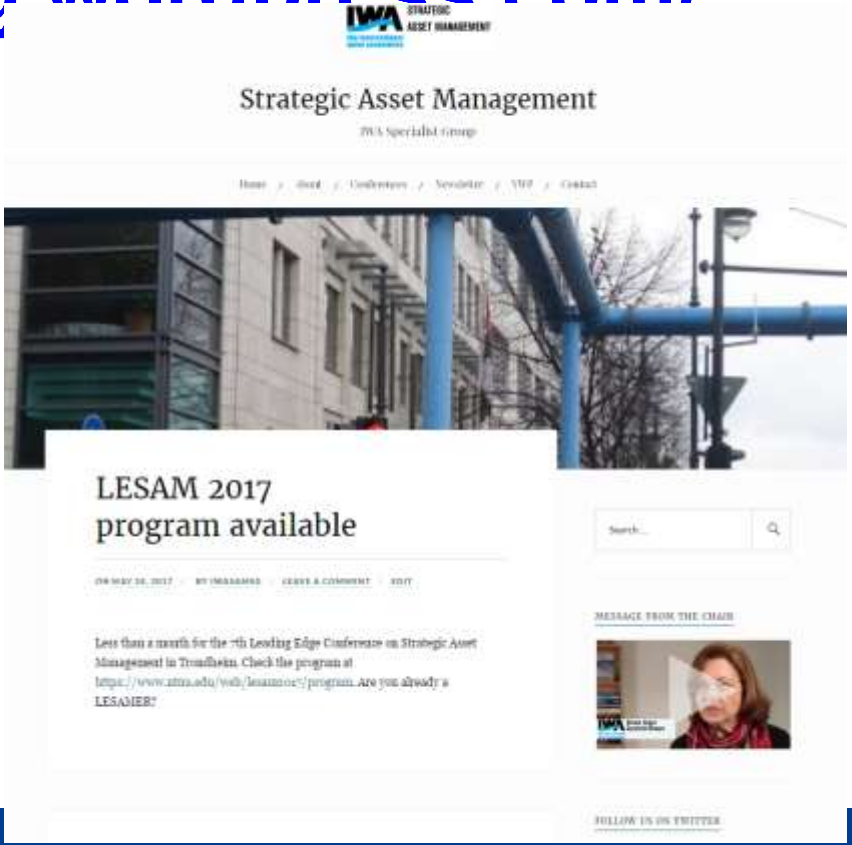
IWA Digital tools: JOIN US ON IWA CONNECT



- ✓ Welcome message
- ✓ Posts
- ✓ Documents
- ✓ Agenda
- ✓ ‘Likes’
- ✓ Comments
- ✓ Invite connections
- ✓ Received e-mails about new connections, likes, comments..

SAM-SG wordpress website

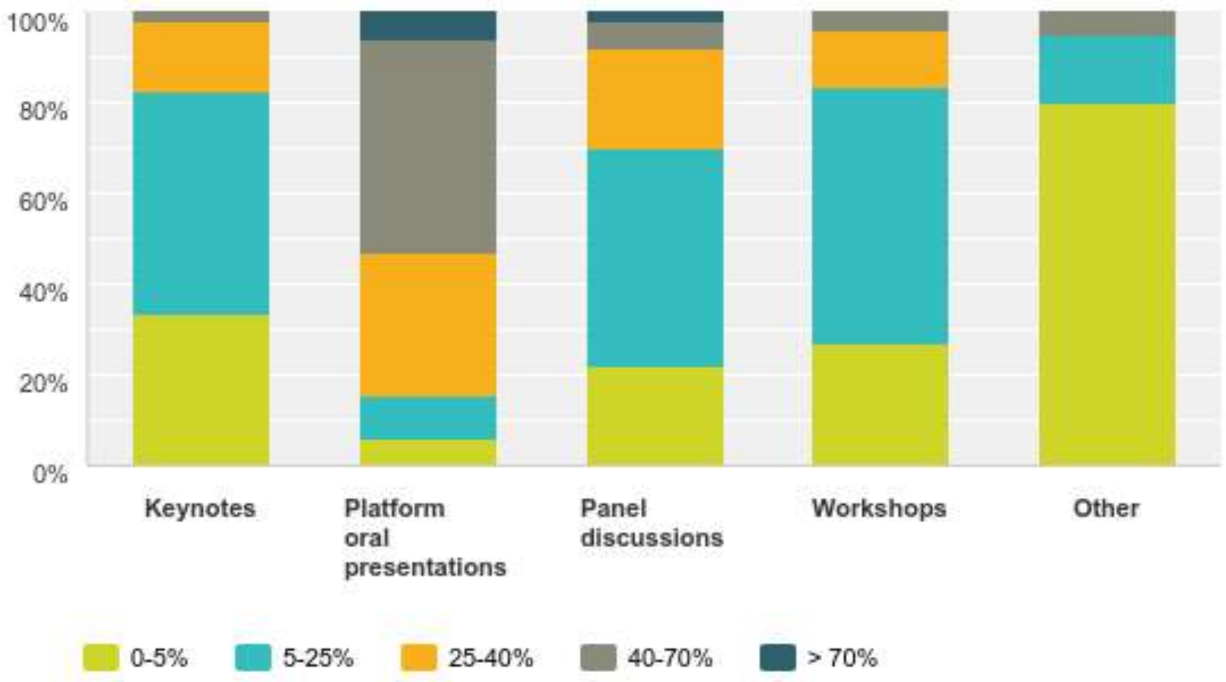
iwasamsg.wordpress.com/



HOW DO LESAM 2017 PARTICIPANTS SEE THE WAY FORWARD?

Q3 How would your ideal LESAM 2019 look like? - Please define % time for each category

Respondidas: 51   Ignoradas: 1



Other

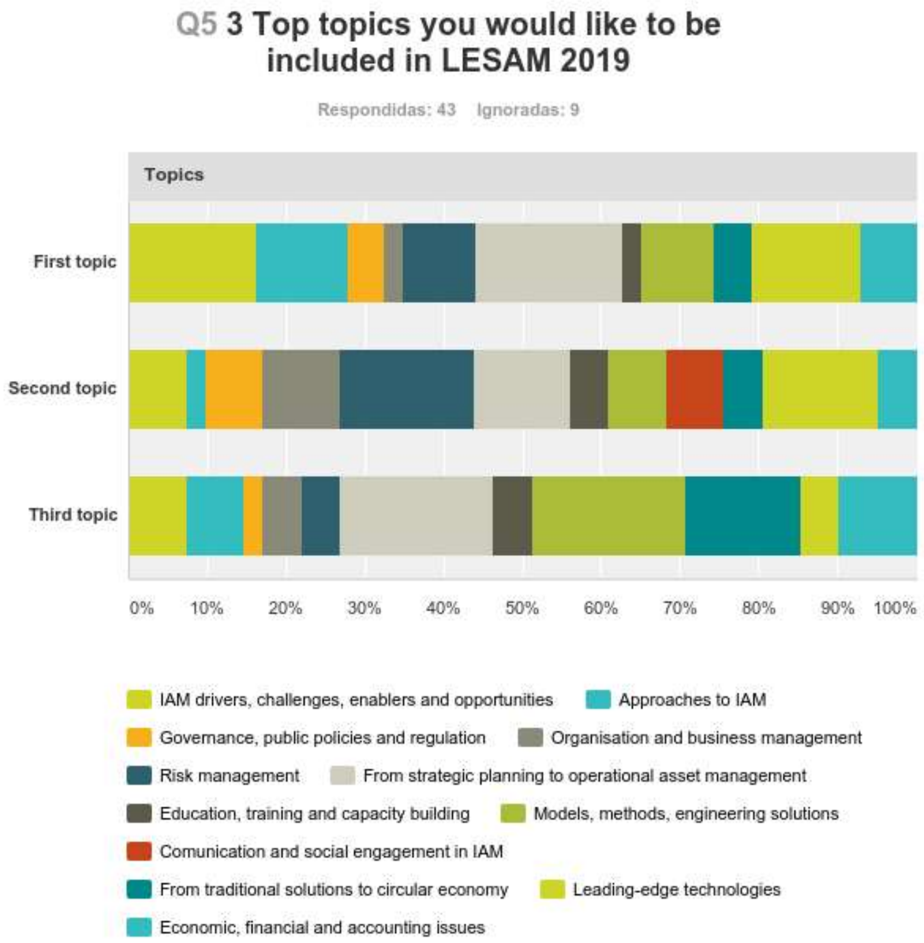
- Posters presentations
- Plant visits, case studies by utilities
- Socialize
- Specialist masterclasses on IAM relevant topics.
- "Think tanks" or other interative ways of discussion
- Smaller group discussions on certain IAM topics

- Include other forms of sharing IAM experiences and results such as panel discussions or workshops.
- Improve communication to external stakeholders (through press or social media, for instance).

Other organisational wishes for LESAM 2019

- Very good idea if LESAM can be combined with the IWA PI conference
- Bring people from other public infrastructures
- Stay aware of focus and specialization and stick to it (rather than go broad). Maintain a clear differentiation from other conference series.
- Promote discussion about regional issues and solutions, focused on the practice, legal framework and challenges.

In summary:
To promote more discussion between the attendees.

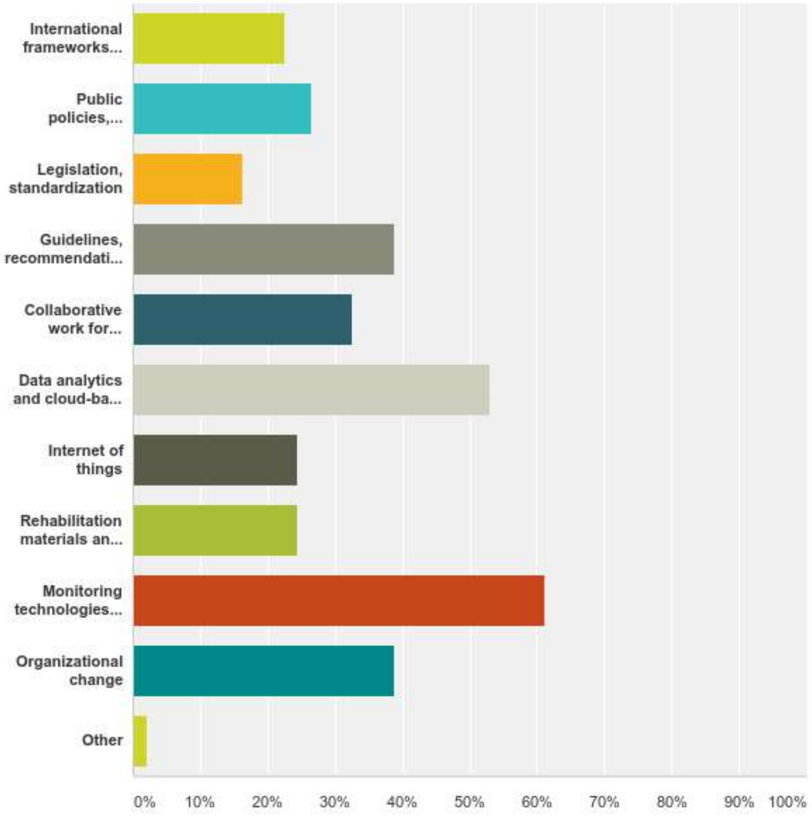


Q5 3 Top topics you would like to be included in LESAM 2019
Respondidas: 43 Ignoradas: 9
Topics
First topic
Second topic
Third topic
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
IAM drivers, challenges, enablers and opportunities
Approaches to IAM
Governance, public policies and regulation
Organisation and business management
Risk management
From strategic planning to operational asset management
Education, training and capacity building
Models, methods, engineering solutions
Comunication and social engagement in IAM
From traditional solutions to circular economy
Leading-edge technologies
Economic, financial and accounting issues

ıt © 2013

Q7 In your view, the most impacting innovations on IAM will be in the field of...

Respondidas: 49 Ignoradas: 3



Are you a LESAMER?

Key requirements already fulfilled:

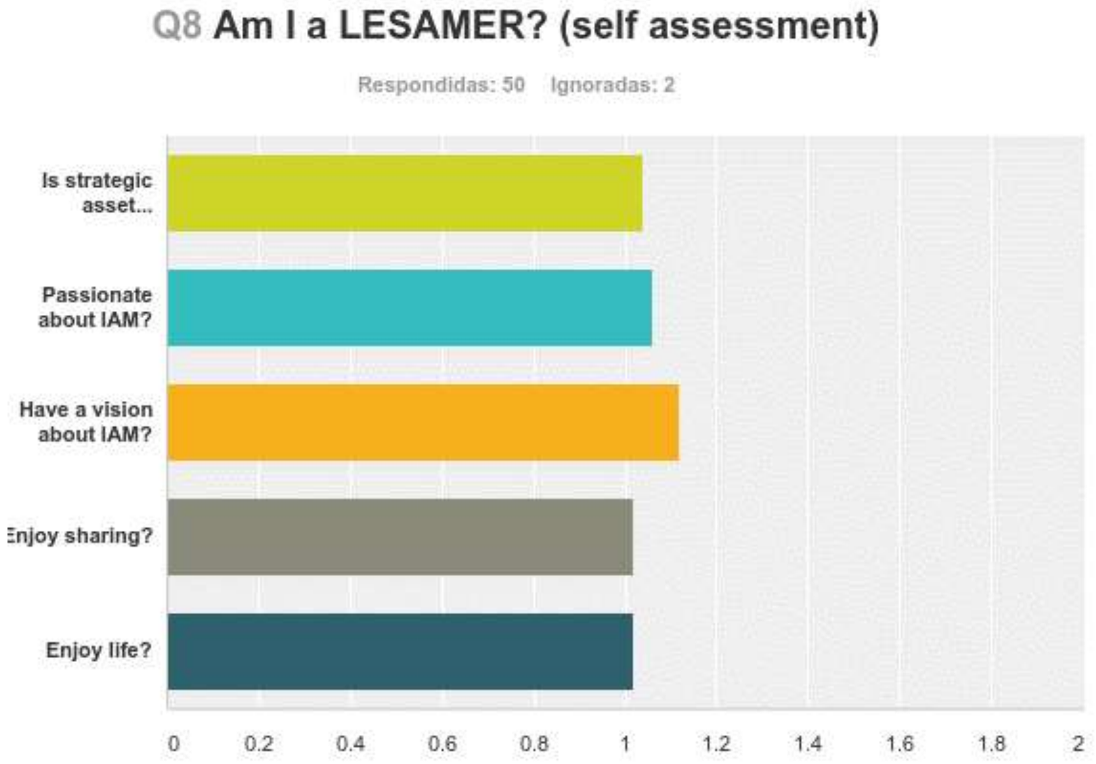
- Understand that strategic asset management is essential for the survival of societies
- Participation in, at least, one LESAM

Are you a LESAMER?

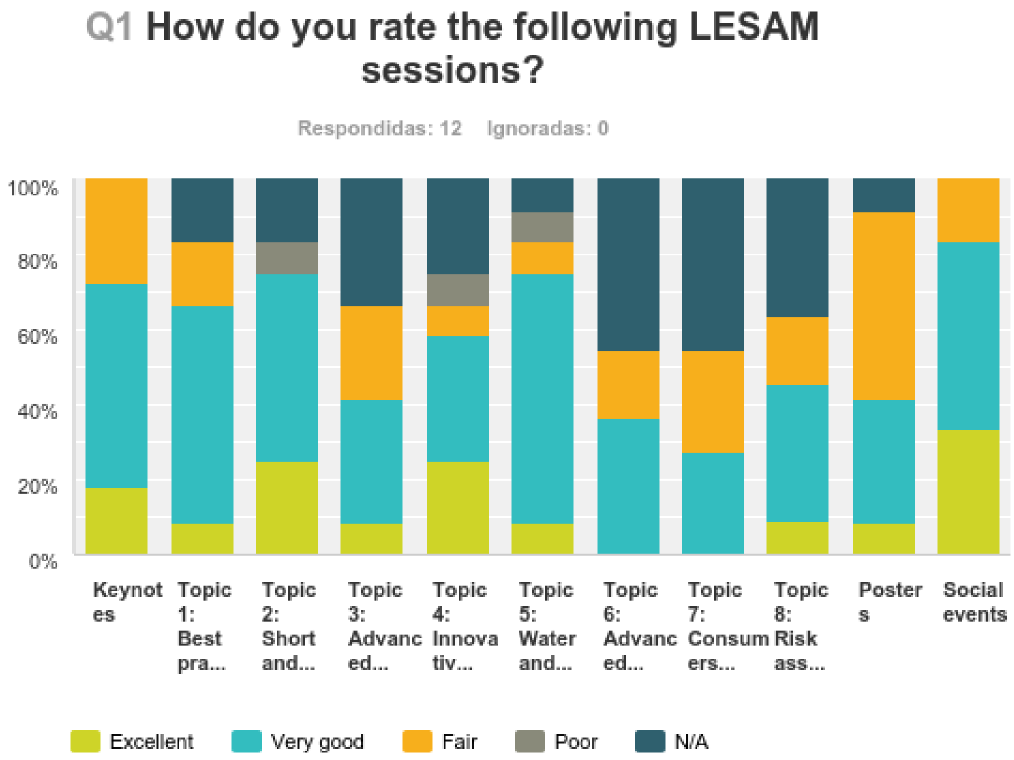
Other key requirements:

- Passioned
- Have a vision
- Enjoy sharing
- Enjoy life

Results from the self-assessment



Results from the self-assessment



TOP LESAMERS

A very special new LESAMER

Aisha Mamade, secretary of the SAM SG, gave birth to **Mariyah**, yesterday!

ACKNOWLEDGEMENTS

Organisers

NTNU – Trondheim
Norwegian University of
Science and Technology

- IWA hq (marketing)
- Trondheim kommune
- NTNU

International Water Association
Specialist Group
Strategic Asset Management

Sponsors

- Trondheim kommune
- Norwegian Water Association
- IWA Norway
- NTNU

Committees

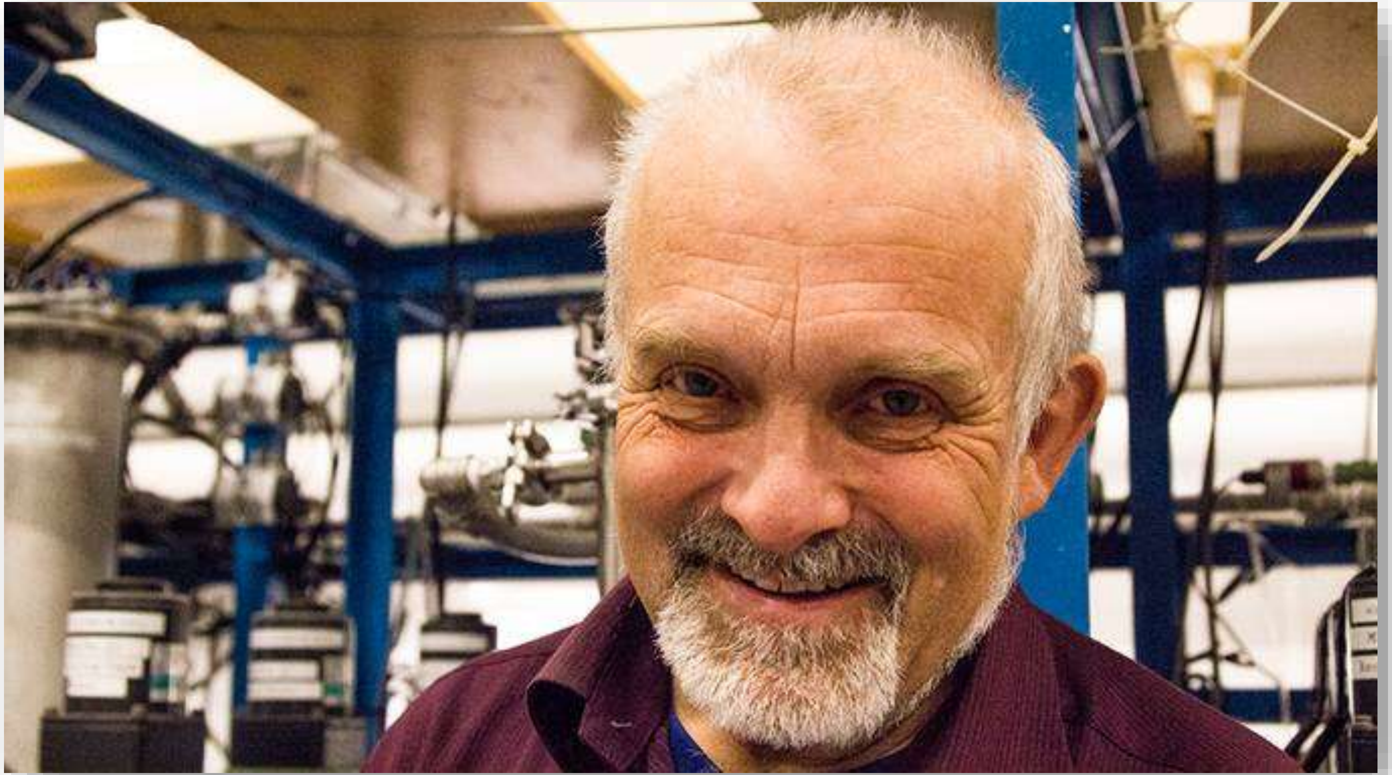
Scientific and Program Committee

- **Helena Alegre (chair)**, LNEC/IWA Strategic management Specialist Group, Portugal
- Sveinung Sægrov, Professor, Norwegian University of Science and Technology (NTNU), Norway
- Rita Ugarelli, Adjunct professor NTNU, senior researcher SINTEF
- Jon Røstum, Dr, Powel, Norway
- Cathy Werey, Dr. Irstea-Engees GESTE, Strasbourg, France
- Takayuki Sawai, Japan Water Works Association, Japan
- Walter Graf, Water Environment Research Foundation (WERF), USA
- Will D Williams, BV, USA
- Didia Covas, IST, Technical University of Lisbon, Portugal
- Peter Cheung, Federal University do Sul, Brazil
- Scott Haskins, C2M HILL OMI, USA
- Suwan Park, Pusan National university, Korea
- David Marlow, Wiser Analysis pty ltd, Australia
- Kapil Gupta, Professor, Indian Institute of Technology Bombay

Committees

Organisers and Organizing Committee

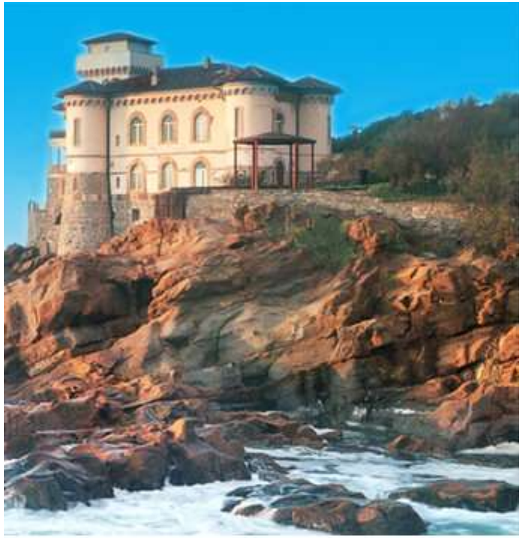
- **Geir Walsø (chair)**, NTNU, Norway
- Sveinung Sægrov, NTNU, Norway
- Hanne K Sandtorv, NTNU, Norway
- Tone Muthanna, NTNU, Norway
- Maryam Beheshti, NTNU, Norway
- Stian Bruaset, NTNU, Norway
- Arnhild Krogh, Norwegian Water
- Anne-Kristine Misund, Trondheim municipality



RELEVANT EVENTS TO COME

Livorno, 11-13 September 2017

Conference on Infrastructure Asset Management and Utility Bankability



http://iwa2017.ec.unipi.it/

- Under the 3rd IWA Conference on Water Challenges in XXI Century
- Jointly organized with the IWA Statistics and Economics SG

IWA Search

SAVE THE DATE: IWA Water and Development Congress & Exhibition 2017

13 – 16 November 2017, Buenos Aires, Argentina

EURO-SAM 2018

- 2 days in June 2018
- Limited to 20-25 participants
- Research only
- Topic: Sewer Asset Management

- Easy to participate / free of charge
- Share and Learn
- Work together
- No dissemination

Call in January 2018

Contacts:

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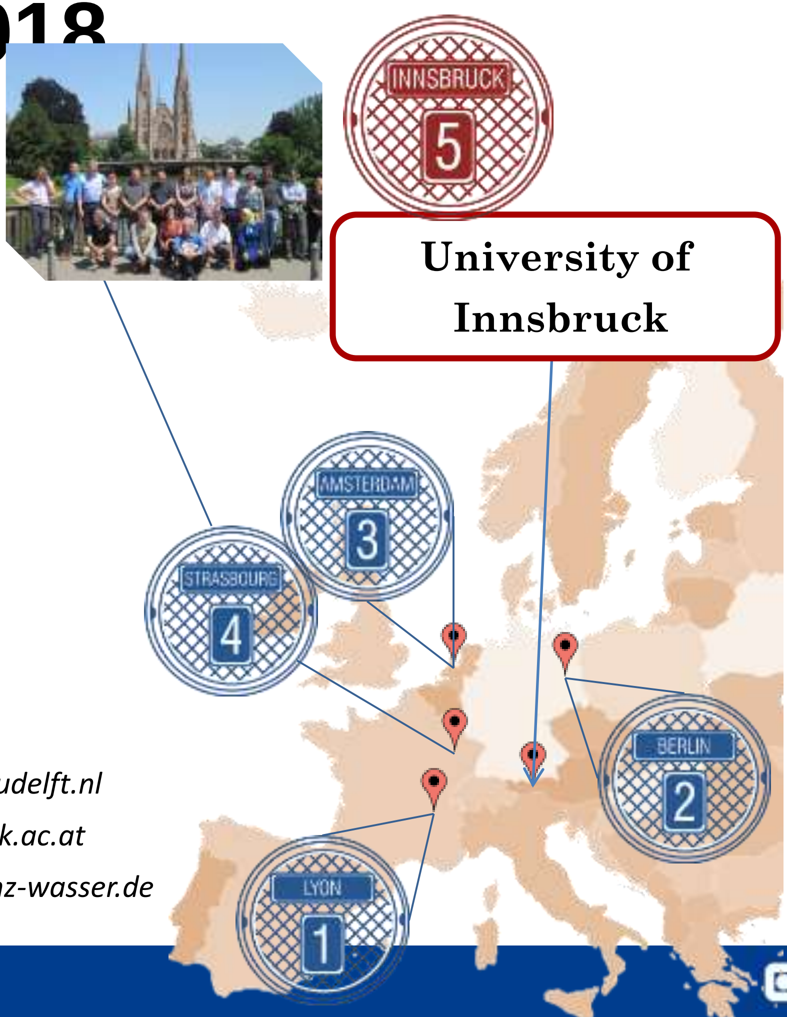

The IWA World Water Congress & Exhibition 2018, Tokyo

LESAM 2019

- Vancouver? – NEWS TO BE POSTED SOON

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LESAM 2017
NTNU, Trondheim, Norway

Norwegian University of Science and Technology

Presentations

Session 1, Best practices in IAM

Presentation 1

Jon Røstum: Innovation in the water sector: opportunities, barriers and instruments towards a modern water service

Duet / Dialogue

Jon Røstum (Powel) and Rita Ugarelli (NTNU/SINTEF)

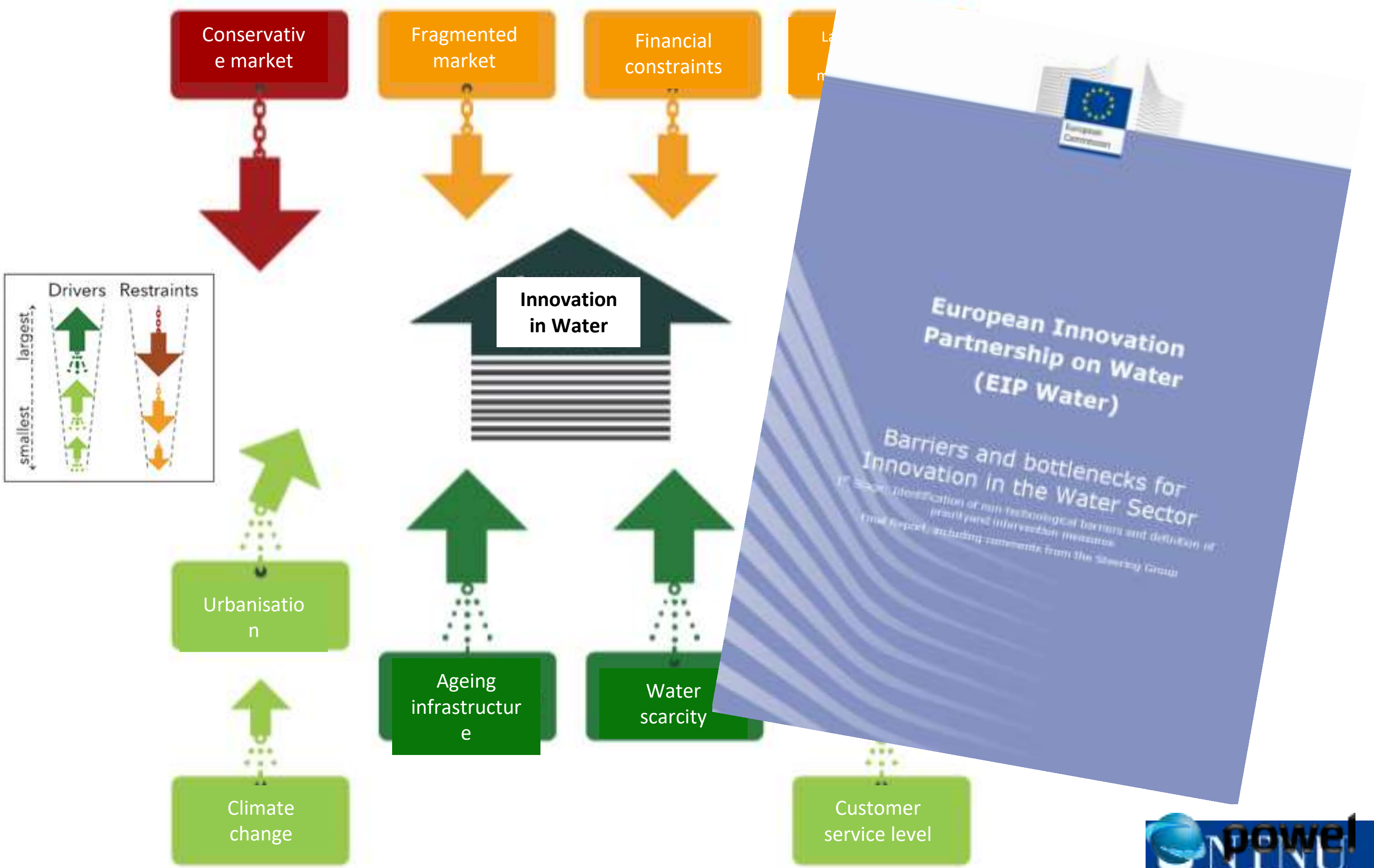
NTNU
Norwegian University of Science and Technology
SINTEF
powel

WHO ARE WE?

Rita Ugarelli
SINTEF and NTNU
Providing R&D and education for the water sector

Jon Røstum
POWEL (Software company proving IT solutions for the water industry)
Previously 15 years research at SINTEF

DRIVERS AND BARRIERS FOR INNOVATION IN THE WATER SECTOR (INSPIRED BY GWI, 2016)



TRL → CAN WE COVER THE VALUE CHAIN?

Technology Readiness Level (TRL)

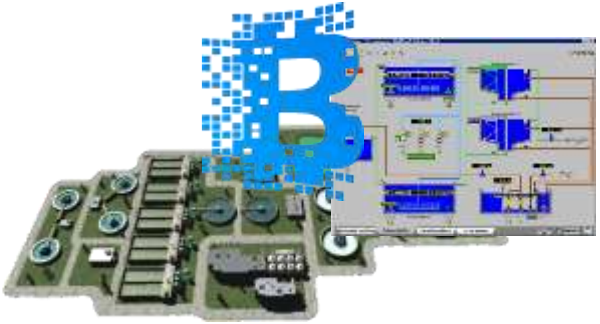
Research				Innovation			Commercial	
Technology Readiness Level								
1	2	3	4	5	6	7	8	9

Basic Research	Laboratory Research	Technology Development	Technology Demonstration	Product Development	Product Complete

"There is no evidence that people will want to use these things"
John C Dvorak (1984)

STOP-IT - Strategic, Tactical, Operational Protection of water Infrastructure against cyber-physical Threats

MODULAR OVERVIEW



WATER INDUSTRY IN THE CLOUD!

- *Cloud based services are spreading and encouraged*
- *Categorisation of data*

NEW LEGISLATION IN NORWAY (2017) - INCREASED DEMAND FOR IAM

§ 15. Water distributionsystem

"The owner of the water supply system should ensure that the water distribution system is in a satisfactory condition and it is being operated in a satisfactory way for avoiding contamination and contribute to a sustainable use of water.

<u>The owner should develop an IAM plan for maintenance and renewal of the water distribution system and this plan should be updated and implemented."</u>

NORWAY’S MOST FAMOUS WASTEWATER PIPE (BERGEN 2004)

THE CHALLENGE

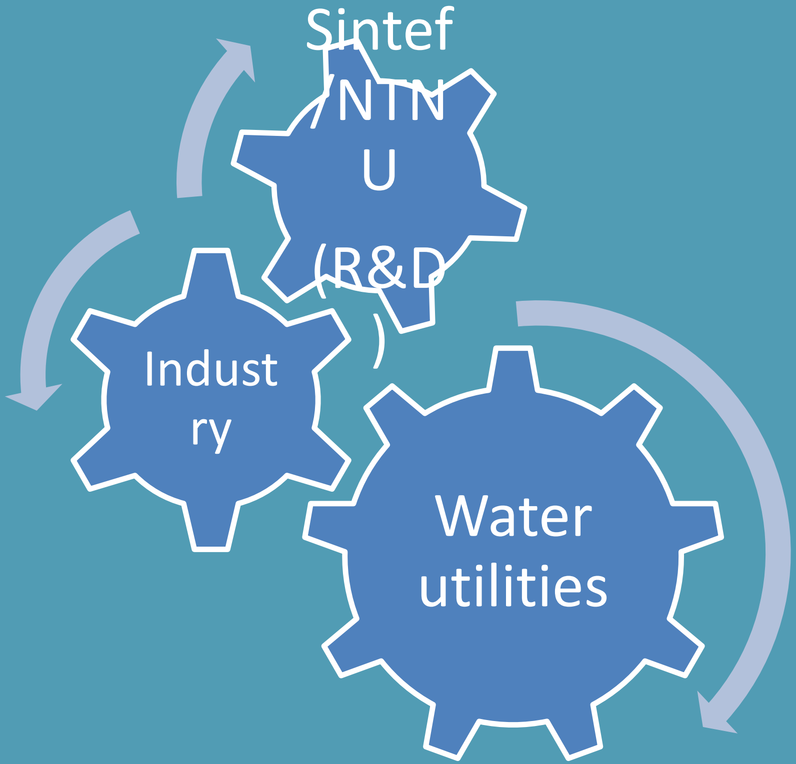
The challenge is to work at different levels to provide the complete value chain of TRL identifying the right form of investment and cooperation

CLUSTER - A SOLUTION TO BOOST INNOVATION IN THE WATER SECTOR IN NORWAY?

"Bring together a diverse and valuable mix of consulting companies, technology suppliers, clients, researchers and governmental bodies, who can join forces to share knowledge and through this collaboration create stronger solutions for water infrastructure asset management (end-user driven)."

Central aspects:

- Common build-up of knowledge
- Collaborative build-up of R&I
- Communication
- Co-creation
- Co-development



Sweden inspired

NORWAY HAS STARTED…..

- A new national competence cluster on pipe technology
- Physical focus
- What about IAM perspectives/Digital water and pipes?

07 jun 2017

Pressemelding: Budsjettavtale med viktig vannsatsing

Skrevet av Tone Bakstad.

Etableringen av et nasjonalt kompetansesenter for vann- og avløpsinfrastruktur ved NMBU på Ås er viktig for kvaliteten på vann- og avløpstjenestene fremover.

Samfunnet er helt avhengig av at vann- og avløpstjenestene fungerer godt, slik at det er rent vann i springen og rent vann i naturen. En hovedutfordring i dette arbeidet er det omfattende ledningsnettet for vann, avløp og overvann, som i sum er på hele 280.000 km i Norge. Dette må bygges, driftes og vedlikeholdes på en bærekraftig og kostnadseffektiv måte.

Budsjettavtalen som ble inngått mellom regjeringspartiene og Venstre og KrF i dag, bevilger 2,5 millioner kroner til etablering av et nasjonalt kompetansesenter for vann- og avløpsinfrastruktur ved NMBU på Ås.

IAM OF STORM WATER INFRASTRUCTURE

Trondheim

- How and what to register?
- How to maintain function?
- www.Klima2050.no

FINAL REMARK

By cluster we achieve:

- close cooperation between public sector and technology providers supported by the research environment
- Covering the whole TRL chain
- Co-creation with end-users (going from we have a tool and looking for problems)
- Relevant Master degrees and education, Industrial PhD
- Creation of Community of Practice

→ End of the era of «blue sky research»!

Thank you for your attention!

Q4U: DO YOU HAVE EXPERIENCE WITH NATIONAL CLUSTERING?

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Presentation 2

Takayuki Sawai: Implementation of asset management at the utility level – initiatives for the future improvement

Implementation of Asset Management at Utility Level

- Initiatives for the Future Improvement -

Takayuki SAWAI

Deputy Director for International Affairs,
Japan Water Works Association
(JWWA)

Contents

I. Context: Current Situation of Water Supply Assets in Japan

II. Waterworks Vision – The Policy towards Future

III. AM Guidelines for Water Supply Utilities

IV. Issues and Improvement for the Future

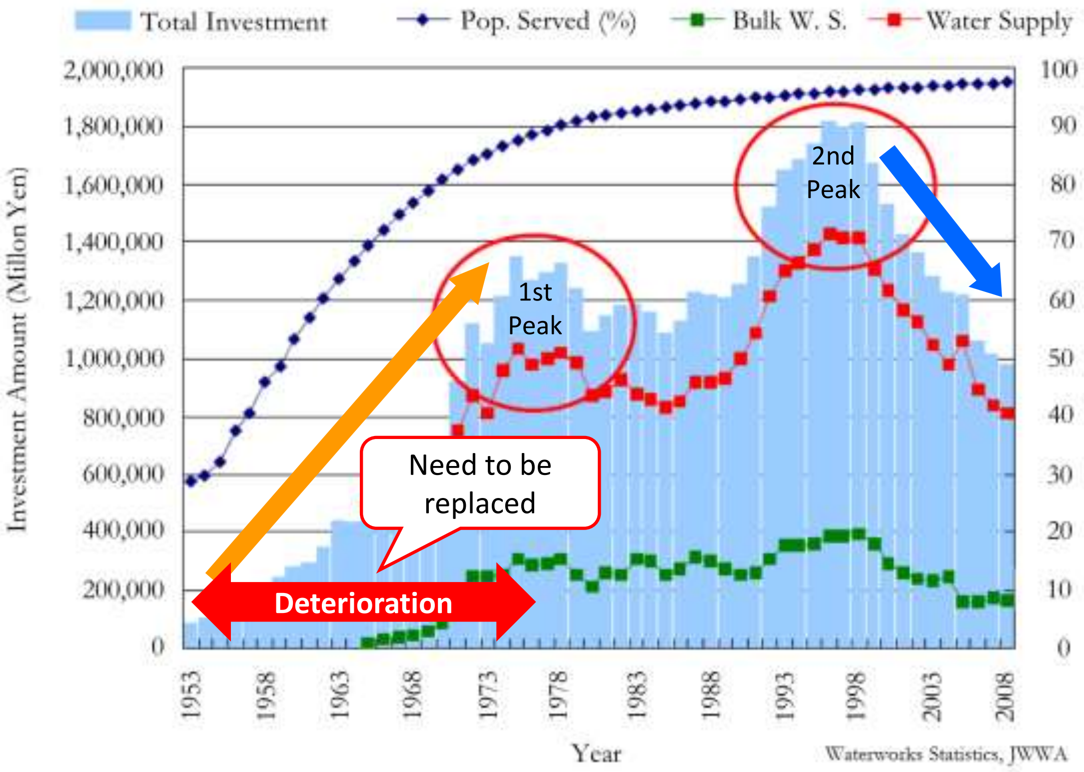
I. Context: Current Situation of Water Supply Assets in Japan

Water Supply in Japan

- Water utilities are basically operated by municipalities
- Coverage: 97.7% (2015)
- Tap water is drinkable safely everywhere, 24h/365d

- Cu Taste Water

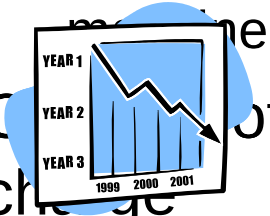
Age of Water Supply Assets



Decreasing Water Demand and Income

- Decrease of water consumption
  - ✓ Rapid population decrease

  Pop. Forecast: **128 million** in 2010 >>> **43 million** in 2110
  - ✓ Water-saving devices: Toilet, Washing machine etc.



- Cost not fully covered by water charge

Our Tasks

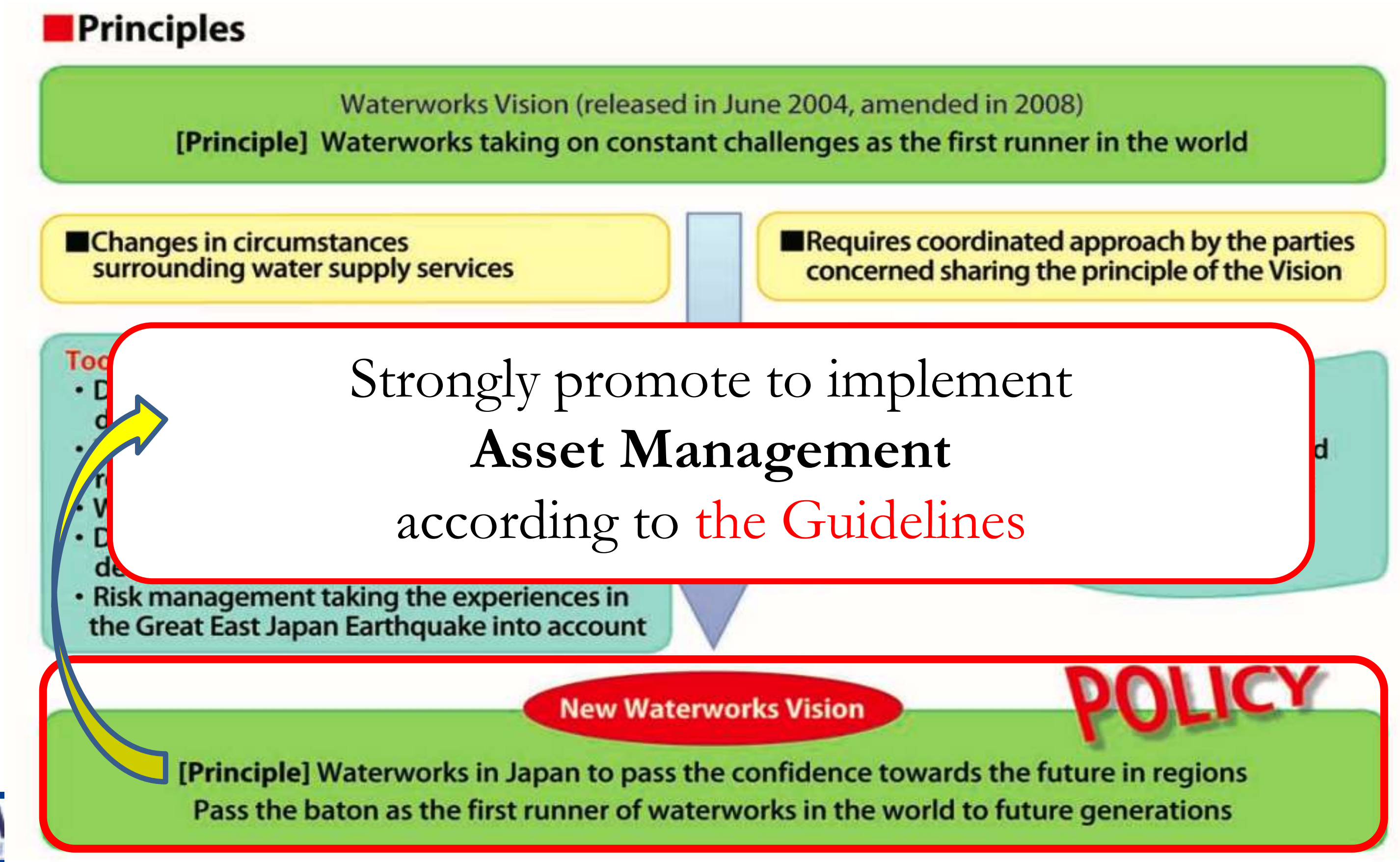
- To Improve Business Efficiency
  - ✓ Integrate and optimize water utilities and supply systems to expand supply area and gain economies of scale
- To Guarantee Sustainability and High Level of Service
  - ✓ Replace/rehabilitate aged pipes and facilities continuously
  - ✓ Promote earthquake proofing of pipes and facilities

II. Waterworks Vision
– The Policy towards Future

Development of Waterworks Vision and AM Guidelines

- 2004 Waterworks Vision
  - ✓ Safety, Stability, Sustainability, Environment and Globalization
- 2008 Waterworks Vision revised
- 2009 Asset Management Guidelines for Water Supply Utilities
- 2011 *Great East Japan Earthquake and Tsunami on March 11*
- 2013 New Waterworks Vision (current goal to achieve)
  - ✓ Safety, Sustainability and Resilience

New Waterworks Vision



Strongly promote to implement
Asset Management
according to the Guidelines

III. AM Guidelines for Water Supply Utilities

AM Gui
Water Sup

To make all utilities und

- ✓ Select the feasible
- ✓ Start with simplified met
- ✓ Case studies and "Entry Forms" included
- ✓ **"Support Tool for Implementing AM"** was also released in 2013

Pop. served	No. of utilities	%
> 1,000,000	15	0.2%
100,000 – 999,999	210	2.8%
10,000 – 99,999	824	11.0%
< 9,999	6,453	86.0%
Total	**7,502**	

•

•

period

- ✓ To increase the awareness of the "n investing in replacement" and "securing funds" among the utility staffs
- ✓ **To start implementing AM at any stage possible**, and make continual improvements
- ✓ To create **mid/long term replacement plans including the financial plan**

- Download: http://www.mhlw.go.jp/za/0723/c02/c02-01.html

Concept of AM in the Guideline

a) Create a database

b) Micro-management

- ✓ Daily AM (O&M work) for each facility
- ✓ Check facility conditions and store the collected data in a database

c) Macro-management

- ✓ AM for all facilities
- ✓ Select feasible examination level (methods) and forecast replacement demand and fiscal balance

d) Utilize examination results

- ✓ Plan strategies and tactics to ensure sustainability of waterworks
- ✓ Provision of information to gain customer recognition

Repair/ Replace -ment etc.

Process management & review

Good Practices by the Utilities

- **Setting longer durable years for pipes**
  - ✓ Legal durable years for pipes (depreciation period).... 40 years (unrealistic)
  - ✓ Set the durable years based on the actual condition.... Av. 60-80 years
- **Setting renewal priority by the scoring system based on;**
  - ✓ pipe types and functions (strength, anti-corrosion, anti-seismic, etc.)
  - ✓ pipe diameters, soil types/condition, characteristics of buried area
- **Systemized water leakage prevention and detection activity**
  - ✓ Water leakage: JP Average.... approx. 7% Tokyo MWB.... 3.2% (2015)

IV. Issues and Improvement for the Future

Improvem

Definition of "AM Implementation"

- ✓ To calculate future rehabilitation demand and financial balance (30-40 years)
- ✓ Judged by utility's self-assessment

- ***AM Implementation Ratio*** *at the Water Supply Utilities 2012-2015* -

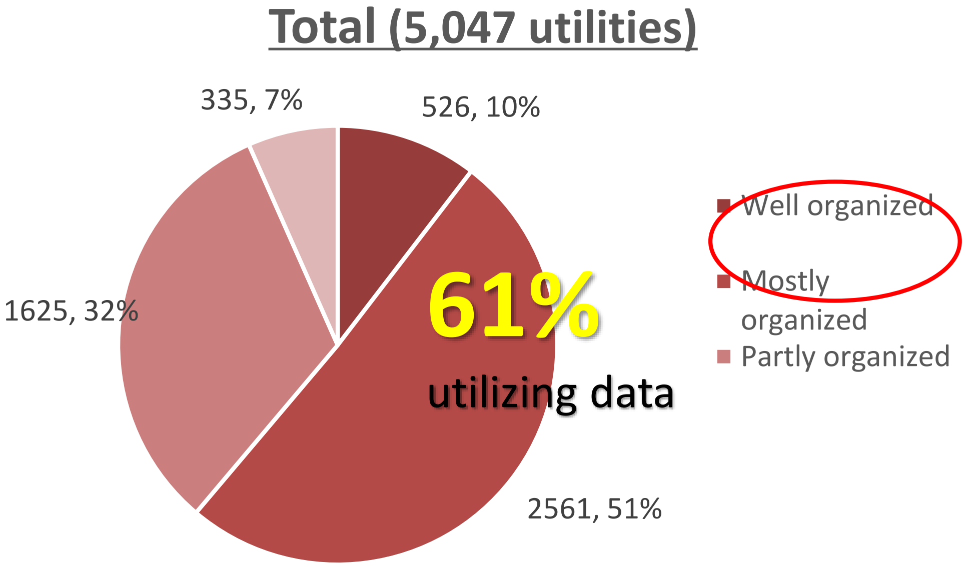
Supply Population		less than 50,000 (SMALL)	50,000-100,000	100,000-250,000	250,000-500,000 (LARGE)	more than 500,000	Bulk	Total
2012	Ratio	12.5[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]%	29.4%
2013	Ratio	36.3[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]%	51.6%
2014	Ratio	45.1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]%	59.9%
2015	Target Utilities	906	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,440
	Implemented	496	[illegible]	146	52	29	75	972
	Ratio	54.7%	83.7%	94.2%	94.5%	100.0%	86.2%	67.5%
Increasing Ratio 2014 - 2015		9.7%	6.6%	2.9%	1.4%	0.0%	7.7%	7.6%

Why not? (survey result)

1. No time to do, lack of personnel 57%
2. Lack of facility data 13%
3. Luck of funding 7%

Current Issues

- The Survey on the Inventory and Data Utilization -

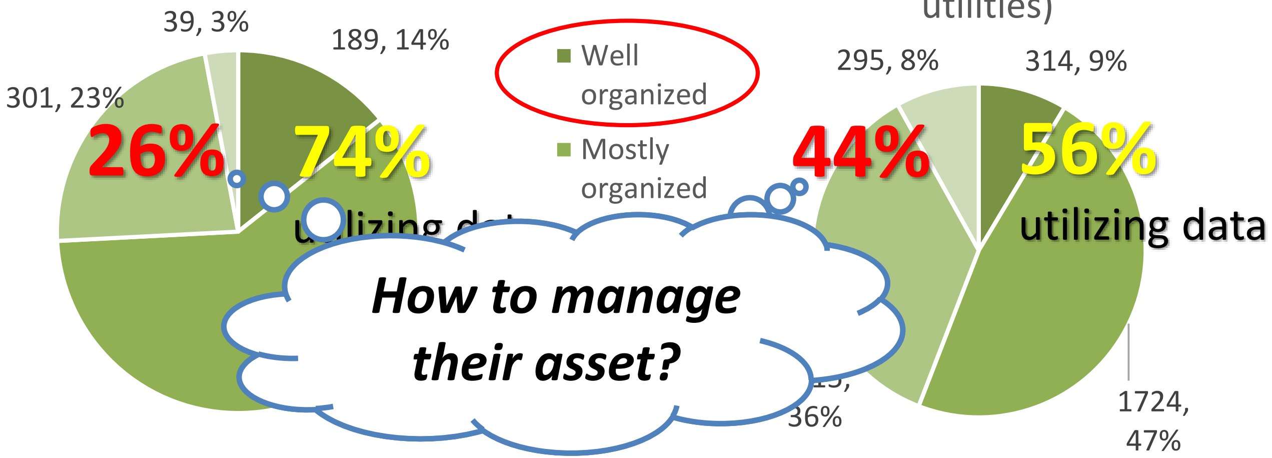


Current Issues

- The Survey on the Inventory and Data Utilization -

Large Utilities Supply pop. > 5,000 (1,317 utilities)

Small Utilities Supply pop. < 5,000 (3,648 utilities)



Current Issues

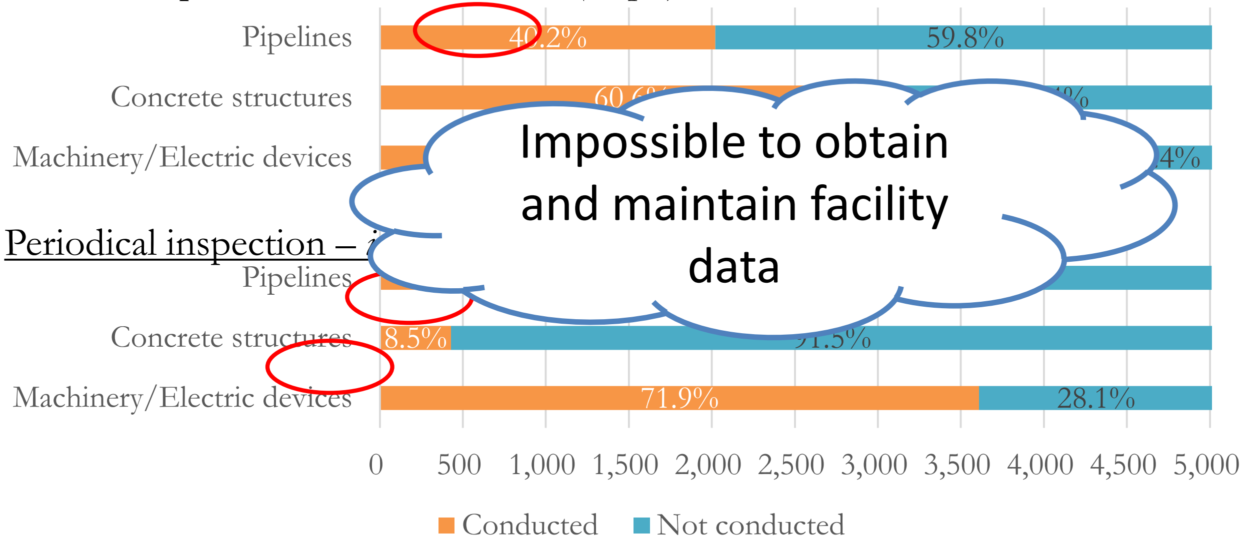
- The Survey on the Inventory and Data Utilization -

- Cause of facility data insufficiency
  1. Effect of municipal mergers - data are not organized yet
  2. Not yet integrated - scatter in different departments
  3. Lack of past data
     - ✓ Not inspected or recorded in the past
     - ✓ Already discarded as the saving period has passed

Current Issues

- The Survey on the Inspection Work at the Utilities -

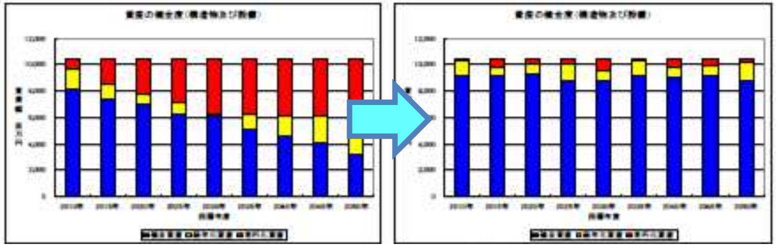
Routine inspection – *visual observation (simple)*



For Strengthening the Foundation of Waterworks

- Amendment of the Waterworks Law (under Diet deliberation) -

Condition without Replacement | Condition with Proper Replacement



- AM related iter
  - Water suppl **repair the f** condition
  - Water suppl **maintain w** to manage the fac ... operly
  - Water supply utili... es **should make effort to replace the facilities according to the business plan** from the long-term point of view
  - Water supply utilities **should make effort to establish business plan for facility replacement including financial**

For Strengthening the Foundation of Waterworks

- Amendment of the Waterworks Law (under Diet deliberation) -

- Other items to be added
  - ➢ For promoting **“Wide Area Cooperation”**
    - National government establish the basic policy
    - Prefectural governments can establish the “Foundation Reinforcement Plan” with the consent of water utilities
    - Prefectural governme **to promote wide area utilities in the area**
  - ➢ For promoting **“Public- vate Partnership”**
    - Introduce the measures for **further promotion of PPP initiatives including concession**

Concession (contract):
To transfer **management right** from public to private

JWWA – for Sound Development of Water Industry

*- **Supporter**, **Speaker** and **Thinktank** for the Water Sector -*

- Research and Consulting
  - Management and Technical Issues, Annual Research Conference
- Training
  - On Management and Technical, 20 Training Courses
- Publishing
  - Design/Anti-seismic/O&M criteria, Management Manuals, National Standards, Statistics, etc.
- Inspection and Certification of Water Supply Products

IWA World Water Congress & Exhibition 2018

IWA
the international water association

Shaping our Water Future

Taka SAWAI
International Affairs Division,
Japan Water Works Association (JWWA)
Member of ISO/TC 224
sawai@jwwa.or.jp

16-21 September 2018
Tokyo, Japan

www.worldwatercongress.org

Presentation 3

Joao Feliciano: Knowledge creation through the implementation of an infrastructure management methodology

Knowledge creation through the implementation of an infrastructure asset management methodology

LESAM 2017

IWA Leading Edge Conference on Strategic Asset Management of Water and Wastewater Infrastructures

Trondheim - June 2017

Contents

AGS

1. Introduction
2. IAM and knowledge creation and transfer methodologies
3. Knowledge creation and knowledge transfer in AGS' IAM initiatives
4. Knowledge creation at the sub-processes level – outputs of the research work
5. Final remarks

1. Introduction

LESAM 2017

IWA Leading Edge Conference on Strategic Asset Management of Water and Wastewater Infrastructures

Trondheim - June 2017

1. Introduction

AGS

AGS PRESENTATION

Infrastructures

7'000
km water

4'700
km wastewater

701
tanks

21
water treatment plants

366
wastewater treatment plants

Service

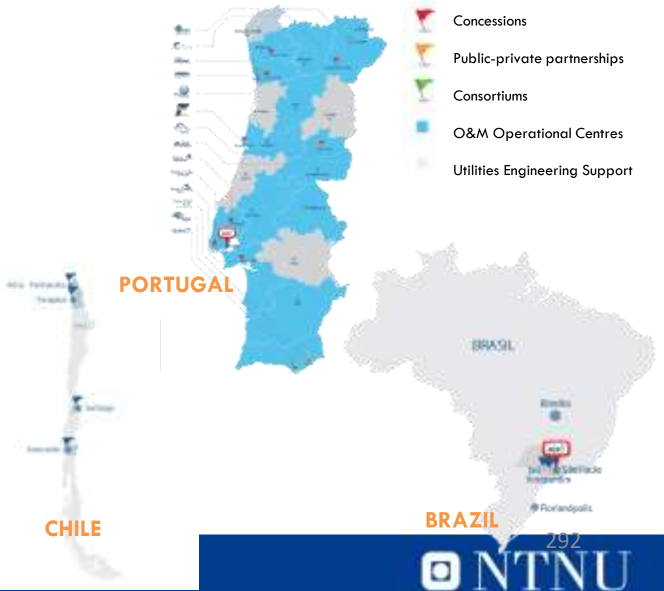
95 million
m^3 water/year

260 million
m^3 wastewater/year

1'300'000
population served

475'000
customers

Where we are



1. Introduction

AGS

AGS BACKGROUND IN ASSET MANAGEMENT

CARE-W	AWARE-P	National Civil Engineering Laboratory (LNEC) IAM initiatives		
2005 - 2006	2009 - 2011	2012 - 2013	2014 - 2016	2017 - 2018

Computer Aided Rehabilitation of Water Networks

Advanced Water Asset Rehabilitation - Portugal

Research & Development

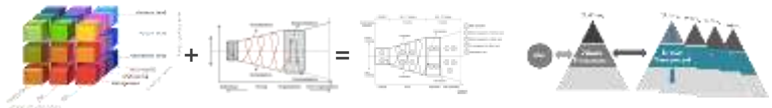
AGS IAM initiatives

1st edition
18 months

2nd edition
18 months

Methodology adapted to the case study – collaborative project

Timeline of the research work (PhD thesis)



2011 — 2016

2. IAM and knowledge creation and transfer methodologies

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2. IAM and knowledge creation and transfer methodologies

INFRASTRUCTURE ASSET MANAGEMENT METHODOLOGY | AWARE-P APPROACH

Integrated organizational approach that seeks the balance between performance, cost and risk

Incorporates different competences: engineering, information and management

Alignment and feedback between decision levels are ensured (strategic / tactical / operational)

Set up a clear course of action from organization's strategic objectives to operational activities

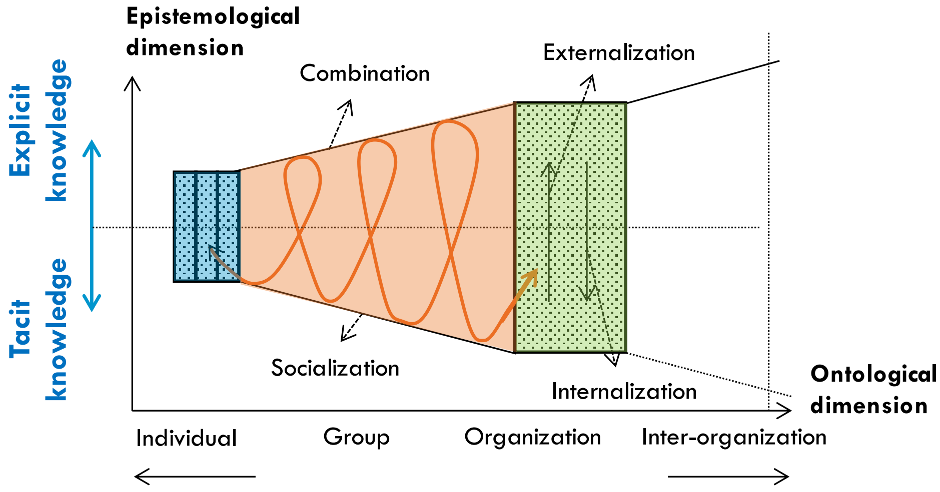
Alegre *et al.*, 2011

KNOWLEDGE CREATION AND TRANSFER METHODOLOGY

The knowledge creation and knowledge transfer are crucial in a fast movement society

The topics are gaining relevance due to the added value that can be generated in organizations, in terms of competitive advantage but…

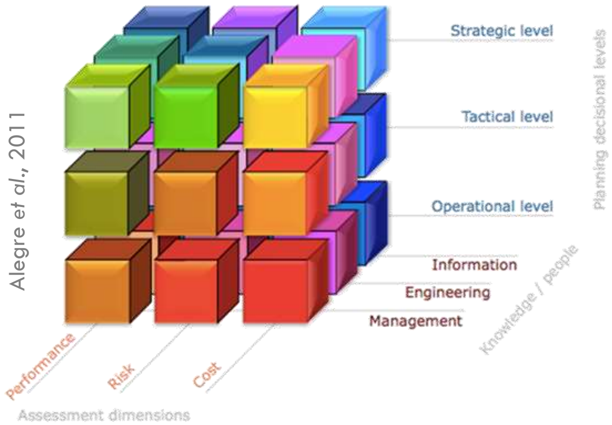
… they are not deeply explored in water utilities due to the lack of competitiveness in natural monopoly environments



Nonaka and Takeuchi, 1995

2. IAM and knowledge creation and transfer methodologies

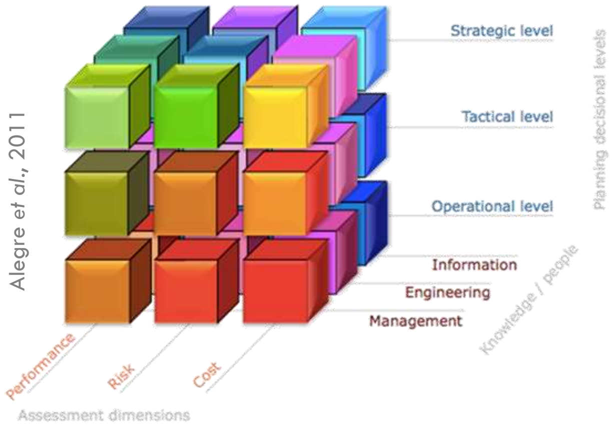
COMBINED METHODOLOGIES



Alegre *et al.*, 2011

The implementation of the IAM methodology alone would lead to the development of IAM plans by the utilities' teams without taking advantage of the process itself or adding extra value to the organizations

COMBINED METHODOLOGIES



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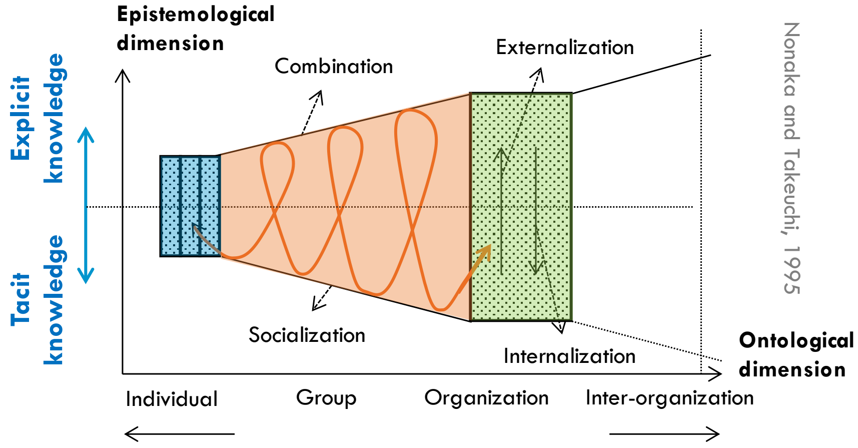
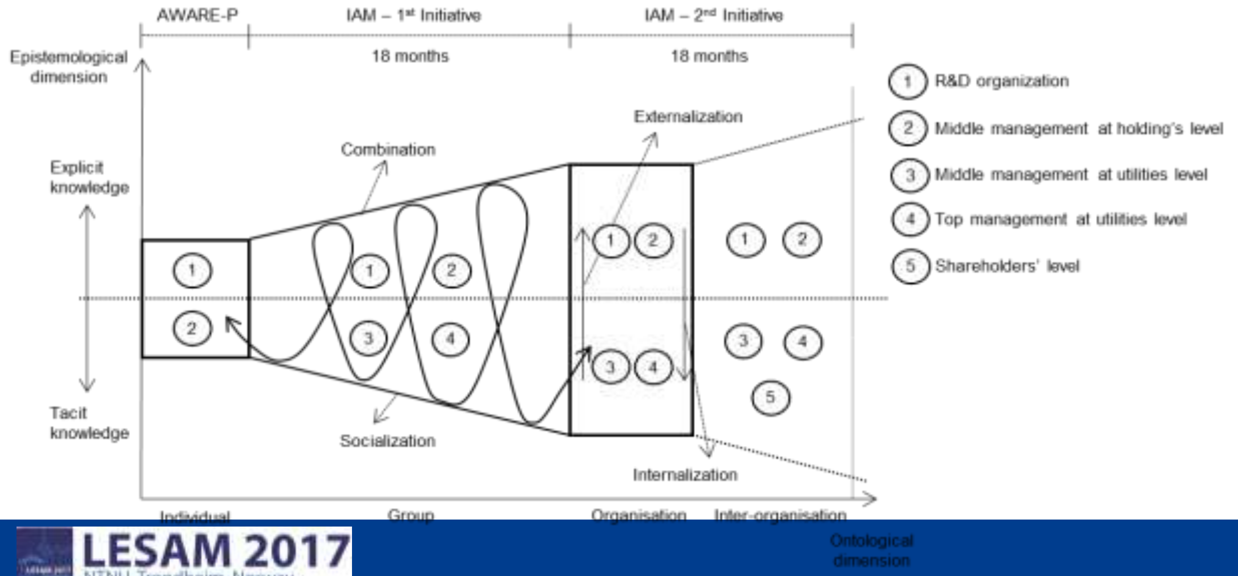


The combination of the two methodologies allowed to speed up the IAM implementation and to force knowledge creation through "outputs pop-up" generated during the initiatives

2. IAM and knowledge creation and transfer methodologies

COMBINED METHODOLOGIES

Nonaka and Takeuchi (1995) methodology was adapted and applied in two IAM initiatives in a living lab of 13 water utilities during two periods of 18-months each

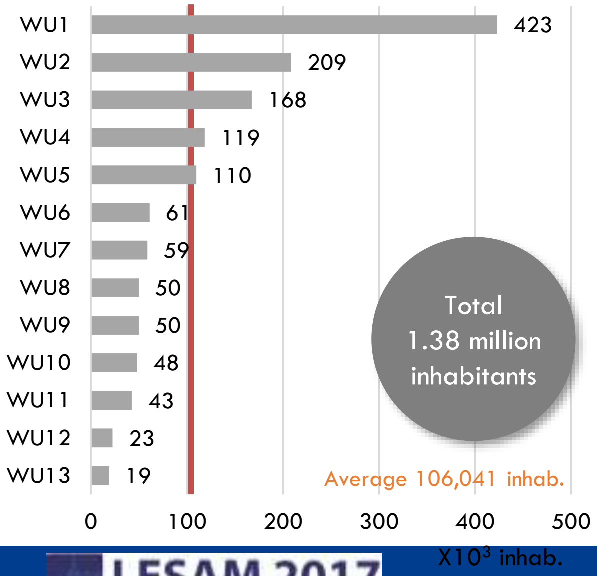


- Start the interaction with a small number of experts
- Dissemination to a larger group of technicians
- Key concepts: communication, context, assessment, expectations and skills

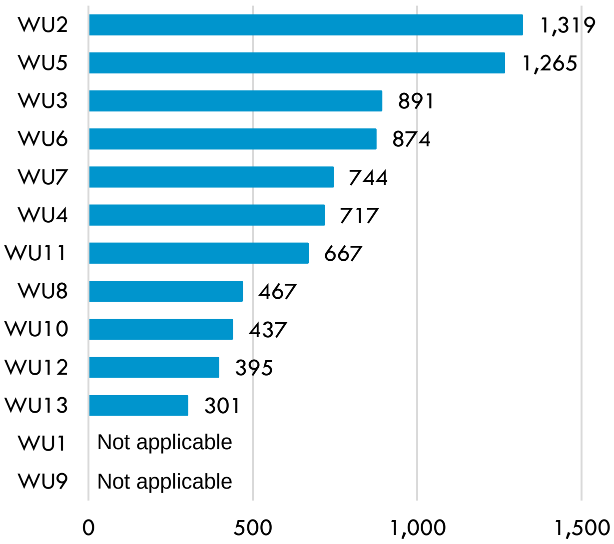
CASE-STUDY | A LIVING LAB OF 13 UTILITIES

Water services

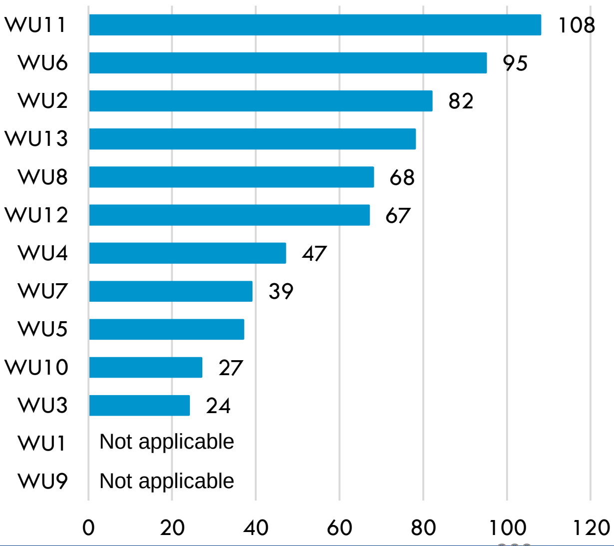
Served inhabitants (no.)



Mains length (km)



Facilities (no.)

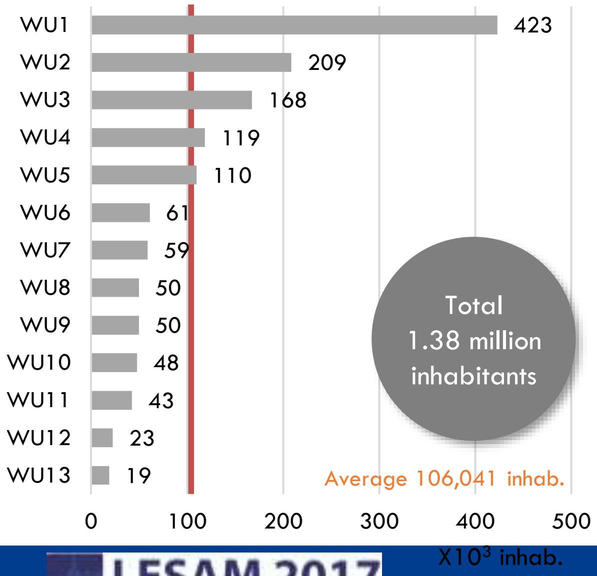


2. IAM and knowledge creation and transfer methodologies

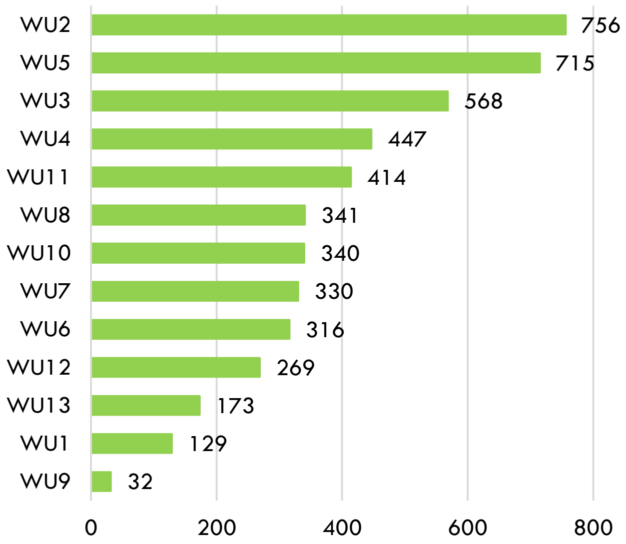
CASE-STUDY | A LIVING LAB OF 13 UTILITIES

Wastewater services

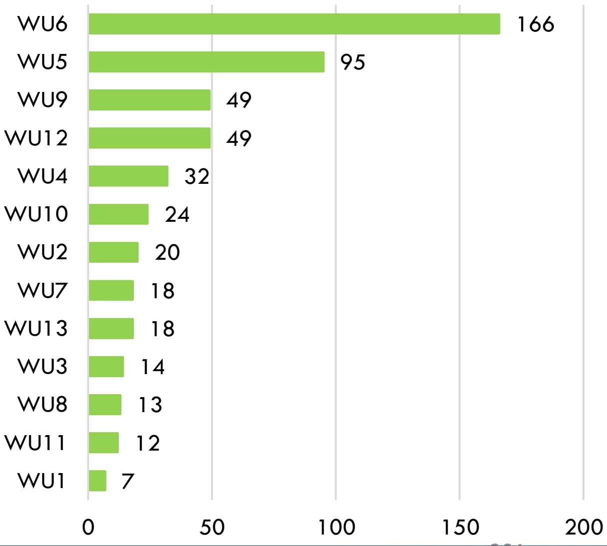
Served inhabitants (no.)



Sewer length (km)



Facilities (no.)



2. IAM and knowledge creation and transfer methodologies

CASE-STUDY | A LIVING LAB OF 13 UTILITIES

- Main goal was to implement the IAM methodology in the utilities which led them to develop their own asset management plans

- Implicitly, it aimed to test the implementation in utilities with different maturity levels, understanding how the process could be throttled from the holding perspective and how it could lead to novel outputs

1st Initiative
may 12 - oct 13

Stage 0
Program start-up

Stage 1
Strategic and tactical planning: objectives and diagnosis

Stage 2
Strategic and tactical planning: plans' development

Stage 3
Tactical planning: intervention alternatives development

Stage 4
Tactical planning: comparison and assessment of intervention alternatives

2nd Initiative
sep 14 - mar 16

Stage 1
Strategic planning: monitoring and review; Inventory and evaluation of linear assets

Stage 2
Strategic planning: assets evaluation: Inventory and evaluation of linear assets

Stage 3
Tactical planning: monitoring and review: assessment system definition per assets group type

Stage 4
Tactical planning: increase the alternative analysis to other intervention areas

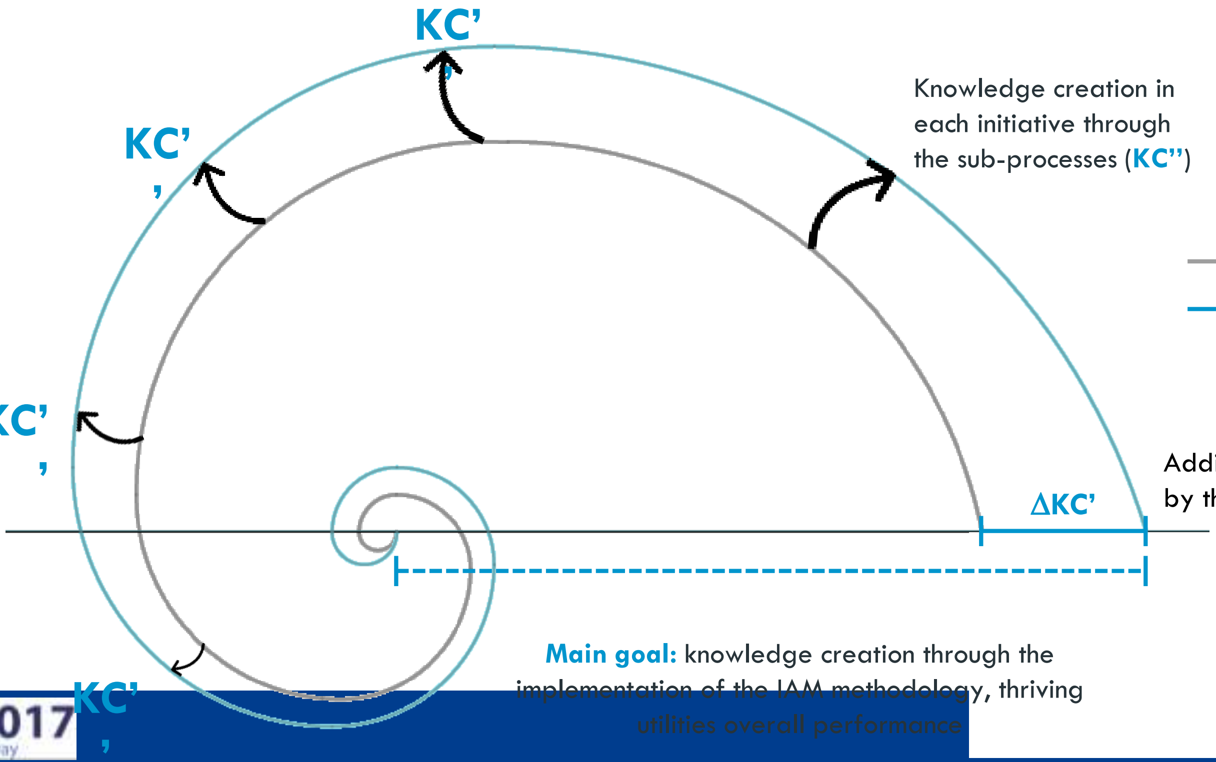
Stage 5
Human and technological assets

2. IAM and knowledge creation and transfer methodologies

KNOWLEDGE CREATION (KC) LEVELS

KC'
Knowledge creation at the IAM level

KC''
Knowledge creation at the output's level



Main goal: knowledge creation through the implementation of the IAM methodology, thriving utilities overall performance

KNOWLEDGE CREATION (KC) LEVELS

KC'

KC

Knowledge can be transformed and created through the interactions and the "outputs" can happen at several stages

IAM methodology

Combined methodologies

...itional knowledge generated ...he combined methodologies

KC''

Main goal: knowledge creation through the implementation of the IAM methodology, thriving utilities overall performance

3. Knowledge creation and knowledge transfer in AGS' IAM initiatives (KC')

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3. Knowledge creation and knowledge transfer in AGS' IAM initiatives (KC')

INCREASE OF THE OVERALL PERFORMANCE

First initiative (18-months)

2012 | 2013 | 2014 | 2015 | 2016

- Focus on the alignment of the holding engineering team with utilities management
- Transferring IAM fundamentals
- Capacitating water utilities' teams towards the development of IAM plans

3. Knowledge creation and knowledge transfer in AGS' IAM initiatives (KC')

AGS

INCREASE OF THE OVERALL PERFORMANCE

Second initiative (18-months)

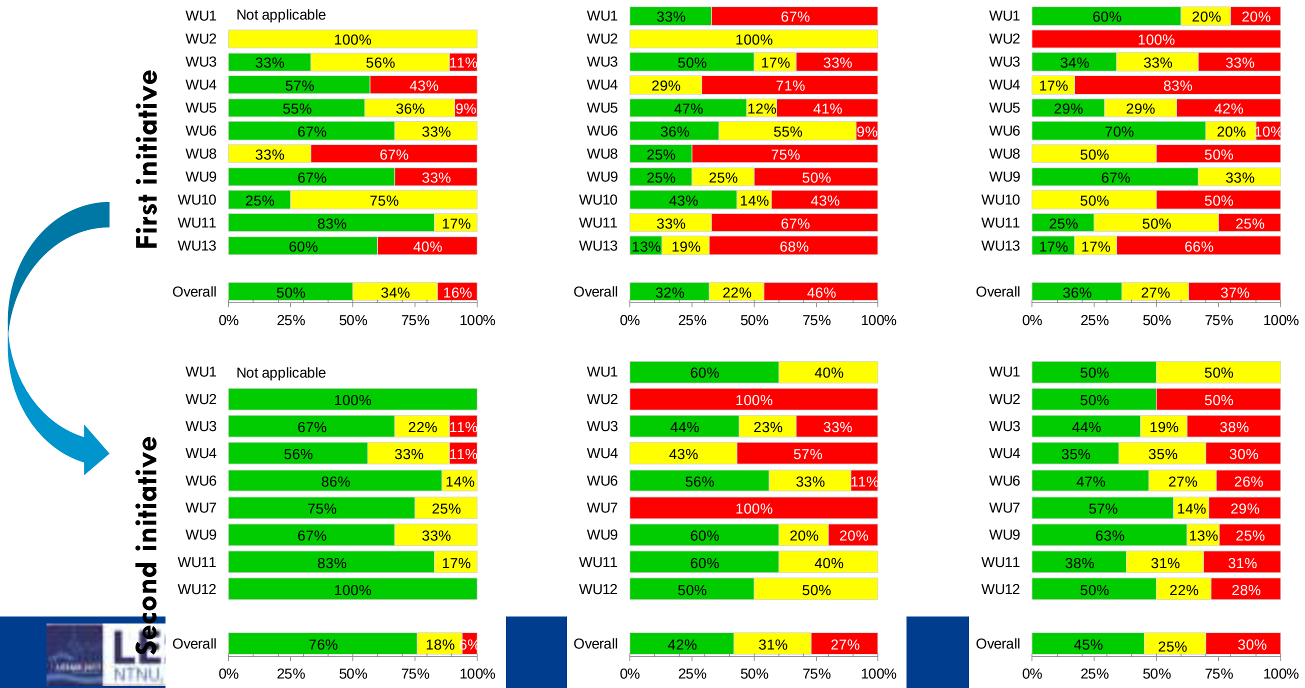
2012	2013	2014	2015	2016

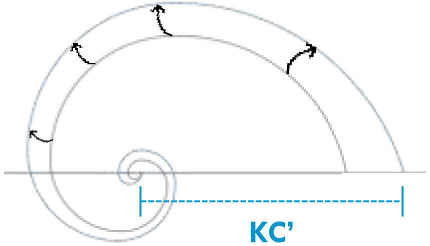
- Re-visit of the plans developed during first initiative
- Upgrading the scope of the plans to the whole water utilities' system

3. Knowledge creation and knowledge transfer in AGS' IAM initiatives (KC')

INCREASE OF THE OVERALL PERFORMANCE | STRATEGIC GOALS OF THE NATIONAL REGULATOR

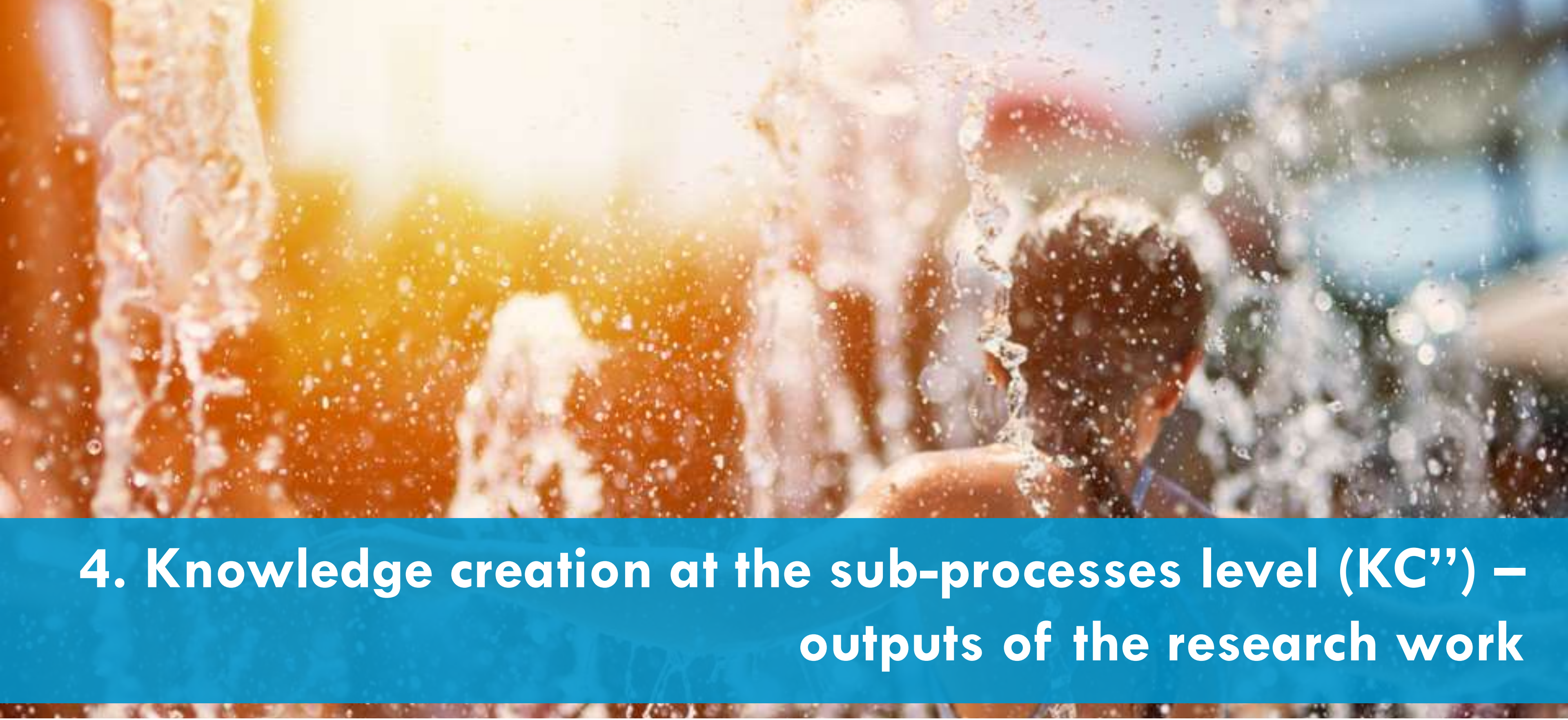
Protection of the users' interests | Operator's sustainability | Environmental sustainability





It was possible to perceive the increase of the overall performance, when comparing it before and after the initiatives

Scale
- Good
- Average
- Poor



4. Knowledge creation at the sub-processes level (KC'') – outputs of the research work

LESAM 2017

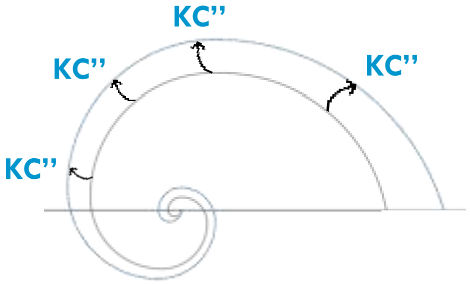
IWA Leading Edge Conference on Strategic Asset Management of Water and Wastewater Infrastructures

Trondheim - June 2017

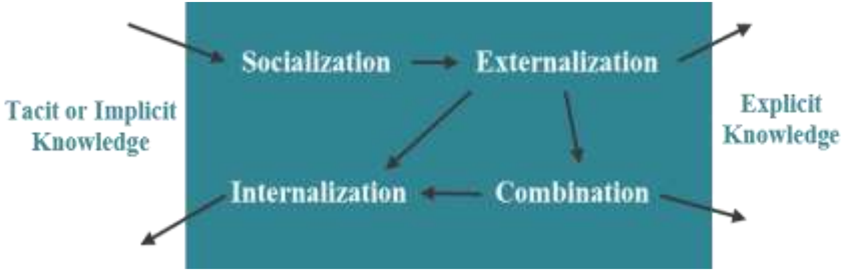
4. Knowledge creation at the sub-processes level (KC'') – outputs of the research work

AGS

KNOWLEDGE CREATION SCALE



In order to summarize the knowledge creation process and to reference the knowledge created in each of these stages, a *"knowledge level"* scale was proposed based on the methodology of Nonaka and Takeuchi (1995)



Liikkanen, 2010

Proposed scale to classify the level of knowledge generated by each output:

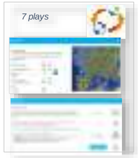
1 ✓	2	3	4	Tacit knowledge creation - socialization
1 ✓	2 ✓	3	4	Explicit knowledge creation - externalization
1 ✓	2 ✓	3 ✓	4	Explicit knowledge creation - combination
1 ✓	2 ✓	3 ✓	4 ✓	Explicit knowledge creation - internalization

Allows the assessment of the generated outputs maturity level

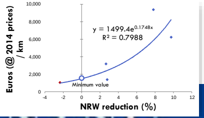
4. Knowledge creation at the sub-processes level (KC'') – outputs of the research work

GENERATED OUTPUTS

Output	Level of knowledge	Outcome
Work orders application	1 ✓ 2 ✓ 3 ✓ 4 ✓	Software
Dynamic platform for data and information management	1 ✓ 2 ✓ 3 ✓ 4	Software
Work orders data and information structure	1 ✓ 2 ✓ 3 ✓ 4	Model
Role-play game prototype – waterchallenge	1 ✓ 2 ✓ 3 ✓ 4	Prototype
"Organic approach" in IAM	1 ✓ 2 ✓ 3 4	Case-study
Human assets in water utilities – assessing personnel aging	1 ✓ 2 ✓ 3 ✓ 4 ✓	Index
Contribution of an IAM approach to improve operational efficiency	1 ✓ 2 ✓ 3 ✓ 4	Equation
Knowledge creation scale	1 ✓ 2 ✓ 3 ✓ 4	Scale



$$PAI(t) = \frac{\sum_{i=1}^{n} RUpl_{i,t}}{\sum_{i=1}^{n} Cl_i}$$



5. Final remarks

5. Final remarks

AGS

- The implementation of the initiatives **contributed to utilities' overall performance improvement**

- **Collaborative projects** can be relevant **catalysers** to promote engagement and to concentrate teams in the development of **new knowledge and more added value** to the organizations

- It is possible to **create knowledge with a strategy** and tacit or implicit forms of knowledge can be turned into explicit knowledge

- Knowledge creation can be planned, **putting aside knowledge creation** by **coincidence**

5. Final remarks

Example of improvement at **data's level**, before and after the IAM methodology's implementation, regarding **work orders data**

5. Final remarks

- **Natural monopolies**, typically managed at a regional or a local level providing granted public services, mainly through buried infrastructures, either by public or private operators, **are not the most appealing environment to improve**

- It is possible to globally improve the management of the organizations through the **middle management**, having the commitment of the top management

- **Inspiring teams** should be turned into **strategic knowledge creation bodies** working towards the improvement of the **quality of service** and performing in favour of the **public interest**

Acknowledgments

Scientific supervision

Dr. Dídia Covas

Dr. Helena Alegre

TÉCNICO LISBOA

LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

Utilitie's group

AGS Water Solutions

Knowledge creation through the implementation of an infrastructure asset management methodology

LESAM 2017

IWA Leading Edge Conference on Strategic Asset Management of Water and Wastewater Infrastructures

Trondheim - June 2017

LESAM 2017
NTNU, Trondheim, Norway

Presentation 4

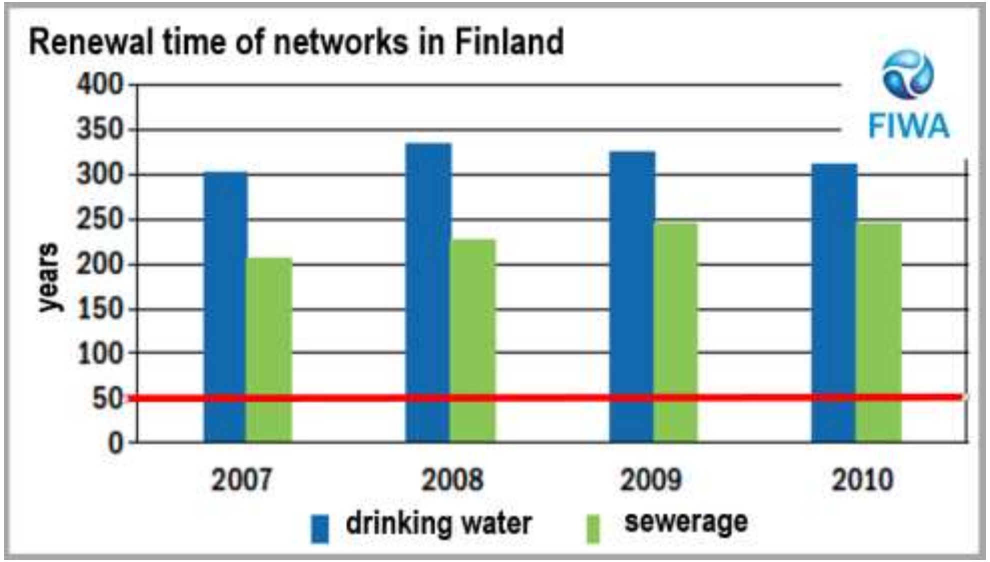
Riika Rajala: Asset life cycle management in Finnish water industry: Decision-making, strategies, systems and practices

ASSET LIFE CYCLE MANAGEMENT IN FINNISH WATER INDUSTRY:

DECISION-MAKING, STRATEGIES, SYSTEMS AND PRACTICES

Jarmo Hukka & Riikka Rajala

The aging water infrastructure: Out of sight, out of mind?



ROTI 2017

2017

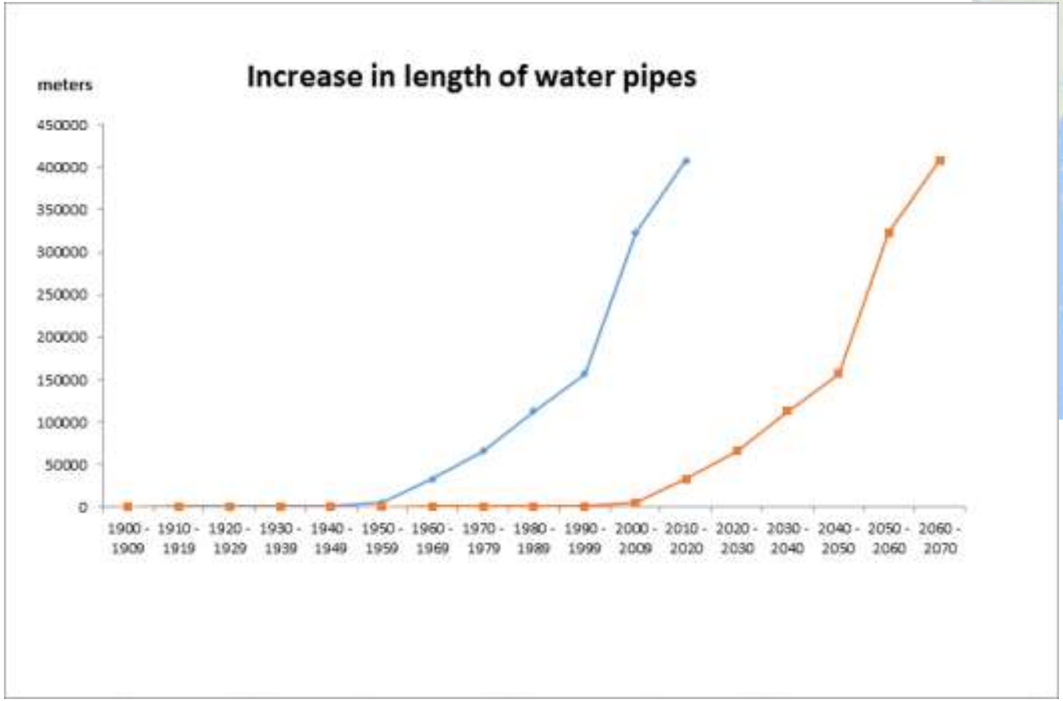
7½

2015 7 1/2
2013 8-
2011 8
2009 8-

Investment gap is increasing

- Rehabilitation and replacement investment level: 120 M EUR/a
- The required investment level: 320 M EUR/a

PORVOO (50 000 inhabitants)



Questionnaire

Based on a comprehensive asset management system, which include these components:

- Define service levels
- Learn about risks
- Focus on life cycle costs
- Use triple bottom line
- Optimize data and data systems
- Create strategic asset management plans
- Clarify roles and responsibilities
- Make large investment decisions via asset management committee

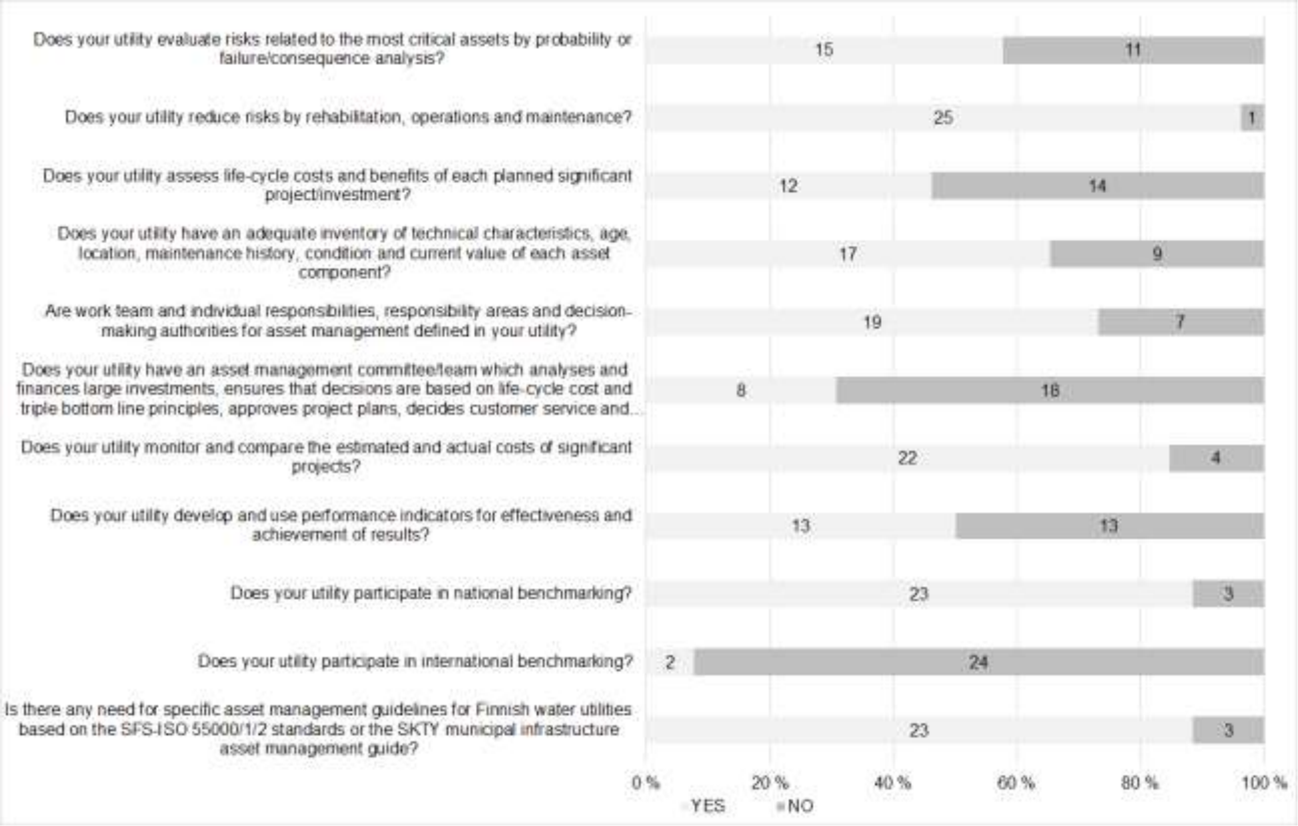
The idea was to explore if utilities use these components.

Based on Components of Seattle Public Utilities (SPU) Asset Management System (Vinnari 2006)

Questionnaire

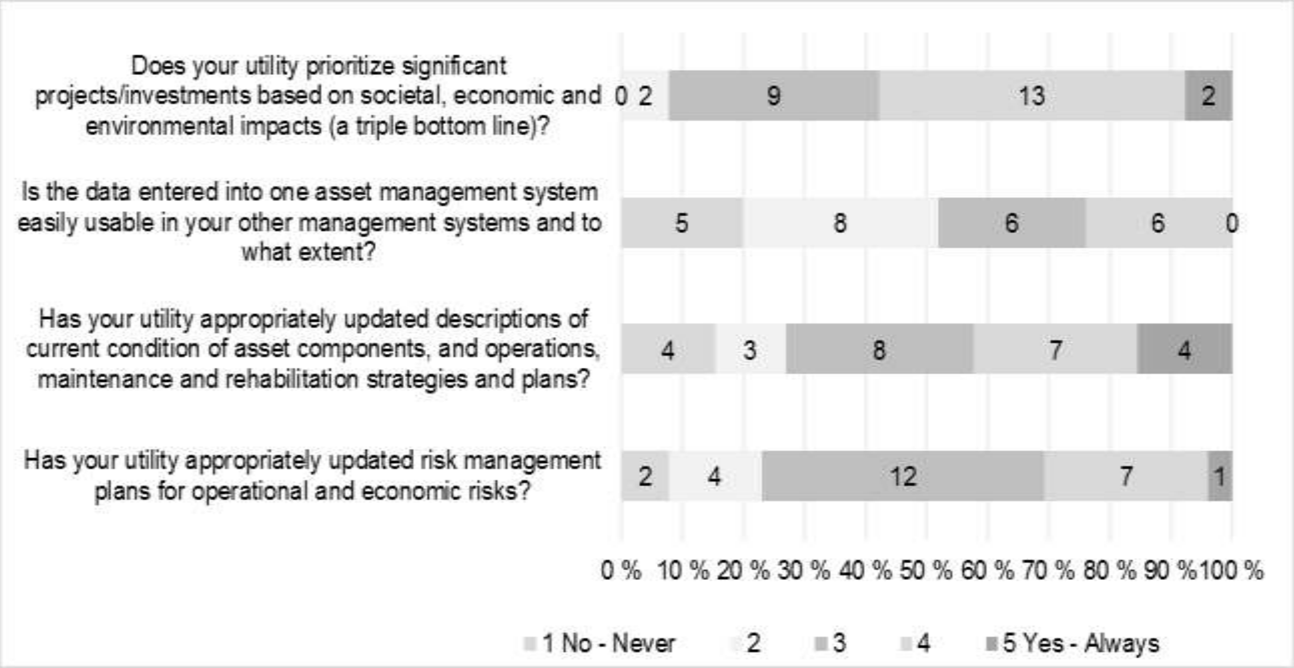
- The questionnaire was sent to 78 municipal water undertakings during February-March 2017.
- Altogether 26 utilities (33%) replied.
- Webropol Survey and Analysis tool was used to diagnose the replies.
- Interestingly enough: none of the replied utilities have adopted the **SFS-ISO 55000 Asset Management standard series** for optimized management of their physical assets.
- Five utilities use other asset management guides in their business operations.
- "Infrastructure management guide for municipalities”**.** Kuntainfran omaisuudenhallinta. Pikaopas. Alatyppö & Paavilainen. Suomen kuntatekniikan yhdistys ry. Based on this: International infrastructure management manual (IIMM), IPWEA 2015.

Questionnaire: yes or no



Questionnaire:

1 (no, never) – 5 (yes, always)



Conclusions

- The biggest challenge in the water industry is aging and deteriorating water and wastewater infrastructure today and in the coming 20-30 years.
- The municipalities/utilities have very limited knowledge of the current condition of their critical physical assets.
- Although most of the surveyed utilities have in practice adopted several processes and sub-processes of asset management, and few utilities are using some asset management guides for their business operations
- Asset management guidelines for the water services undertakings is needed.

Thank you

Presentation 5

Oliver Nachevski: Development & Implementation of an Asset Management Business Planning Model as a Decision Support Tool for Public Utilities and Local Governments in South-Eastern Europe

Development & Implementation of an Asset Management Business Planning Model as a Decision Support Tool for Public Utilities and Local Governments in South-Eastern Europe

Dr. Petros Kolovopoulos – Executive Director, Hydro-Comp Enterprises Ltd., Nicosia, Cyprus, petros@edams.com
Mr. Oliver Nachevski – Project Manager, GIZ Macedonia, Strategic Alliance on Integrated Asset Management, oliver.nachevski@giz.de

AM Business Planning Model – What is it?

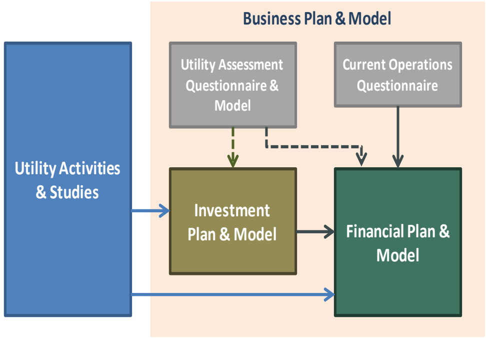
Business Planning Model is a Decision Support Tool that enables the Municipalities/ Funding organisations to assess:

- the performance and sustainability of the Public Utility's future operation;
- the ability of the Public Utility to repay loans,

as a result of implementing an Investment Plan made up of interventions proposed through carrying out effective Integrated Asset management.

It is a high level assessment/ development of Municipal infrastructure investment requirements over the planning horizon.

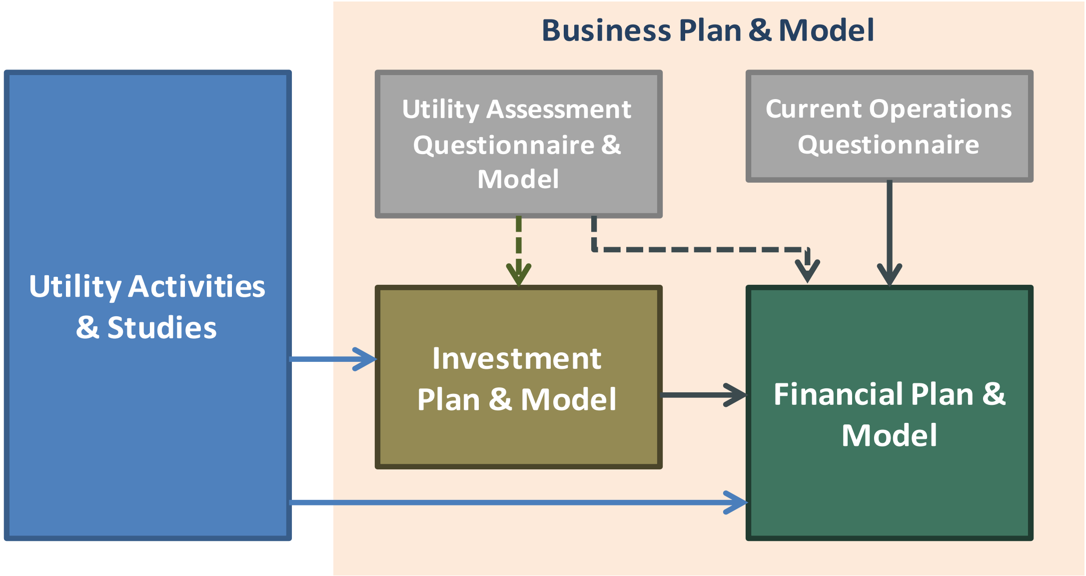
Why the need for an AM Business Planning model?



Decision Makers in spite of AM programs in place most often take a short term approach to business planning:

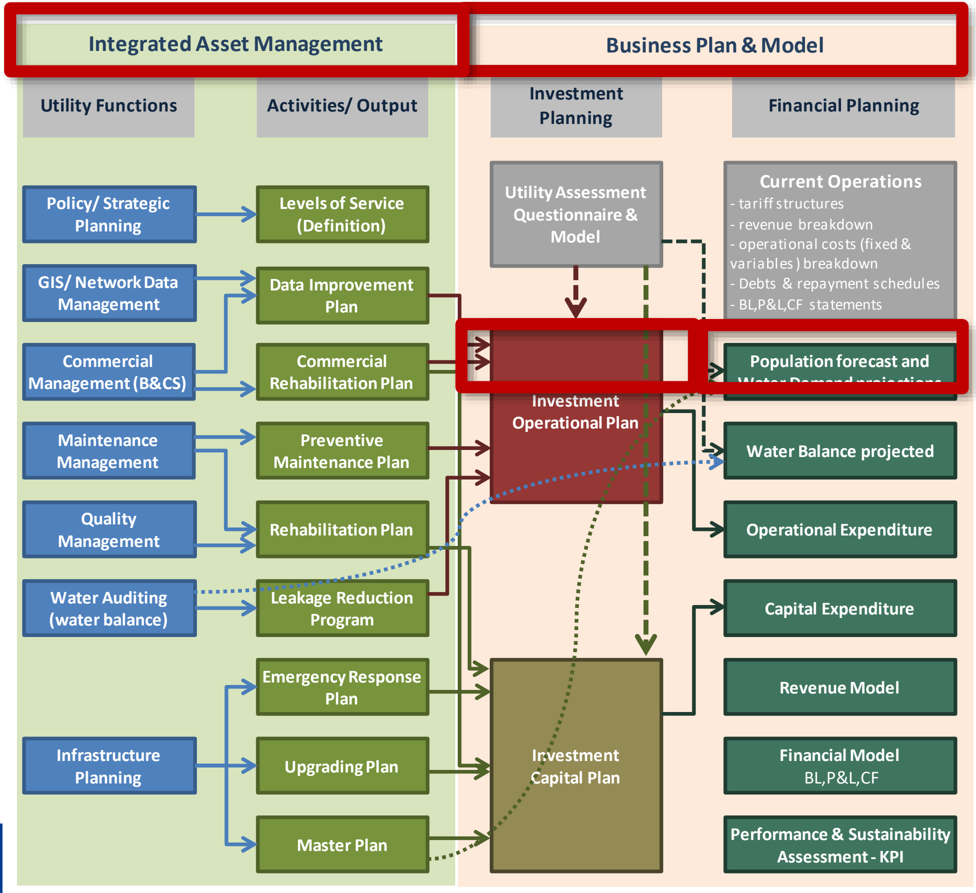
- **Easier to fund creation of new assets, but no adequate funding for properly maintaining existing assets**
- **Maintenance deferred because:**
  - **Pressure to keep rates low**
  - **Other increased costs of doing business**
  - **Competing priorities / other projects**
- **Maintenance problems often are "invisible" until something goes wrong**

AM Business Planning Model Components



AM Business Planning Model

Components & Detailed Logical Diagram



AM Business Planning Model – Implementation Steps
1. Utility Assessment Questionnaire & Model

- **Objective:** The Utility Assessment model is used prior to carrying out all the Utility AM activities or at any stage during the execution of those activities to provide supplementary information (not yet derived from the said activities) to the Investment Plan and the Financial Model.

- **Description:** The Model analyses town planning, commercial and technical macro indicators, such as number of properties, number of metered private connections, percentage debt recovery, fixed production costs and length of transmission & distribution networks.

2	Revenue Breakdown from Charges (Tariffs)						
Item	Consumer type	Number of Conne-ctions	Billed Consumption (m3/year)/ Note 2		Billed Consumption Revenue	Total Billed Revenue	% debt recovery
			metered	estimated	Euro/year	Euro/year	%
2.1	Standpipes/kiosks	5		2,800	2,800	2,800	60.00%
2.2	Indigents	8,000	708,000	472,000	265,808	457,808	25.00%
2.3	Domestic-yard connection	3,000	245,000	105,000	183,136	291,136	40.00%
2.4	Domestic-house connection	33,000	6,552,000	728,000	3,809,219	5,220,000	75.00%
2.5	Domestic-Buildings	500	4,560,000	0	2,385,994	2,685,994	80.00%
2.6	Commercial	1,500	747,000	83,000	694,868	784,868	82.00%
2.7	Industrial	150	139,000	0	174,554	192,554	85.00%
2.8	Institutional	150	198,000	0	165,764	183,764	75.00%
2.9	Other	0	0	0	0	0	0.00%
	Sub-total	46,305	13,149,000	1,390,800	7,682,143	9,818,924	73.75%

AM Business Planning Model – Key features
1. Utility Assessment Questionnaire & Model

1	Tariff Structures				
Item	Consumer type	Billing cycle (BC)	Free Volume per BC	Fixed Charge/ BC	Minimum Charge/BC
		months	m3	Euro	Euro
1.1	Standpipes/kiosks	1	0	0.000	0.000
1.2	Indigent				
1.3	Domest				
1.4	Domest				
1.5	Domest				
1.6	Comme				
1.7	Industria				
1.8	Institutio				
1.9	Other				

4	Operational Costs - Fixed Costs - Staffing		
Item	Description	Number of people	Yearly Cost Euro
4.1	Management & Administration		
4.2	Financial Management & Support Services		
4.3	Co		
4.4	Ma		
4.5	Op		
4.6	Ot		
	Su		

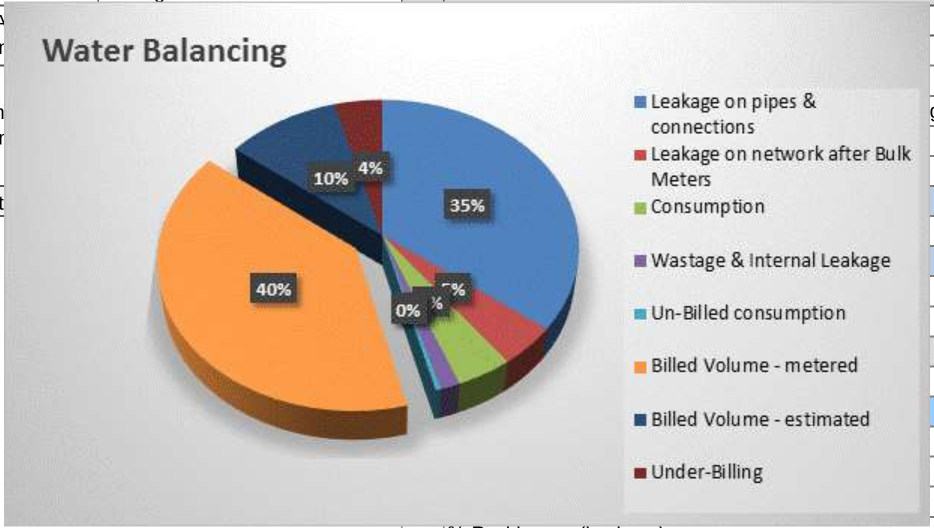
5	Operational Costs - Fixed Costs -
Item	Description
5.1	Consumables
5.2	Offices & Stores - Running Expenses
5.3	Programs & Fees
5.4	Maintenance/ replacement of Equipment
5.5	Insurance (CAPEX)
5.6	Other
	Sub-total for: Operational Costs - Fixed (

11	Financial Statements		
	The model will produce sample Financial Statements using assumptions		
	A copy of the latest financial statements of the organisation should be included for comparison purp		
	as well as for obtaining opening balances for the model		
	The following Balance Sheet information should be obtained from the current financial statements:		
	If the balance is not zero an adjustment will be made as shown,		
	Assets		
11.1	Current Value of existing Assets	Euro	5,150,000
11.2	Current Assets (do not include receivables from bad payers)	Euro	250,000
11.3	Current Cash Reserves	Euro	350,000
	Liabilities		
	Existing Loans	Euro	3,000,000
	Current liabilities & provisions:		250,000
11.4	Current Shareholder's Equity	Euro	3,400,000
	Adjustment to Shareholder's Equity		-900,000
	Balance: Assets - (Liabilities + Shareholder's Equity) = 0		0
	Additional Information required from P&L statement		
11.2	Current Annual Depreciation of existing Assets	Euro	250,000

AM Business Planning Model – Implementation Steps
2. Utility Assessment & Water Audit & Balancing

2	Water Balance using Billed volumes			
Item	Description		unit	Amount
1	Real Losses	Leakage on pipes & connections		
3		Leakage on network after Bulk Met		
4	Un-A			
5	Conn			
6				
	Auth			
	Conn			
7				
	Syst			

3	UFW/ NRW Analysis [using Billed Volumes]	unit	Amount (kl/day)
	Description	unit	Amount (kl/day)
		kl/day	28,276
		kl/day	3,600
		kl/day	3,392
	ge	kl/day	1,200
		kl/day	300
		kl/day	3,397
		kl/day	40,165
		kl/day	9,973
		kl/day	50,138
		kl/day	28,021
		kl/day	1,841
		kl/day	80,000
		%	62.7%
		%	50.2%
		%	73.8%
	% Real losses (Leakage)	%	39.8%
	% Apparent Losses -Unauthorised Consumption	%	5.7%
	% Apparent Losses -Authorised Connections	%	4.6%



AM Business Planning Model – Implementation Steps
3. Setting up the Investment Plan & Model

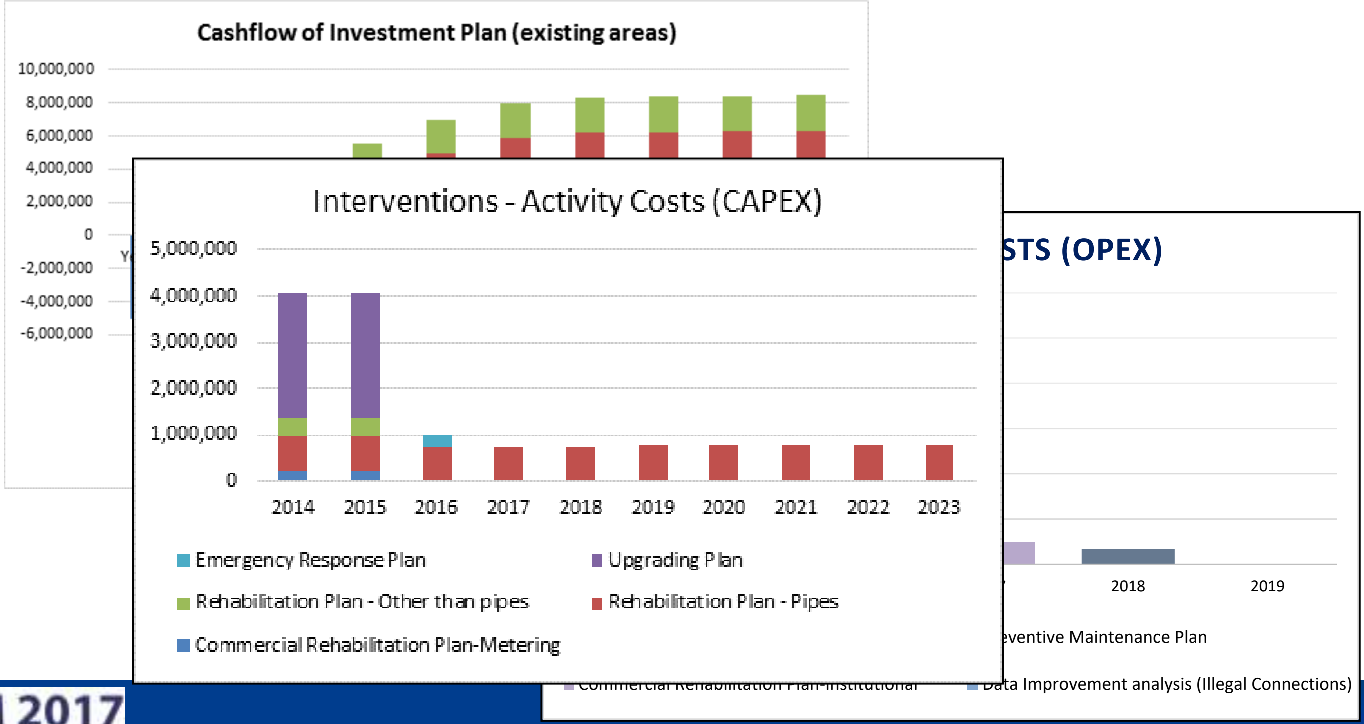
- **Objective:** To come up with an Investment Plan that will ensure a desired level of service in a cost-effective manner. To carry out interventions in the system that will improve (a) reliability of Service, (b) Performance of service delivery and (c) performance of the Utility
- **Description:** The investment plan receives recommended interventions from the activities of (a) Data Improvement analysis, (b) Rehabilitation Plan, (c) Maintenance Plan, (d) Commercial Rehabilitation Plan, (e) Leakage Reduction Program, (f) Upgrading Plan, (g) Emergency Response Plan and the (h) Master Plan

Investment Plan 1: Possible interventions with direct benefits

Description of Intervention/Activity		Recomm	Cost	Total Activity Cost	Effect-calcs	Benefit/d	Benef/Cost	Define IP
				Euro				
Capital Costs (CAPEX)								
1	Commercial Rehabilitation Plan-metering			503,837				
2	Rehabilitation Plan - Pipes			24,248,180				
3	Rehabilitation Plan - Other than pipes			780,000				
4	Upgrading Plan			5,400,000				
5	Emergency Response Plan			260,000				
6	Master Plan			22,600,000				
Operational Costs (OPEX)								
7	Data Improvement analysis (Illegal Connections)			573,804				
8	Commercial Rehabilitation Plan-institutional			850,920				
9	Preventive Maintenance Plan			0				
10	Leakage Reduction Program			728,968				

AM Business Planning Model – Key features

Investment Plan & Model – Main Outputs > Annual Effect

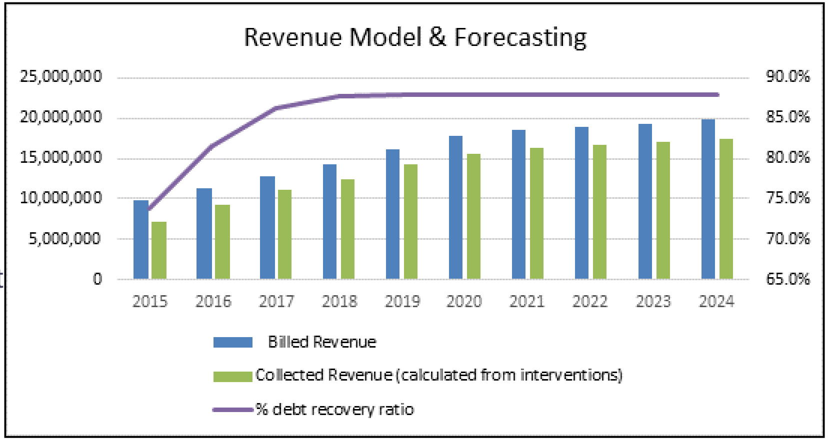


AM Business Planning Model – Implementation Steps
4. Setting up the Financial Plan & Model

- The Financial Model will project costs and revenues and present full financial statements and key performance indicators (KPI) for the Utility over the Planning period. The model allows for a 20-year planning period

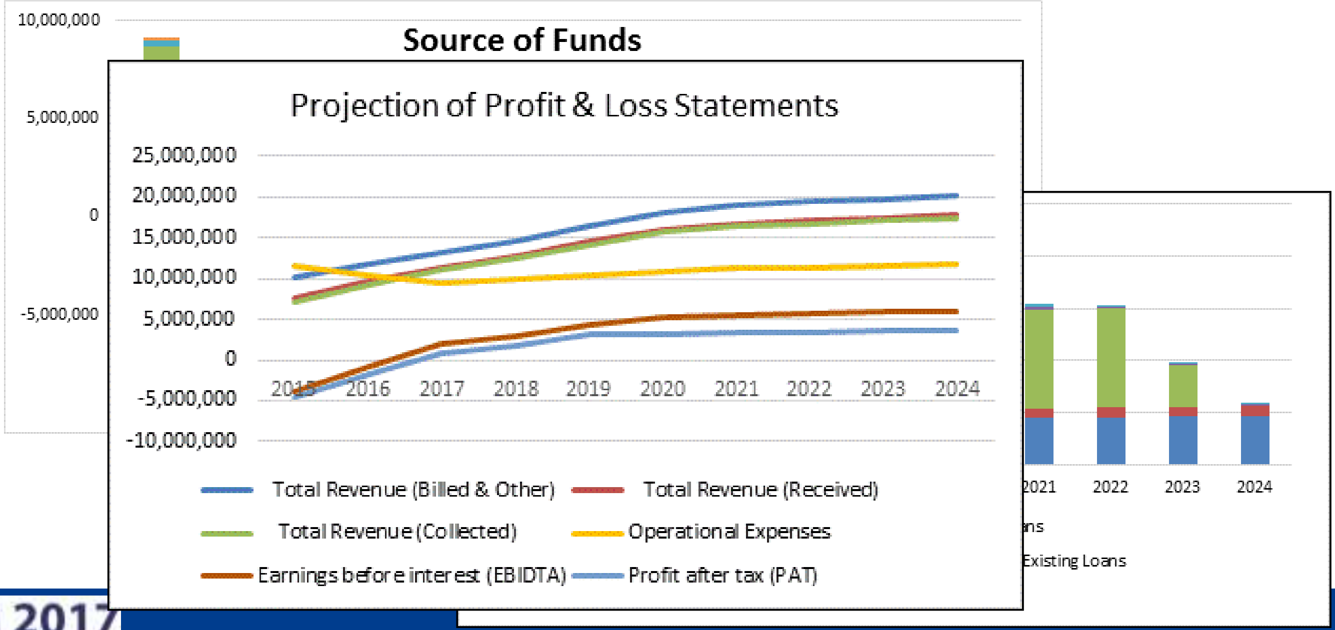
- **Objective:** To come up with a comprehensive Financial Plan that will enable the implementation of an Investment Plan that will ensure a desired level of service in a cost-effective and sustainable manner, including the repayment of loans required for the investment

- Serves as a **decision support tool** to assist in compiling the Investment plan in such a manner that sustainability of Utility's operations are ensured. In some cases tariff increases might be required to increase Utility's income to achieve such sustainability.



AM Business Planning Model – Implementation Steps
4. Setting up the Financial Plan & Model

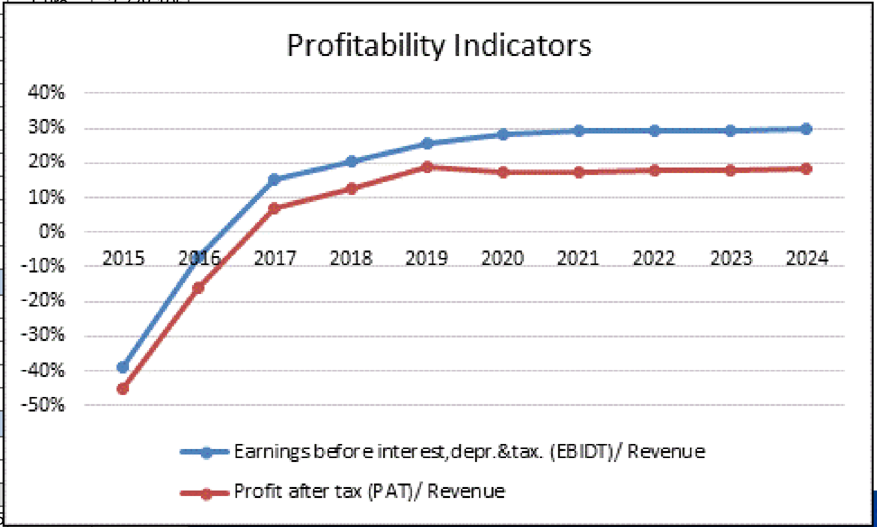
Cash flow Statement & Forecasting, including funding and debt repayment assumptions and calculation



AM Business Planning Model – Implementation Steps
5. Evaluating KPI – Performance & Sustainability Assessment

Performance & Sustainability Assessment – KPI: A summary of Utility's performance (present and projected) based on suitable Key Performance Indicators (KPI).

1	Shareholders Input and Return			Unit	Amount
	Contribution				
1.1	Shareholders Equity Contribution - for CAPEX			Euro	2,778,105
1.2	Shareholders Equity Contribution - for Cashflow				
1.3	NPV for Shareholders Equity Contribution				
	Return				
1.4	NPV for Total return (allows for divident tax)				
1.5	R.O.I (Based on NPV)				
	Other Indicators				
1.6	Pay-back period (all CAPEX)				
1.7	IRR (Internal rate of return)				
1.8	EIRR (Equity Internal rate of return)				
1.9	Project NPV				
2	Loans				
2.1	Total Loans Given				
2.2	Repayment Period (from commencement of project)				
2.3	Average DSCR - from project commencement				
2.4	Average DSCR - during capital repayment period				
3	Utility Performance				
3.1	Net Present Value of PAT (Profit after tax)				
3.2	Performance	Current	3-years		
	EBIDT/ Revenue	-39%	0.15		
	PAT/ Revenue	-45%	0.07	19%	18%



AM Business Planning Model – Key features Reports & Output

Aggregate Reports

The model shall include aggregate reports for groups of Utilities at (a) Regional (b) National level. The reports will compare computed average KPI for the selected groups of Utilities.

Scenario Analysis

The system shall maintain history of business planning models with the ability to provide reports with comparisons with the previous datasets. Scenario Analysis will be supported by storing alternative scenarios and comparing the KPI results.

Sensitivity Analysis-The Model shall allow sensitivity analysis through variation of various parameters including:

- tariff structure,
- Assumptions relating to Water Losses
- Assumptions relating to IP
- Population projections

AM Business Planning Model – Benefits

- Evaluates the current status of the AM programs in the Utility & provides a basis for integrated AM technical planning
- Enforces a clear & documented strategy for managing municipal assets from design to disposal at end of useful life
- Institutes verifiable and monitored investment plans related to defined levels of service
- Links investment plans to long term funding requirements
- Creates a long-term capital funding program with fact based analysis to document funding needs for all stakeholders
- Provides for meaningful Financial Reporting

Presentation 6

Tore Leland-Try: DiVA as instrument for IAM adoption in managing the Norwegian urban water service.

DiVA as instrument for IAM adoption in managing the Norwegian urban water service

LESAM 2017

Tore Leland-Try

Norconsult

About DiVA

DiVA
Digital VA-forvaltning

- 4-year project

- The objective of the DiVA project is to help Norwegian water utilities to manage the urban water networks in an efficient way, by being able to implement Infrastructure Asset management (IAM) principles, regardless the level of preparedness.

- Involving twenty partners with different roles

- water utilities, engineering consultant companies, R&D institutes, entrepreneurs.

The two DiVA products

- The **DiVA guide** is a step by step (digital) guide with the aim to drive the user through an intuitive set of process and practice guidelines, templates and decision support tools that will simplify the development of consistent IAM plans.
  - Developing plans at strategic or tactical level

- The guide links to the **DiVA toolbox** containing relevant tools or documents describing the type of analysis required

Organization

Project manager: Jonny Ødegård, Norconsult AS

Participants

- Asplan Viak
- Rosim
- Breivoll
- NTNU
- SINTEF
- Norsk Vann
- NPG
- Basal
- Maskinentreprenørenes forbund (MEF)

Organization

- Bærum kommune
- Vestfold interkommunale vannverk*
- Oslo kommune
- Asker kommune
- Oppegård kommune
- Tromsø kommune
- Drammen kommune
- Kristiansand kommune

*Vestfold interkommunale vannverk inkluderer også vannverkets eierkommuner (Sandefjord, Stokke, Andebu, Tønsberg, Nøtterøy, Tjøme, Horten, Re, Holmestrand og Hof).

The driver for DiVA

- The Association of Consulting Engine (RIF) published the first “State of the Nation” report in 2010 and a revised version in 2015.
  - The drinking water infrastructure is considered to be in acceptable, but not good condition
  - The waste water and stormwater infrastructure is considered in poor condition
- The report foresees further worsening of urban water networks due to a lack of minimum maintenance and rehabilitation, putting at risk the service sustainability

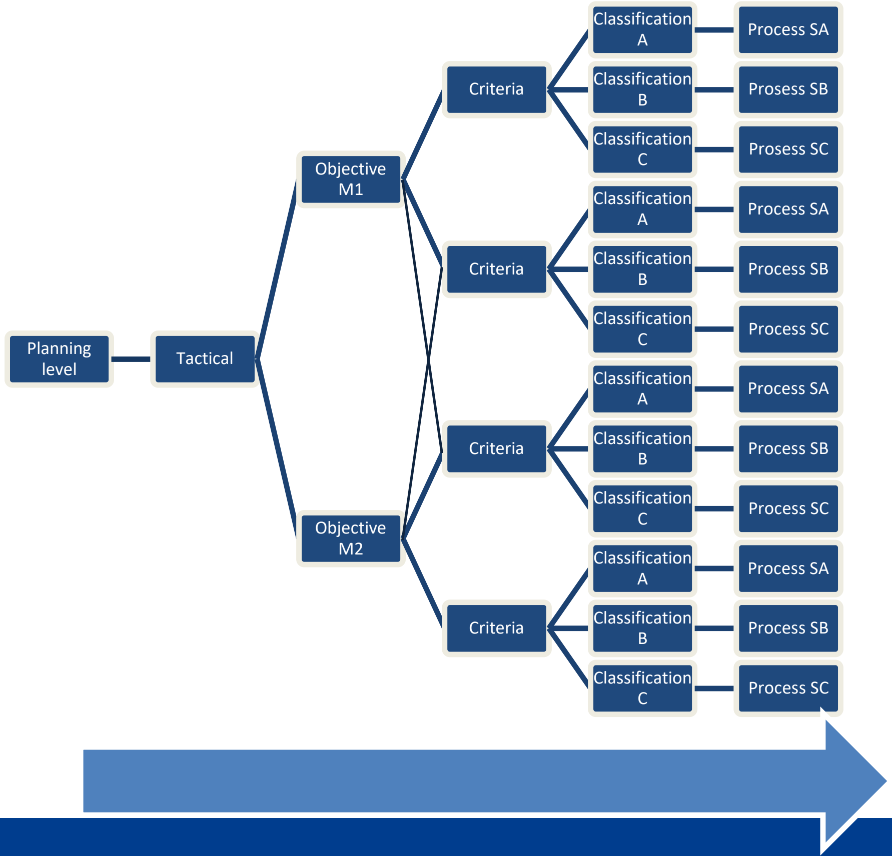
OMRÅDE	ESTIMERT VERDI (gjenkjøpsverdi ekskl. kjøp av eiendom)	TILSTANDS-KARAKTER (1-5 der 5 er best)	FREMTIDS-SIKRING	ESTIMERT KOSTNAD, OPPGRADERING TIL KARAKTER 4 (Dagens anlegg ekskl. kjøp av eiendom)
	mrd. NOK			mrd. NOK
Kommunale bygg	1060	3		140
Helsebygg (statlige)	330	3		40
Andre statlige bygg	310	3		10
Jernbane	400-600	2		500
Lufthavner	80-120	4		0
[redacted]				
Vannforsyningsanlegg	520	3		100
Avlopsanlegg	590	2		110
[redacted]				
Sum	5800	3		2600

Challenges for the implentation of IAM in Norwegian water utilities

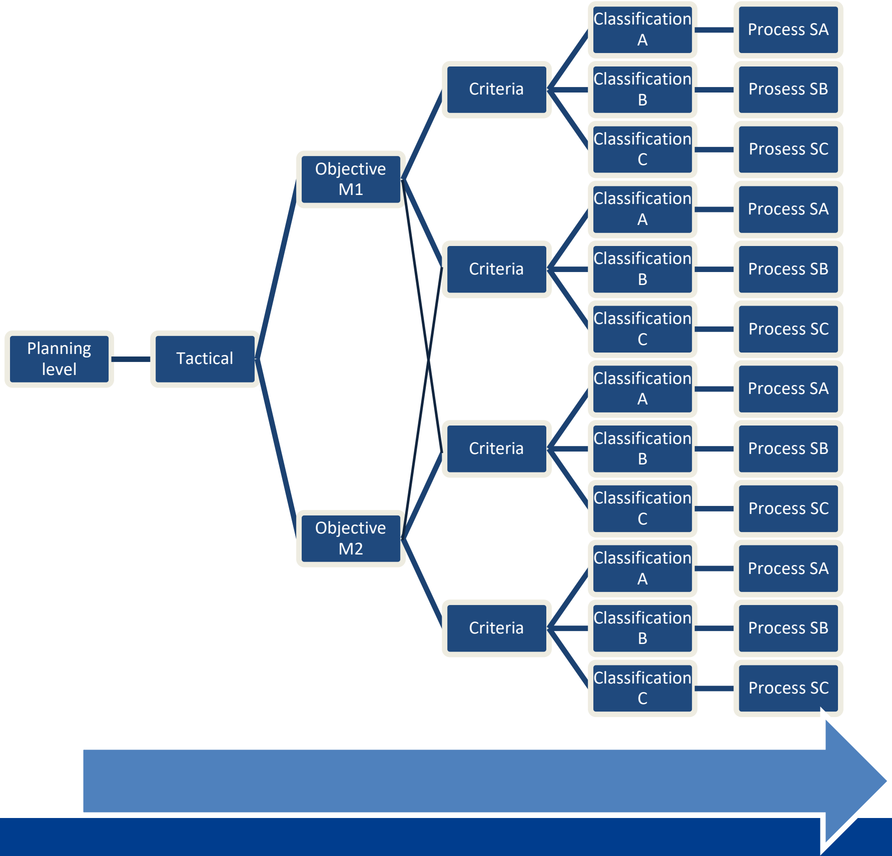
- Population growth, climate change and asset deteriorations

- Specific Norwegian challenges:
  - Scarcity of data and data specification routines
  - Fragmentation of Norwegian water service, many small utilities
  - Traditional organizational culture

The Content of DiVA

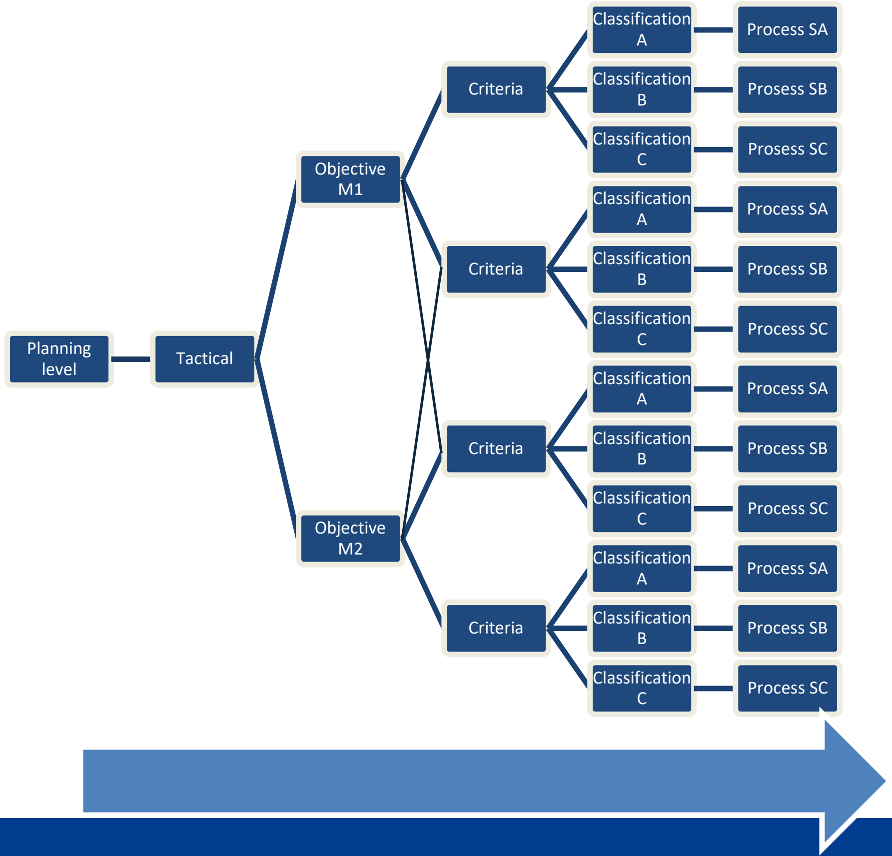


The Content of DiVA




DiVA
Hjem
Kom i gang
Hovedplan
Saneringsplan
Eksempler
Verktøykasse
Kom i gang
For å komme i gang må du først velge plantypen du ønsker å lage.
I infrastrukturell verdiforvaltning deler man planleggingen i 3 nivåer: Strategisk, Taktisk og Operativt.
I det strategiske nivået snakker vi om hovedplaner, mens det taktiske tar for seg saneringsplaner.
Dersom du ønsker å lese mer om infrastrukturell verdiforvaltning og teorien som ligger bak DiVA kan du gjøre det her.
HOVEDPLAN
SANERINGSPLAN

The Content of DiVA



The DiVA process

- Step 1: Setting the team
- Step 2: Setting objectives, measures and targets
- Step 3: Water Utility classification
- Step 4: Diagnosis and prognosis
- Step 5: Developing strategies and tactics
- Step 6: Plan production

Step 3: Water Utility classification

Water Utility Class A

Advanced approach

The utility has the ability to perform a scenario-based analysis using the appropriate tool with respect to its objective. The utility is also able to forecast the expected effect of alternative interventions with respect to its metrics.

Water Utility Class A

Intermediate approach

The utility has the ability to perform analyses using the appropriate tools with respect to its objective, but only with the baseline-scenario (status quo).

Water Utility Class C

Basic approach

The utility does not have the ability to perform the baseline scenario analysis, and must use a simplified approach with respect to said objective.

Step 3: Water Utility classification

- The same utility can be classified at different levels, for different objectives.
  - The same utility can be classified as A for a given objective, being able to applied an advanced approach to measure the performance versus the said objective, but also be classified as C for another objective for which it has no data to support an or intermediate advanced approach.

Vurderingen for anbefalt klasse er gjort på bakgrunn av nåværende klasse og hvilke data som er realistiske å få innhentet i nær fremtid.

Mål	Nåværende klasse	Anbefalt klasse	Nødvendig data for å nå anbefalt klasse
A21 - Eliminere flaskehalser	B/C	B	• Produsert avløp fordelt per avløpssone • Kjente problemområder • Hydraulisk modell for avløpsnettet
A22 - Redusere antall kjelleroversvømmelser	B	B	• Produsert avløp fordelt per avløpssone • Kjente problemområder • Hydraulisk modell for avløpsnettet
A23 - Redusere mengden fremmedvann i avløpsnettet	Ikke nok tilgjengelig data for klassifisering	B	• Kjente problemområder • Driftsdata for pumpestasjoner • Driftsdata for overløpsdrift • Produsert avløp fordelt per avløpssone • Hydraulisk modell for ledningsnettet

Step 3: Water Utility classification

- Example of grading for a utility given performance indicator *QS10: Pressure*

Objectives					Data								
					Inventory					Operational data			
Strat./tact.	Objective	Criterion	PI / target value	Analysis	Pipe properties (SID, mat., dim., …)	Network properties (SID, height, …)	Network topology	…		Current consumption & patterns	Consumption forecasts	Op. status (pumps, valves)	Analysis grade
Tact.	S2) Effectively satisfy the current users' needs and expectations	S21) Quality of the service	QS10: Pressure supply adequacy (less than 2 % of delivery points	EPANET (with consumption forecast)	X	X	X			X	X	X	A
				EPANET status quo	X	X	X			X		X	B
				"Simplified approach"	X	X							C

Step 3: Water Utility classification

Table 2 Utility classification summary matrix (DiVA guide)

Objectives	Relative planning importance	Analysis grade	Analysis	Limiting data	Comments / resources to improve availability
Objective 1	Very important	B	…	…	…
Objective 2	Moderate	A	…		…
Objective 3	Less important	C	…	…, …	…
Objective 4	Less important	C	…	…, …	…
…	…	…	…	…	…

The DiVA process

Step 1: Setting the team

Step 2: Setting objectives, measures and targets

Step 3: Water Utility classification

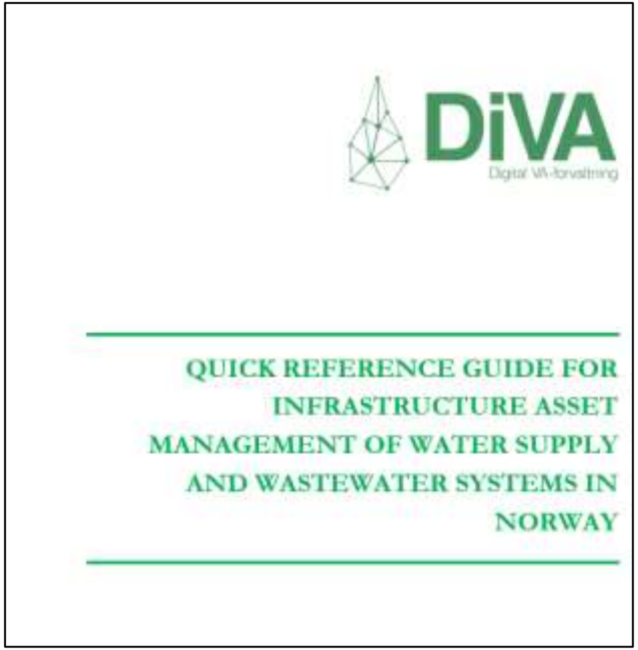
Step 4: Diagnosis and prognosis

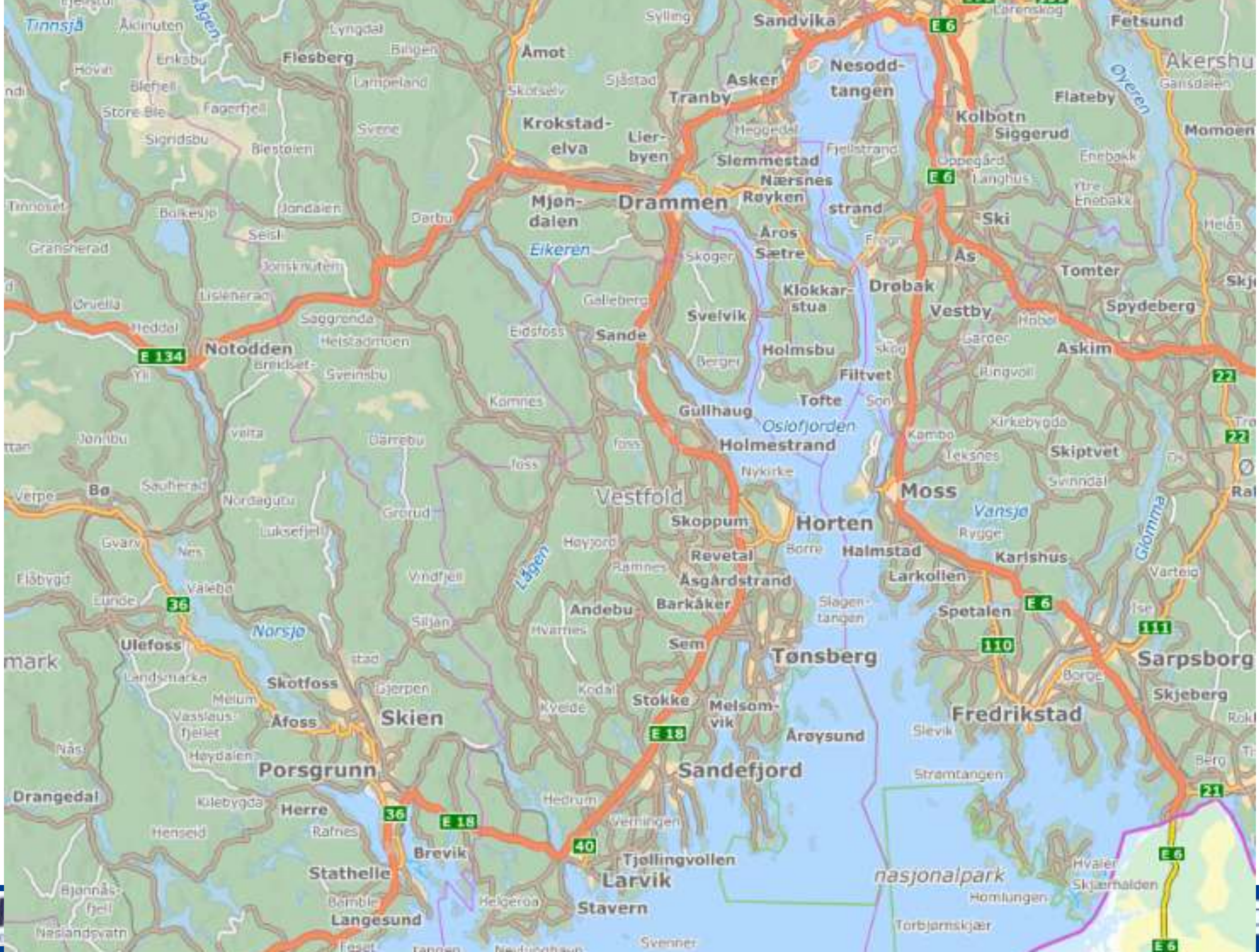
Step 5: Developing strategies and tactics

Step 6: Plan production

The Case study of Porsgrunn

- The purpose is to test the guide and provide feedback

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Sylling
Sandvika
Lørenskog
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Lampeland
Skotselv
Sjåstad
Asker
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tangen
Blefjell
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Svene
Tranby
Gansdalen
Flateby
Øyeren
Kolbotn
Siggerud
Momoen
Sigridsbu
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Heggedal
Slemmestad
Fjellstrand
Oppegård
Enebakk
Langhus
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Bolkesjø
Jondalen
Darbu
Mjøn-
dalen
Drammen
Nærsnes
Røyken
strand
Ytre
Enebakk
Ski
Helås
Seljord
Gransherad
Jonsknuten
Eikeren
Skoger
Åros
Sætre
Frogn
Ås
Tomter
Lisleherad
Galleberg
Svelvik
Klokkar-
stua
Drøbak
Vestby
Spydeberg
Skj
Orvella
Heddal
Saggrenda
Hobøl
Eidsfoss
Sande
Garder
Askim
E 134
Notodden
Heistadmoen
Breidset-
Sveinsbu
Berger
Holmsbu
Filtvet
Skiig
Ringvoll
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Yli
Kamnes
Tofte
Son
Gullhaug
Oslofjorden
Kirkebygda
Jønnbu
Veita
Darrebu
foss
Kambo
22
Holmestrand
Teksnes
Skiptvet
Bø
Sauherad
Nordagutu
Vestfold
Nykirke
Svinndal
Verpe
Grorud
Moss
Vansjø
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Horten
Gvarv
Luksefjell
Høyjord
Borre
Halmstad
Rygge
Karlshus
Glomma
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Siljan
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Tønsberg
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Sarpsborg
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Landsmarka
Borge
Melum
Skotfoss
Gjerpen
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Skjeberg
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Kvelde
Fredrikstad
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Porsgrunn
Sandefjord
Berg
Strømtangen
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Verningen
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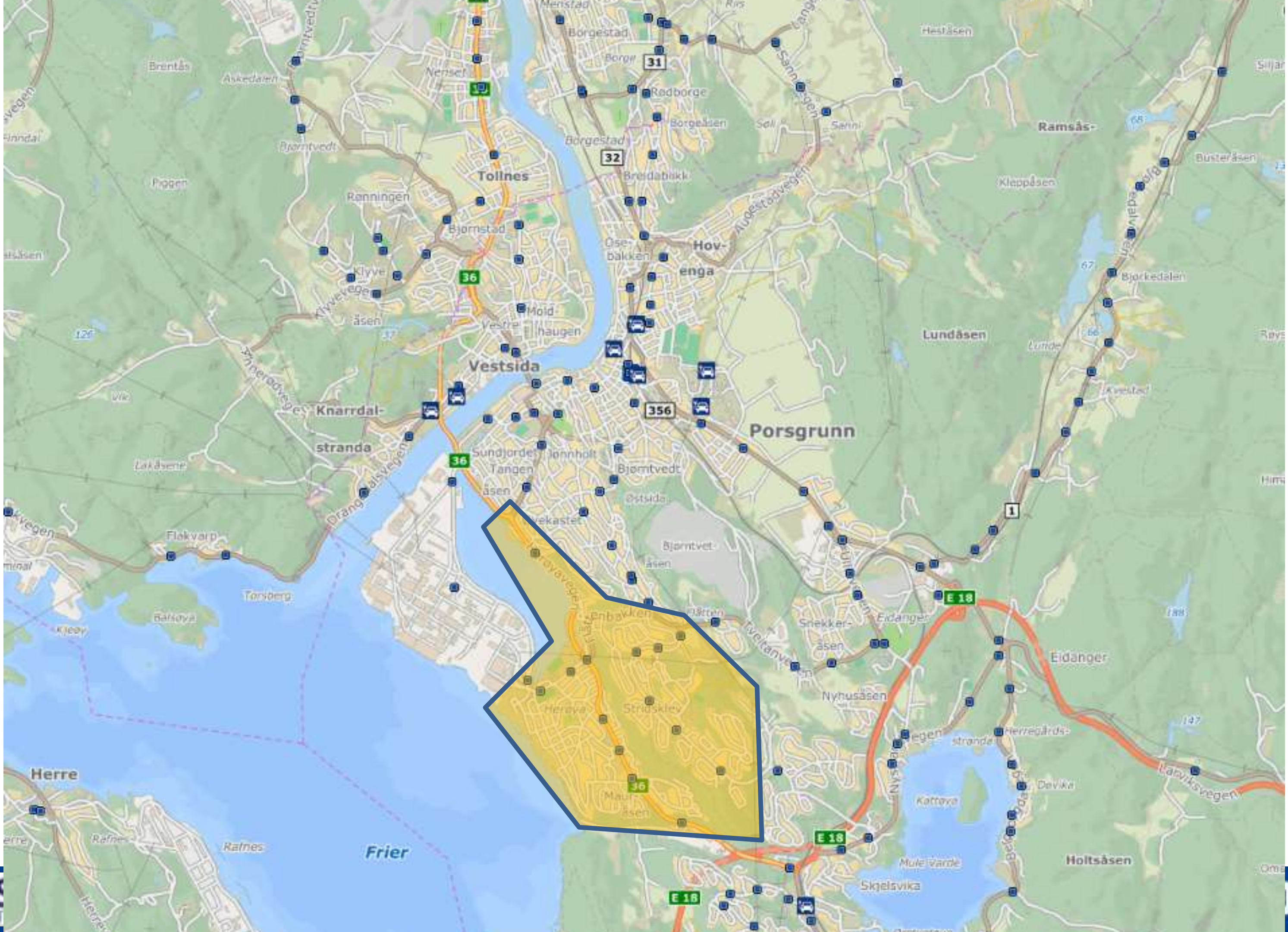
Brevik
Tjøllingvollen
Stathelle
Larvik
nasjonalpark
Hvaler
Bjønnås-
fjell
Skjærhalden
Bamble
Helgeroa
Homlungen
Stavern
Langesund
Torbjørnskjær
Neslandsvatn
Svenner
E 6


Tollnes
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Porsgrunn
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Bjørnstad
Borgestad
Rødborge
Heståsen
Ramsås-
Kleppåsen
Bjørkedalen
Lundåsen
Eidanger
Knarrdal-
stranda
Sundjordet
Tangen
Jønnholt
Bjørntvedt
Østsida
Snekker-
åsen
Nyhusåsen
Herøya
Stridsklev
Mauråsen
Herregårds-
stranda
Kattøya
Skjelsvika
Holtsåsen
Flakvarp
Torsberg
Balsøya
Herre
Rafnes
Frier
Brentås
Askedalen
Piggen
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Moldhaugen
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Sanni
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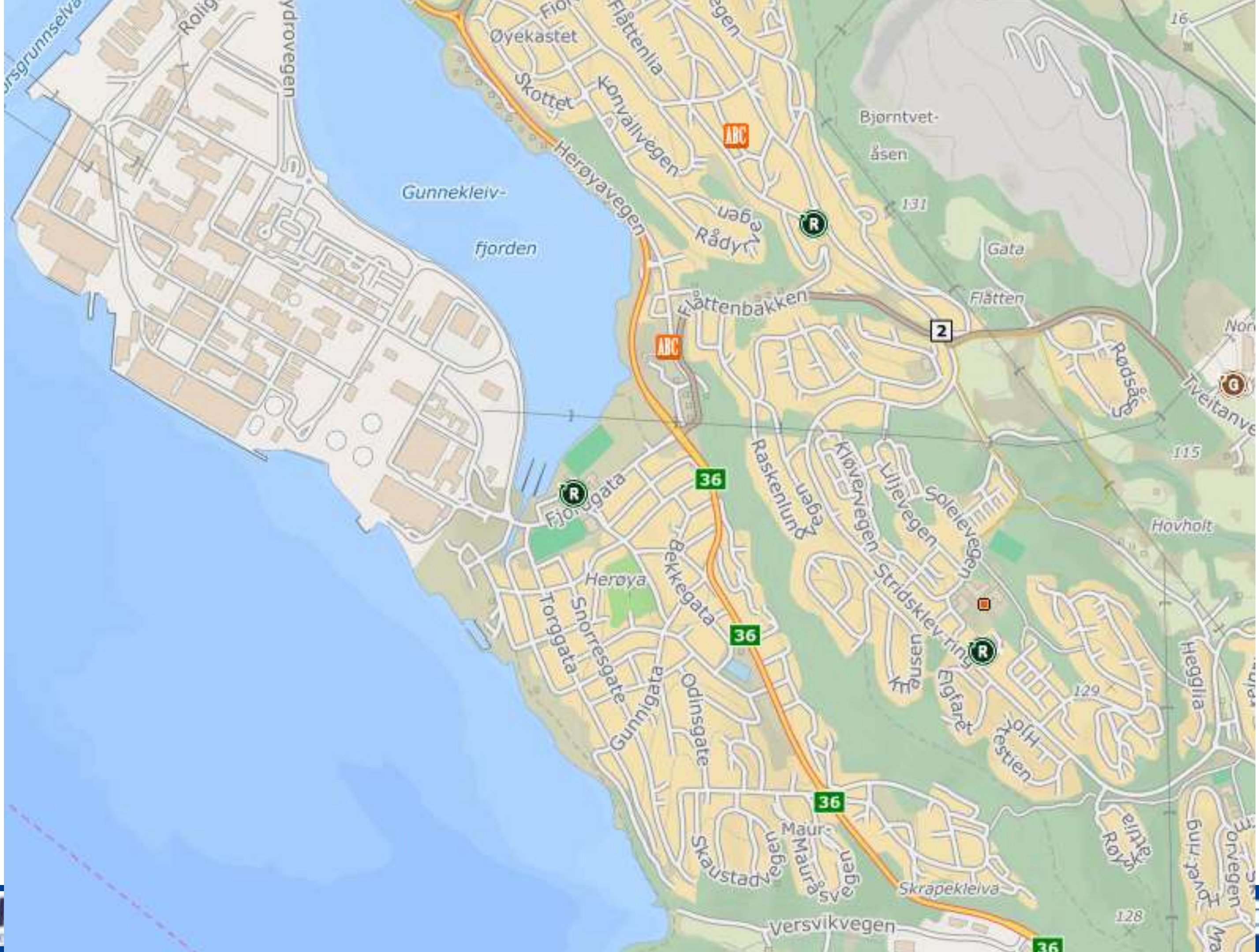

Øyekastet
Skottet
Flåttenlia
Konvallvegen
Herøyavegen
Gunnekleiv-
fjorden
Rådyrvegen
Bjørntvet-
åsen
131
Gata
Flåtten
Flåttenbakken
Rødsåsen
Tveitanve
115
Raskenlund
Kløvervegen
Liljevegen
Soleievegen
Hovholt
Fjordgata
Herøya
Bekkegata
Torggata
Snorresgate
Stridsklev ring
Gunnigata
Odinsgate
Elgfaret
Hegglia
129
Maur-
Mauråsvegen
Skaustadvegen
Skrapekleiva
Versvikvegen
128
36
2

Strategic plan waste water

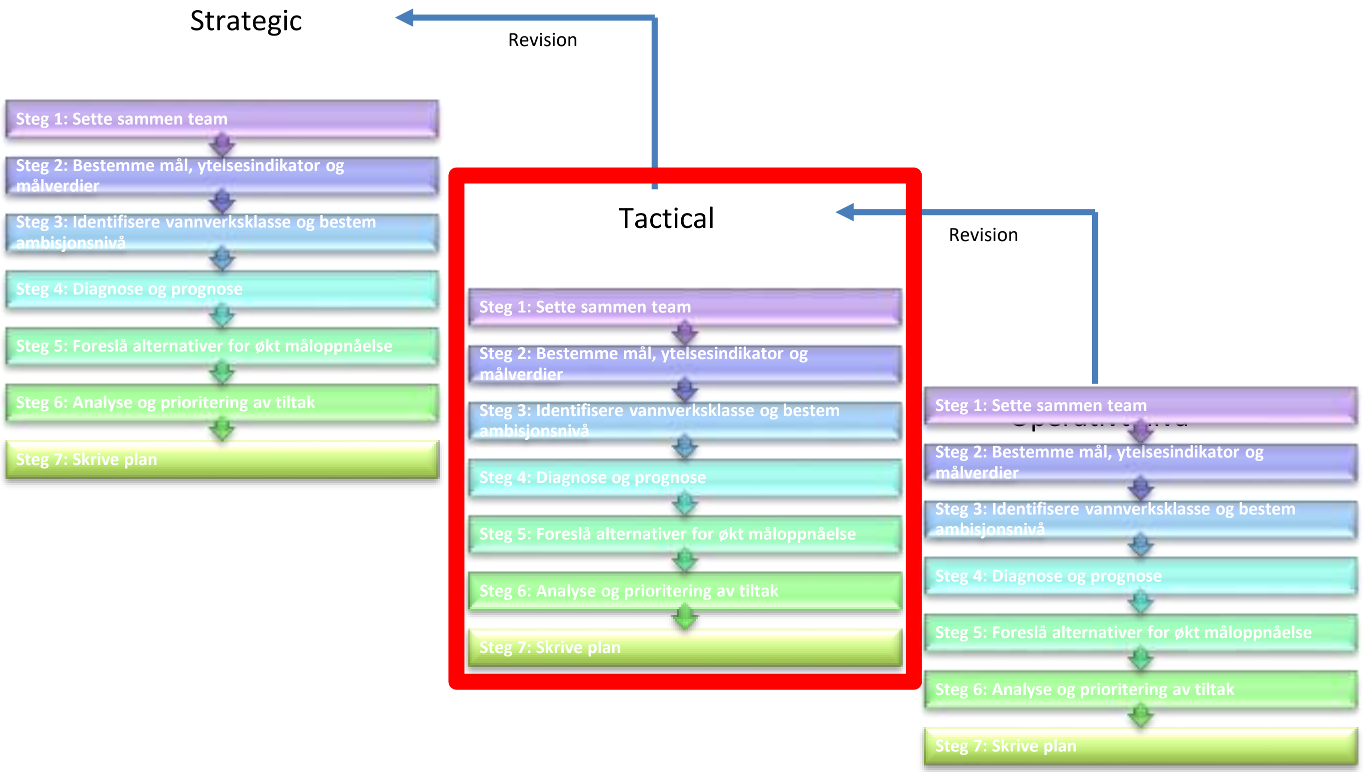
- 3 main challenges

1. Reducing the number of water damages to zero
2. Reducing CSO’s
3. Reducing Rainfall derived infiltration and inflow

Strategic plan water supply

- 3 main objectives
  - Reducing water leakage
  - The annual rehabilitation rate should be 1%
  - Reducing vulnerability
  - Adequate supply of water for fire fighting

- The strategic plan points out Herøya as an pilot for «complete effort» with analyses and actions


Strategic
Revision
Steg 1: Sette sammen team
Steg 2: Bestemme mål, ytelsesindikator og målverdier
Steg 3: Identifisere vannverksklasse og bestem ambisjonsnivå
Steg 4: Diagnose og prognose
Steg 5: Foreslå alternativer for økt måloppnåelse
Steg 6: Analyse og prioritering av tiltak
Steg 7: Skrive plan
Tactical
Revision
Steg 1: Sette sammen team
Steg 2: Bestemme mål, ytelsesindikator og målverdier
Steg 3: Identifisere vannverksklasse og bestem ambisjonsnivå
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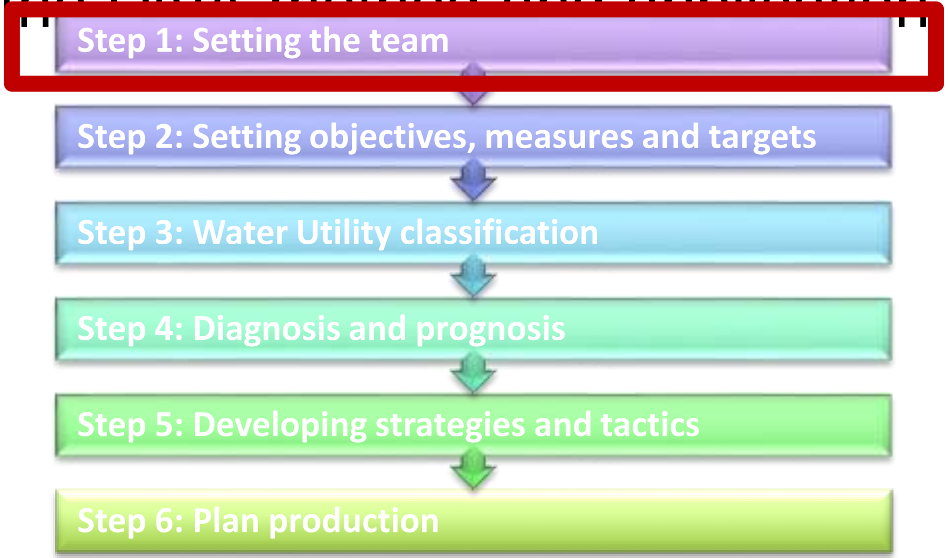
Steg 7: Skrive plan

Tactical plan for Porsgrunn municipality

- Provides as a case studie for the guide and a reference project for the DiVA method and application of IAM in Norway



Tactical plan for Porsgrunn municipality

- Step 1: Setting the team
- **Step 2: Setting objectives, measures and targets**
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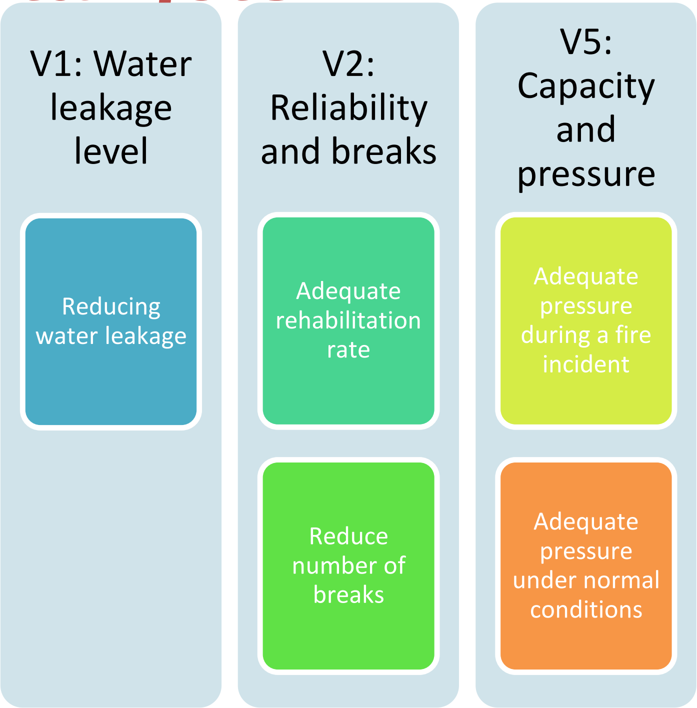
Step 2: Setting objectives, measures and targets

- The process of setting objectives, measures and targets is designed as a workshop in collaboration with the municipality.
- In the DiVA webpage, at step 2 -Setting objectives, measures and targets, a link to the DiVA toolbox provides templates and plans for setting up an efficient workshop



TEGNFORKLARING		
Analyseverdi	Farge	Lengde
Mangler data		3m
1900-1939		271m
1940-1969		11,217m
1970-1979		9,298m
1980-1989		2,825m
1990-1999		7,183m
2000-2009		2,147m
2010 og nyere		4,564m


1970
1967

TEGNFORKLARING		
Analyseverdi	**Farge**	**Lengde**
Mangler data		204m
Betong		19,762m
Glassfiber		4,487m
Plast		11,636m
Stål		96m
Stein		4,308m
Rehabilitert		179m

Norconsult

TEGNFORKLARING	
Analyseverdi	**Farge**
Mangler høydeverdier	(rød)
Har noen høydeverdier	(gul)
Har alle høydeverdier	(grønn)

Norconsult

Step 3: Water Utility classification

- Identifying missing data
- Assigning water utility classification to each objective
- Recommendation for improving data availability
  - data quality; •
  - consistency between data sources; •
  - simplicity of use; •
  - integration of information sources; •
  - updating procedure.

Vurderingen for anbefalt klasse er gjort på bakgrunn av nåværende klasse og hvilke data som er realistiske å få innhentet i nær fremtid.

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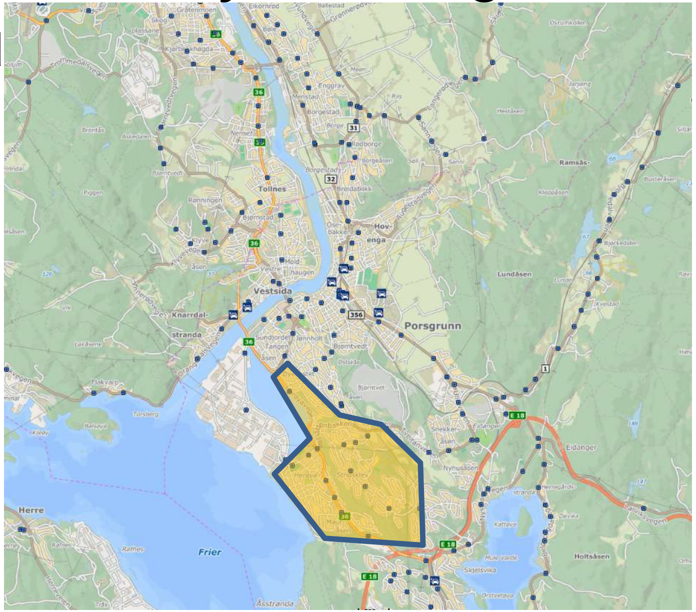
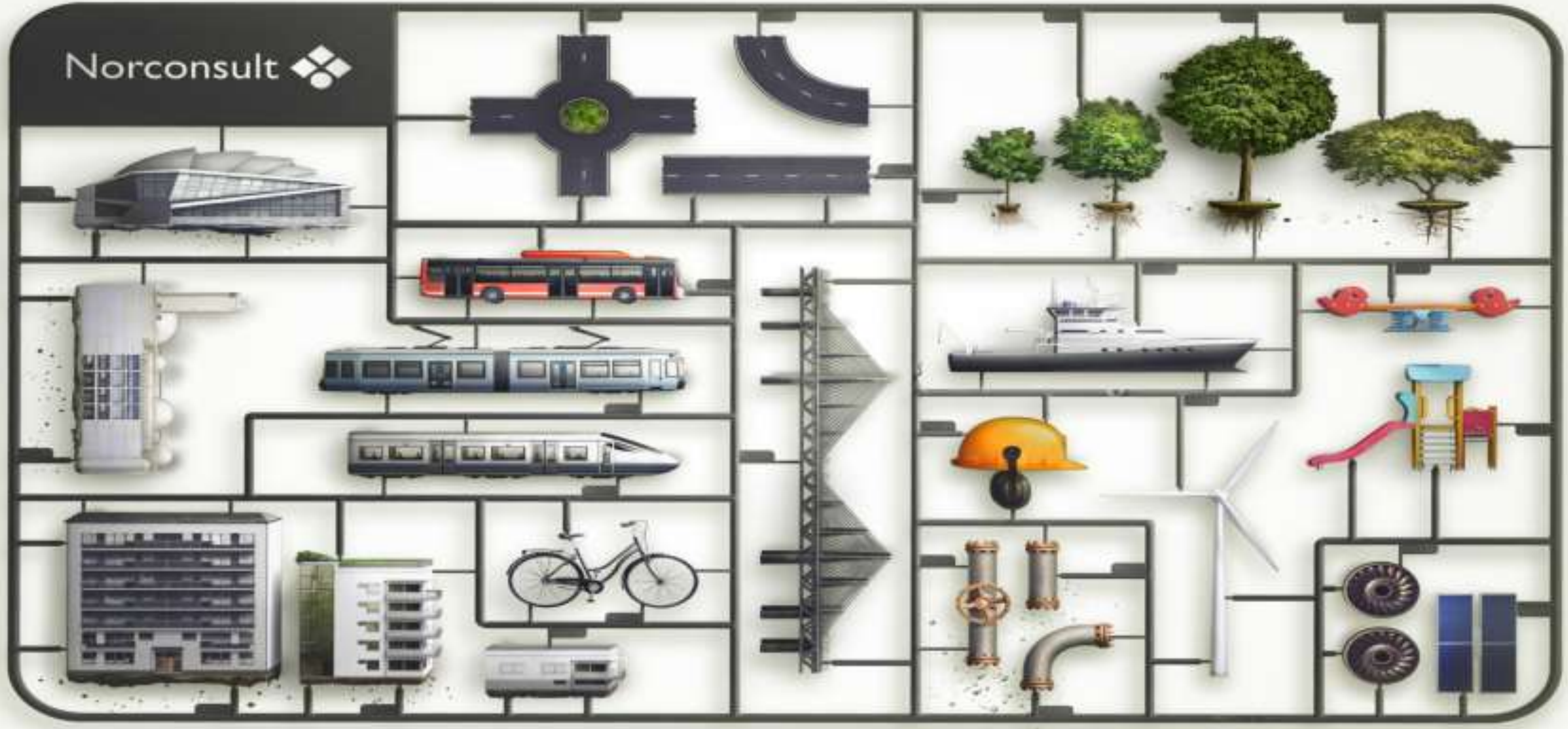
Step 4-6

- The case study in Porsgrunn is still work u



Conclusions

- The DiVA guide, as instrument to improve the Norwegian water infrastructure management approaches, is developed as a web-based step by step approach, based on the AWARE-P process
- DiVA provides tailored IAM pathways and suggests different analysis solutions according to the utility level
- The proposed objective-specific grading system is considered a relevant contribution to the IAM R&D, proposing a data-based approach to classify the utilities
- The evaluation method proposed, also enable to identify the domain in which a specific water utility should best invest to improve data quality and quantity.



Thank you

Presentation 7

Rita Ugarelli:: Optimal DMA design based on the WDN-oriented modularity index: a real case application

OPTIMAL DMA DESIGN BASED ON THE WDN-ORIENTED MODULARITY INDEX: A REAL CASE APPLICATION

Daniele Laucelli (Politecnico di Bari, Italy)
Antonietta Simone (Politecnico di Bari, Italy)
Luigi Berardi (Politecnico di Bari, Italy)
Rita Ugarelli (SINTEF, Trondheim, Norway)
Orazio Giustolisi (Politecnico di Bari – IDEA-RT, Italy)

Outline

- ✓ Division (segmentation) of WDNs into District Metering Areas (DMAs) for analysis, planning and management purposes.
- ✓ Need for effective cheap strategies for leakage management in medium- large WDNs
- ✓ Complex network theory: ***modularity index*** as a measure of the strength of the network division into communities (***metric of segmentation***)
- ✓ **Two-steps strategy for DMAs design**:
  - ➢ **Phase A** - Optimal network segmentation: minimizing the number of “conceptual cuts” versus the maximization of the modularity index (defiining conceptual cuts, candidate positions for flow meters and closed valves for optimal DMA design)
  - ➢ **Phase B** - Optimal DMA design: minimizing the number of flow observations, the background leakages and the unsupplied customer demand in EPS
- ✓ Need for pressure-driven analysis and background leakage model

Modularity Index

$$Q = \frac{1}{2n_p}\sum_{ij}\left(A_{ij} - P_{ij}\right)\delta\left(\mathrm{M}_i, \mathrm{M}_j\right) = \frac{1}{2n_p}\sum_{ij}\left(A_{ij} - \frac{k_i k_j}{2n_p}\right)\delta\left(\mathrm{M}_i, \mathrm{M}_j\right)$$

- ✓ rewritten using general topological matrix of WDNs

$$Q = 1 - \frac{n_c}{n_p} - \sum_{m=1}^{n_m}\left[\sum_{i=1}^{n_n}\frac{\left(\left|\bar{\mathbf{A}}_{pn}^T\right|\mathbf{u}_p\right)_i \delta\left(\mathrm{M}_m, \mathrm{M}_i\right)}{2n_p}\right]^2$$

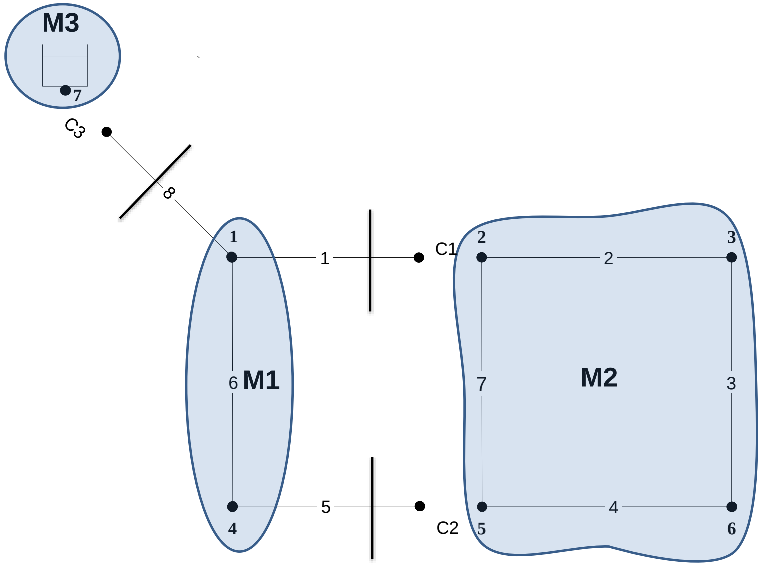
- ✓ n_p = number of pipes/edges
- ✓ n_n = number of nodes/vertex
- ✓ n_m = number of modules
- ✓ n_c = number of cuts in the middle of the pipes

Components of the Modularity

$$Q = \underbrace{1 - \frac{n_c}{n_p}}_{Q_1} - \underbrace{\sum_{m=1}^{n_m} \left[\sum_{i=1}^{n_n} \frac{\left(\left| \bar{\mathbf{A}}_{pn}^{T} \right| \mathbf{u}_p \right)_i \delta\left(\mathrm{M}_m, \mathrm{M}_i \right)}{2 n_p} \right]^2}_{Q_2}$$

- ✓ Q_1, strictly decreases with the number of cuts and penalizes the excess of cuts for a given number of modules
- ✓ Q_2 generally is an increasing function of the number of modules (and generally of n_c). It drives the search to the set of most similar modules for a given number of cuts
- ✓ The segmentation issue (i.e. the optimal clustering) is performed maximizing the modularity Q which ranges in [0,1]

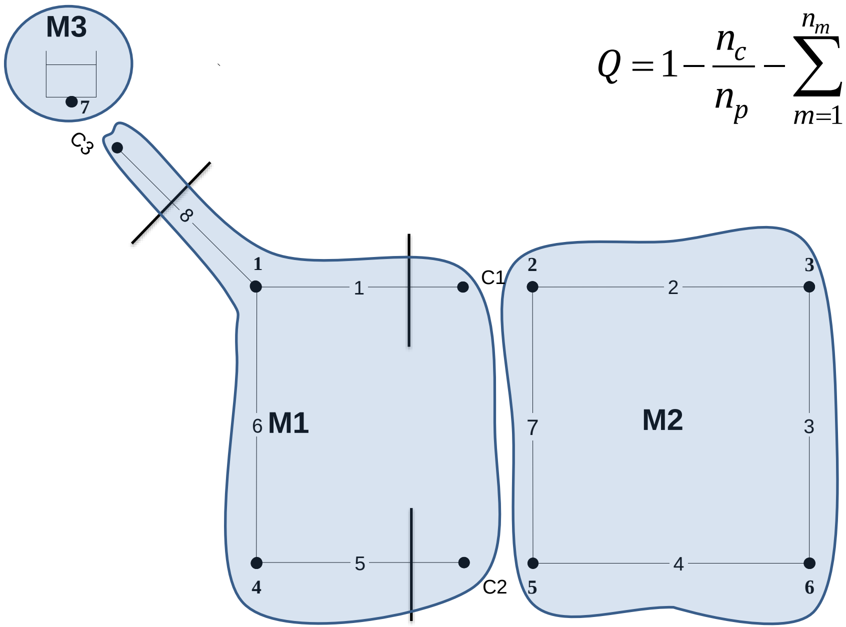
Example



- ✓ *Note that in order to compute Q_2* (i.e. a_m) the pipes are counted unit if they belong to a module and half if they belong to two modules being the cut in the middle.
- ✓ Need for WDNs to consider that devices (really or conceptually dividing the network) are placed close to ending nodes

WDN-oriented modularity index

$$Q = 1 - \frac{n_c}{n_p} - \sum_{m=1}^{n_m}\left[\sum_{k=1}^{n_p}\frac{(\mathbf{w}_p)_k\,\delta(\mathrm{M}_m,\mathrm{M}_k)}{W}\right]^2$$



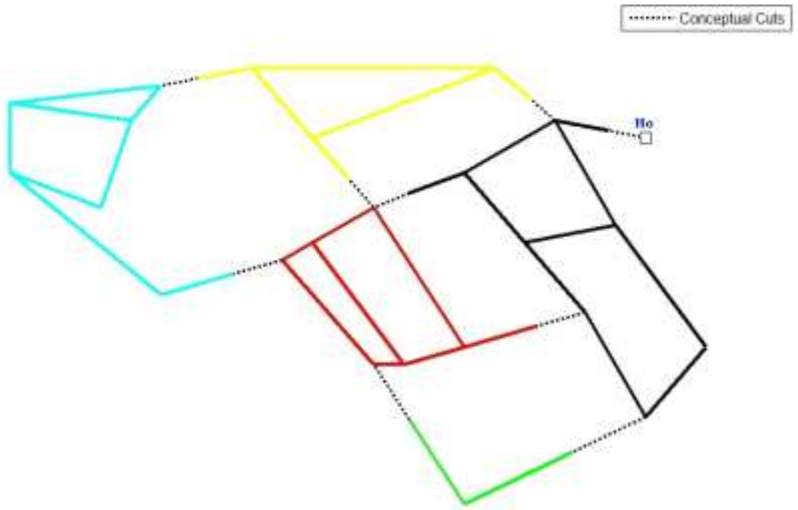
✓ Note that the Modularity index is position cut-sensitive and pipes are attributed to one module according to the cut position

Phase A
Optimal Network Segmentation:
bi-objectives optimal network segmentation

$$\begin{cases} [M, n_c, n_{act}] = \text{Connectivity}\left(I_c, \left|\bar{\mathbf{A}}_{np}\right|\right) \\ f_1 = \max\left\{IQ\left(\mathbf{L}_p\right)\right\} = \max\left\{\left(1 - \frac{n_c}{n_p}\right) + \frac{\left(n_{act} - 1\right)}{n_p} - \sum_{m=1}^{n_{act}}\left[\sum_{k=1}^{n_p} \frac{\left(\mathbf{L}_p\right)_k \delta\left(\mathrm{M}_m, \mathrm{M}_k\right)}{L}\right]^2\right\} \\ f_2 = \min\left\{n_c\right\} \end{cases}$$

- ✓ Note that the length of pipes is used as weight for the network pipes, and such information is stored in the vector L_p. The sum of pipes lengths is L.
- ✓ The choice of the pipe length as weight for the modularity index has a technical meaning linked to all the WDN phenomena related to pipe length (background leakages, probability of pipe burst, ect.)

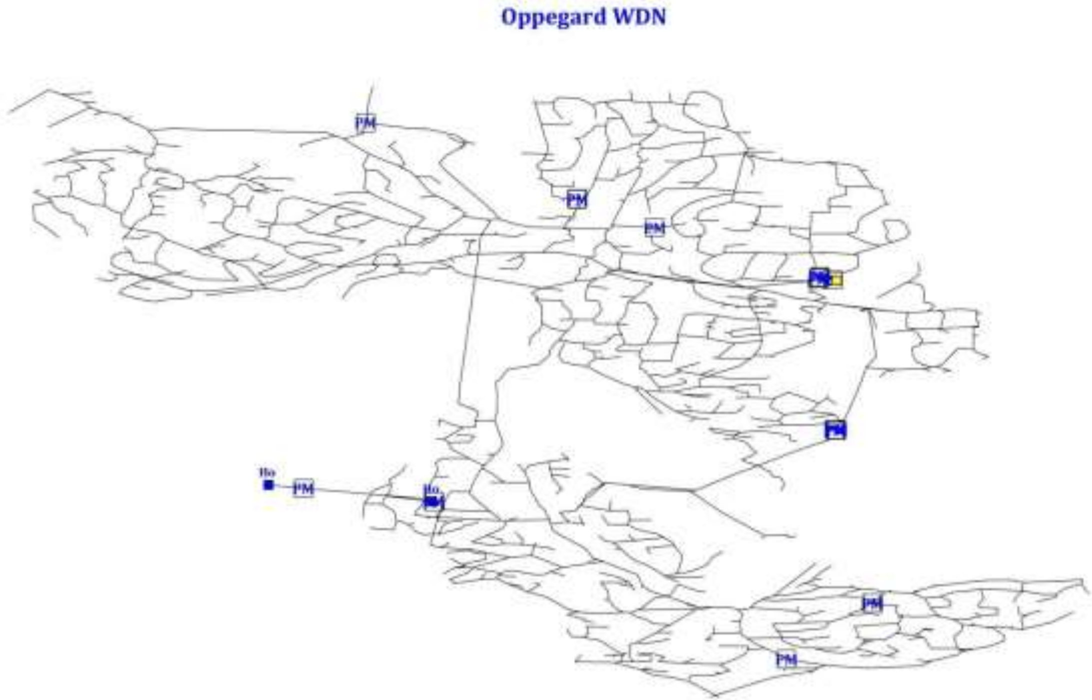
Phase B
From segmentation to Optimal DMAs design



$$\begin{cases} f_1 = \min\left\{n_{fm}\right\} \\ f_2 = \max\left\{1 - \dfrac{V_T^{leak}(\mathbf{v})}{V_T^{leak}}\right\} \\ f_3 = \min\left\{1 - \dfrac{V_T^{cust}(\mathbf{v})}{V_T^{cust}}\right\} \end{cases}$$

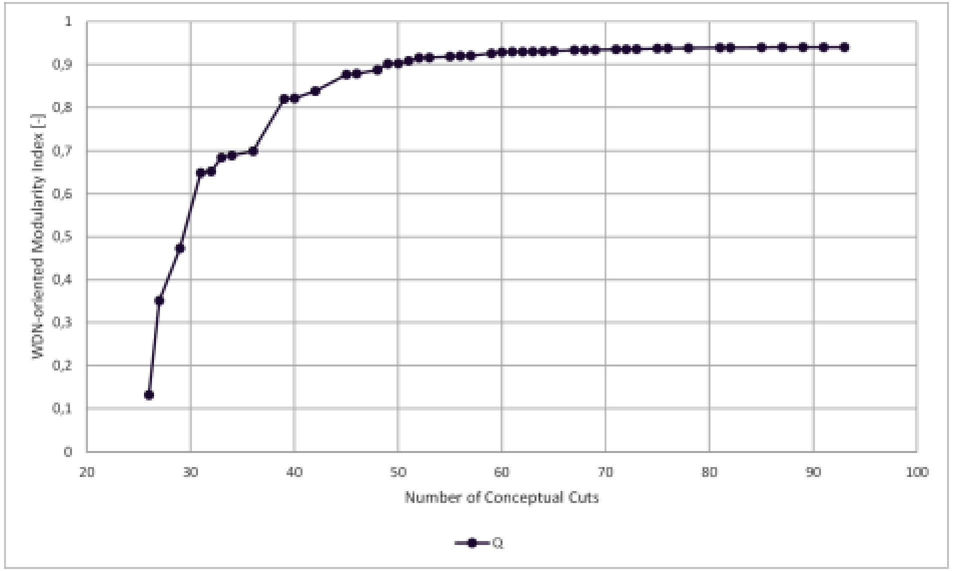
- ✓ Hydraulic modeling using PDA and leakage model
- ✓ Decision variables: position of flow meters and closed valves in conceptual cuts
- ✓ Three-objective function that minimizes the number of flow observations, the background leakages and the unsupplied customer demand

Case study: Oppegård network



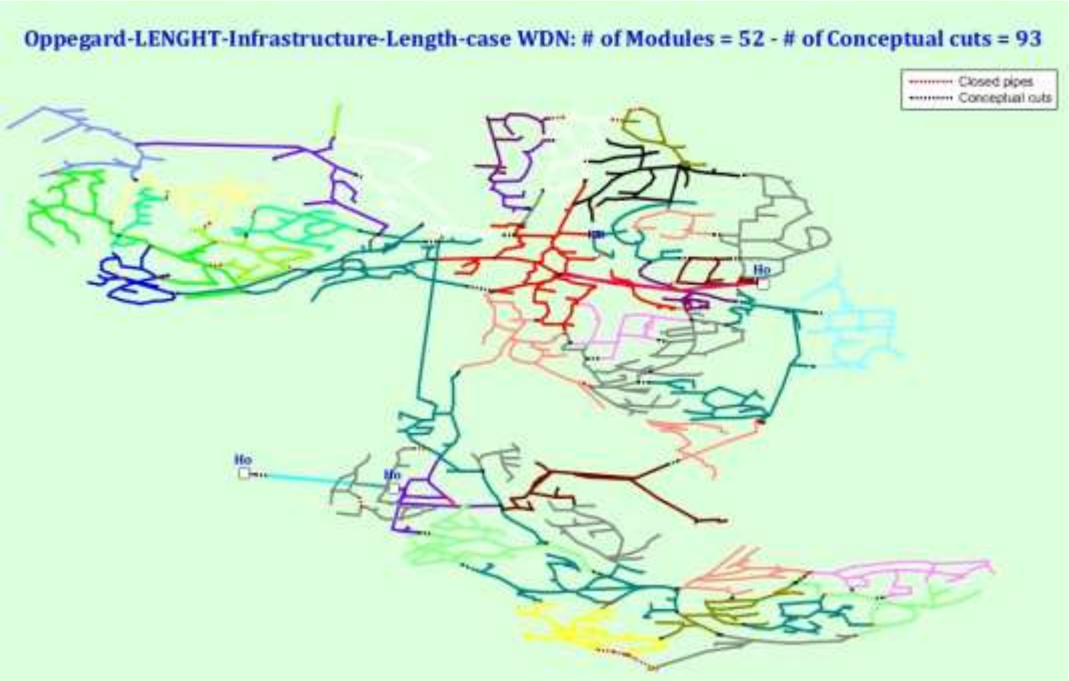
2,565 nodes (2 reservoirs and 1 tank comprised) and 2,713 pipes

First phase: Optimal segmentation design



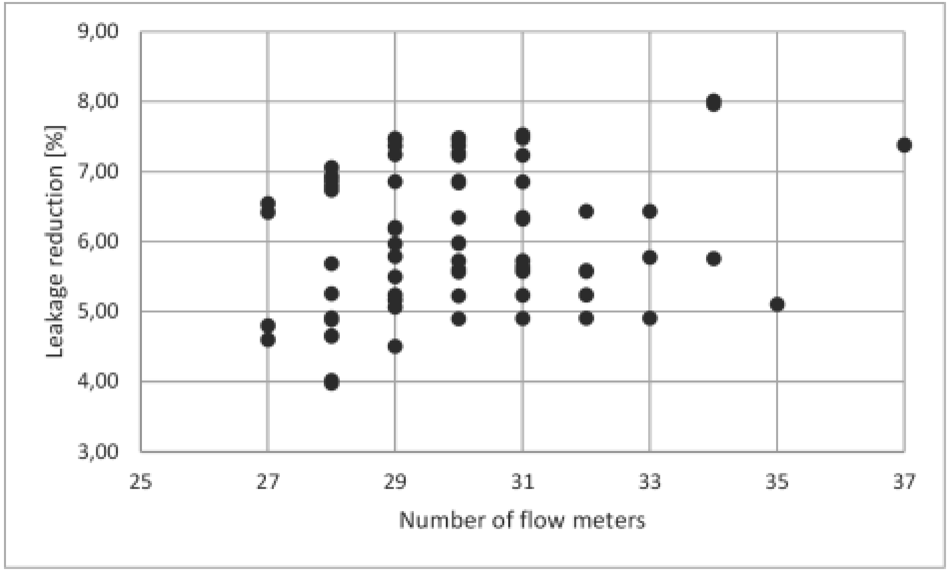
- ✓ Pareto set of 67 optimal segmentation solutions is provided for the Oppegård network, with a varying number of “conceptual cuts” and related modules
- ✓ The locations of PCV (17) are included among the “conceptual cuts” in each returned solution and the location of closed valves (46) are always

From segmentation to Optimal DMAs design



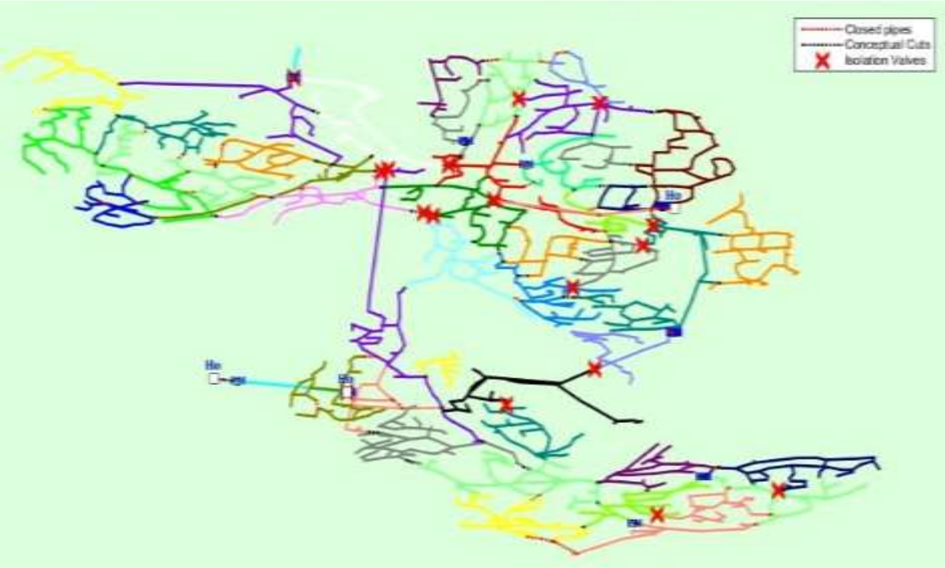
The maximum value of the WDN-oriented modularity corresponds to an optimal segmentation solution with 93 “conceptual cuts” dividing the network in 52 modules

Second phase: Optimal DMAs design



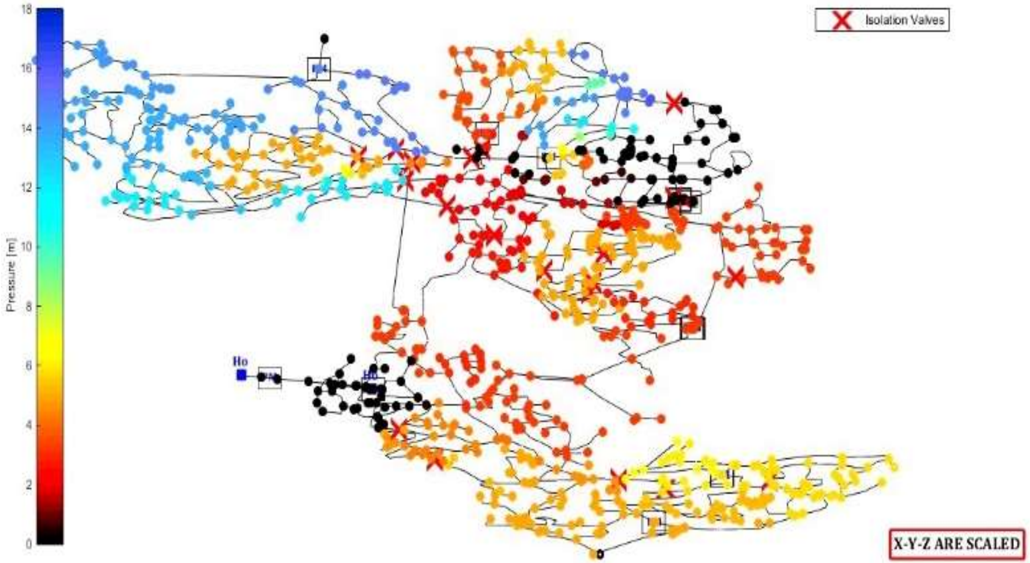
- ✓ The DMA design procedure returned 80 solutions all characterized by null and almost null unsupplied demand, with different percentages of leakage reduction.
- ✓ The 80 solutions show a number of flow meters ranging from 26 to 37 (i.e. closed gate valves decreasing from 67 to 56)

Second phase: Optimal DMAs design



- ✓ Optimal DMA solution with 34 flow meters and 59 closed valves, with an unsupplied demand to customers of 0.0025% and a reduction of the existing background leakages of about 8.01%.

Second phase: Optimal DMAs design



- ✓ Pressure drop causing a leakage reduction of 8.01% with 34 flow meters and 59 closed valves.

Concluding remarks

- ✓ Multi-objective design strategy for optimal DMAs design
- ✓ The proposed approach can achieve a **significant reduction of leakages by means of an optimal district design** (with negligible detriment of the service quality), **without adding further PCVs** and **avoiding additional problems of valve settings and management**
- ✓ **Phase A**: network optimally segmented in **conceptual DMAs**
- ✓ **Phase B**: identification of **optimal location of flow meters and closed gate valves among the "conceptual cuts"** of an optimal segmentation solution returned by the first phase
- ✓ **Decision support for Water utilities**: immediate quantification of operative effectiveness of DMA design solution in terms of water saving
- ✓ It is relevant the use of **enhanced hydraulic modeling using PDA** in order to account for pressure-deficient conditions, i.e. unsupplied demand, and background leakages

Thank you!

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Presentation 8

Maria Adriana Cardoso: Infrastructure Asset Management – Maturity Assessment of Water Utilities Based on International Standards ISO 55000

INFRASTRUCTURE ASSET MANAGEMENT – MATURITY ASSESSMENT OF WATER UTILITIES BASED ON INTERNATIONAL STANDARDS ISO 55000

Maria Adriana Cardoso, Rita Salgado Brito, Rita Ribeiro, Helena Alegre
LNEC, DHA

LESAM 2017 – 20-22 June, 2017 – Trodheim, Norway

Structure

- Introduction
- ISO 55000 series on asset management
- IAM assessment system
- Results
- Conclusions

Introduction

Introduction

Infrastructure Asset Management in the **water sector**

- management of infrastructure assets that provide a service to users
- achieving required levels of service
- minimizing the total cost of owning, operating and maintaining these assets
- considering the short, medium and long terms
- protecting the environment
- ensuring safety

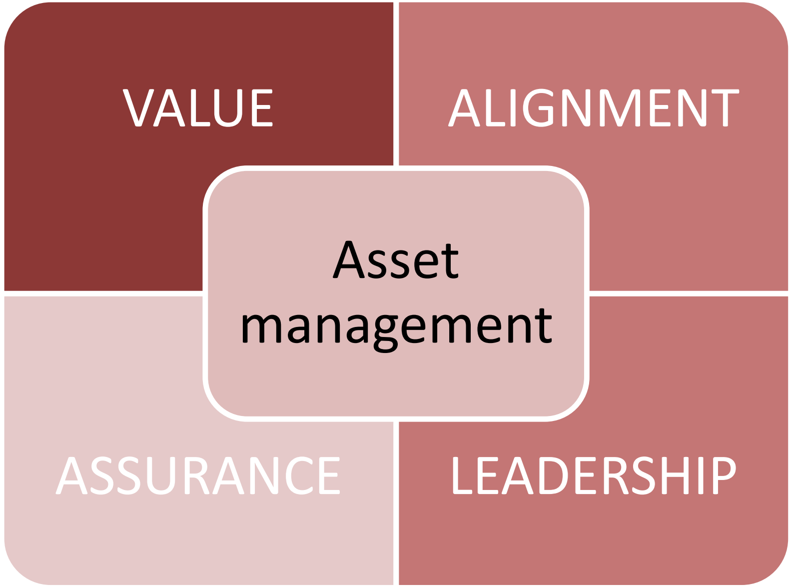
Relevance of implementing IAM processes in water utilities highly recognised worldwide

ISO 55000 series on asset management

ISO 55000 series FUNDAMENTALS

assets exist to provide value to the organizations and to its stakeholders needs and expectations

ensuring that assets **guarantee their function** at all life cycle stages, provided the **necessary resources and competent personnel**, considering the **continuous monitoring and improvement**



focusing at the strategic level and **unfolding** at tactical and operational level

translating organizational **objectives** into technical and financial **decisions, plans and activities**

coordination of contributions and interaction between **various functional units**, within the organization, with an impact on asset management

ISO 55000 series on asset management

Provide

- common approach to improve the consistency and alignment of management systems in different disciplines
- clear links between objectives, targets and decisions at all levels of the organization
- understanding of the relationship between the proposed investments and the expected results, as well as for a long-term view of asset performance

ISO 55000 series on asset management

Set of standards for asset management elaborated by ISO/TC 251

- ISO 55000:2014, Asset management — Overview, principles and terminology
- ISO 55001:2014, Asset management — Management systems — Requirements
- ISO 55002:2014, Asset management — Management systems — Guidelines for the

ISO 55000 series

An opportunity to assess the maturity of water utilities regarding the implementation of IAM systems and processes

ISO 55001: 2014

Asset management — Management systems — Requirements

7 clauses

Context of the organization (clause 4)	– Determine the external and internal aspects that are relevant to the mission and that affect the ability to achieve the results intended with the AMS – Identify stakeholders that are relevant to the AMS, its requirements and expectations – Determine the boundaries and applicability of the AMS, to establish its scope – The scope should be aligned with the strategic AM plan (clause 4.4) and the AM policy (clause 5.2) and consider the context of the organization (clause 4.1), stakeholders (clause 4.2) and interaction with other management systems – Determine a strategic AM plan that includes documentation on the role of the AMS to achieve asset management objectives
Leadership (clause 5)	– Demonstrate leadership and commitment to the AMS, ensuring e.g. the integration of AMS requirements into the organization's business processes, the alignment with the risk management approach, resource availability and collaboration between different organizational levels – Establish an AM policy appropriate to the purpose of the organization, that includes a commitment to the applicable requirements, to continuous improvement, and which is a framework for AM objectives – Ensure the assignment (and communication) of the responsibilities and authorities within the organization, namely for establishing, updating and implementing the strategic AM plan
Planning (clause 6)	– Define actions to address risks and opportunities for the AMS, to ensure that the system can achieve the desired results, prevent or reduce undesirable effects and achieve continuous improvement – Establish AM objectives for relevant functions and levels, taking into account the requirements of the relevant stakeholders – Establish the financial, technical, legal, regulatory and organizational requirements of the AM planning process. These should be consistent and align with organizational objectives and AM policy (clause 5.2) – Establish, document and maintain AM plan(s) to achieve AM objectives

ISO 55001: 2014

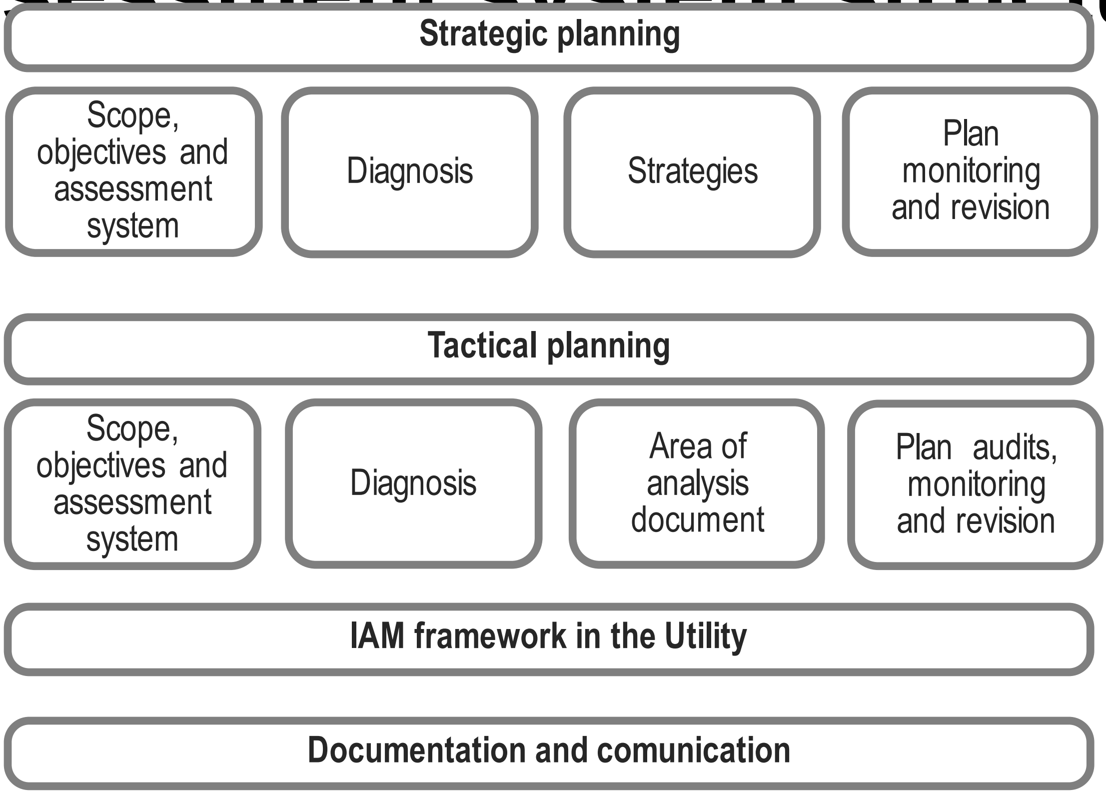
Support (clause 7)	– Determine and provide the resources required for the establishment, implementation, maintenance and continuous improvement of the AMS, including the activities specified in the AM plan(s) (clause 6.2) – Determine and ensure the necessary skills of the people who develop, under their control, tasks that affect asset performance, AM or the AMS and that they are aware of their impact on meeting the objectives of AM – Determine the relevant internal and external communication needs (what, when, with whom and how) – Determine information requirements to support AM and the achievement of the objectives (clause 6.2) – Ensure that internal and external documentation required by the AMS and ISO 55001 is identified and controlled
Operation (clause 8)	– Plan, implement and control the processes required to meet requirements and implement the actions determined to address risks and opportunities (clause 6.1), AM plan(s) (clause 6.2) and corrective (clause 10.1), preventive (clause 10.2) and improvement (clause 10.3) measures – Evaluate in advance the risks associated with any planned, permanent or temporary change, that may have an impact on the fulfillment of AM objectives, prior to its implementation – Monitor the planned changes and review the unintended consequences arising therefrom, taking action to mitigate any adverse effects as necessary (clauses 10.1 and 10.2) – Ensure that outsourced processes and activities are controlled, whenever they may have an impact on the fulfillment of their AM objectives, and assess the associated risks
Performance evaluation (clause 9)	– Determine what should be monitored and measured, and what methods of monitoring, measurement, analysis and evaluation are applicable – Determine when monitoring and measurement should be carried out and when correspondent results should be analyzed and evaluated – Conduct internal audits at planned intervals to provide information on whether the AMS conforms to the requirements of the organization and of ISO 55001 and whether it is effectively implemented and maintained – Via top management, review the organization's AMS at planned intervals to ensure its continued relevance, adequacy and effectiveness
Improvement (clause 10)	– Ensure the treatment of eventual nonconformities or incidents in the AM and evaluate the need for actions to eliminate the associated causes, so that it does not recur or occur elsewhere; these actions must be adequate to the effects of the nonconformities or incidents found – Establish processes for the proactive identification of potential asset performance failures and evaluate the need for preventive actions; when a potential failure is identified, the organization shall ensure its treatment (clause 10.1)

IAM assessment system

IAM assessment system background and purpose

- Based on ISO 55000 series, **adapted for urban water infrastructures**
- Benefits from developments of previous national collaborative projects on IAM (Alegre et al., 2013; Cardoso et al., 2016a; Leitão et al., 2016)
- Objectives of the assessment system
  - stimulate application of best IAM practices by the water utilities;
  - recognize utilities that present coherent and consistent results, in terms of implementation and maintenance of the IAM process
- To assess the maturity of water utilities regarding implementation of IAM systems and processes
- Potential benefits, provide a framework for
  - pre-assessment of any water utility
  - utilities' self-assessment
  - assessing the progress along the IAM process, ensuring the continuous improvement principle

IAM assessment system structure



IAM assessment system

Set of relevant questions, organized into four sections

STRATEGIC PLANNING (E.G.)
Are the long-term strategic objectives defined, particularly those relevant for IAM?
Were the strategic objectives described by assessment criteria?
Have reference values for the metrics been defined, allowing for a judgement of the monitoring results?
Was the strategic diagnosis carried out based on the pre-defined evaluation system?
…

IAM assessment system structure

TACTICAL PLANNING (e.g.)
Has the asset's network behavior been taken into account?
Were the tactical and strategic objectives clearly aligned?
Have relevant scenarios, with impact in the utility's activity in the planning horizon, been defined?
Was the reason for the prioritization of the functional sectors clear?
Have the resources needed for each tactic been defined?
…
FRAMEWORK OF THE IAM IN THE UTILITY (e.g.)
Have the relevant IAM stakeholders been identified?
…
DOCUMENTATION AND COMMUNICATION (e.g.)
Have the internal communication needs, relevant for IAM, been identified?
…

Results

iGPI – National Initiative for IAM of Urban Water Services

Iniciativa Nacional para a Gestão Patrimonial de Infraestruturas



1st Edition - 2012/13
19 utilities

- Collaborative projects create awareness for the need of sound IAM
- To incorporate fundamental concepts, principles and best practices
- To promote the adoption of the AWARE-P planning approach and corresponding support tools
- To capacitate water utilities on IAM
- To get enough scale to develop reference support tools (manuals, training material, templates, software)
- To support utilities implement and maintain IAM systems and develop their own SAMPs and Tactical IAM plans
- To create diverse and representative business cases to inspire other utilities



2nd Edition 2015
18 utilities

iGPI 2015 – National Initiative for IAM of Urban Water Services

Consortium | LNEC, IST, Addition

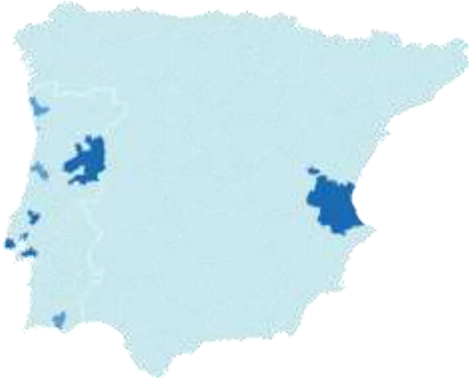
Participating water utilities

Focused on IAM **plan development**

Perfil-base
Águas do Porto
Águas de Santarém
Águas Lisboa e Vale Tejo
Aguas de Valencia
Aqualia
CM Barreiro
CM Palmela
SMAS Vila Franca de Xira

Focused on IAM **plan monitoring and review**

Perfil-aperfeiçoamento
AGERE
Águas de Barcelos
Águas de Coimbra
Infralobo
Inframoura
Infraquinta
INOVA
SIMAS Oeiras e Amadora
SMSB Viana do Castelo



iGPI 2015 – National Initiative for IAM of Urban Water Services

Consortium | LNEC, IST, Addition

Participating water utilities

Focused on IAM **plan development**

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Águas do Porto
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CM Barreiro
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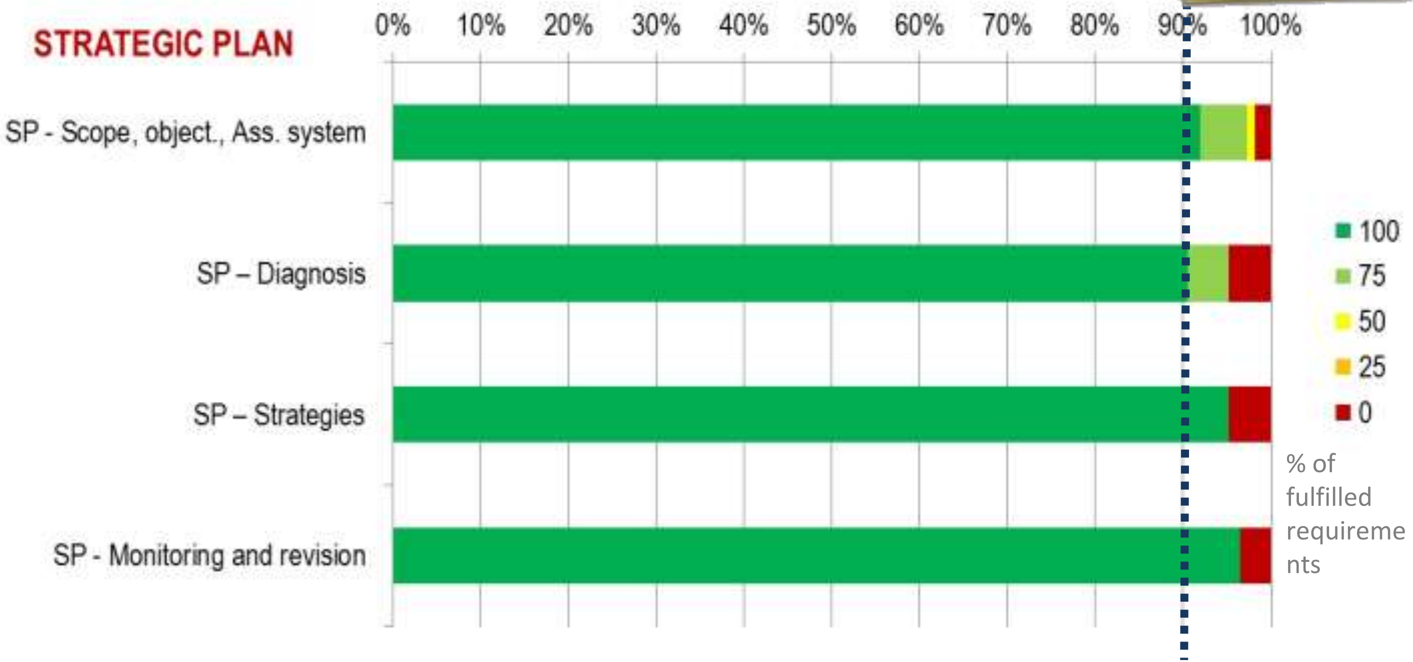
SMAS Vila Franca de Xira

IAM maturity of the assessed utilities

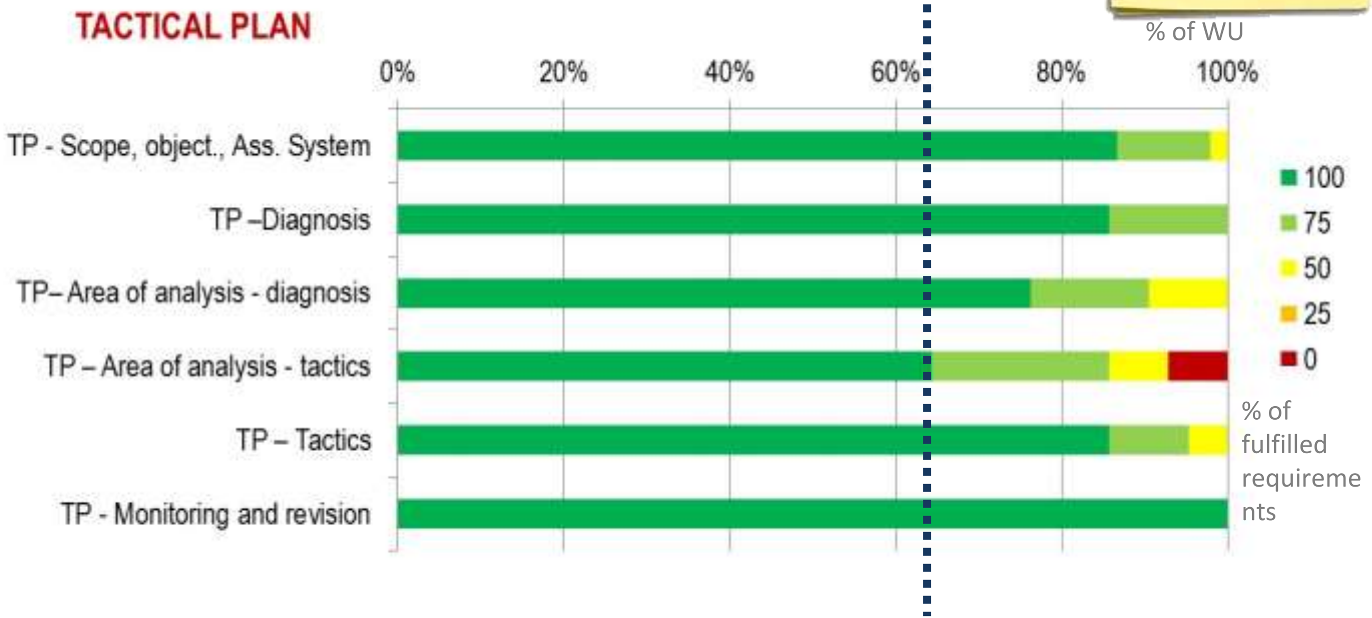
High level of development!



IAM maturity of the assessed utilities

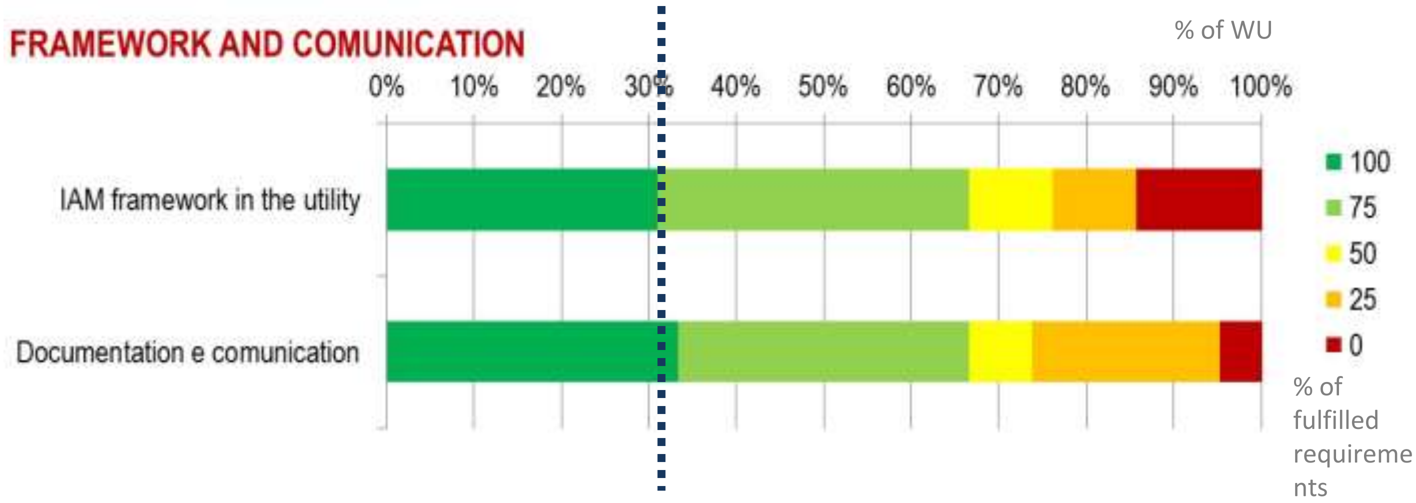
i

Opportunities for improvement and for development completion!



IAM maturity of the assessed utilities
iGPI 2015

Greater opportunities for improvement!



Conclusion

- IAM assessment system developed
  - successfully implemented in WU
  - allows to demonstrate the strengths, weaknesses and opportunities for improvement
  - demonstrated the importance of adapting the general principles of the standards to the specificities of network-based public infrastructures
- WU assessed correspond to an advanced level of response regarding the IAM maturity
- The application of this assessment systems has a great potential to be generalized, being currently incorporated into the Portuguese Regulatory system

Thank you for your attention

INFRASTRUCTURE ASSET MANAGEMENT – MATURITY ASSESSMENT OF WATER UTILITIES BASED ON INTERNATIONAL STANDARDS ISO 55000

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Presentation 9

Sergio Coelho: Crowdsourcing infrastructure asset management data and analysis results

baseform

Crowdsourcing IAM data and analysis results

S.T. Coelho[1], D. Vitorino[1], M. Azeitona[1], J. Rostum[2]

[1] Baseform, Lisbon, Portugal
[2] POWEL, Trondheim, Norway.

LESAM 2017 - June 20-22 Trondheim Norway

Infrastructure asset management

baseform

- Should address the overall process of balancing capital improvement, rehab, and O&M expenditure
  - over the long term
  - driven by set strategic objectives (service, cost, risk).
- A long-term 'sustainability window' of time.

Urban planning & engineering: undergoing a revolution

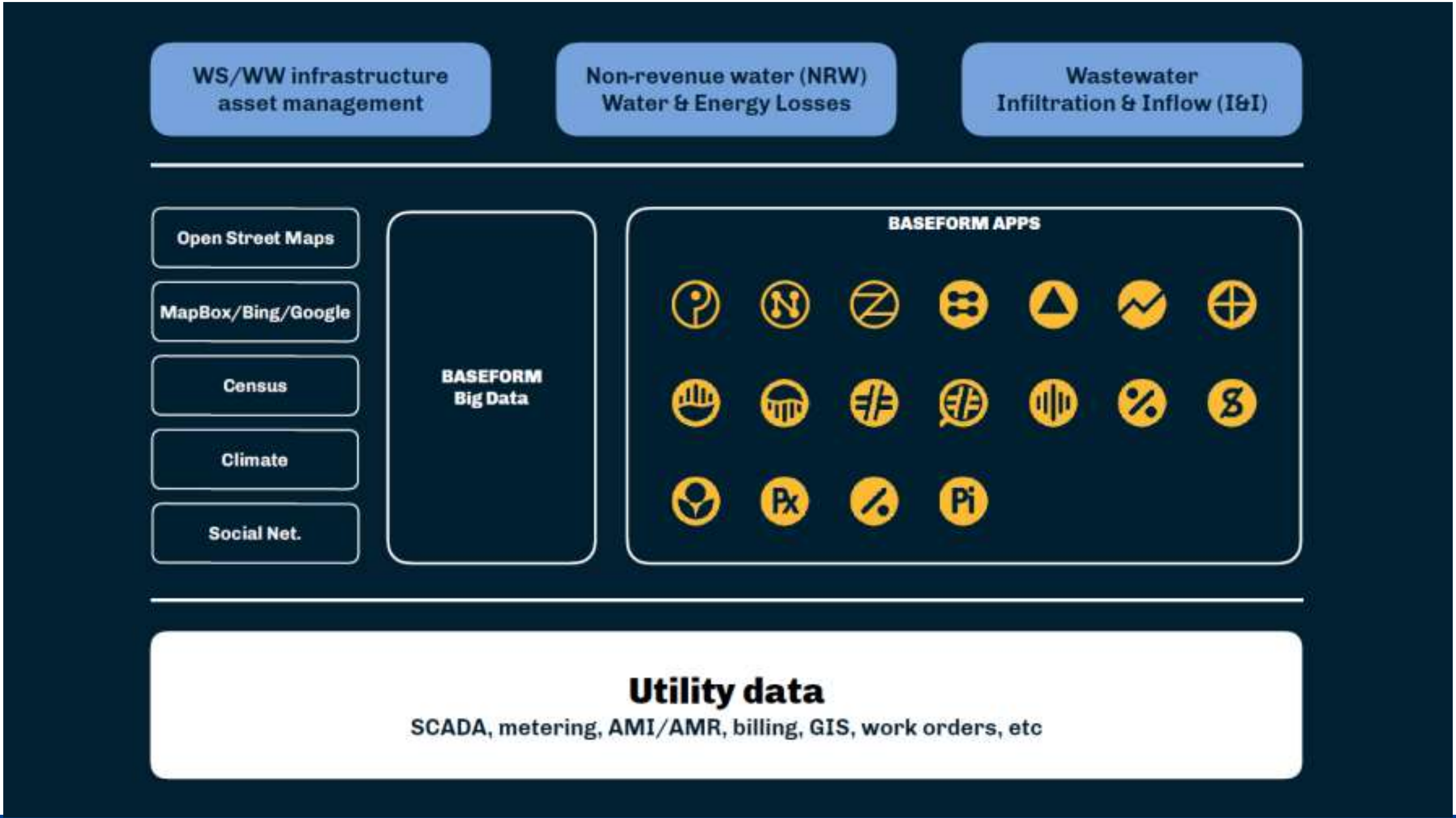
baseform

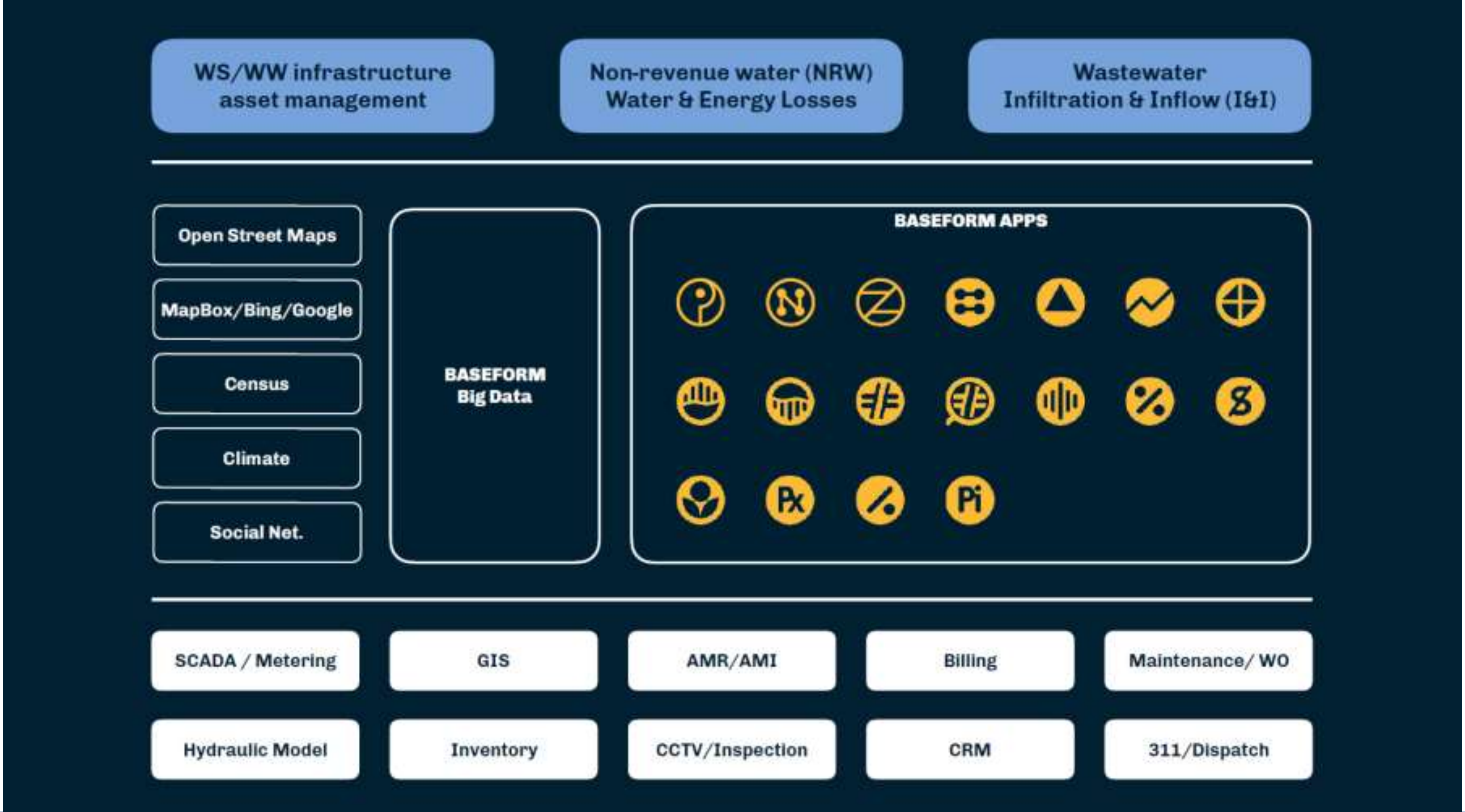
- As sensors and data sources multiply (SCADA, telemetry, AMR, billing, work orders, GIS, inspections, models), urban water networks generate very large amounts of information on a daily basis.
- Instead of relying only on projected versions of reality (often from decades ago), we can now increasingly observe that reality in detail.
- We can continuously adapt the designed infrastructures to the changing needs and intensities.
- That reality, and those needs, do change.

An ongoing, continuous system design process

baseform

- Operations, maintenance, rehabilitation and (re)design should be seen as components of a permanently ongoing, long-term system design process.
- IAM should concern itself with systems engineering.
- Above all, IAM should not be a separate thought, or an after thought.
- Infrastructure utility management


WS/WW infrastructure asset management
Non-revenue water (NRW) Water & Energy Losses
Wastewater Infiltration & Inflow (I&I)
Open Street Maps
MapBox/Bing/Google
Census
Climate
Social Net.
BASEFORM Big Data
BASEFORM APPS
Utility data
SCADA, metering, AMI/AMR, billing, GIS, work orders, etc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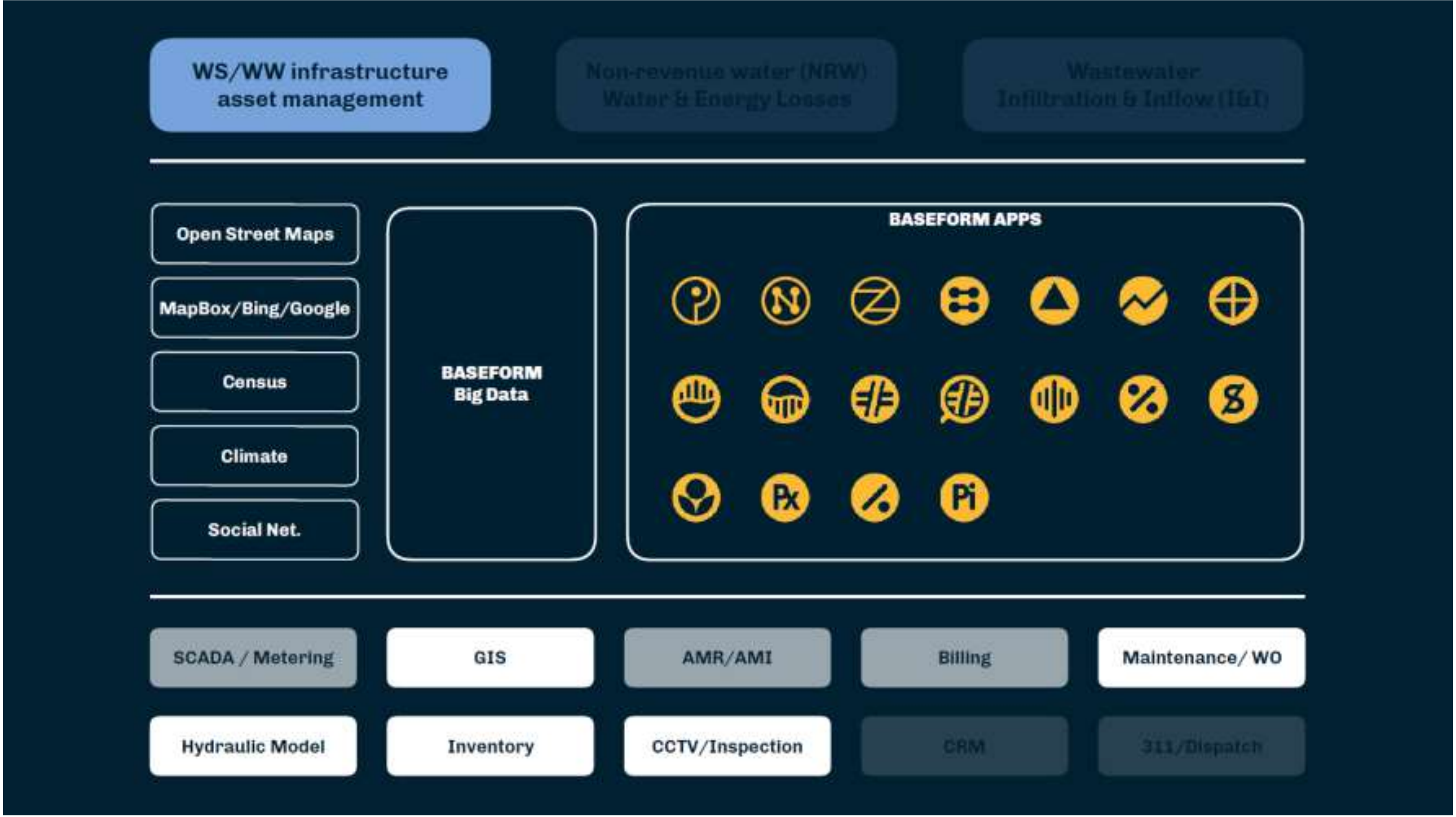
Census
Climate
Social Net.
BASEFORM Big Data
BASEFORM APPS
Px
Pi
SCADA / Metering
GIS
AMR/AMI
Billing
Maintenance/ WO
Hydraulic Model
Inventory
CCTV/Inspection
CRM
311/Dispatch


WS/WW infrastructure asset management
Non-revenue water (NRW) Water & Energy Losses
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Open Street Maps
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BASEFORM Big Data
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Px
Pi
SCADA / Metering
GIS
AMR/AMI
Billing
Maintenance/ WO
Hydraulic Model
Inventory
CCTV/Inspection
CRM
311/Dispatch

Why 'crowdsourcing'

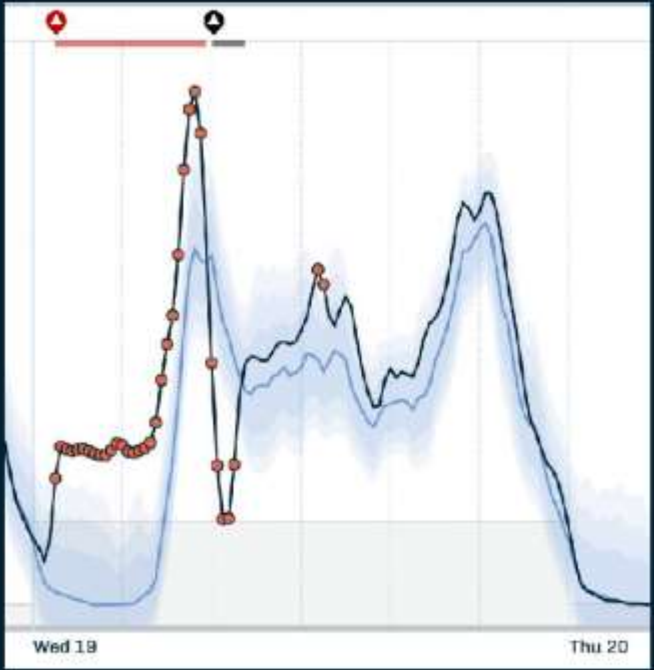
baseform

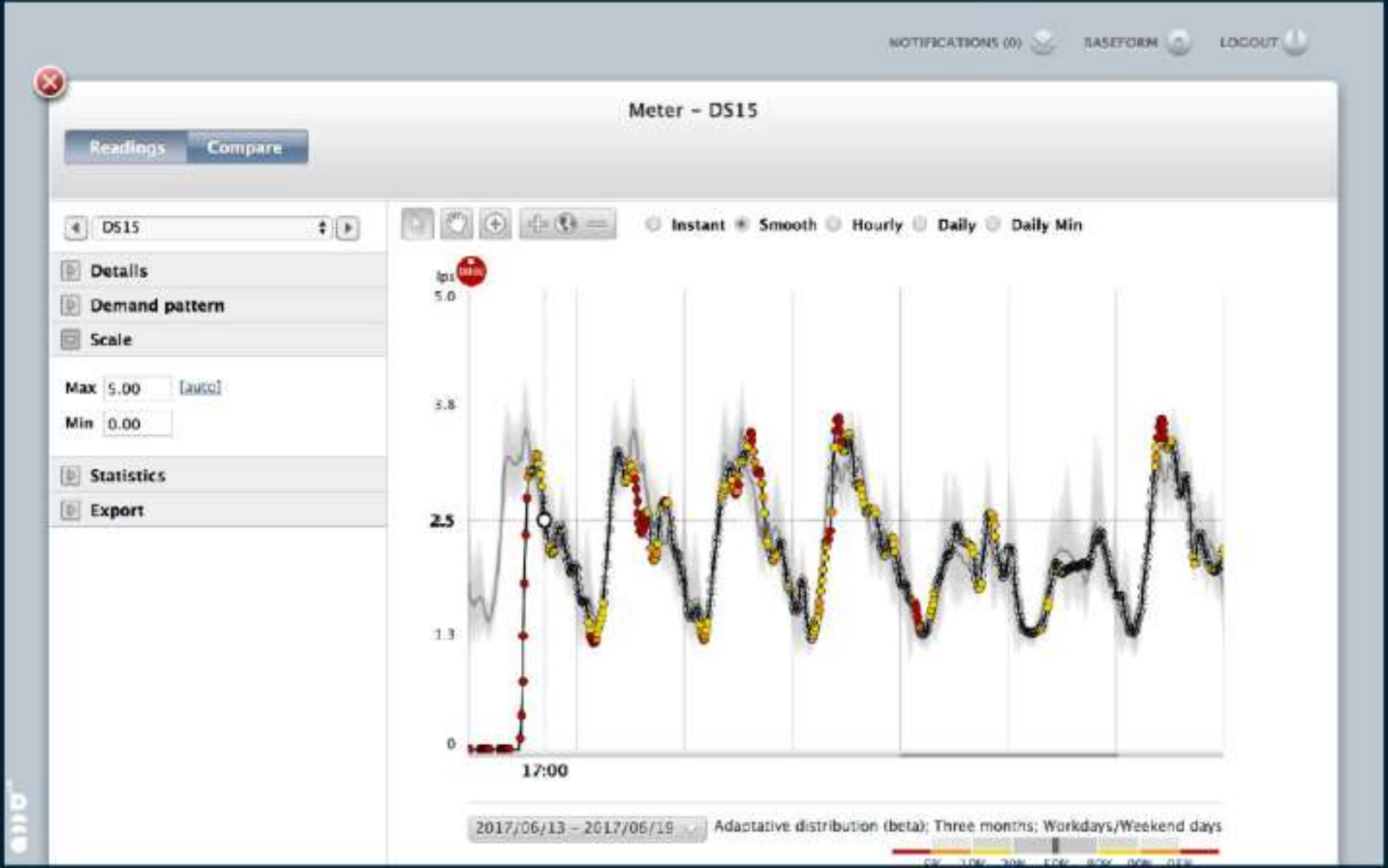
- Jun 2017:
  - 3500 DMA/sectors/sub-catchments in real time
  - 20 cities, 3 continents
- Large quantities of key metrics
- Failure rates, replacement costs, operational costs
- External crowdsourcing
- Internal *crowdsourcing*

IAM: embedded in everyday energy

baseform

- The ability to follow the entire network daily, and to track down, collect, validate, organize the relevant data, is key.
- Continuously making available the key metrics used for diagnosis and prioritization of assets, zones and systems.
- IAM gains in validation and repeatability – no longer the tedious chore undertaken once a year with piecemeal results.





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Readings
Compare
DS15
Details
Demand pattern
Scale
Max 5.00 [auto]
Min 0.00
Statistics
Export
Instant
Smooth
Hourly
Daily
Daily Min
lps
5.0
3.8
2.5
1.3
0
17:00
2017/06/13 - 2017/06/19
Adaptative distribution (beta); Three months; Workdays/Weekend days


NOTIFICATIONS (0)
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DS12
Details
Config DS12
Type Flow
Zone DS12
System Drammensregionen
Demand pattern
Show Pattern
Adaptative distribution (beta)
Window Three months
Match Workdays/Weekend days
Scale
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Min 0.00
Statistics
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Med (P50) 24.18 lps
Max (P95) 29.89 lps
Instant
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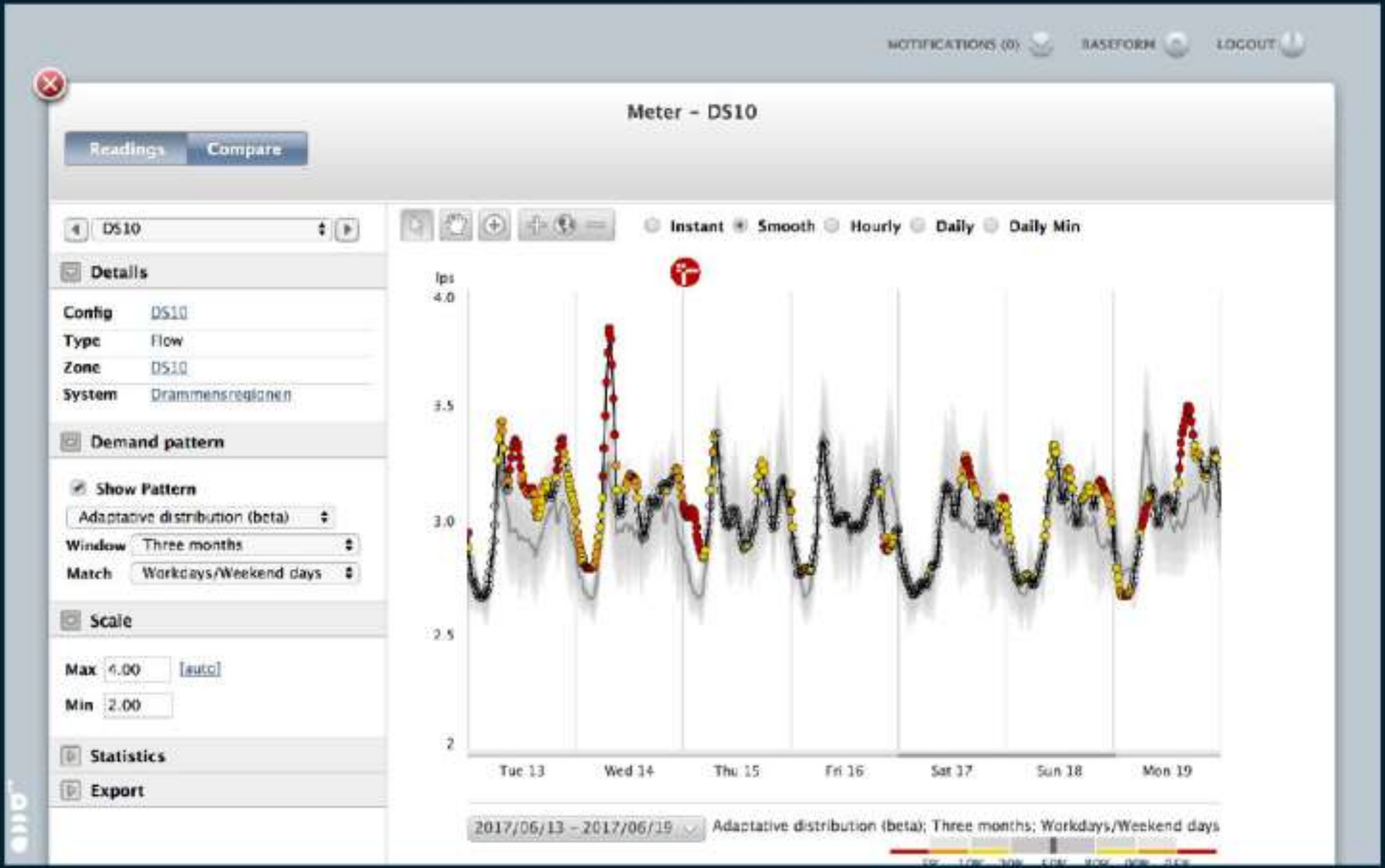
Mon 19
2017/06/13 - 2017/06/19
Adaptative distribution (beta): Three months; Workdays/Weekend days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Show Pattern
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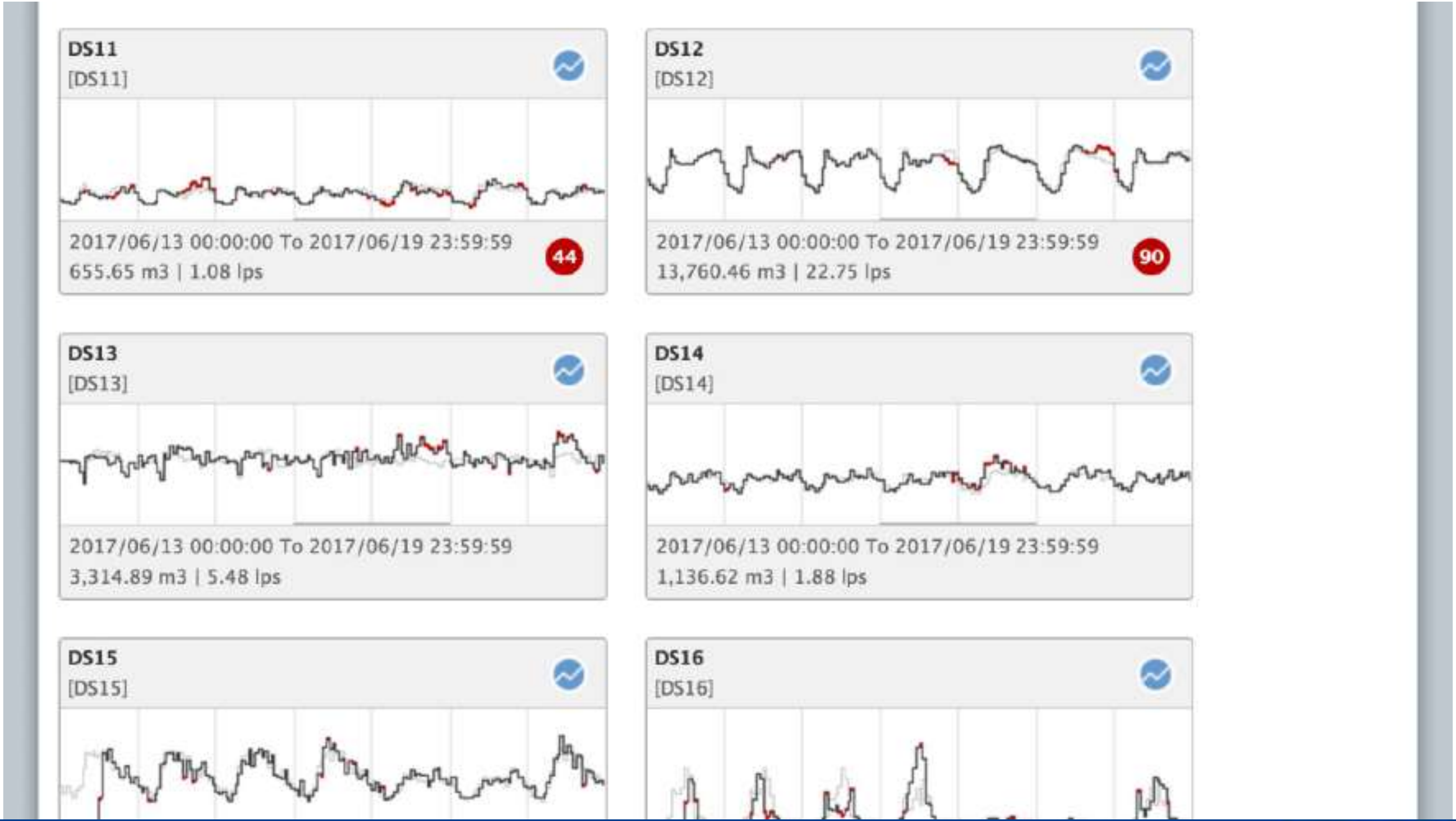
Adaptative distribution (beta); Three months; Workdays/Weekend days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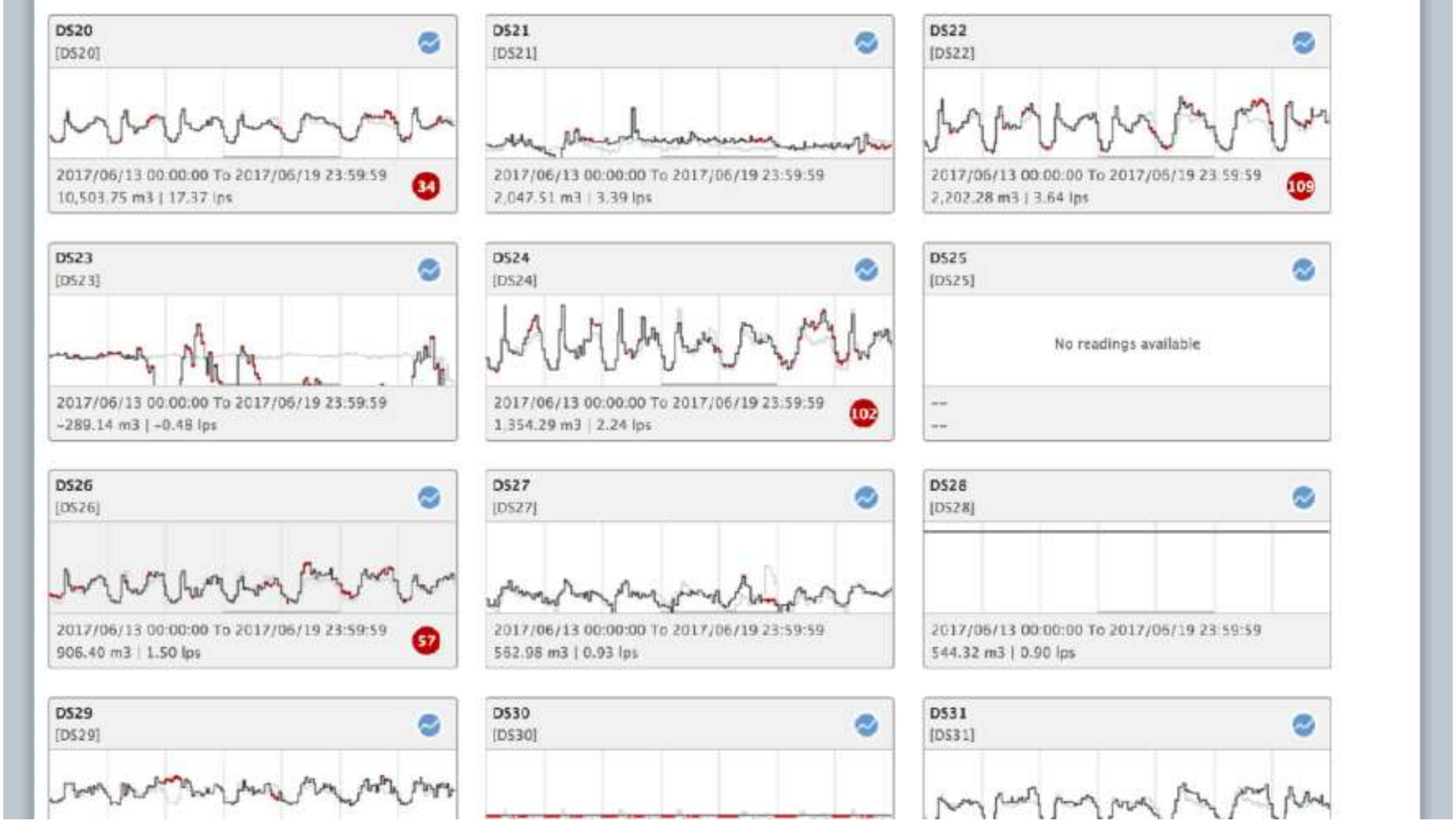
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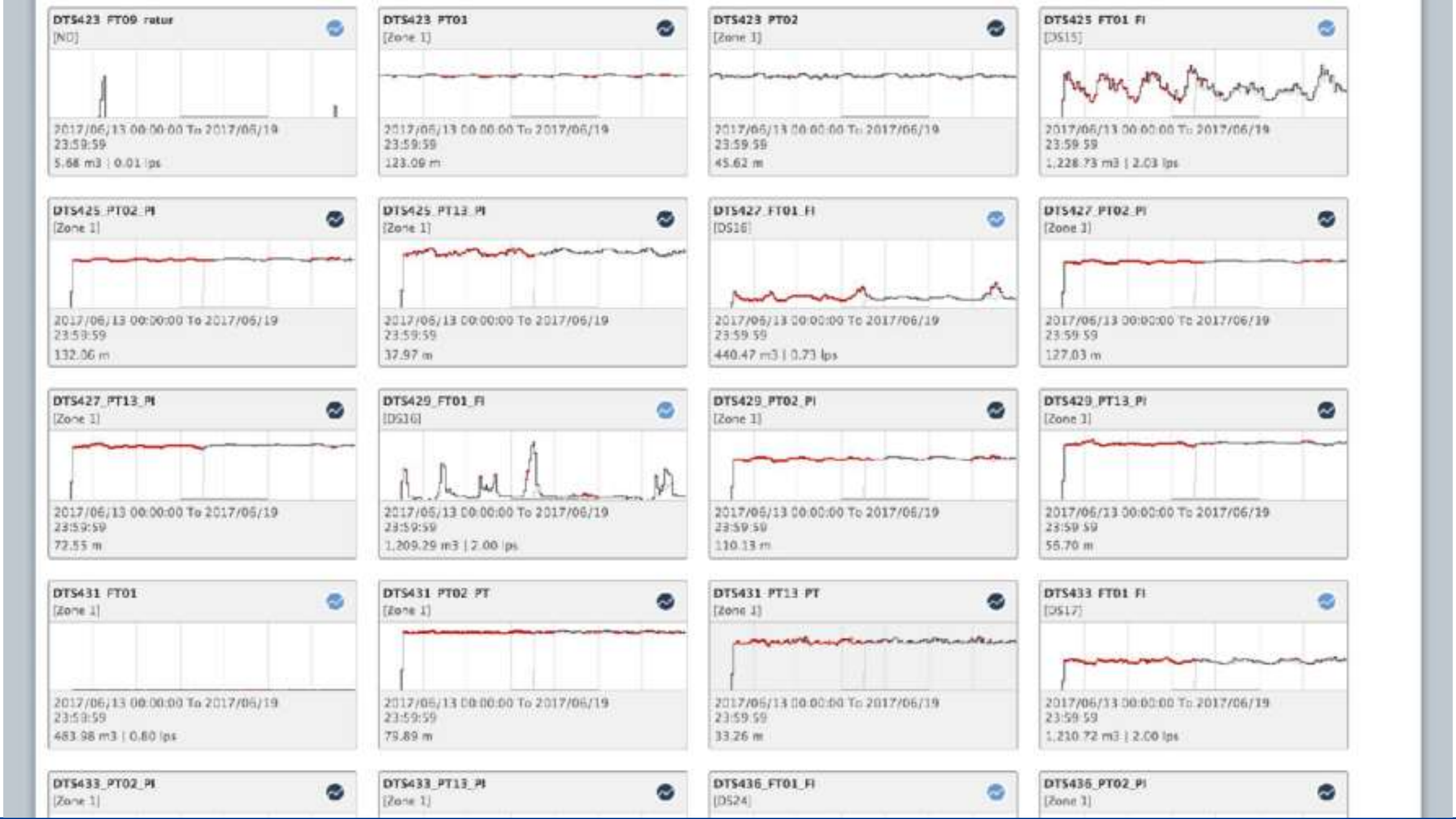
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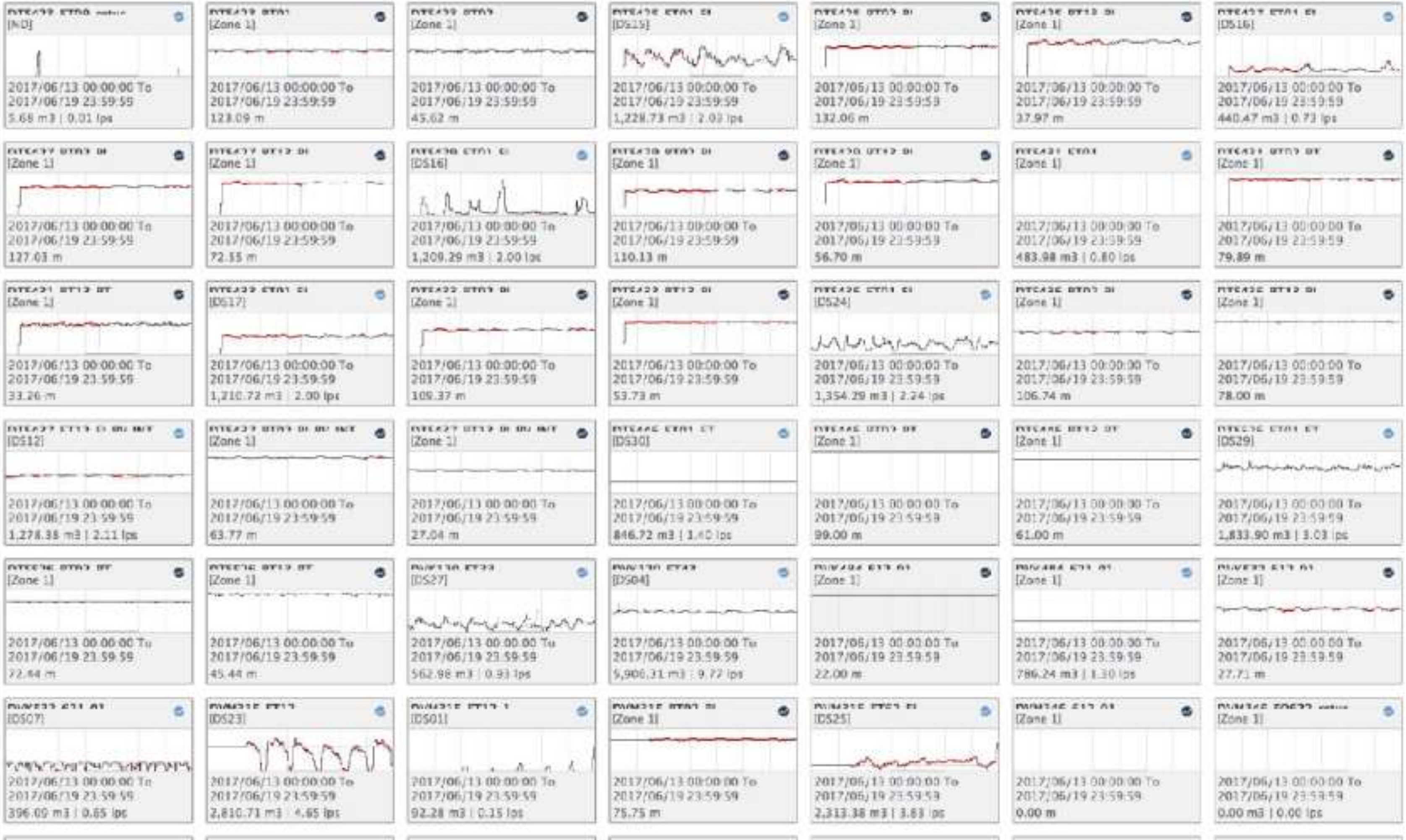
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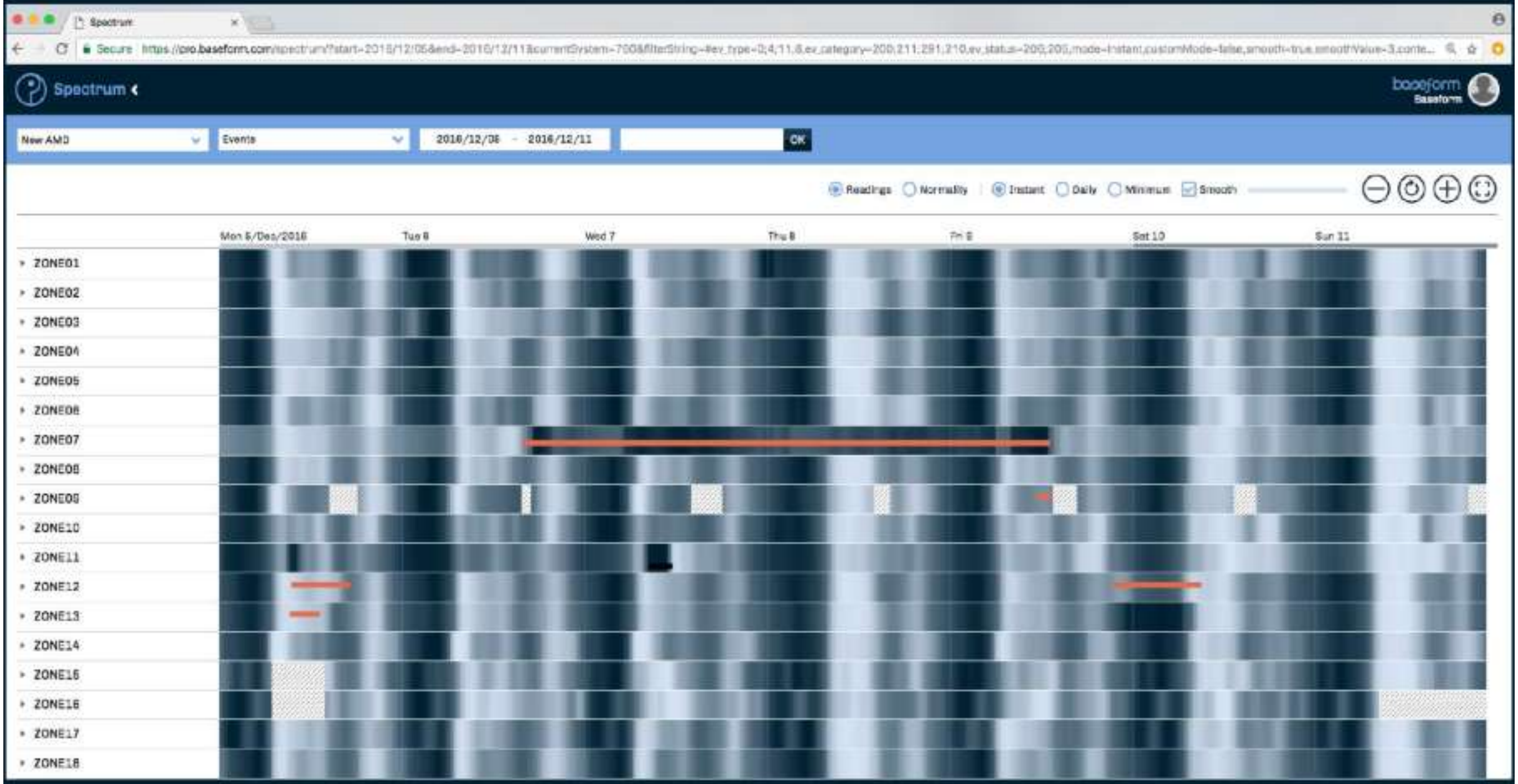
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 109.37 m
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 53.73 m
[DS24] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 1,354.29 m3 | 2.24 lps
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 106.74 m
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 78.00 m
[DS12] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 1,278.38 m3 | 2.11 lps
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 63.77 m
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 27.04 m
[DS30] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 846.72 m3 | 1.40 lps
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 99.00 m
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 61.00 m
[DS29] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 1,833.90 m3 | 3.03 lps
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 72.44 m
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 45.44 m
[DS27] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 562.98 m3 | 0.93 lps
[DS04] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 5,906.31 m3 | 9.77 lps
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 22.00 m
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 786.24 m3 | 1.30 lps
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 27.71 m
[DS07] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 396.09 m3 | 0.65 lps
[DS23] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 2,810.71 m3 | 4.65 lps
[DS01] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 92.28 m3 | 0.15 lps
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 75.75 m
[DS25] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 2,313.38 m3 | 3.83 lps
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 0.00 m
[Zone 1] 2017/06/13 00:00:00 To 2017/06/19 23:59:59 0.00 m3 | 0.00 lps


Spectrum
Diogo
Secure
Spectrum
baseform
Addition
Water supply demo (new)
Events
2016/09/30 - 2016/10/07
OK
Readings
Normality
Instant
Daily
Minimum
Smooth
Fri 30/Sep/2016
Sat 1/Oct
Sun 2
Mon 3
Tue 4
Wed 5
Thu 6
Fri 7
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5


Spectrum
Spectrum
baseform
Baseform
New AMD
Events
OK
Readings
Normality
Instant
Daily
Minimum
Smooth
Mon 5/Dec/2016
Tue 6
Wed 7
Thu 8
Fri 9
Sat 10
Sun 11
ZONE01
ZONE02
ZONE03
ZONE04
ZONE05
ZONE06
ZONE07
ZONE08
ZONE09
ZONE10
ZONE11
ZONE12
ZONE13
ZONE14
ZONE15
ZONE16
ZONE17
ZONE18


Spectrum
Spectrum
baseform
Waste water demo (lg)
Events
2014/07/18 - 2014/07/24
OK
Readings
Normality
Instant
Daily
Minimum
Smooth
Fri 18/Jul/2014
Sat 19
Sun 20
Mon 21
Tue 22
Wed 23
Thu 24
BR
BR-01
BR-02
BR-03
BR-04
BR-05
BR-06
BR-07
BR-08
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BR-12
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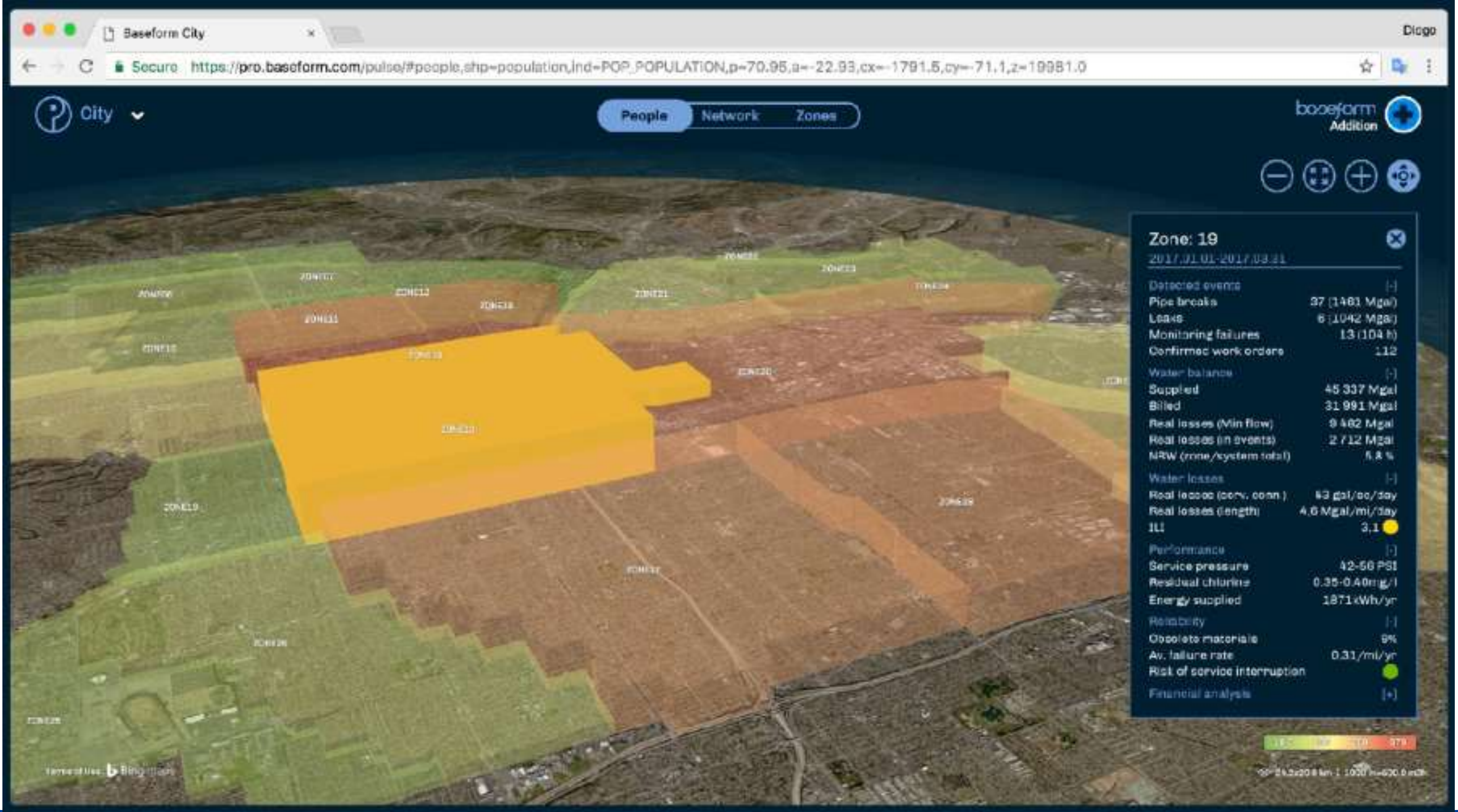
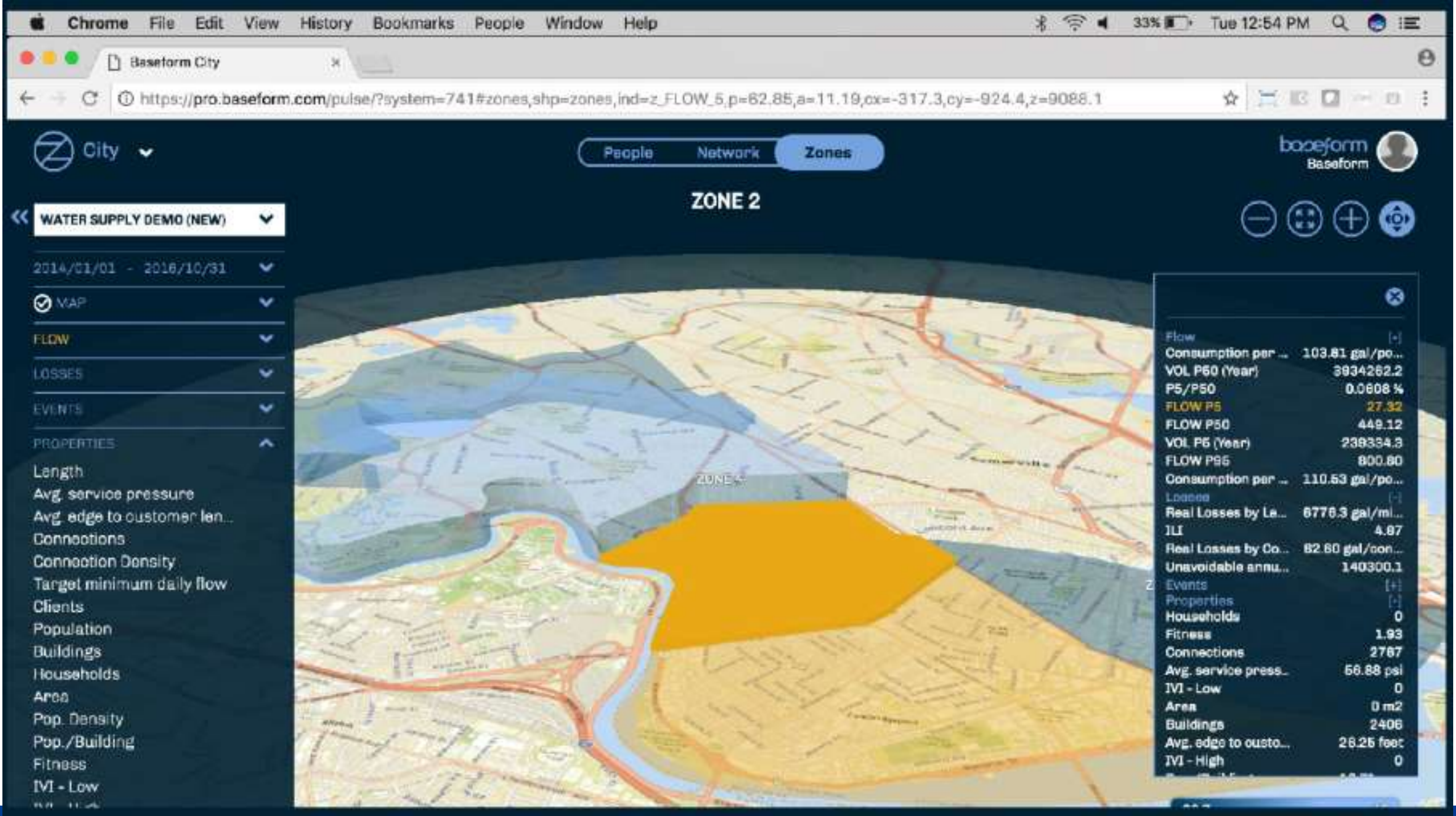
BR-50
BR-51
BR-52



Baseform City
Diogo
Secure https://pro.baseform.com/pulse/#people,shp=population,ind=POP_POPULATION
City
People
Network
Zones
baseform
Addition
Zone: 19
Detected events
Pipe breaks 37 (1461 Mgal)
Leaks 6 (1042 Mgal)
Monitoring failures 13 (104 h)
Confirmed work orders 112
Water balance
Supplied 45 337 Mgal
Billed 31 991 Mgal
Real losses (Min flow) 9 462 Mgal
Real losses (in events) 2 712 Mgal
Water losses
Real losses (length) 4,6 Mgal/mi/day
ILI 3,1
Performance
Service pressure 42-56 PSI
Residual chlorine 0.35-0.40mg/l
Energy supplied 1871 kWh/yr
Obsolete materials 9%
Av. failure rate 0.31/mi/yr
Risk of service interruption
Financial analysis [+]



Baseform City
https://pro.baseform.com/pulse/?system=741#zones,shp=zones,ind=z_FLOW_5,p=62.85,a=11.19,cx=-317.3,cy=-924.4,z=9088.1
City
People
Network
Zones
baseform
Baseform
ZONE 2
WATER SUPPLY DEMO (NEW)
2014/01/01 - 2016/10/31
MAP
FLOW
LOSSES
EVENTS
PROPERTIES
Length
Avg. service pressure
Avg. edge to customer len...
Connections
Connection Density
Target minimum daily flow
Clients
Population
Buildings
Households
Area
Pop. Density
Pop./Building
Fitness
IVI - Low
Flow
Consumption per ... 103.81 gal/po...
VOL P50 (Year) 3934262.2
P5/P50 0.0608 %
FLOW P5 27.32
FLOW P50 449.12
VOL P5 (Year) 239334.3
FLOW P95 800.80
Consumption per ... 110.53 gal/po...
Losses
Real Losses by Le... 6776.3 gal/mi...
ILI 4.87
Real Losses by Co... 82.60 gal/con...
Unavoidable annu... 140300.1
Events
Properties
Households 0
Fitness 1.93
Connections 2767
Avg. service press... 56.88 psi
IVI - Low 0
Area 0 m2
Buildings 2406
Avg. edge to custo... 26.25 feet
IVI - High 0

baseform

thank you

LESAM 2017
NTNU, Trondheim, Norway

Presentation 10

Margarida Monte: Assessment of the quality of service provided to users of the water services in Portugal: revision of the infrastructure asset knowledge and management index

Assessment of the quality of service provided to users by water utilities in Portugal:

Revision of the infrastructure asset knowledge and management index

Paula Freixial, Adriana Cardoso, Rute Rodrigues, Margarida Monte

ERSAR

ENTIDADE REGULADORA
DOS SERVIÇOS DE ÁGUAS E RESÍDUOS

THE WATER AND WASTE SERVICES
REGULATION AUTHORITY

LESAM 2017
NTNU, Trondheim, Norway

IWA LESAM 2017

Trondheim, 20th to 22nd June 2017

TABLE OF CONTENTS

THE WATER SECTOR IN PORTUGAL

MAIN FIGURES

ERSAR

Universe of about **400** utilities

… State owned and municipalities … in direct management model, by delegation or concession … operating bulk or retail systems or both

263 water supply utilities

266 wastewater management services utilities

278 municipal solid waste management utilities

10 million consumers

THE WATER SECTOR IN PORTUGAL
MAIN FIGURES

n

ERSAR

Abstraction	Treatment	Pumping	Storage	Mains	Supply	Consumption
267 surface water 6016 ground water	261 WTP 3406 other TP	2313 pumping stations	8732 reservoirs	108 757 km		

Source: www.adp.pt

THE WATER SECTOR IN PORTUGAL
MAIN FIGURES
n

ERSAR

Discharge

Sewerage **Sewers**

60 353 km

Pumping

5375 pumping stations

Treatment

2673 WWTP

1585 collective septic tanks

Discharge

24 submarine outfalls




Source: www.adp.pt

INFRASTRUCTURE ASSET MANAGEMENT IN PORTUGAL
BACKGROUND

ERSAR

INVEST MENT

In the last two decades, **important investments were carried out in Portugal** in water supply and wastewater management systems.

New efforts should guarantee that existing infrastructures are managed properly –

– **IAM approach**.

LAW

The importance of IAM was recognized in the Portuguese legislation in the **Decree-Law 194/2009**, of 20 August.

This legal document states that **all water utilities should have information concerning the current status of the infrastructures**.

WHO?

Water utilities attending **more than 30 000 inhabitants** must develop and maintain an IAM system.

INFRASTRUCTURE ASSET MANAGEMENT IN PORTUGAL

BACKGROUND

n

ERSAR

2009 — 2010 — 2011 — 2016

Decree-Law 194/2009

Technical Guides

2nd generation

IAKMI

3rd generation

IKI

IAMI

IAKMI

INFRASTRUCTURE ASSET KNOWLEDGE AND MANAGEMENT INDEX

Simplifications:

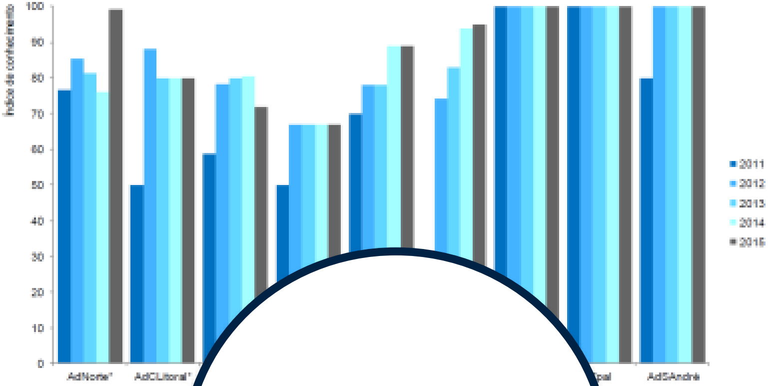
1. It only allows the assessment of buried infrastructures (as mains, sewers and network accessories)
2. The score does not distinguish if the information is in paper or is in a geographic information system (GIS)
3. It evaluates the implementation of an IAM system in a very superficial way

The index is scored from 0 to 100 points.

INFRASTRUCTURE ASSET KNOWLEDGE AND MANAGEMENT INDEX
RESULTS 2011-2015

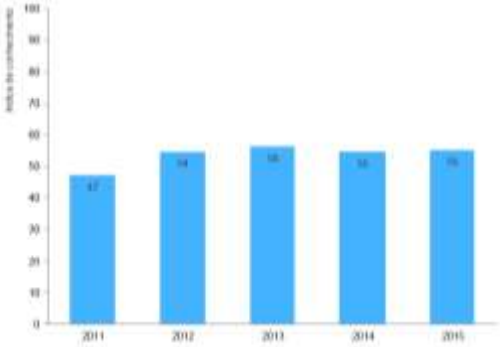
n

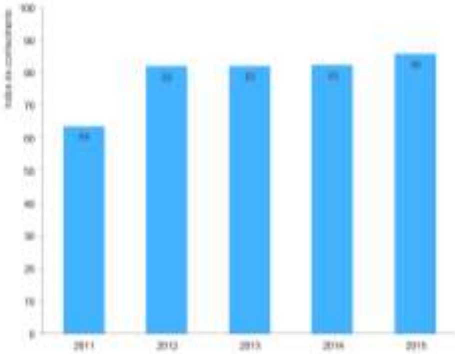
WATER SUPPLY SERVICE



86/100
2015
bulk systems

55/100
2015
retail systems

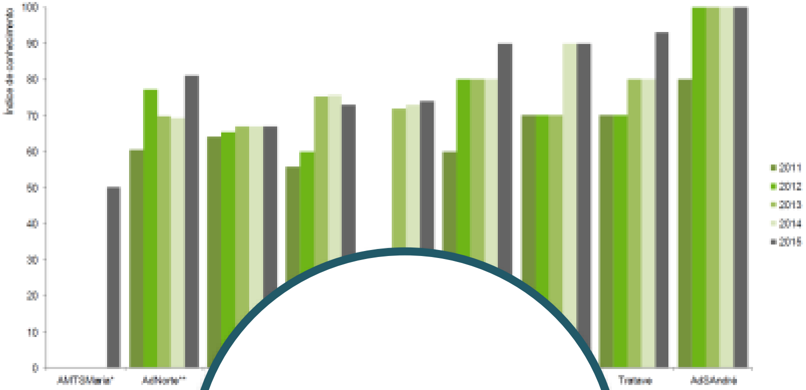


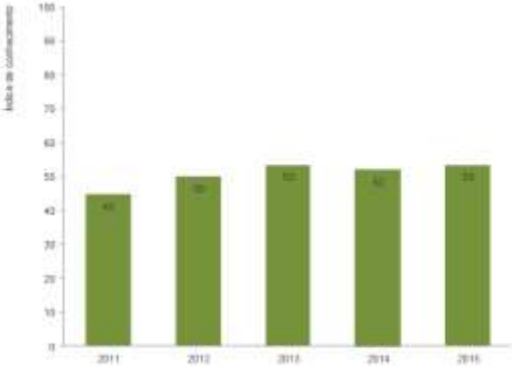


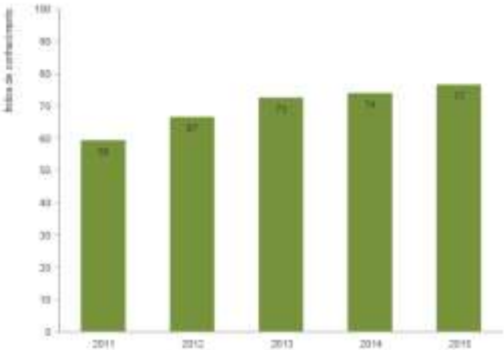
INFRASTRUCTURE ASSET KNOWLEDGE AND MANAGEMENT INDEX
RESULTS 2011-2015

n

WASTEWATER SERVICE







77/100
2015
bulk systems

53/100
2015
retail systems

IAKMI = IKI + IAMI

Differences:

1. It allows the assessment of all buried and non-buried infrastructures (as mains, sewers, WTP, WWTP, reservoirs, pumping stations, network accessories)
2. It allows the requirement for more detailed information regarding each infrastructure
3. The score will distinguish the information support, such as paper, AutoCAD or equivalent software or geographic information system (GIS)
4. Each index will be scored from 0 to 200 points.

ERSAR

INFRASTRUCTURE KNOWLEDGE INDEX

Aims to evaluate the utility's knowledge on the water supply or wastewater infrastructure assets in its area of intervention.

Classes:

A. Existence of an infrastructure assets' drawing
B. Information on mains/sewers and service connections
C. Information on other infrastructures (WTP, chorine stations, WWTP, reservoirs, pumping stations, *etc*.)
D. Information on measuring equipment
E. Information on the state of conservation
F. Information on interventions in the public network
G. Interconnection between GIS and other information systems and risk factors

B
51 points

B.1 Georeferenced information on sewers and manholes
B.2 Information on the characteristics on sewers
(type, section shape, length, diameter and material)
B.3 Information on the characteristics on manholes
(type, section shape and dimension)
B.4 Information on sewers' invert levels and on manholes' invert and cover levels
B.5 Information on the year/decade of installation of sewers and manholes in the same support that the network drawing
B.6 Location and characteristics of other network accessories (as siphon, inverted siphon, grit removal equipment, etc.)

NEW INDICES
INFRASTRUCTURE ASSET MANAGEMENT INDEX (IAMI)
n

ERSAR

INFRASTRUCTURE ASSET MANAGEMENT INDEX	Aims to evaluate whether the IAM process has been or is being properly implemented by the utility.

Classes:

A. IAM framework in the Utility
B. Documentation and communication
C. Strategic planning
D. Tactical planning
E. Operational planning

Operational planning

- Is there a document (Operational Plan) that contains the short-term operational objectives established by the utility and the actions with relevance to the infrastructures of water supply and wastewater management services?
- Was this document approved by the Administration and is being implemented?
- Is the operational plan aligned with the tactical objectives and with the established tactics?
- Is the monitoring being done in a quarterly basis as well as the registration of the actions' implementation?
- Is the operational plan being reviewed every six months? Is it assigned the responsibility for this revision?

FINAL REMARKS

With the implementation of the new indices, **ERSAR intends to evaluate, in a more detailed way, if water utilities fulfil all the requirements needed to implement and maintain an infrastructure asset management system**.

The **new infrastructural asset management index will allow to evaluate the compliance with the legislation** that determines the obligation to implement infrastructural asset management systems.

ERSAR

ENTIDADE REGULADORA
DOS SERVIÇOS DE ÁGUAS E RESÍDUOS

THE WATER AND WASTE SERVICES
REGULATION AUTHORITY

Thank you!

margarida.monte@ersar.pt

LESAM 2017
NTNU, Trondheim, Norway

Presentations

Session 2, Short and long-term planning

Norwegian University of Science and Technology

Presentation 1

Takahiro Yokokawa: Asset Management at Yokohama Waterworks Bureau

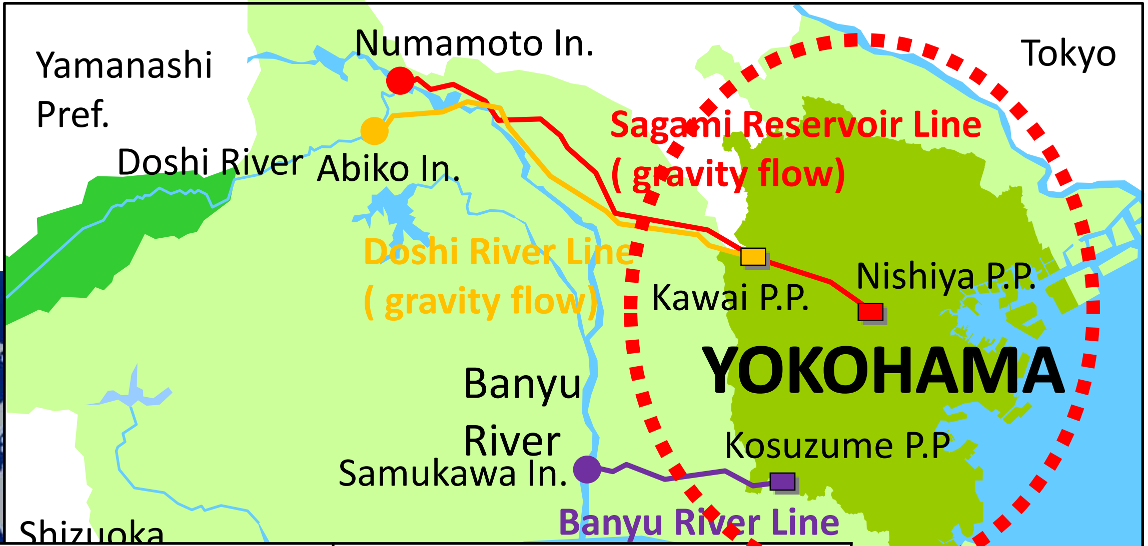
Asset Management at Yokohama Waterworks Bureau

Takahiro YOKOKAWA
Yokohama Waterworks Bureau,
Planning Division
JAPAN

Contents

Contents

About YWWB



Population supplied	3.7 million people
Service area	440 km^2
Average daily supply	1.11 million m^3/day
Number of Purification plant	3 purification plants
Number of reservoir	22 reservoirs
Total length of pipe line	9,200km

Increase of renewal demand

deteriorated pipes dug up in Yokohama

renewal demand will increase in the near future.

YWWB was established.

Most of facilities ware installed

1887

1960s-1970s
(period of high economic growth)

2016

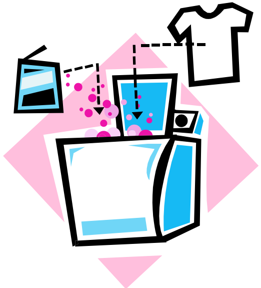
About 50 years

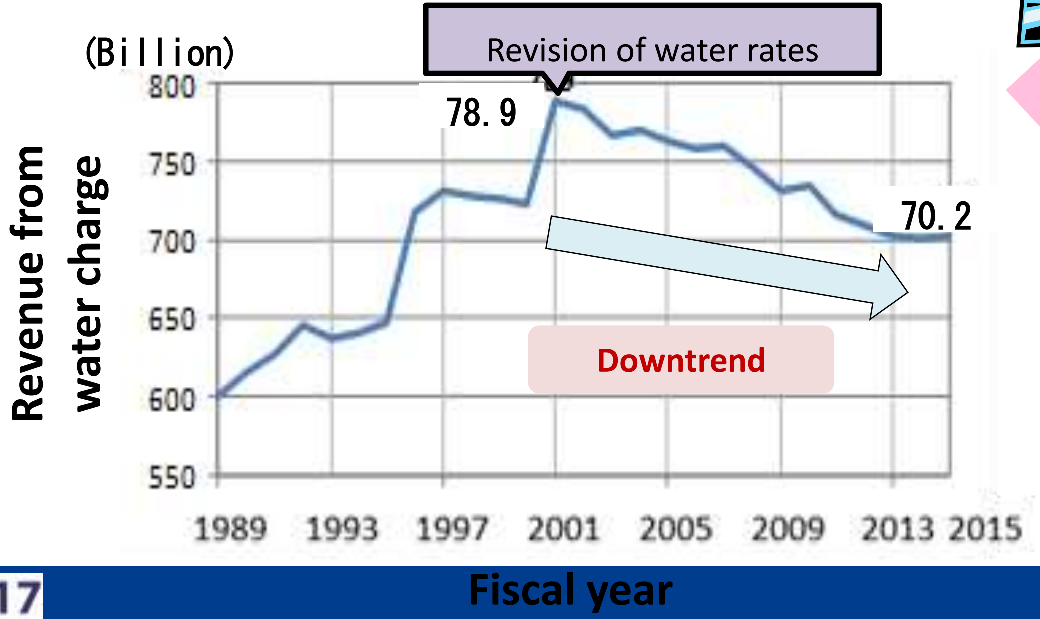
129 years

Decline of revenue from water charge

Caused by:

- the improvement of water-saving awareness
- the spread of water-saving device.



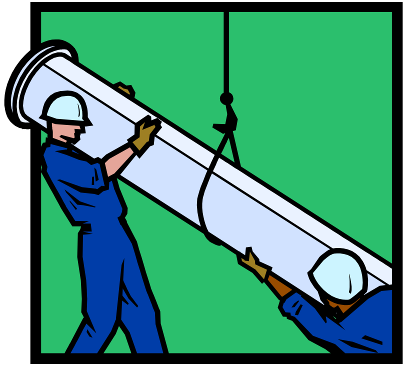


To realize a sustainable water supply operation

Increase of renewal demand

V.S.

Decline of revenue from water charge

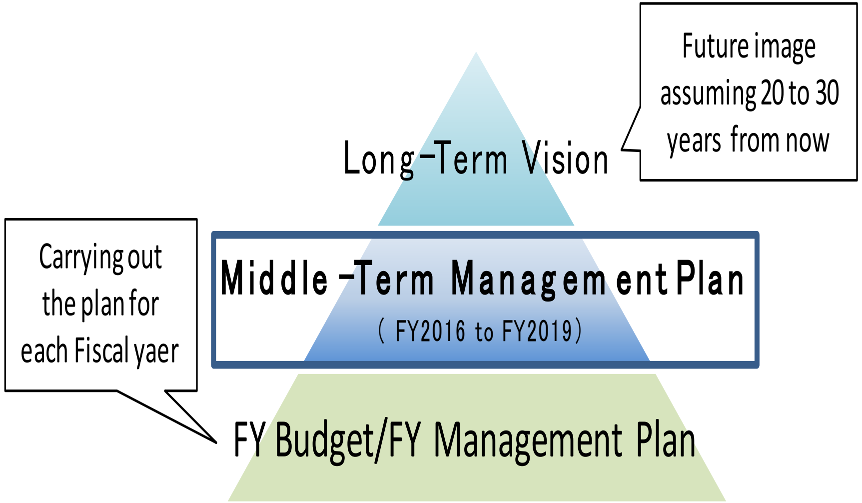


YWWB use concept of asset management

Contents

Long-Term Vision & Middle-Term Management Plan of YWWB

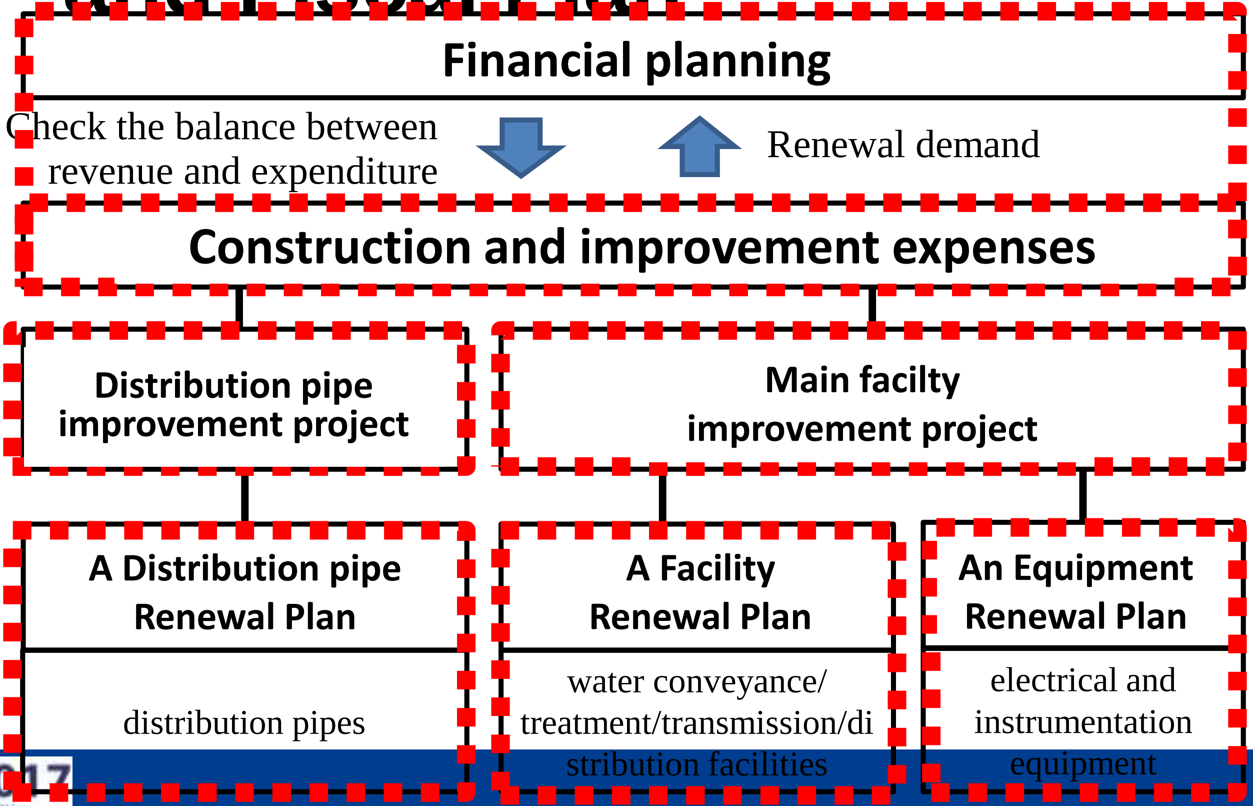
Long-Term Vision & Middle-Term Management Plan of YWWB



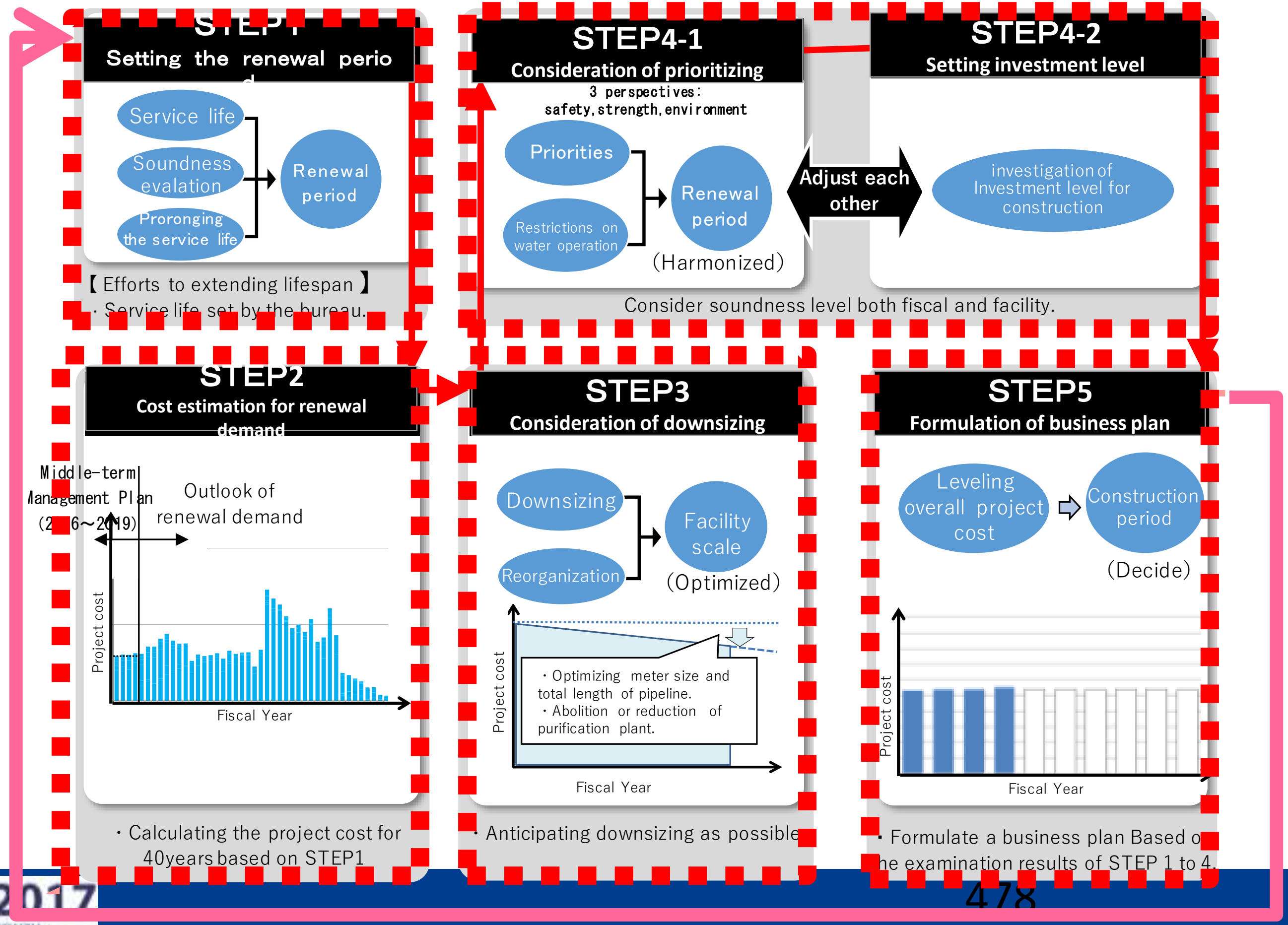
Hierarchy of Plans of YWWB

Contents

Concept on Conformity between Renewal Demand and Fiscal Plan



Asset Management flow at YWWB

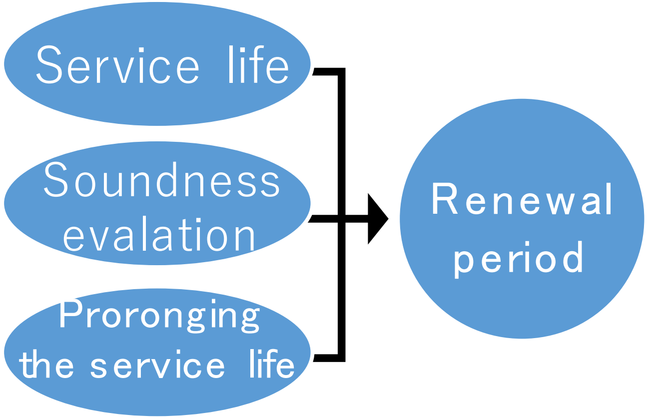


Contents

STEP1 (Setting renewal period)

Civil engineering structure	Pipeline	Equipment
Inspection of Concrete strength and carbonation depth	Investigation of the remaining thickness of pipe in corrosive soil	Analysis by the database of inspection results

STEP1 (Setting renewal period)



Example of service lives by the bureau（Pipeline）

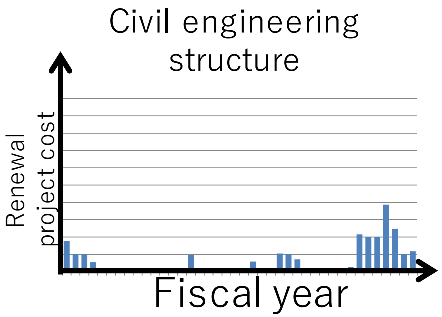
Type of pipe		Service lives
Cast-iron pipe		50years
Steel pipe		60years
Ductile iron pipe	Without polyethylene sleeve	70years
	With polyethylene sleeve	80years

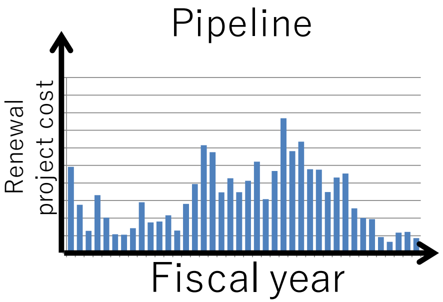
※ legal service life of pipeline is 40 years

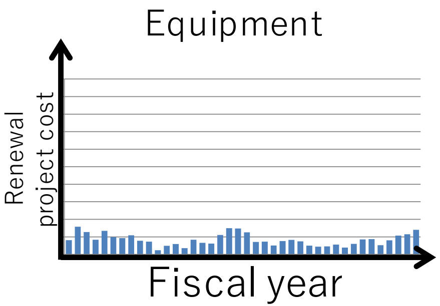
STEP 2 (Cost estimation for renewal demand)

Condition of cost estimation

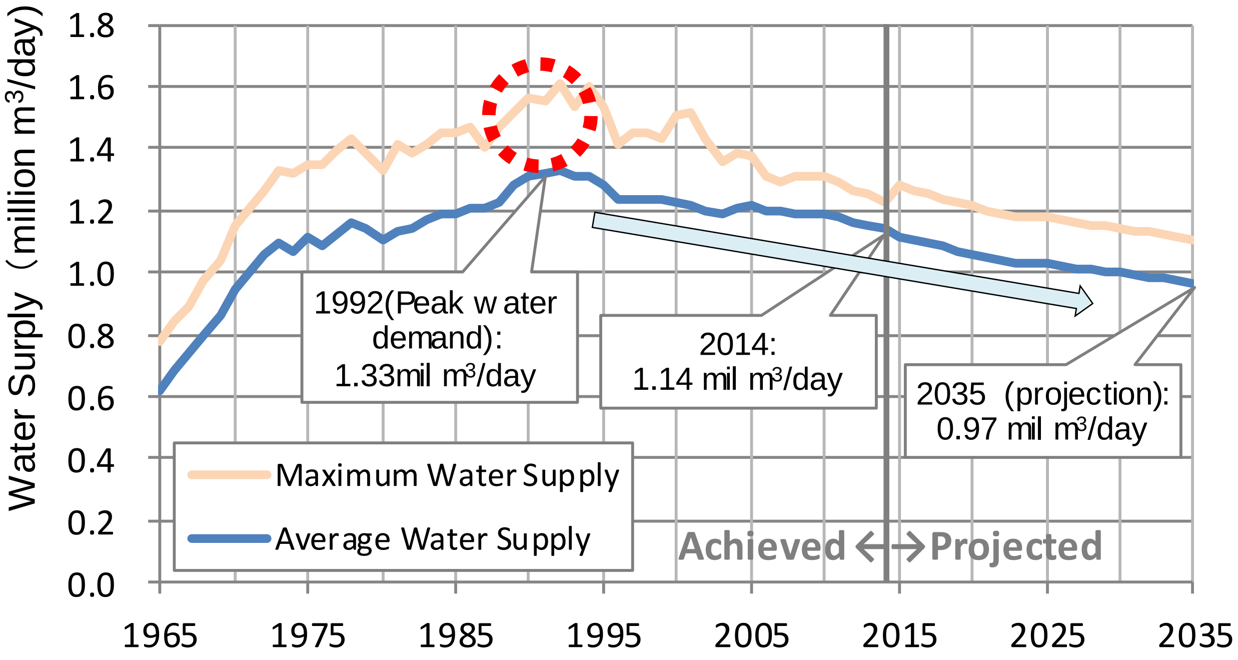
- including earthquake resistant work.
- estimation period is 40 years.







STEP 3 (Consideration of Downsizing)



Water demand of YWWB

STEP 3 (Consideration of Downsizing)

Examples of downsizing implemented thus far (FY2006 onward)

Category	Outline
Civil engineering structures	･Abolition part of reservoir. ･Reorganization of purification plant.
Pipelines	･Reducing diameter ･Optimizing pipeline network
Equipment	･Abolition part of pumping station. ･Reviewing pump capacity.

STEP4-1 (Consideration of Prioritizing)

Long-term Vision

Directions of efforts
Priority directions to realization of the desired future image

1 Safe and high quality water → **Safety**

2 Disaster resistant water works → **Strength**

3 Environment-friendly water works → **Environment**

4 Complete information and services → (Customer communication)

5 Contributing to society at home and abroad → (Contribution to society)

(Customer communication) and (Contribution to society): Achievements

6 Sustainable management infrastructure → 4 Sustainability (project leveling to continue projects)

Perspectives on the study of facility construction

STEP4-1 (Consideration of Prioritizing)

Perspective	Civil engineering structure（0～24point）	Pipeline（0～16point）	Equipment（0～18point）
Safety	･Water quality deterioration risk		･Accidental water contamination risk ･Importance of hypo ･Water quality monitoring & control
Strength	･Years since construction ･Soundness (Concrete strength, carbonization depth etc.) ･Seismic resistance ･Secondary disaster risk	･Pipe type ･Renewal time ･Leakage history ･Corrosive soil ･Seismic intensity 7 region ･Backup	･Renewal time ･Accident history ･Operating time ･Soundness of equipment ･Backup ･Importance of pumps
Environment			･Renewable energy ･Energy-saving control

STEP4-1 (Consideration of Prioritizing)

Priority score

Indices to quantify the priority

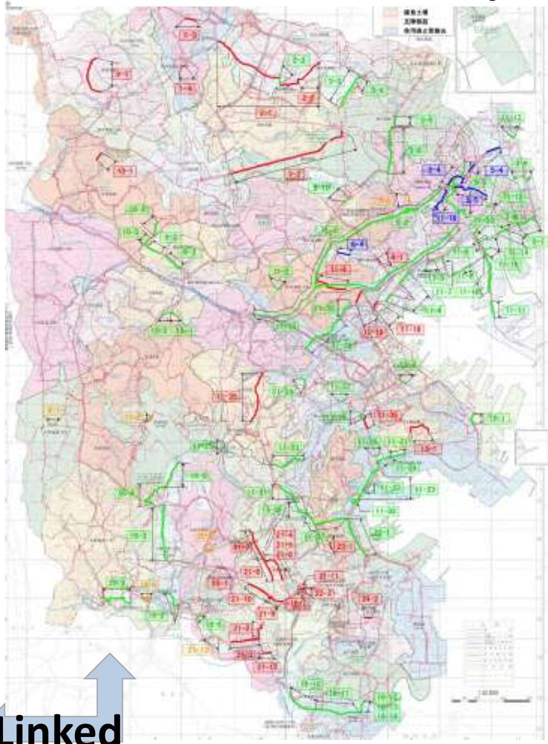
Name of Pipe line	更新優先度	1:管種（CIP・PC）	2:布設年度	3:漏水履歴	4:腐食土壌	5:震
磯子高区線P	6	0	1	0	1	0
夏山線G	6	0	1	0	1	1
釜利谷線G	11	2	3	1	1	1
関内線G	10	2	1	1	0	1
金沢線G	11	2	5	1	0	1
上大岡線G	13	2	5	1	1	0
上飯田線G	1	0	0	0	0	0

Use

・：Timing of construction

No	Construction name	延長(m)	種別	第1期 H28 2016	H29 2017	H30 2018	H31 2019	第2期 H32 2020	H33 2021	H34 2022	H35 2023	H36 2024	H3 20
1-1	㎜配水管布設替工事	600	腐食土壌					←→	←→				
1-2	美しが丘高区線口径600㎜配水管布設替工事（その2）	1,200	腐食土壌							←→	←→	←→	
1-3	保木高区線口径500㎜配水管布設替工事（その2）	750	腐食土壌	→									
1-4	保木高区線口径400㎜配水管布設替工事	135	腐食土壌									←→	
2-1	牛久保線口径500㎜配水管布設替工事	5,280	腐食土壌	工法・工事時期等検討中									
2-2	牛久保線口径500㎜配水管布設替工事	980	腐食土壌				←→ 都市計画道路宮内新横浜線街路整備事業（	←→	←→				

Water distribution map



Linked

・：(consider restriction of water operation)

STEP4-2 (Setting investment level)

policy of financial plan

Item	Financial condition
Assuring net income	We will assure net income about 5 billion yen in every fiscal year.
Reducing balance of enterprise bonds	We will reduce the balance of bonds about 3.5 billion yen over four years.
Securing internal reserves	We will secure internal reserves about 3 billion yen by the end of FY2019.

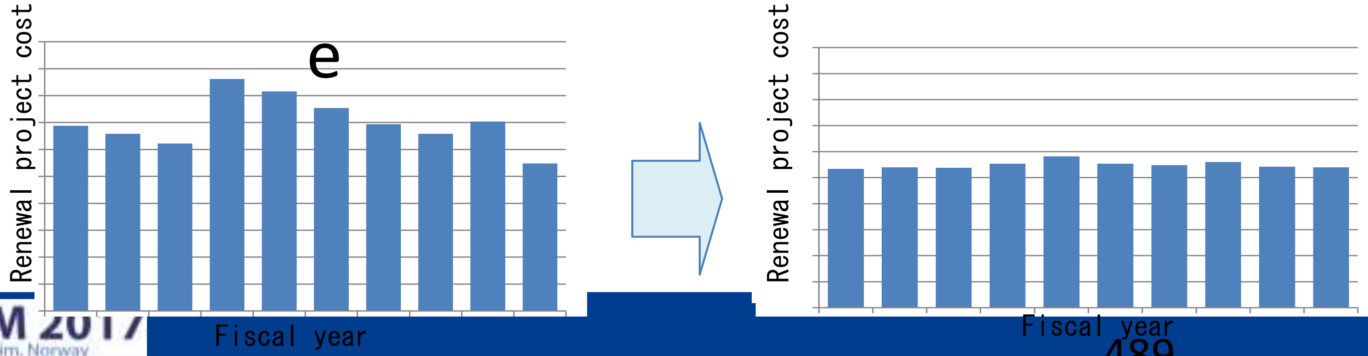
STEP 5
(Formulation of Business Plans)

- Prolonging service lives
- Optimizing facility scale
- Harmonizing renewal times

Reducing and leveling project cost

befor
e

after



STEP 5 (Formulation of Business Plans)

Examples of project in Middle-Term Management Plan

Policy aim	Project name	Performance indicator	Current status (Outlook for 2015)	Aim (Up to end of FY2019)
Safe and high quality water	Nishiya Purification Plant redevelopment	Progress status of work	Formulation of basic plan	Work underway to strengthen filtration basin against earthquakes
Disaster resistant waterworks	Renewal & earthquake resistance of pipelines	Ratio of earthquake resistant pipelines	23%	28%
Environment-friendly waterworks	Optimizing energy efficiency of distribution pumps	Number of pumps equipped with	10 locations	14 locations

Image of reconstruction of Nishiya PP

Laying earthquake resistant pipe

Distribution pump

Contents

5 Future prospect

Item	Future prospect
Maximizing asset value	・We will appropriately attend to daily maintenance management, such as inspections and repairs.
Optimizing facility scale	・ We will downsize facility scales that suit the water demand In the future. ・ We are collaborating with nearby water suppliers, to consider reorganization of purification plants from a broad perspective.
Considering suitable water rate structure	・We are considering a suitable water rate structure that will achieve both the securing of appropriate revenue of water charges and sustainable facility

Thank you so much for your kind attention.

Presentation 2

Natalie Hernandez: Support tools to predict the critical structural condition of uninspected sewer pipes in Bogota d.c.

Pontificia Universidad JAVERIANA Bogotá

KOMPETENZZENTRUM WasserBerlin

SUPPORT TOOLS TO PREDICT THE CRITICAL STRUCTURAL CONDITION OF UNINSPECTED SEWER PIPES IN BOGOTA D.C.

Nathalie Hernández,
Nicolas Caradot, Hauke Sonnenberg, Pascale Rouault and Andrés Torres

LESAM 2017
NTNU, Trondheim, Norway

The Leading Edge Sustainable Asset Management of Water and Wastewater Infrastructure Conference 2017
20-22 June 2017 - Trondheim, Norway.

THE PROBLEM

Urban Drainage Networks
Deterioring and Aging Rates – Worldwide

Caused by:
- Accelerated growth of cities
- Climate change
- Environmental Pollution
- Resource limitation ($$)
- Infrastructure Aging

ESTRUCTURAL

Source: Echeverri (2009)." Aplicación de modernas tecnologías para la planeación de la operación, mantenimiento y rehabilitación de acueductos y alcantarillados". 52° Congreso ACODAL

OPERATIONAL

Source: Road on Bogota's district: San Cristóbal, Bogotá. Newspaper"la Nación" May 11, 2016

LIFE'S QUALITY - COMUNITIES

Source: Neighborhood "Santo Domingo de los Tsáchilas" – Ecuador. TV News Ecuavisa- January 20, 2015

CHALLENGE

Utility Water companies

Sewer asset managent -> Timely plans

- ✓ RATIONAL
- ✓ EFFICIENT
- ✓ EFECTIVE
- ✓ SUSTAINABLE

- ❑ (-$) Budget
- ❑ Environmental regulations
- ❑ Urban Infrastructure Benefits
- ❑ Life qualify - Comunities

Methodologies & models
support the sewer asset management

Deterioration models

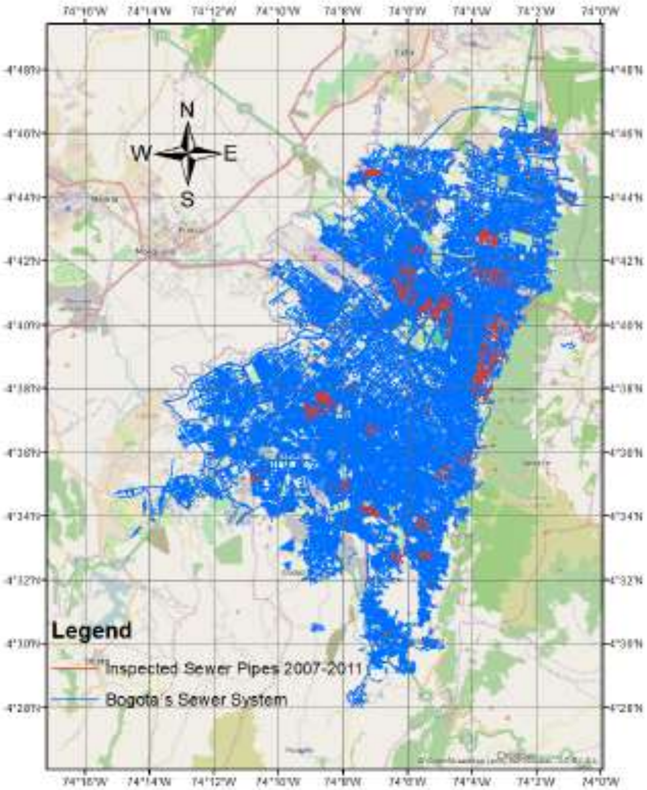
Supporting cost-effective inspection & rehabilitation strategies :-> Prediction condition uninspected sewers
-> Forecasting sewer condition future time

Based on statistical and learning machine approaches:

- Wright et al., 2006 -> LR & DA (Vallejo, California - USA)
- Mashford et al., 2010 -> SVM: (Adelaide, Australia)
- Salman & Salem, 2012 -> LR: (Ohio, USA)
- Havey &McBean, 2014 -> RF: (Ontario, Canadá)

OBJECTIVE

Bogota's Sewer System



Bogota -> Reactive sewer asset management
rehabilitation coverage < 0.3% sewer pipes
- €18 million annually

KEY: Proactive management ⬆ % Rehabilitation rate = Budget

OBJECTIVE:

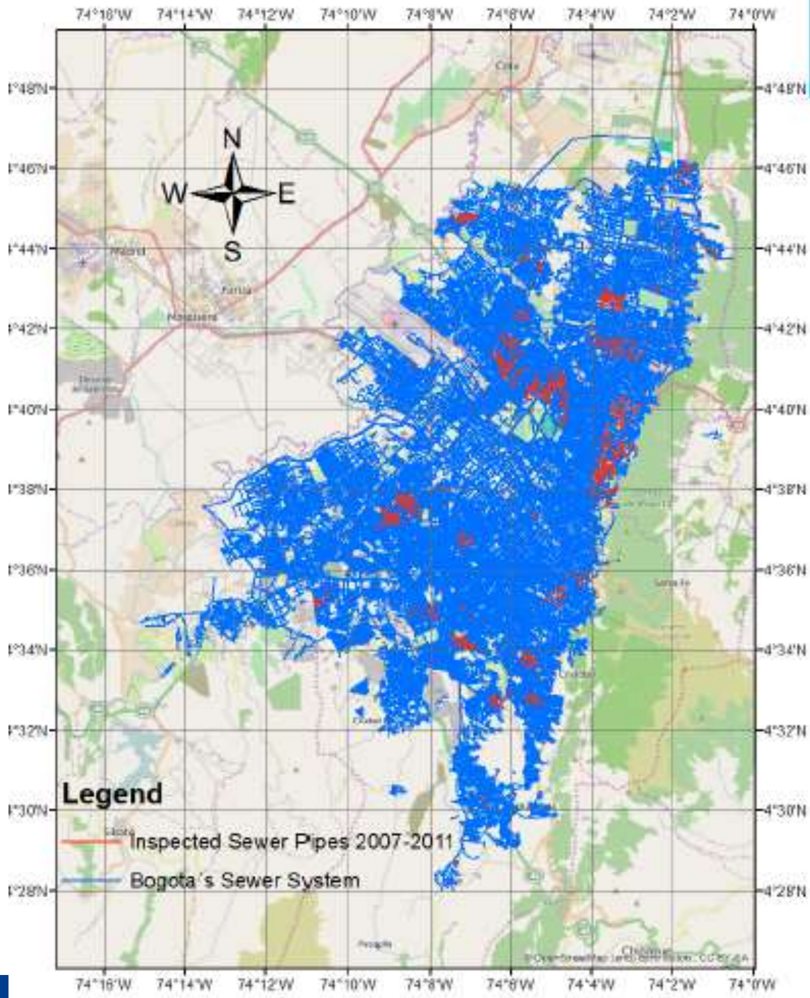
Exploring five deterioration methods:

- Logistic Regression – LR
- Random Forest – RF
- Multinomial Logistic Regression – MLR
- Linear Discriminant Analysis – LDA
- Support Vector Machine - SVM

AGE

AGE + Other sewer characteristics

The most adapted as SEWER ASSET MANAGEMENT TOOL for BOGOTA DC



CASE STUDY: BOGOTÁ DC

Bogota's sewer system GIS – (221.000 sewers)

Sewers physical characteristics (Installation time)

Information data CCTV inspections (4327 sewers) (2007-2011)

Observed sewers physical characteristics
Age, Structural & Operational condition

NS – 058

FAILURE

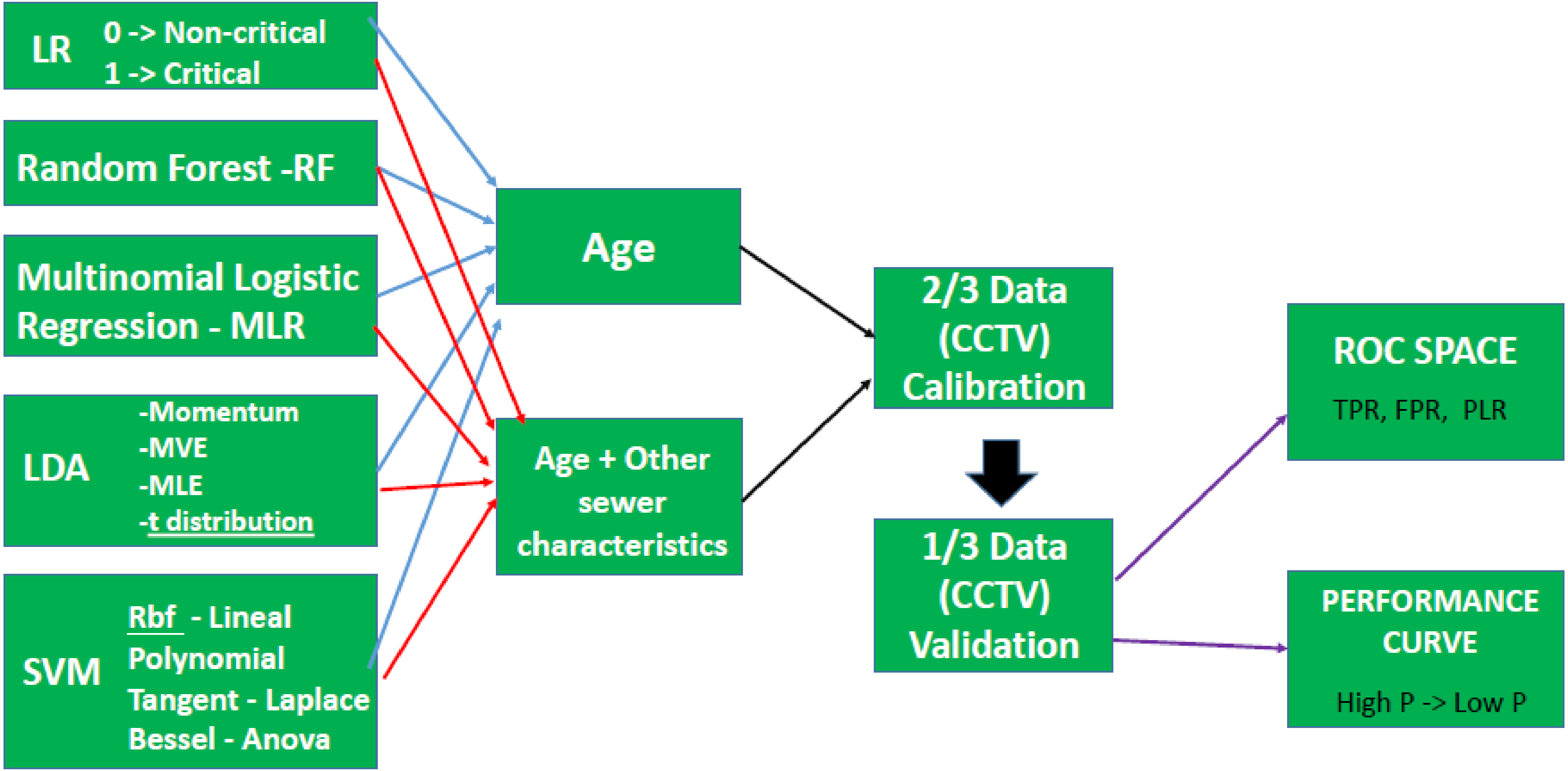
SCORE	GRADE
< 10	1
10-39	2
40-79	3
80-164	4
165+	5

CONDITION
1
2
3
4

Sewer Characteristics (Davis et al., 2001)

- Age
- Material, Type of effluent (Sewerage), Depth, Length, Slope, Diameter

METHODOLOGY



RESULTS – ROC SPACE

Method	option 1			option 2		
	TPR	FPR	PLR	TPR	FPR	PLR
Random Forest (RF)	0.62	0.22	2.82	0.57	0.15	3.80
Logistic Regression (LR)	0.07	0.04	1.75	0.38	0.07	5.43
Multinomial Logistic Regression (MLR)	0.32	0.15	2.13	0.71	0.21	3.38
Linear Discriminant Analysis (LDA)	0.32	0.15	2.13	0.7	0.2	3.50
Support Vector Machine (SVM)	0.32	0.15	2.13	0.66	0.17	3.88

MLR = LDA = SVM

=> MLR and LDA: same coefficient (0.05)

SVM (Rbf): same LD funcion

separation hyperplane

OPTION 1

RESULTS – ROC SPACE

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LR: TPR and FPR close (0,0) – no predict critical condition

RF: 62% critical condition 2.82 TPR (correct)/FPR (wrong)

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OPTION 2

In general: prediction's capacity improves
ROC space ~ all methods (except for LR)
60-70% for TPR and 15-20% for FPR

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  60-70% for TPR and 15-20% for FPR
- **SVM & RF:** high PLR's values (PLR =4)
- **MLR &LDA:** high TPR, high FPR (PLR = 3 – 3.5)
  => Prediction No effective

RESULTS – ROC SPACE

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5 methods: PLR > 1

=> Age vs Structural condition:

older pipe – High probability critical condition (Davis et al., 2001)

OPTION 1 & 2

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Option 1:

- LDA, SVM, MLR: linear relationship Age vs Condition
- LR: weak relationship Age vs Conditions logits
- RF: Prediction condition (specific time period) –intuitive decision rules

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MLR ≠ LR: MLR assumes independence – Groups (structural condition)
Imperfect separation – Linear

OPTION 1 & 2

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Option 2:
- MLR ~ LDA ≠ SVM

SVM non linear: nature of other variables and iteration

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Imperfect separation – Linear

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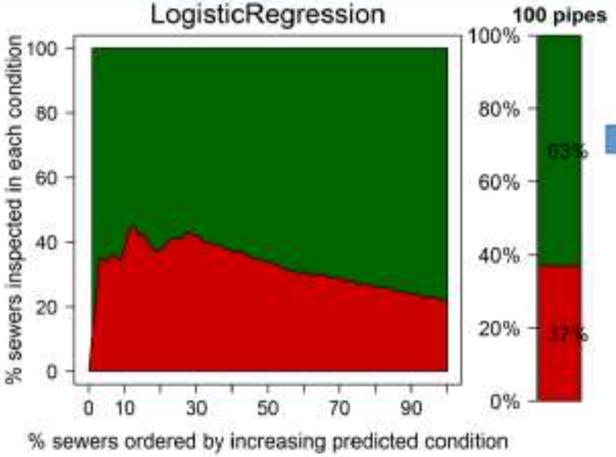
SVM non linear: nature of other variables and iteration

SVM, RF and LR: Models better predictability -> High TPR
-> High PLR

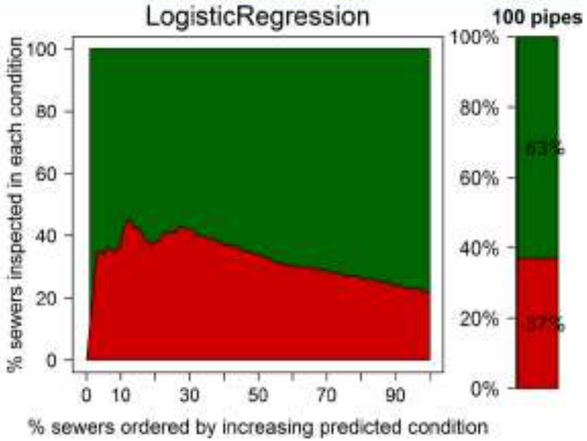
RESULTS – PERFORMANCE CURVE



OPTION 1: AGE

No adapted: Peak 13%
100 pipes -> (37%) – Random

RESULTS – PERFORMANCE CURVE



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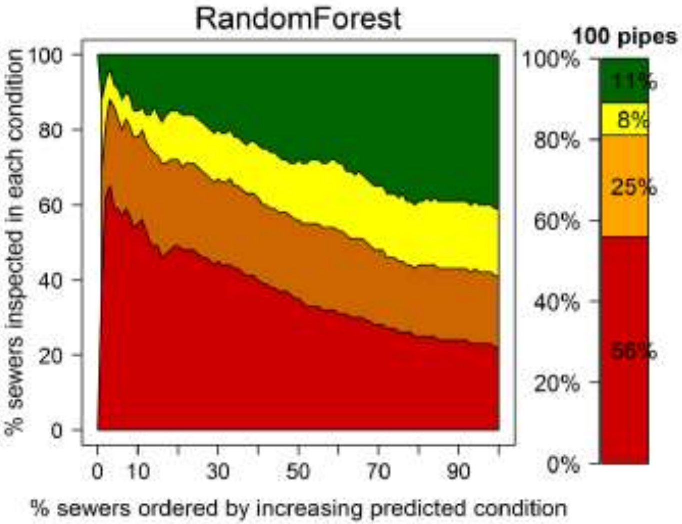
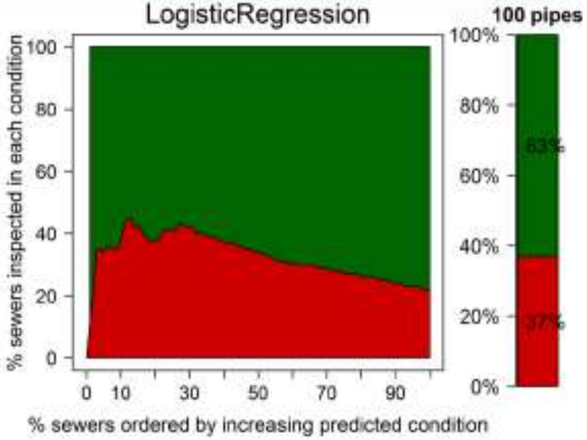


Performance Curve adapted for:
High % successful of prediction:
High probability critical condition

100 pipes -> (56%)

RESULTS – PERFORMANCE CURVE



No adapted: Peak 13%
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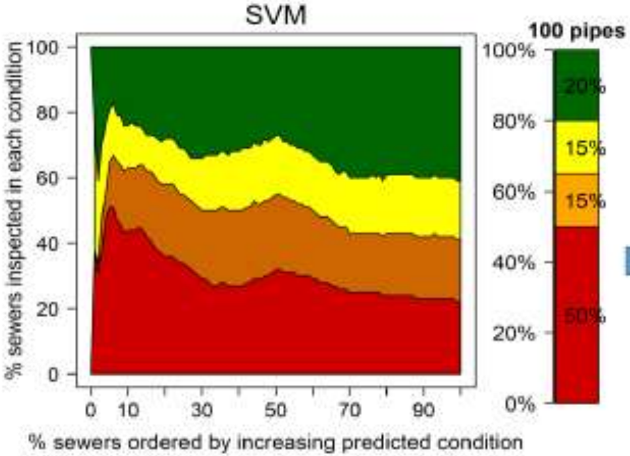
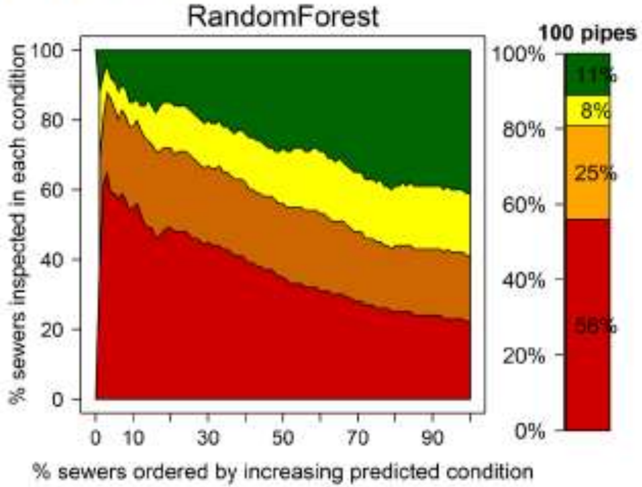


No adapted: Peak 7%
100 pipes -> (50%) – Random

OPTION 1: AGE



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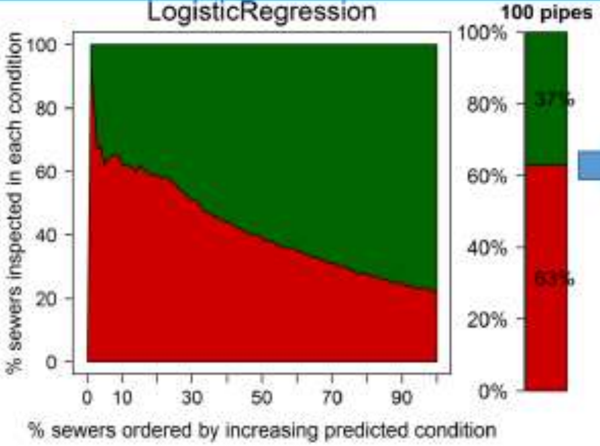

OPTION 2: AGE + OTHER VARIABLES

Performance Curve adapted
High % successful of prediction:
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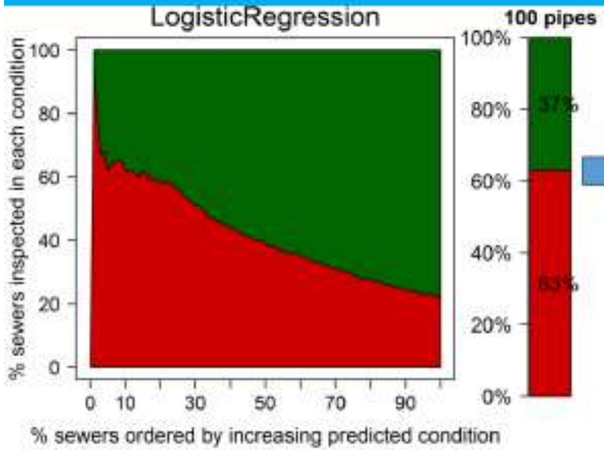
100 pipes -> (63%)

RESULTS – PERFORMANCE CURVE



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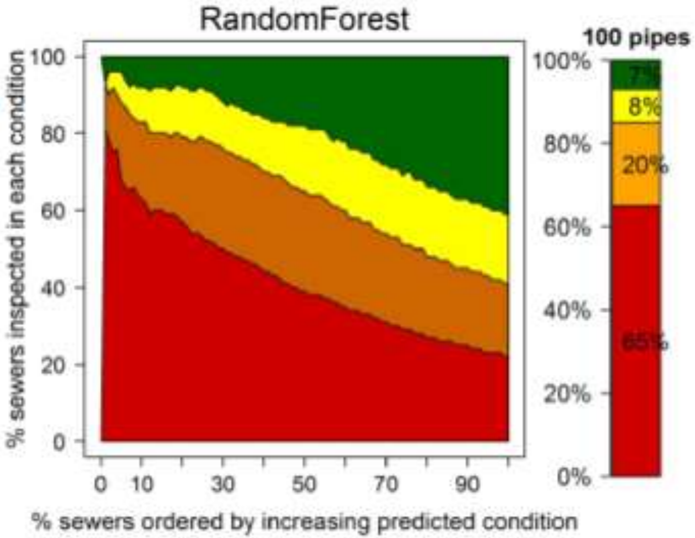

Performance Curve adapted:
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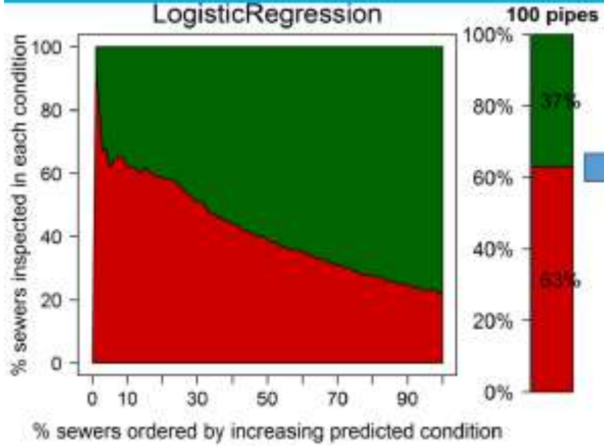
100 pipes -> (65%) - Highest

RESULTS – PERFORMANCE CURVE

OPTION 2: AGE + OTHER VARIABLES



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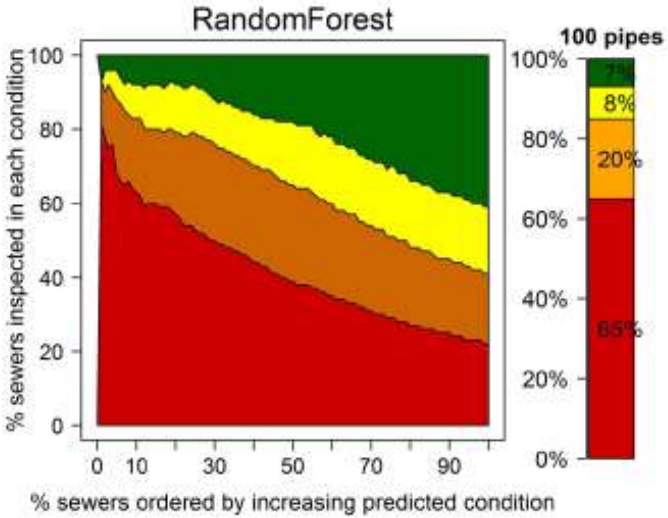

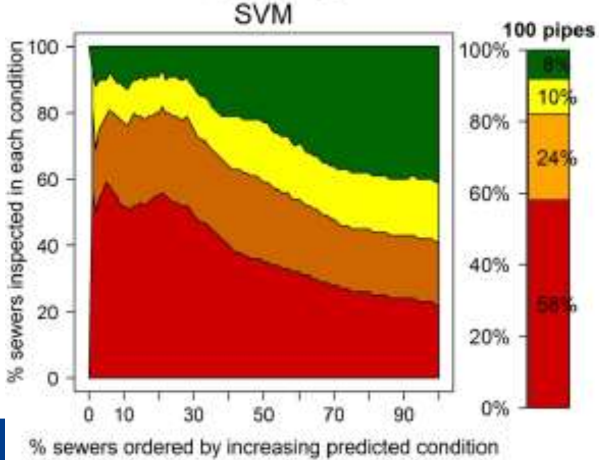

No adapted: Peaks 7 - 22%
100 pipes -> (58%)

Performance Curve adapted:
High % successful of prediction:
High probability critical condition

100 pipes -> (65%) - Highest

CONCLUSIONS

General

- Results better: modelling option 2 (Age + other characteristics)
- Age is not the unique factor -> structural conditions

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ROC space

- LR, SVM and RF: critical structural condition in Bogota's Sewer System
- LR-> highest effectivity **(PLR ~ 5.4)**

CONCLUSIONS

General

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- Age is not the unique factor -> structural conditions

ROC space

- LR, SVM and RF: critical structural condition in Bogota's Sewer System
- LR-> highest effectivity **(PLR ~ 5.4)**

PC

- LR and RF: support strategic plans of inspection and rehabilitation
- High probability in Critical condition, high successful's probability

THANKS YOU FOR YOUR ATTENTION

Any question:
nathalie_hernandez@javeriana.edu.co
PhD student - Engineering
Faculty of Engineering
Pontificia Universidad Javeriana
Bogotá (Colombia)

Presentation 3

Nicolas Caradot: An evaluation of the performance of sewer deterioration models in Germany and Colombia

An evaluation of the performance of sewer deterioration models

Nicolas Caradot, Nathalie Hernandez, Hauke Sonnenberg, Andres Torres, Andreas Hartmann and Pascale Rouault

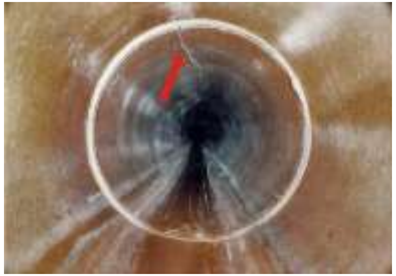
CCTV programs

Manual (sewer operator)

Defect codification
→ EN 13508-2

Scoring procedure

Condition evaluation
→ RERAU



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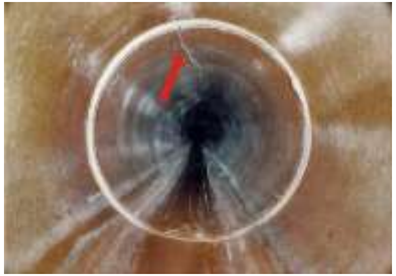

Code BAB – B – A (Example)

Fissure

Pieces still in place

Longitudinal

CCTV programs

Manual
(sewer operator)

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→ EN 13508-2

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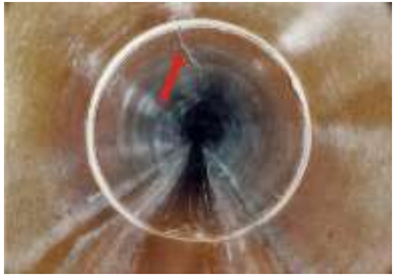
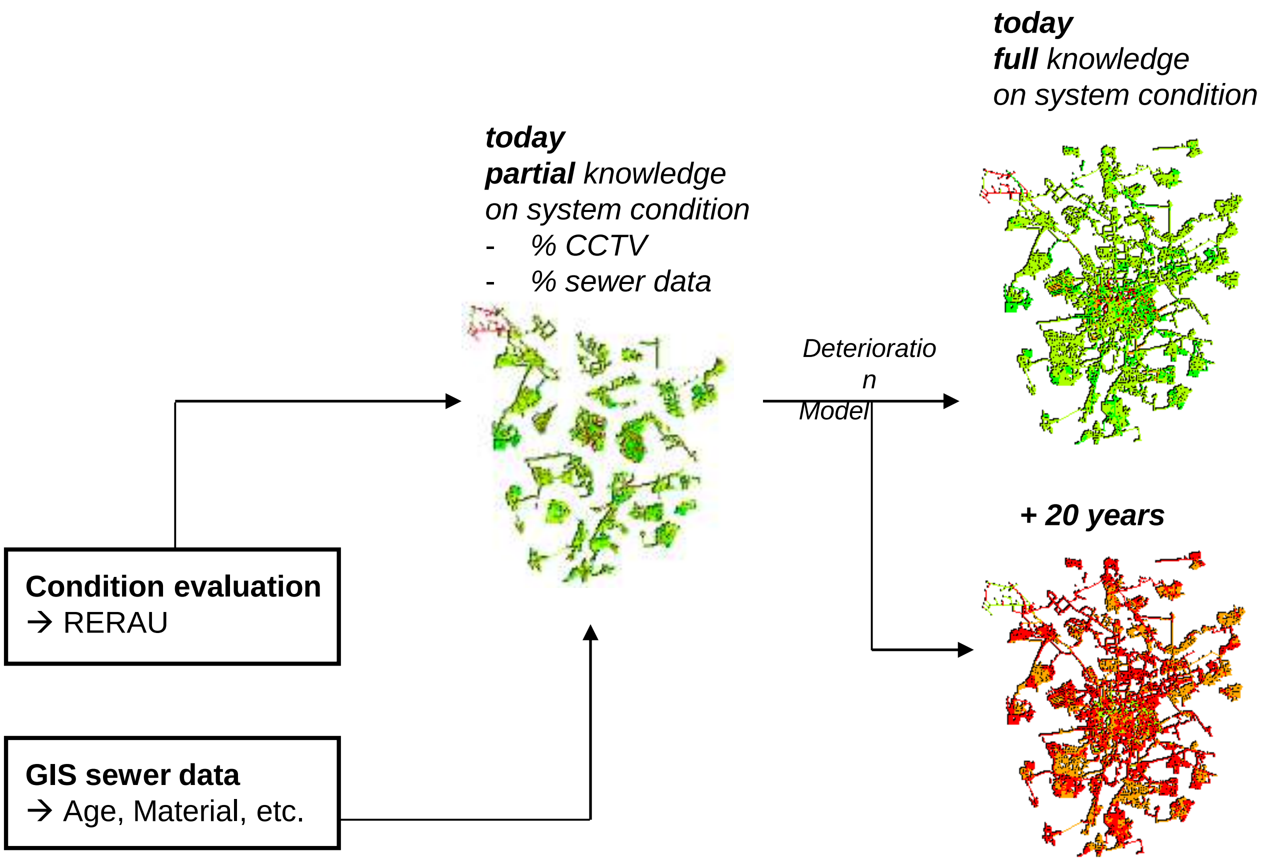


Code BAB – B – A (Example)

Automatic evaluation of the structural condition of each inspected pipe

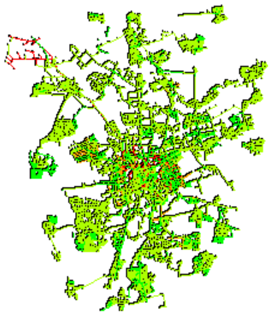
Need for action	Condition class
Immediate	red
short-term	red
medium-term	orange
long-term	yellow
no need for action	green
defect-free	green


today
full knowledge
on system condition
today
partial knowledge
on system condition
- % CCTV
- % sewer data
Deterioratio
n
Model
+ 20 years
Condition evaluation
→ RERAU
GIS sewer data
→ Age, Material, etc.

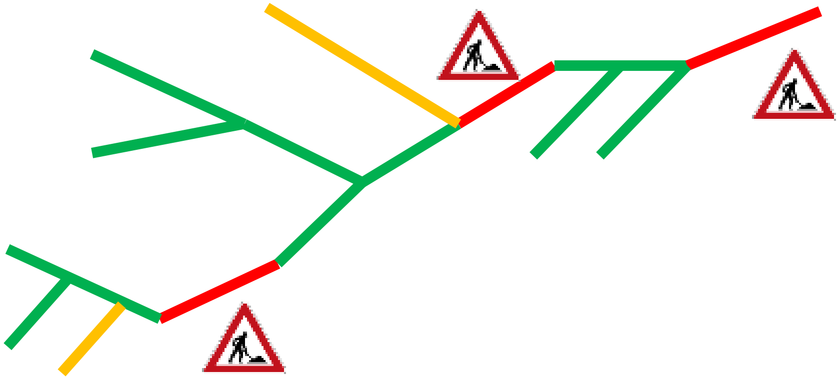
Operational planning: inspection strategy

- ✓ Simulation of pipes in critical condition
- ✓ Prioritization of rehabilitation works

today
***full** knowledge*
on system condition



+ 20 years



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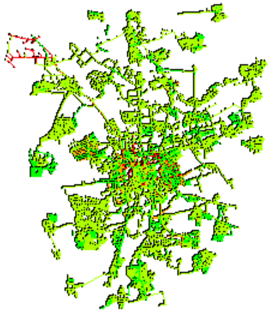
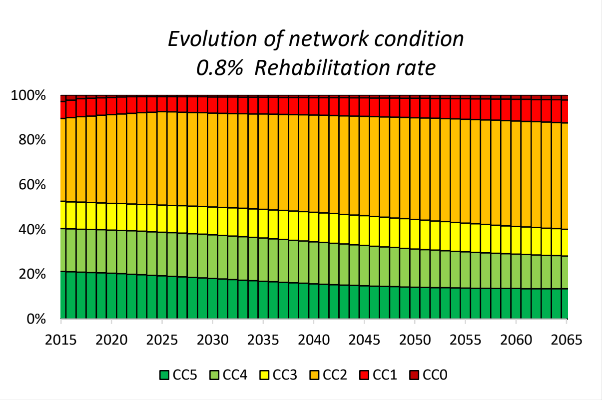
***full** knowledge*
on system condition



Strategic planning: investment strategy

- ✓ Comparison of future rehabilitation scenarios
- ✓ Definition of necessary investment rates
- ✓ Amortization scheduling



+ 20 years

Operational planning: inspection strategy

- ✓ ~~Simulation of pipes in critical condition~~
- ✓ ~~Prioritization of rehabilitation works~~

Strategic planning: investment strategy

- ✓ Comparison of future rehabilitation scenarios
- ✓ Definition of necessary investment rates
- ✓ Amortization scheduling

Until today, no clear demonstration of model benefits !

- ✓ Model validation is needed
- ✓ Build the confidence of utilities and municipalities

CCTV programs

Manual
(sewer operator)

Defect codification
→ EN 13508-2

Scoring procedure

Condition evaluation
→ RERAU

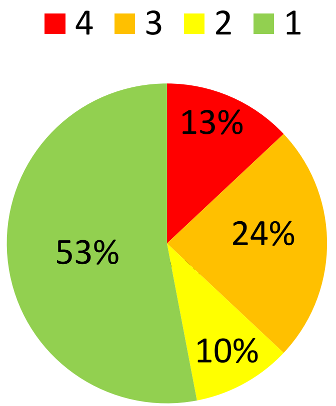
Input data

Sewer network of Braunschweig, Germany (1.300 km)

- Extensive dataset: **150% network inspected**
- 1.300 km / 34.000 pipes / 35.826 CCTV

Evaluation of **sewer structural condition**

- French RERAU methodology
- Algorithm to combined and aggregate defects recorded during CCTV inspection
- Cracks, collapses, surface damages, corrosion…

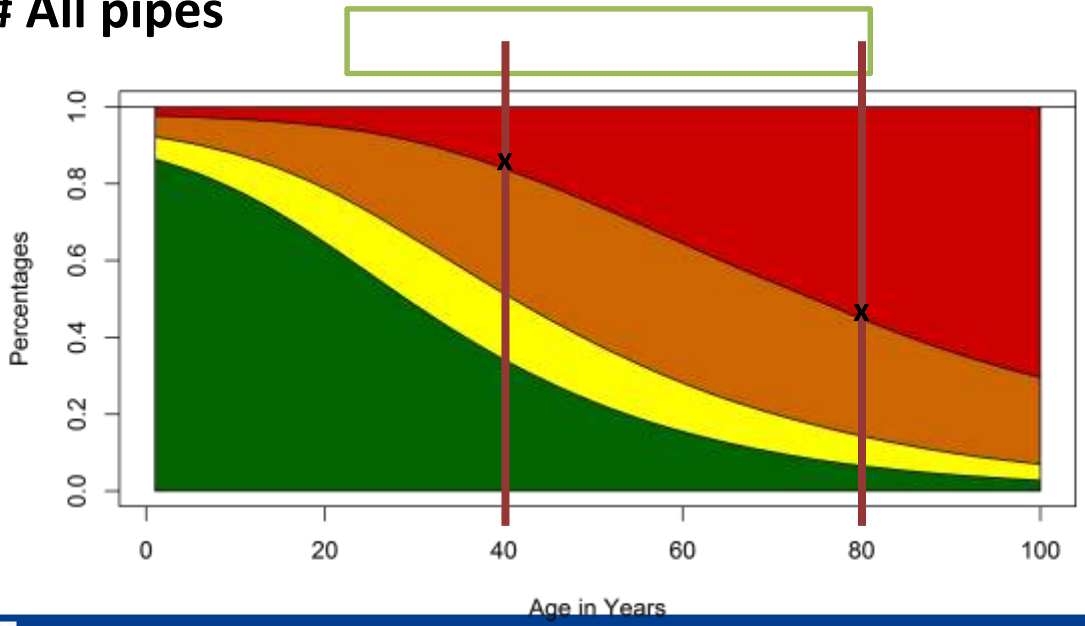


Run model calibration

Model GompitZ (developed by IRSTEA, Project Care-S)

- Mixed regression model, non-homogeneous Markov chain
- Calibration of survival curves (representative of the deterioration processes)

All pipes

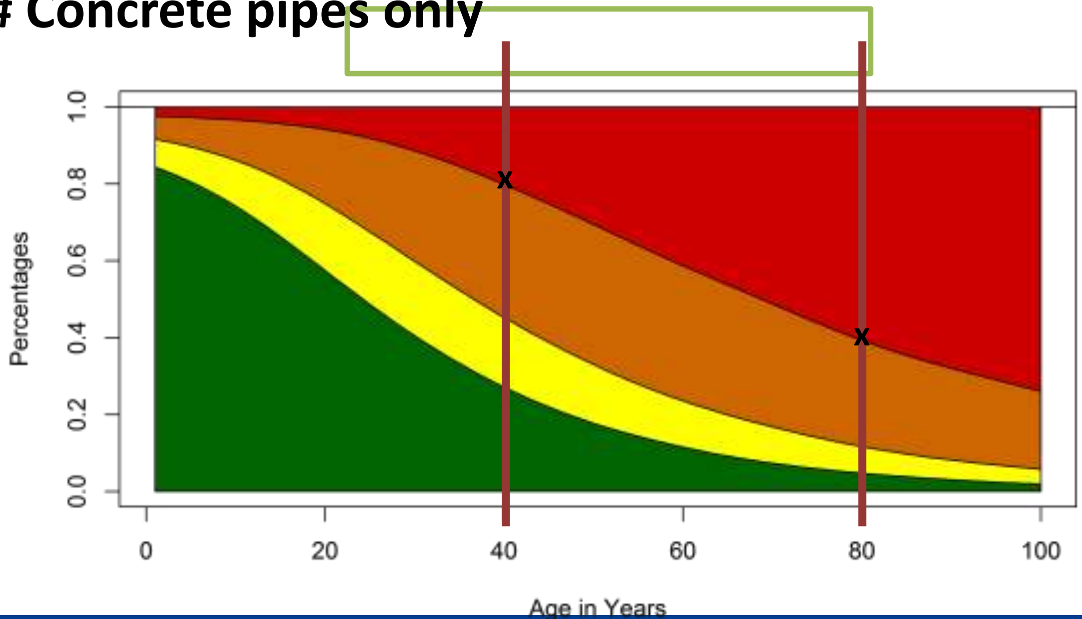


Run model calibration

Model GompitZ (developed by IRSTEA, Project Care-S)

- Mixed regression model, non-homogeneous Markov chain
- Calibration of survival curves (representative of the deterioration processes)

Concrete pipes only

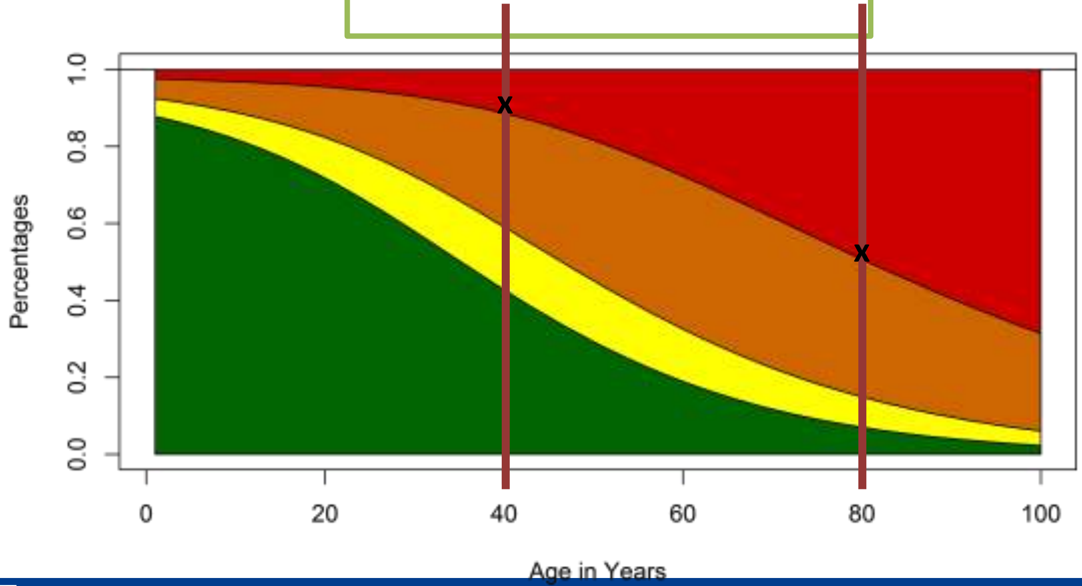


Run model calibration

Model GompitZ (developed by IRSTEA, Project Care-S)

- Mixed regression model, non-homogeneous Markov chain
- Calibration of survival curves (representative of the deterioration processes)

Clay pipes only

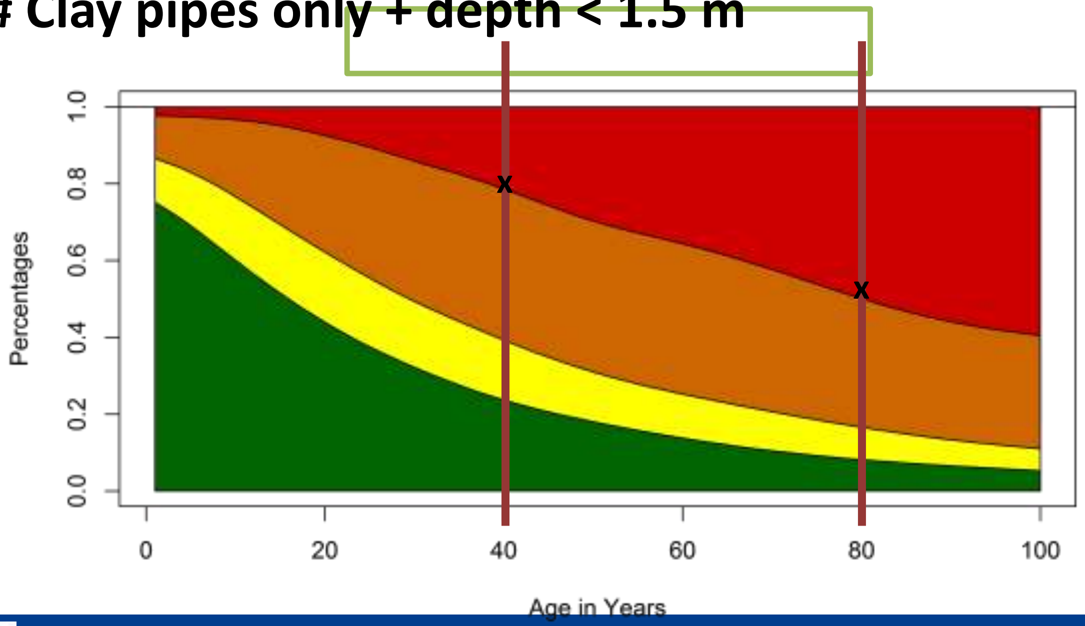


Run model calibration

Model GompitZ (developed by IRSTEA, Project Care-S)

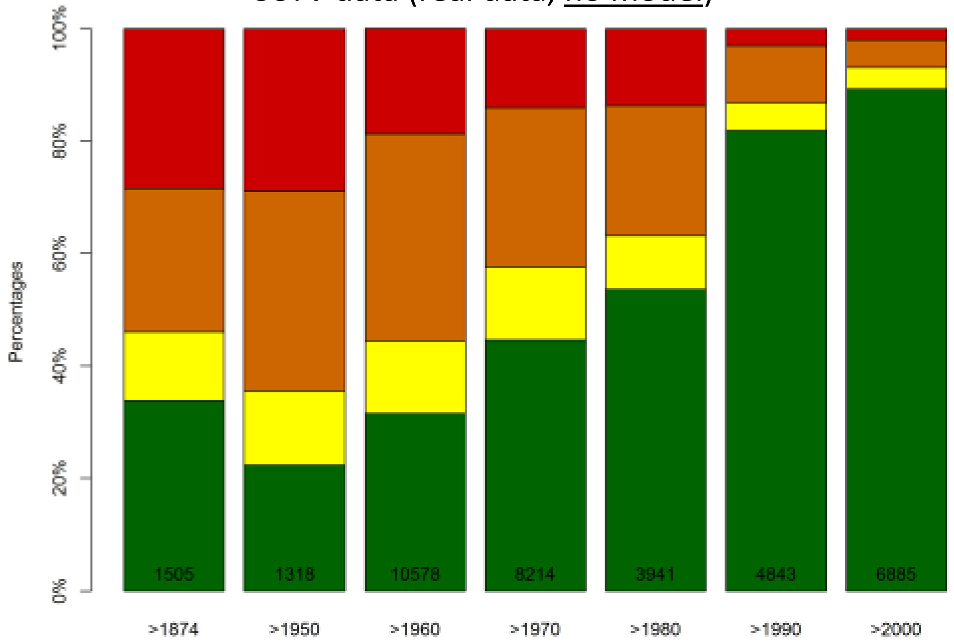
- Mixed regression model, non-homogeneous Markov chain
- Calibration of survival curves (representative of the deterioration processes)

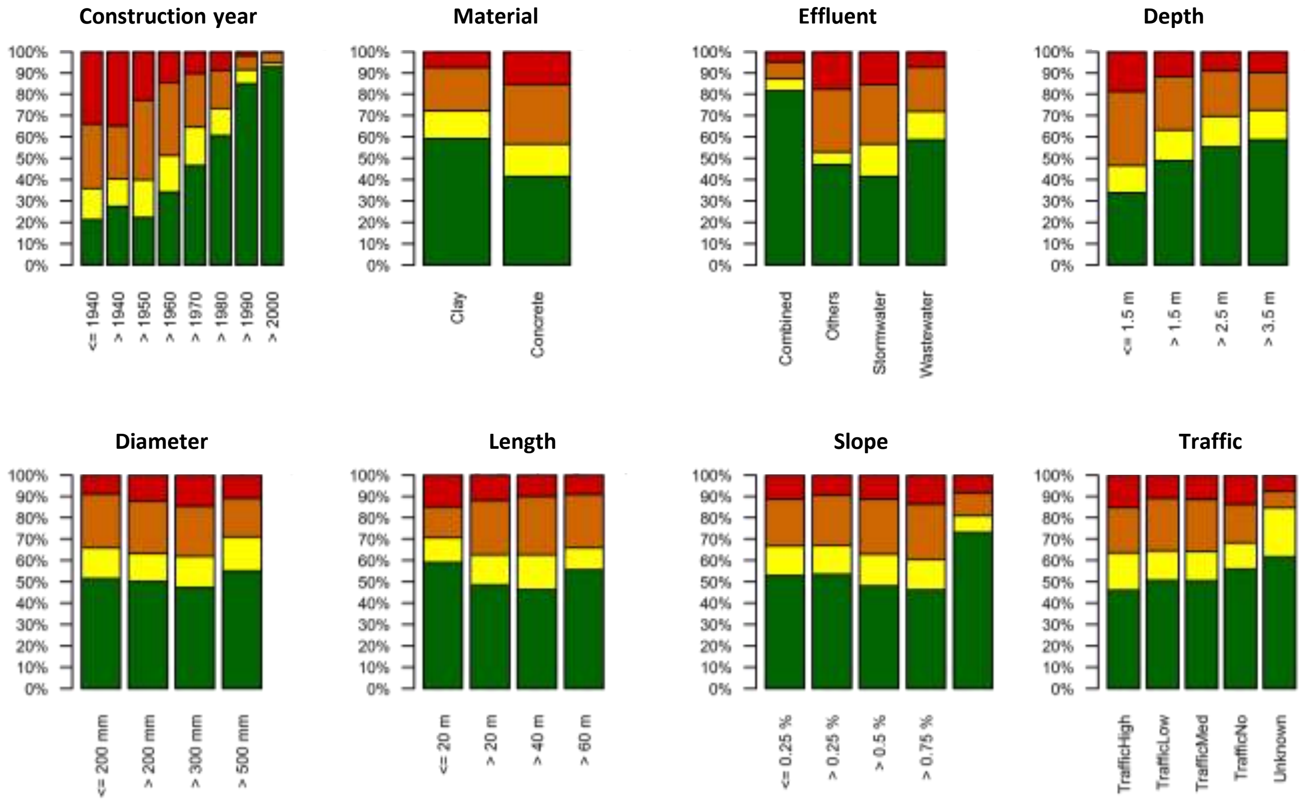
Clay pipes only + depth < 1.5 m



What are the relevant input data for modelling ?

Construction year VS condition
CCTV data (real data, no model)



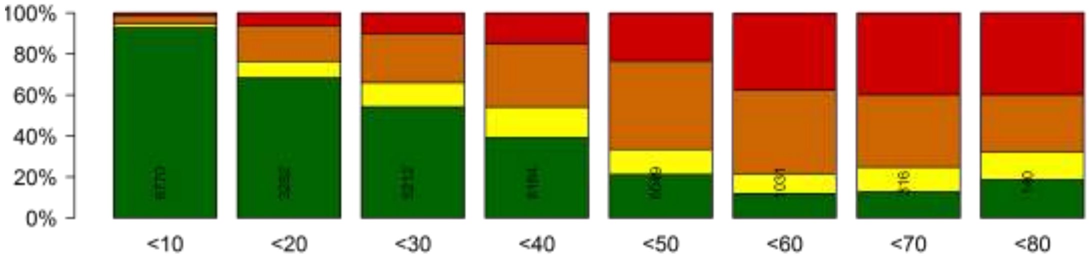


Construction year
Material
Effluent
Depth
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
<= 1940
> 1940
> 1950
> 1960
> 1970
> 1980
> 1990
> 2000
Clay
Concrete
Combined
Others
Stormwater
Wastewater
<= 1.5 m
> 1.5 m
> 2.5 m
> 3.5 m
Diameter
Length
Slope
Traffic
<= 200 mm
> 200 mm
> 300 mm
> 500 mm
<= 20 m
> 20 m
> 40 m
> 60 m
<= 0.25 %
> 0.25 %
> 0.5 %
> 0.75 %
TrafficHigh
TrafficLow
TrafficMed
TrafficNo
Unknown

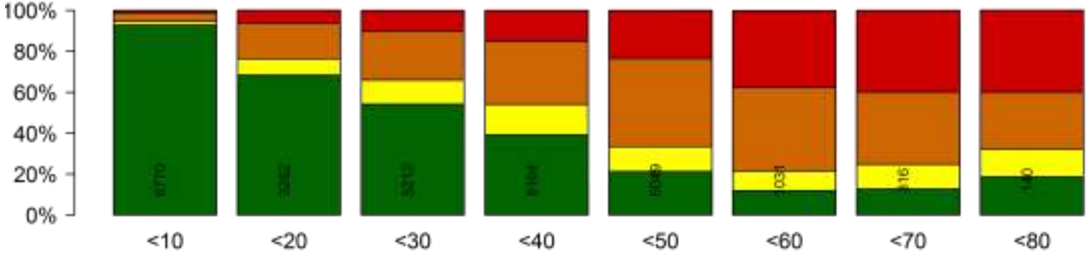
What is the performance of sewer deterioration modelling?

Strategic planning: investment strategy
Is the model able to predict the condition distribution of the system?

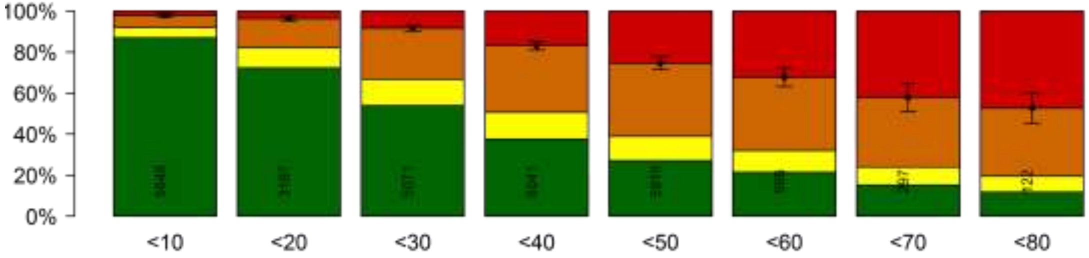
Data (Inspection)



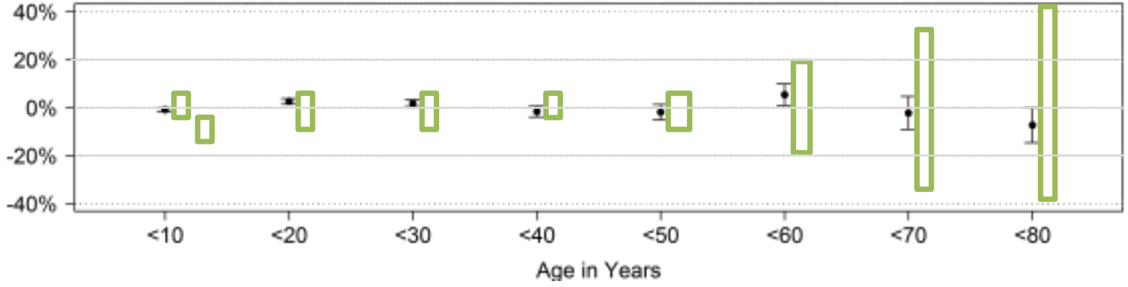
Data (Inspection)



Model – Calibration <u>3% data</u> 1.000 pipes | 50 km

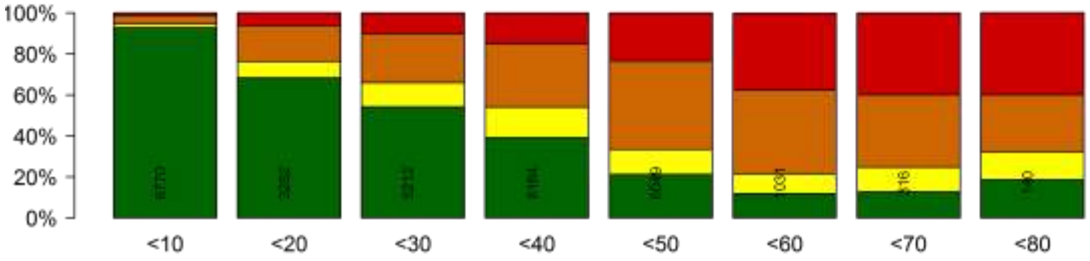


Deviation: Data VS Model

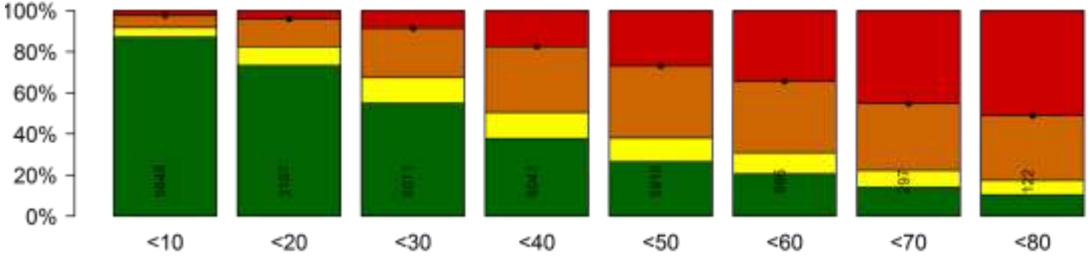


GompitZ model

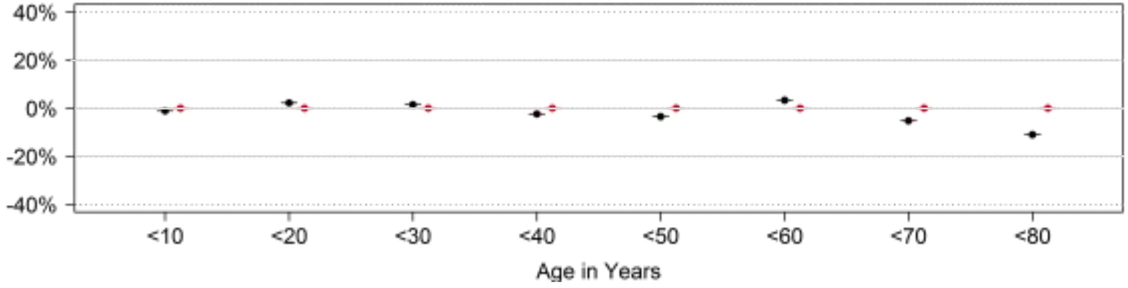
Data (Inspection)



Model – Calibration <u>100% data</u> 30.000 pipes | 1.500 km



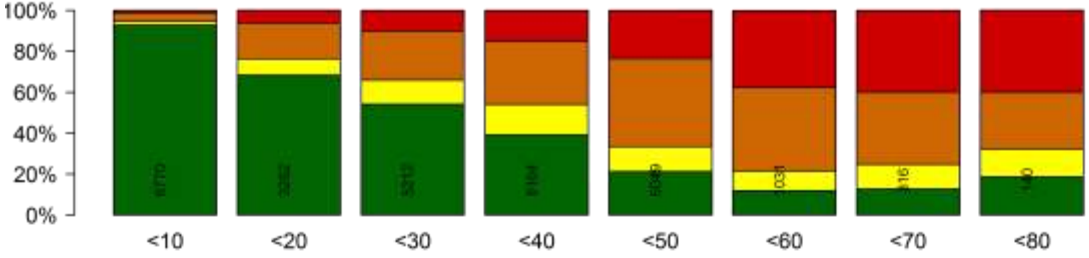
Deviation: Data VS Model



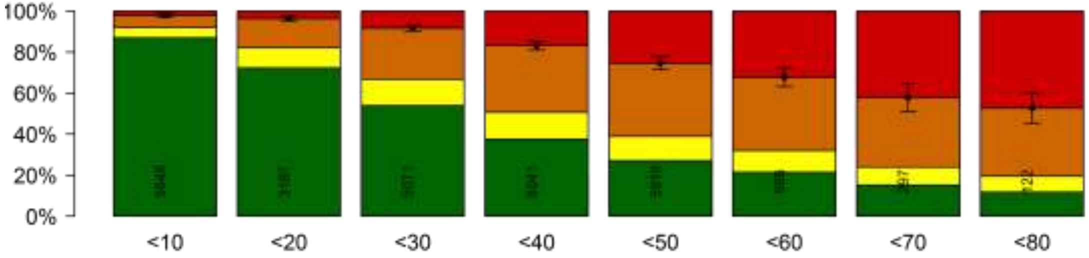
Random model

GompitZ model

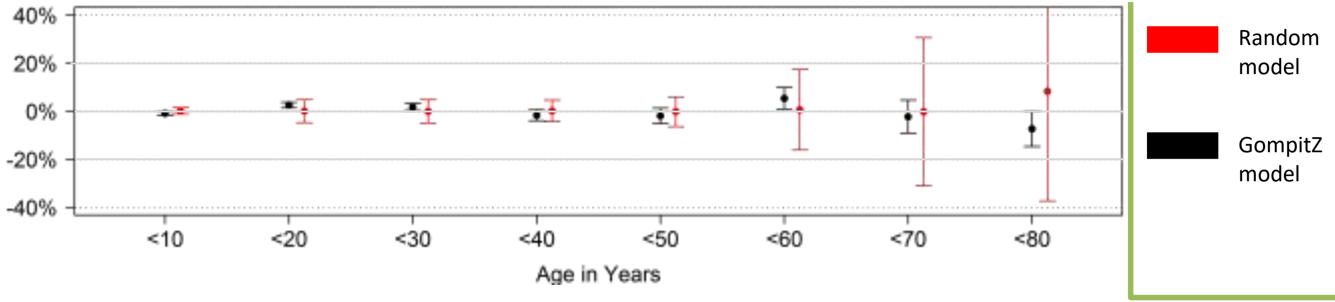
Data (Inspection)



Model – Calibration <u>3% data</u> 1.000 pipes | 50 km



Deviation: Data VS Model



Strategic planning: investment strategy

- ✓ Comparison of future rehabilitation scenarios
- ✓ Definition of necessary investment rates
- ✓ Amortization scheduling

Relevant input data: age, material, effluent type, diameter, depth

Network degradation can be simulated and requires extensive dataset

1500 – 3000 pipes | 5 – 10% of the network

Few data available: calibrated statistical model with covariates performs much better than simple random model

Perspectives

- Uncertainties from CCTV to budget planning: still useful?
- Consideration of repair and renovation: what is right balance?
- Statistic VS data driven
- …

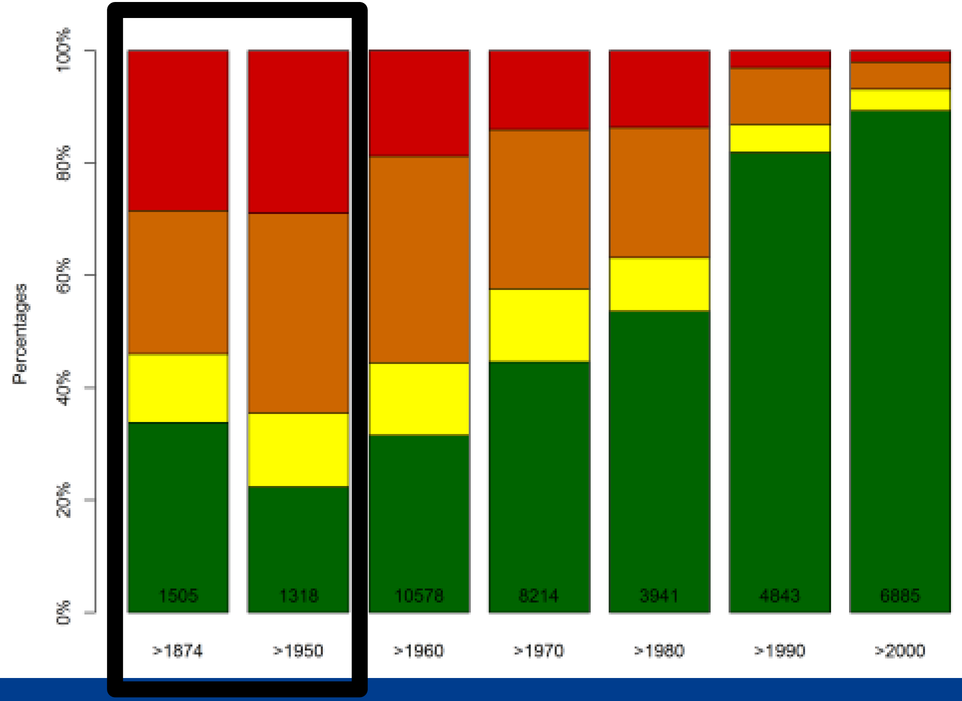
Thank you for your attention !

More information :
nicolas.caradot@kompetenz-wasser.de

Selective survival bias

Left truncation – inspection data

→ Replaced pipes have not been inspected



Presentation 4

Rita Amaral: The Portuguese water sector: let’s journey to sustainability

The Portuguese water sector: let's journey to sustainability

Rita Amaral (IST/LNEC)
Helena Alegre (LNEC)
José Saldanha Matos (IST)

TÉCNICO LISBOA
LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

INTRODUCTION

Portuguese water services

INVESTMENT (last two decades)

+10 000 M€

INFRASTRUCTURE

104 000 km water mains

8600 reservoirs

+2400 Pumping stations

+250 Treatment Plants

+6000 water abstraction facilities

57 000 km sewer mains

+4800 Pumping stations

+2500 WWTP

+1600 Collective septic tanks

26 Long sea outfalls

INTRODUCTION

Portuguese water services

SUSTAINABLE DEVELOPMENT GOALS

National strategic plan of water and waste services

New paradigm

Warns

(in a large number of utilities)

Lack of **asset knowledge**

Clearly **insufficient rehabilitation** rates

Difficulties to ensure **cost recovery**

Trend towards a **reduction** in the availability of **financing**, namely from EU funds

'the strategy should be **less centred on new infrastructure** to increase the population served and **more focused** on the management of the sector assets, its operation and the **quality of the services** provided with an overall **sustainability**'.

PhD Main goal

Contribution to the evolution of the **strategic investment planning framework** in the Portuguese water sector

MAIN RESEARCH STEPS

01 National and international framework

Identification of key drivers and initiatives that help to explain how Infrastructure Asset Management (IAM) has evolved worldwide. A first diagnosis based on a comparative analysis of international and national contexts.

02 Literature review

Synthesis and analysis of the main principles, standards, approaches, key steps and practices in terms of IAM. Particular focus given to asset valuation and strategic investment planning.

03 Diagnosis and testing

A more in-depth diagnosis of the Portuguese water sector.
Exploring and testing of simple approaches to support strategic investment planning.

04 Development of the project outcomes

Development of two main outcomes based on the diagnosis results and on the key lessons acquired in the previous steps.

Diagnosis and testing (phase 3)

In the scope of a collaborative project - National initiative for IAM

(www.iniciativaGPI.org)

Iniciativa Nacional para a Gestão Patrimonial de Infraestruturas

LNEC LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL TÉCNICO LISBOA

DIAGNOSIS AND TESTING

(Phase 3)

1 Assessment of the degree of ageing of infrastructures and long-term reinvestment needs

13 Water supply systems

9 Wastewater systems

14 Answers

36 Questions

2 Survey and analysis of accounting practices

3 Economic values (technical evaluation)

VS

Accounting (book) values

DIAGNOSIS AND TESTING

Degree of ageing of infrastructures and long term re-investment needs

- In general, infrastructures do not currently present concerning **global ageing levels** (in average), but, in some cases, significant percentages of assets have already **exceeded the expected useful life.**
- High risk of **concentrated future re-investment needs**
- Need for **increased re-investment** in networks over the coming years, particularly in wastewater systems
- Some systems need to improve the **quality of the service** provided

Rough estimate for all country
(water and sewer networks*)

Replacement value ≈ 15 billion euros

Current value ≈ 8.9 billion euros

Re-investment needs ≈ 1 billion euros (2015)
≈ 2.9 billion euros (2015-2035)

* Does not include stormwater networks

DIAGNOSIS AND TESTING

Accounting practices | Economic values vs Book values

Great variation of accounting practices between water utilities

Book values are usually underestimated

(e.g. 3-7 times in water supply)

Example – useful lives adopted for accounting purposes

1 Not answered (NR)
3 Not applicable (NA)

Need for greater standardisation!

DIAGNOSIS AND TESTING

Level of implementation of strategic investment planning approaches in water utilities

Continue to be neglected by the majority of utilities in Portugal…

Why?

- Several **awareness and guidance gaps**
- A number of issues that **constrain** its application

Internal constraints

Lack of available information
Lack of connection between information systems
Barriers to communication between decisional levels and departments

External constraints

Rules for the establishment of tariffs
Accounting standards
Contractual obligations
Barriers to communication between stakeholders

MAIN PROJECT OUTCOMES
(Phase 4)

Recommendations for regulatory policies and other national initiatives

Application guide for water utilities

MAIN PROJECT OUTCOMES

Recommendations for regulatory policies

Structural regulation

legislation in order to achieve a greater control and improvement of IAM practices (e.g., requirement for delivery AM plans).

Quality of service regulation

A set of measures and analyses aimed at complementing the assessment of infrastructural sustainability.

Legal and contractual regulation

A set of measures and analyses that should be applied in concession and delegated management contracts in order to clarify the duties of water utilities in terms of infrastructural sustainability.

Economic regulation

Recommendations to promote sounder quantification and analysis of infrastructure asset value and investment needs. Recommendations aimed at structuring and managing information about investment on infrastructure.

36 recommendations

MAIN PROJECT OUTCOMES

Recommendations for regulatory policies

Current ageing of infrastructure

Measure of the degree of ageing of the infrastructure (Infrastructure Value Index)

Measure of risk (% of assets which already have exceeded the expected useful life)

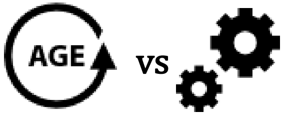
Future investment needs (future)

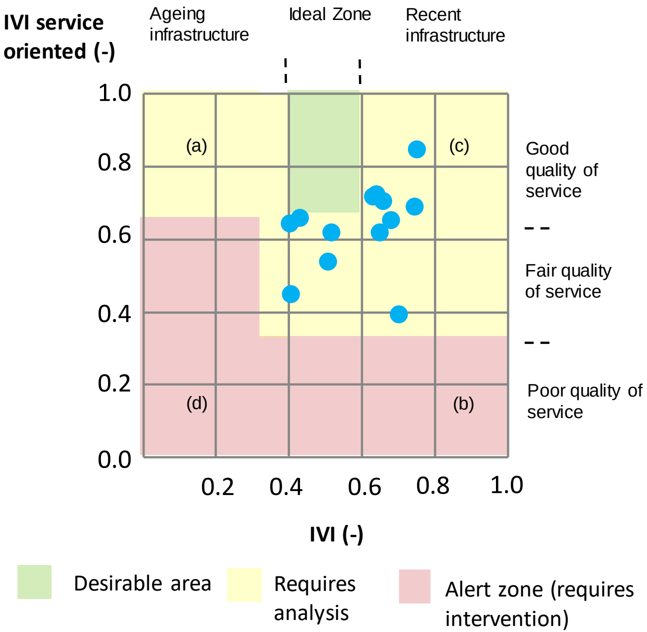
2 Measures to assess the distribution of investment over time

2 Measures of intergenerational responsibility (ageing of infrastructure 20 years from now if current re-investment policy is maintained)

MAIN PROJECT OUTCOMES

Recommendations for regulatory policies

Benchmarking tool  vs Quality of service



(a) The performance is good, but there is a high probability of having problems in the near future

(b) Performance worse then expected as it is recent (management problem) or infrastructure with recent expansion zones and ageing zones in need of rehabilitation

(c) Concentrated investments needs in the future

(d) Low re-investment in

MAIN PROJECT OUTCOMES

Application guide for water utilities

Guidelines for top management
Fundamental principles and key messages that should be kept in mind when investment decisions are made

Guidelines for asset managers
Methodology to support long-term investment planning (eight main steps)

Guidelines for financial managers
Intended to promote the alignment between asset management and financial and accounting issues

FINAL REMARKS

1 The identified **awareness and guidance gaps** and **constraints** in terms of long-term investment planning must be addressed

2 A **better alignment and collaboration** between asset management, finance and accounting functions must be pursued

3 The application of some of the proposals in several utilities has proved its usefulness, with **benefits at different levels**, including: raising awareness and training on strategic investment planning, improving communication and promoting the gathering

FINAL REMARKS

4 Some **proposals** have already been **introduced** by the Portuguese water and waste services regulation authority

5 The **flexibility** and the **relative ease of comprehension** of the proposals make them a **powerful contribution to be applied in other frameworks and countries**

8th World Water Forum
Brasilia-Brazil 2018
Sharing Water

LIS-Water
International centre on public policies, regulation and management for water services and water resources

Acknowledgements

TÉCNICO LISBOA

LNEC LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

FCT Fundação para a Ciência e a Tecnologia

Iniciativa Nacional para a Gestão Patrimonial de Infraestruturas

ERSAR

AGS

ÁGUAS DE PORTUGAL

Parceria Portuguesa para a Água

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Presentation 5

Rita Almeida: Rehabilitation needs in water utilities – asset useful life adjustment and infrastructure value index assessment

Rehabilitation needs in water utilities – asset useful life adjustment and Infrastructure Value Index assessment

LESAM 2017

IWA Leading Edge Conference on Strategic Asset Management of Water and Wastewater Infrastructures

Trondheim - June 2017

Contents

1. Introduction

LESAM 2017

IWA Leading Edge Conference on Strategic Asset Management of Water and Wastewater Infrastructures

Trondheim - June 2017

1. Introduction

AGS

AGS PRESENTATION

Infrastructures

7’000
km water

4’700
km wastewater

701
tanks

21
water treatment plants

366
wastewater treatment plants

Service

95 million
m^3 water/year

260 million
m^3 wastewater/year

1’300’000
population served

475’000
customers

Where we are

PORTUGAL

BRAZIL

CHILE

Concessions
Public-private partnerships
Consortiums
O&M Operational Centres

1. Introduction

AGS

AGS BACKGROUND IN ASSET MANAGEMENT

CARE-W	AWARE-P	National Laboratory for Civil Engineering (LNEC) IAM initiatives	
2005 - 2006	2009 - 2011	2012 - 2013	2014 - 2016
Computer Aided Rehabilitation of Water Networks	*Advanced Water Asset Rehabilitation - Portugal*	Infrastructure Asset Management Program **PGPI 1st Edition**	Infrastructure Asset Management Program **PGPI 2nd Edition**
Rehabilitation planning support tool	Portuguese technical guides IAM methodology IAM support software National decree-law	Infrastructure Asset Management Plans	ISO 55001:2014 Assets: Infrastructures Human resources Technological

2. Rehabilitation needs

LESAM 2017

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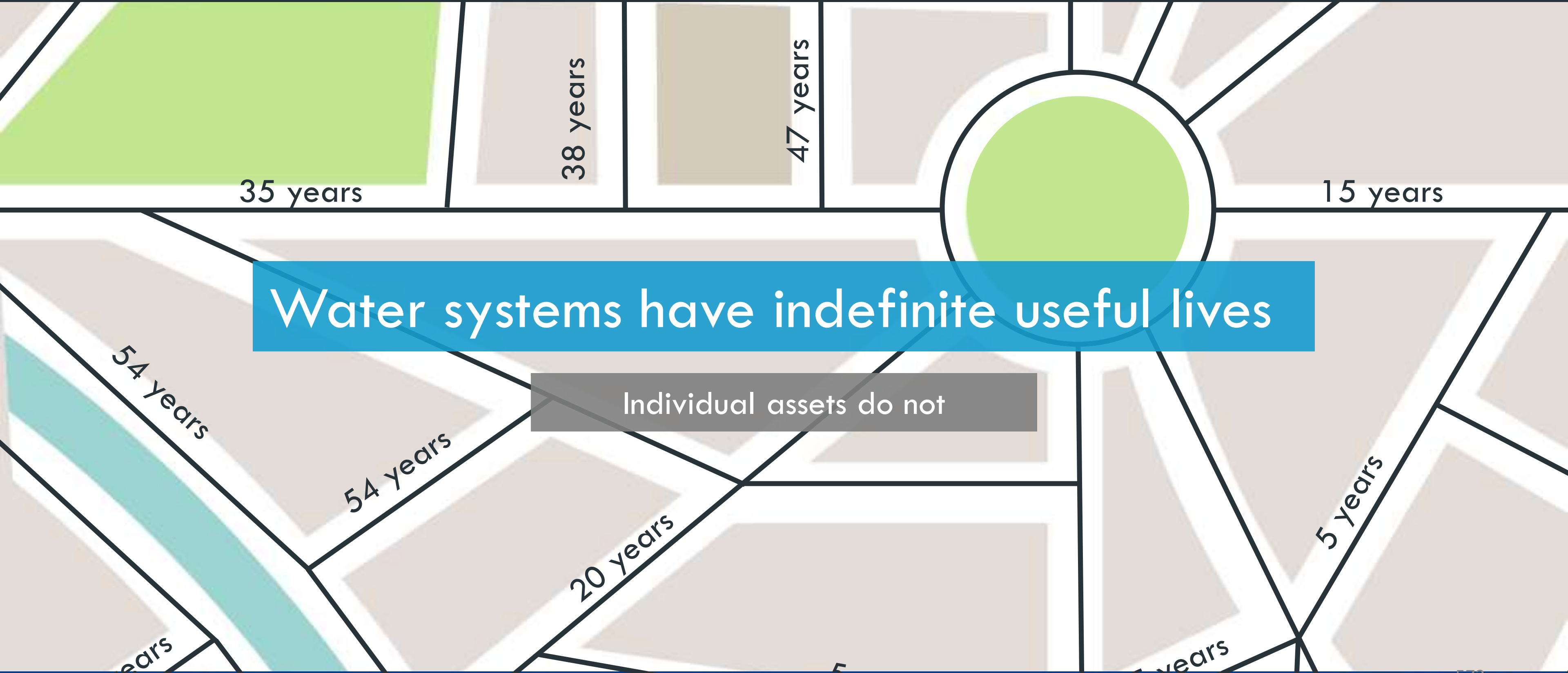
Trondheim - June 2017

2. Rehabilitation needs



Water systems have indefinite useful lives

Individual assets do not

2. Rehabilitation needs

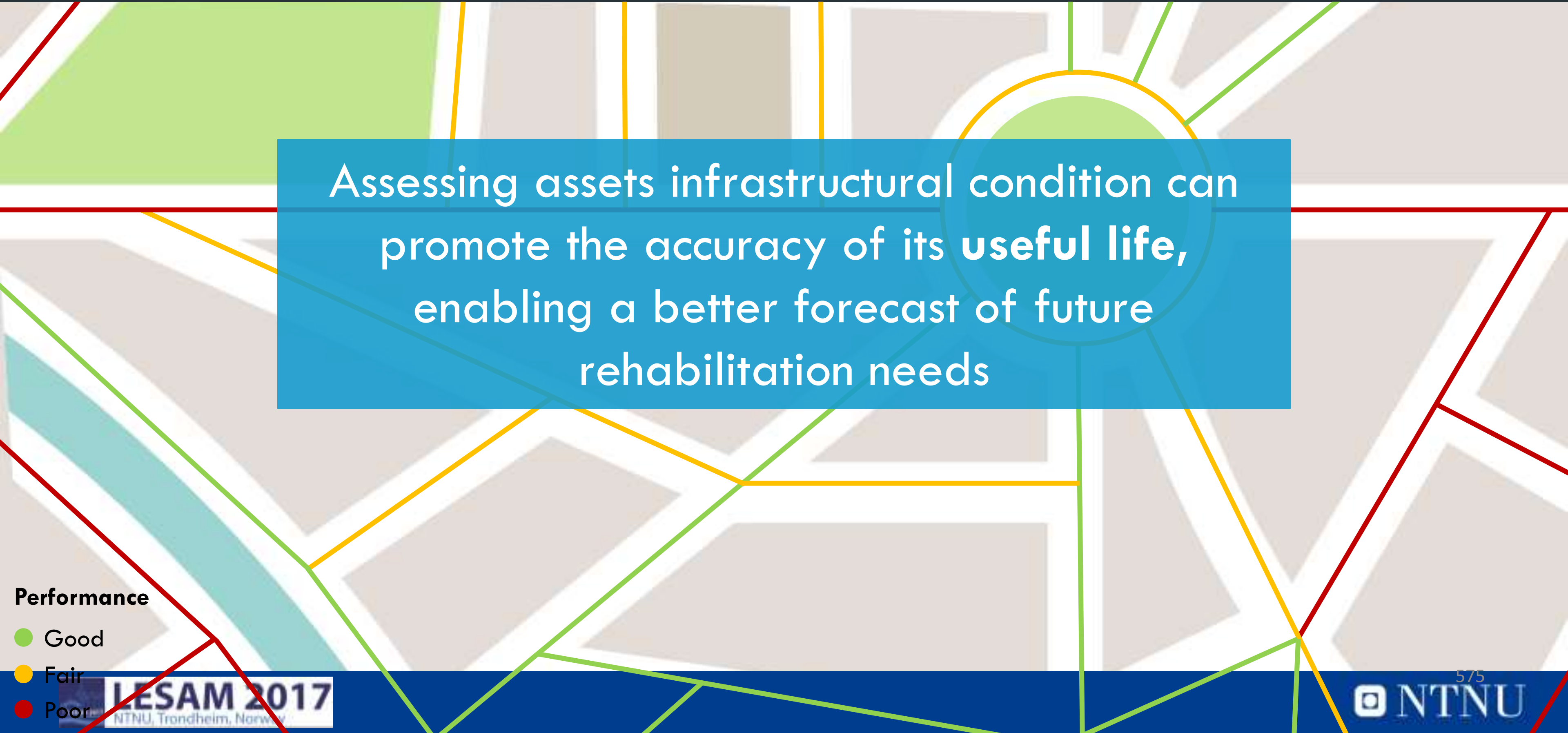
AGS

Deciding **where, when and how** to rehabilitate is a challenge for water utilities

Good decisions on rehabilitation can only be properly developed if supported by asset's deep and reliable knowledge

2. Rehabilitation needs

Assessing assets infrastructural condition can promote the accuracy of its **useful life,** enabling a better forecast of future rehabilitation needs



3. Assessing water network useful life

LESAM 2017

IWA Leading Edge Conference on Strategic Asset Management of Water and Wastewater Infrastructures

Trondheim - June 2017

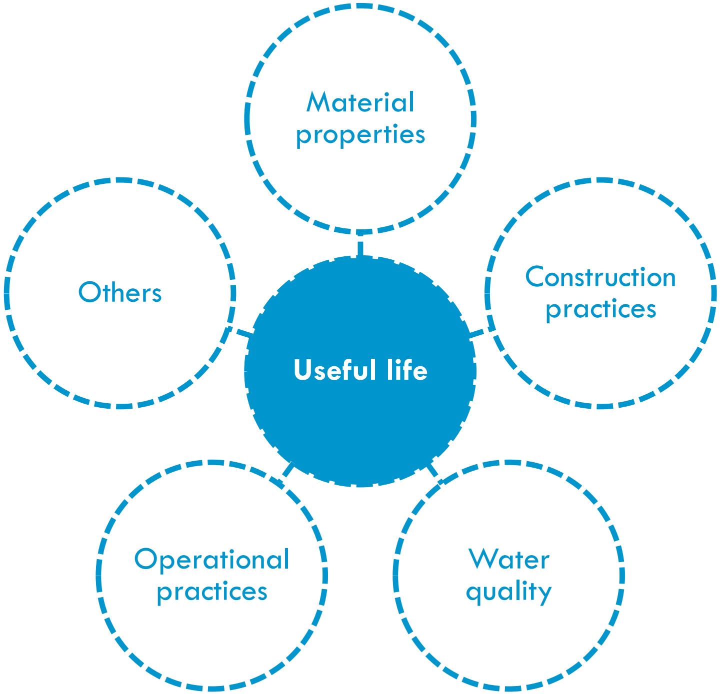
3. Assessing water network useful life

COMMON PIPE USEFUL LIVES

Being water networks buried assets it is commonly assumed that its infrastructural condition is based on **assets' age** and their **useful life**

Table 1. Common pipe useful lives considered in Portugal

Pipe material	Useful life (years)
Steel	40-60
Cast iron	50
Ductile cast iron (DCI)	40-60
Polyvinyl chloride (PVC)	45-50
High-density polyethylene (HDPE)	45-50
Asbestos cement (AC)	30-50



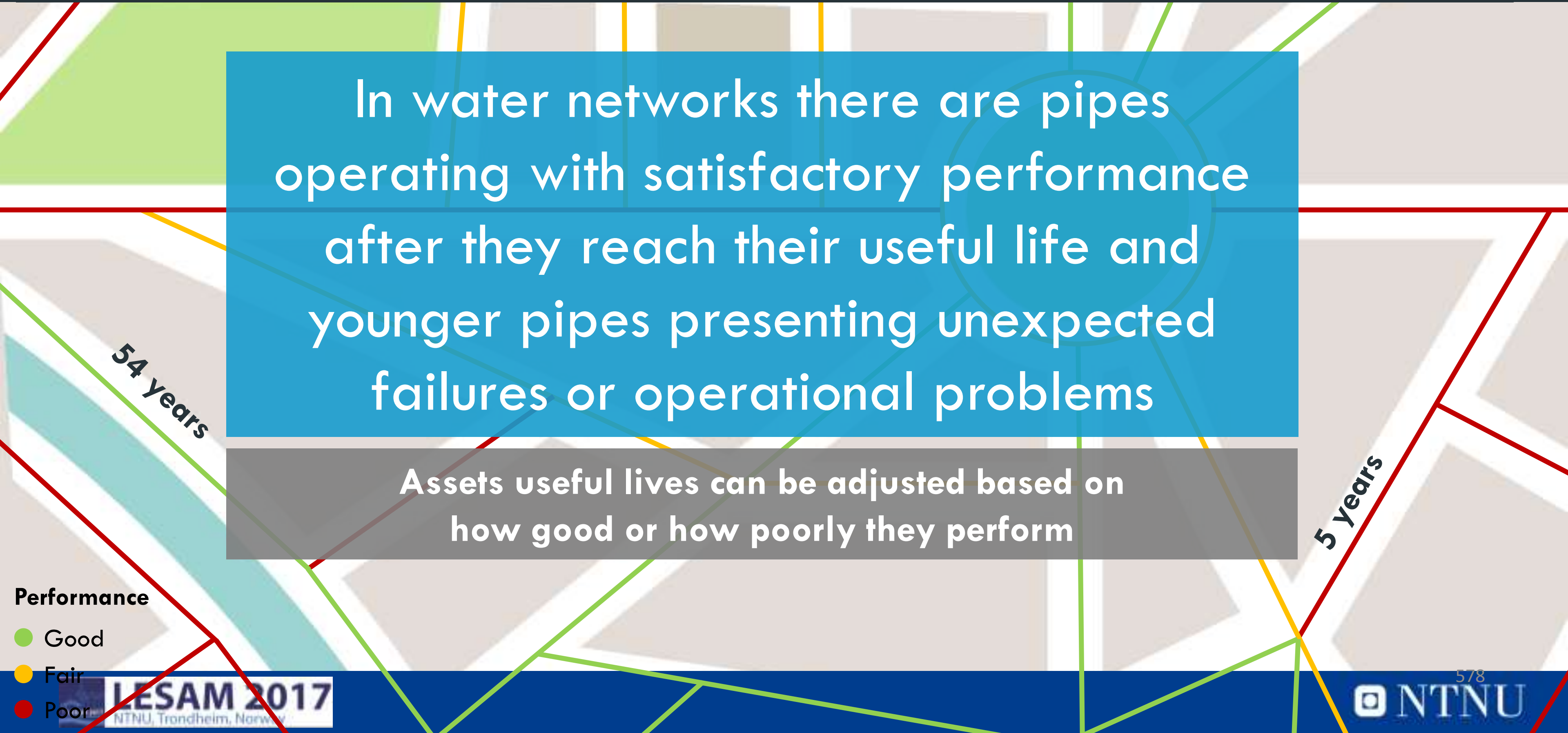
Understanding the interactions of individual factors and their impact on pipe failure is extremely complex

Alegre and Covas, 2010; LNEC, 2013

3. Assessing water network useful life

In water networks there are pipes operating with satisfactory performance after they reach their useful life and younger pipes presenting unexpected failures or operational problems

Assets useful lives can be adjusted based on how good or how poorly they perform



3. Assessing water network useful life

AGS

INCORPORATING PERFORMANCE IN ASSETS' USEFUL LIFE

Allows to understand the infrastructure condition based on its **behavior** and not only on **literature values**

A **relation** between **useful life** and **mains bursts** was adopted based on the reference values of the Portuguese water services regulator for IWA performance indicator **Mains failures [No./(length network x100 km.year)]**

Table 2. Reference values for "Mains failures" performance indicator

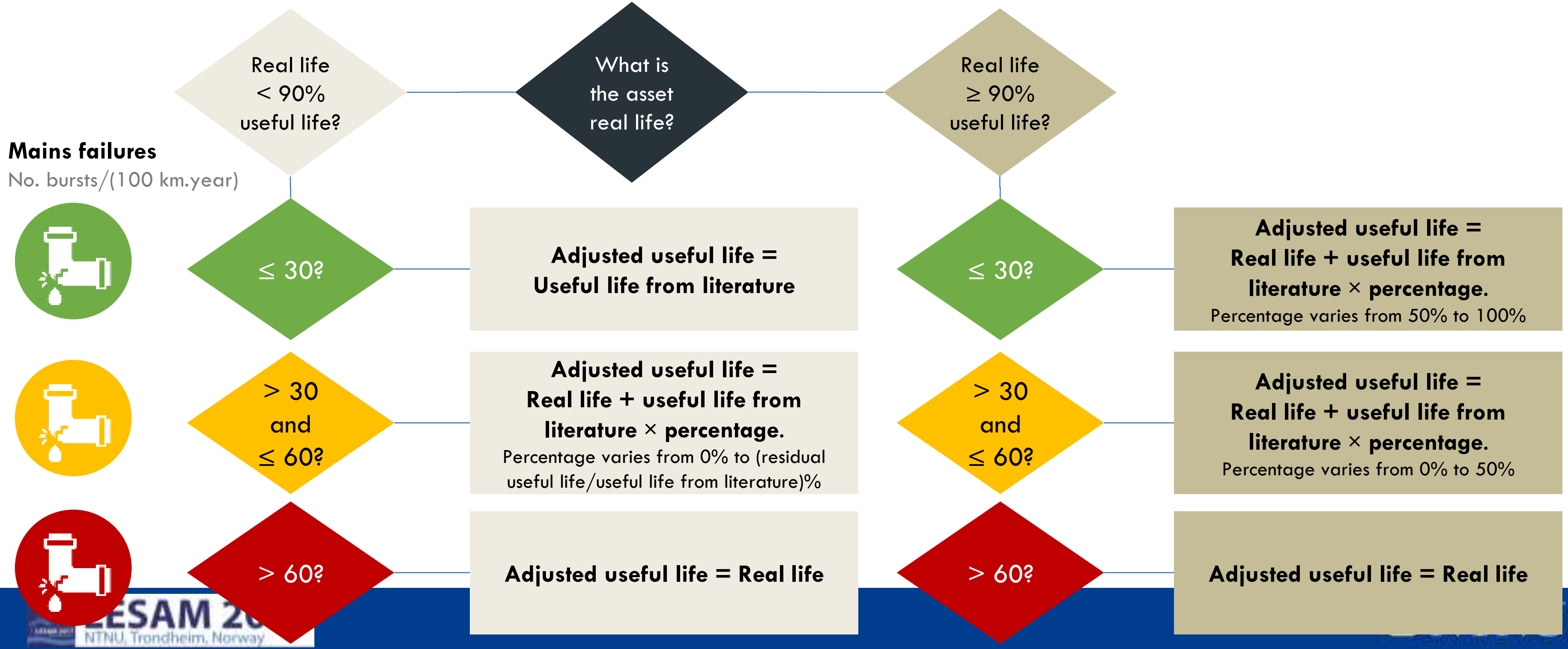
Service assessment	Reference values
Good	[0 ; 30]
Fair	] 30 ; 60]
Poor	] 60 ; +∞ [

Portuguese Water Services Regulator (ERSAR), 2012

3. Assessing water network useful life

AGS

INCORPORATING PERFORMANCE IN ASSETS' USEFUL LIFE



3. Assessing water network useful life

INCORPORATING PERFORMANCE IN ASSETS' USEFUL LIFE

The goal behind this criterion is to **maintain or extend** assets useful life in the cases where they perform in a **satisfactory way** and to **shorten** assets useful life in the cases they perform **poorly**, taking also into account the asset real life

Work orders data are used to determine "Mains failures" by clusters of materials and period of installation (5-year intervals)

Mains failures
No. bursts/(100 km.year)

> 60? — Adjusted useful life = Real life

> 60? — Adjusted useful life = Real life

3. Assessing water network useful life

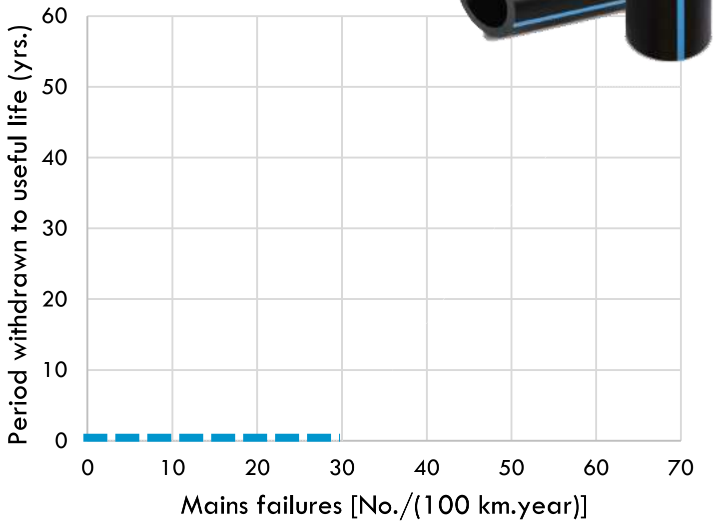
INCORPORATING PERFORMANCE IN ASSETS' USEFUL LIFE | EXAMPLE FOR HDPE PIPES

Recently installed HDPE pipe
with **50 years of useful life**

If mains failures [No./(100 km.year)] …

… is ≤ 30

It is performing **good** and no adjustment will be made (**no period will be withdrawn** to useful life)



3. Assessing water network useful life

AGS

INCORPORATING PERFORMANCE IN ASSETS' USEFUL LIFE | EXAMPLE FOR HDPE PIPES

If mains failures **[No./(100 km.year)] …**

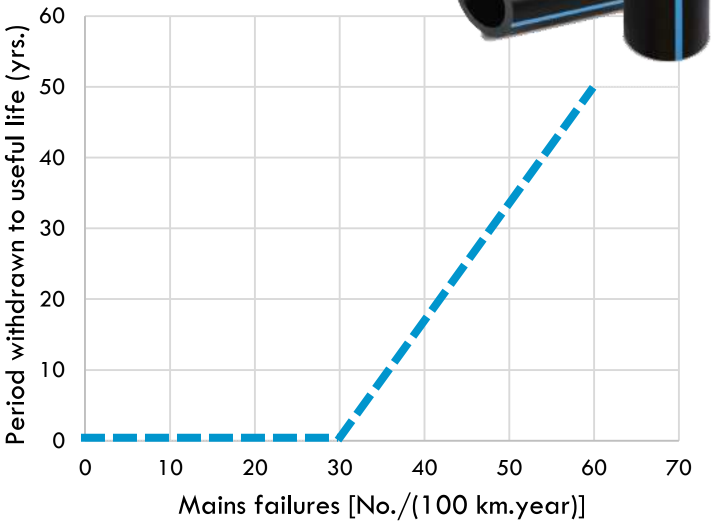
Recently installed HDPE pipe with **50 years of useful life**

… is ≤ 30

It is performing **good** and no adjustment will be made (**no period will be withdrawn** to useful life)

… is > 30 and ≤ 60

It is performing **fairly**; the **period to be withdrawn** will be adjusted **between zero** and **50 years**



3. Assessing water network useful life

INCORPORATING PERFORMANCE IN ASSETS' USEFUL LIFE | EXAMPLE FOR HDPE PIPES

Recently installed HDPE pipe with **50 years of useful life**

If **mains failures** [No./(100 km.year)] …

… is ≤ 30

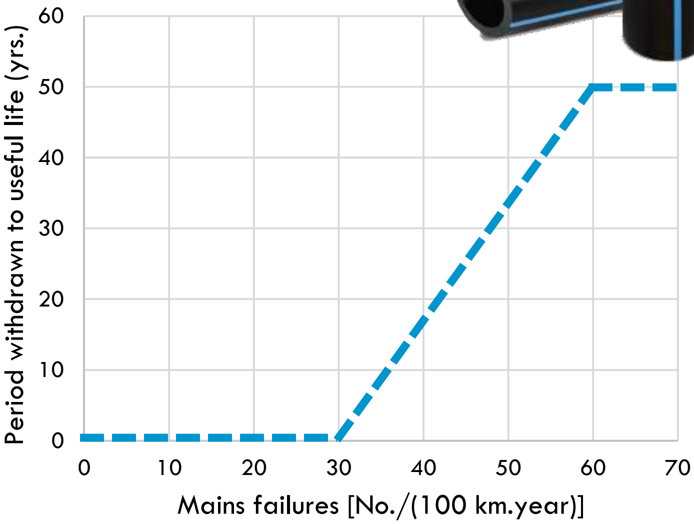
It is performing **good** and no adjustment will be made (**no period will be withdrawn** to useful life)

… is > 30 and ≤ 60

It is performing **fairly**; the **period to be withdrawn** will be adjusted **between zero** and **50 years**

… is > 60

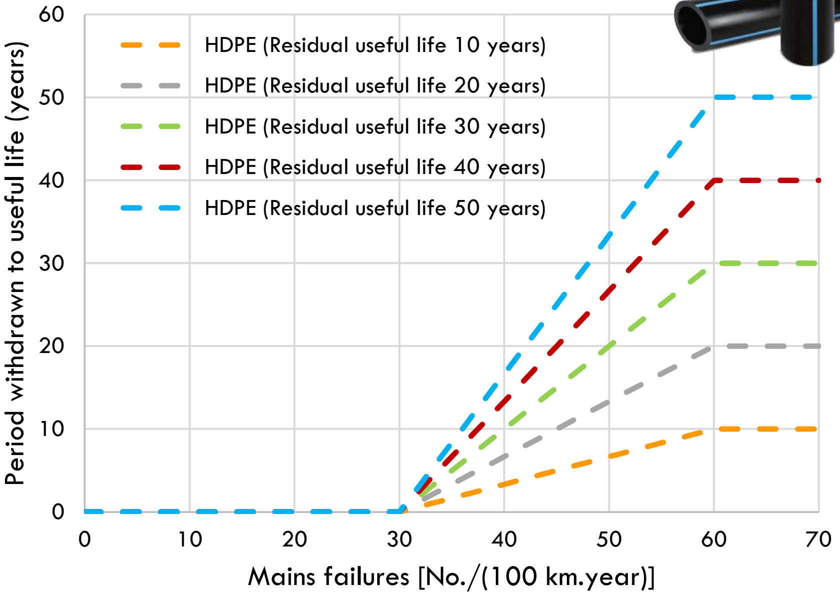
It is performing **poorly** and **it is no longer performing its function**. A **50-year period** will be **withdrawn** to useful life, meaning that the asset has reached the end of its life



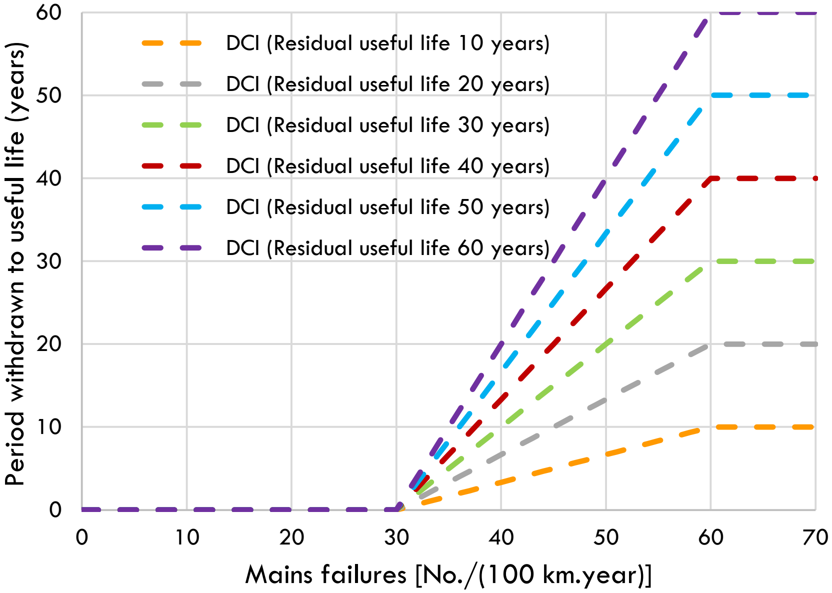
3. Assessing water network useful life

INCORPORATING PERFORMANCE IN ASSETS' USEFUL LIFE | EXAMPLES

High-density polyethylene (HDPE)



Ductile cast iron (DCI)



4. Case-study Estimating rehabilitation needs in water utilities based on network performance

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4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

AGS

- Main goal was to **assess the impact of useful life adjustment** on **future rehabilitation needs** in water utilities by analyzing the evolution of **adjusted IVI** and compare it to **computed IVI based on literature useful lives**

Current value

$$IVI\ (t) = \frac{\sum_{i=1}^{n}\left(rc_{i,t} \times \frac{rul_{i,t}}{eul_i}\right)}{\sum_{i=1}^{n} rc_{i,t}}$$

Replacement value

***IVI(t)*:** **Infrastructure Value Index at time t (-)**
t: reference time
n: total number of assets (-)
rci,t : replacement cost of asset i at time t
ruli,t : residual useful life of asset i at time t
euli : expected useful life of asset i

Alegre, 2007

IVI > 0.6 Young infrastructure; 0.4 ≤ IVI ≤ 0.6 Balanced infrastructure; IVI < 0.4 Aged infrastructure

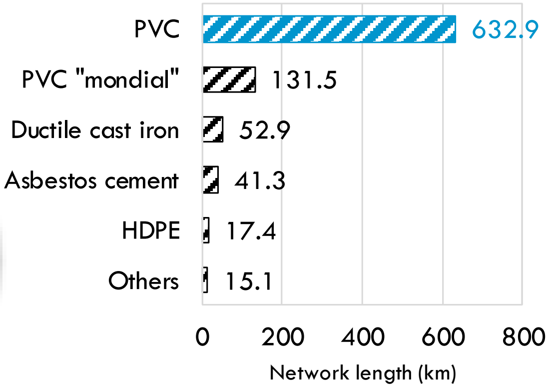
4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

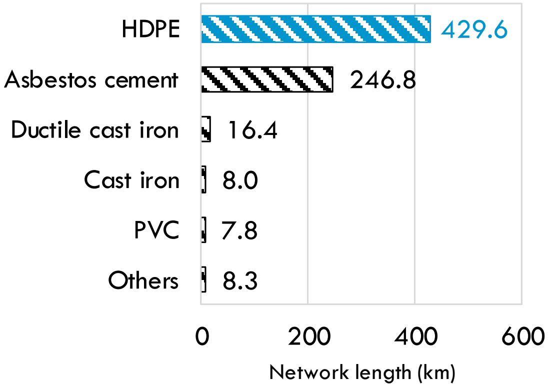
AGS

CASE-STUDY DESCRIPTION

	WATER UTILITY 1	WATER UTILITY 2
Served households (no.)	69’175	56’576
Mains length (km)	891	717

Mains length per material (km)





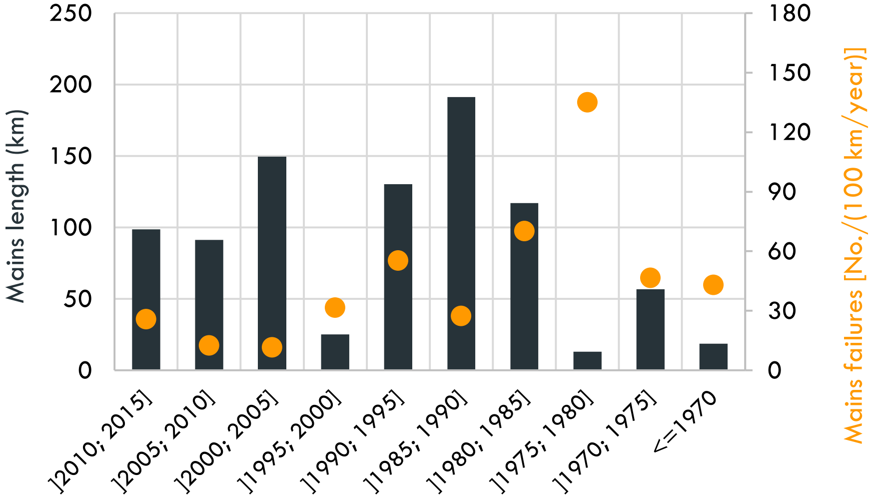
Networks mainly composed by plastic pipes

4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

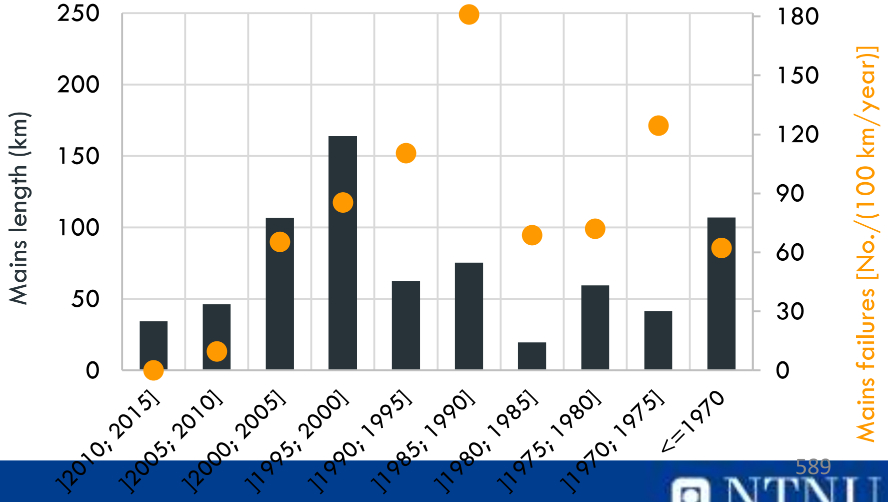
STEP 1: WORK ORDERS DATA | AGEING AND MAINS FAILURES

Data from failures occurred between 2011-2015, organized in 5-year periods and network length constructed since the 1970s, allowed "Mains failures" performance indicator computation

WATER UTILITY 1



WATER UTILITY 2



4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

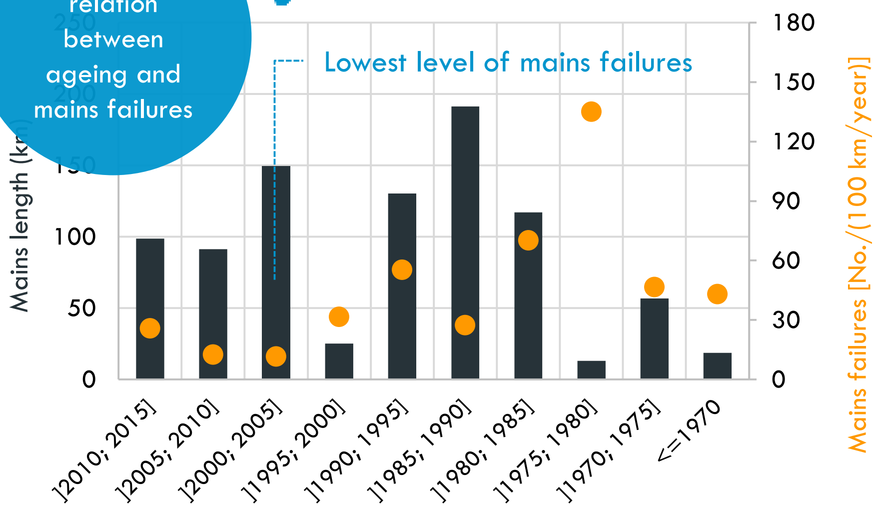
AGS

STEP 1: WORK ORDERS DATA | AGEING AND MAINS FAILURES

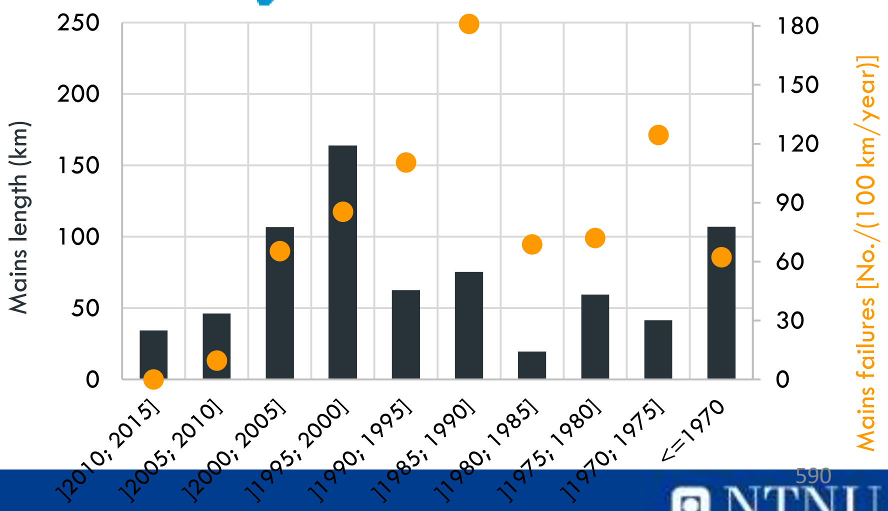
Data from failures occurred between 2011-2015, organized in 5-year periods and network length constructed since the 1970s, allowed "Mains failures" performance indicator computation

No evident relation between ageing and mains failures

WATER UTILITY 1



WATER UTILITY 2



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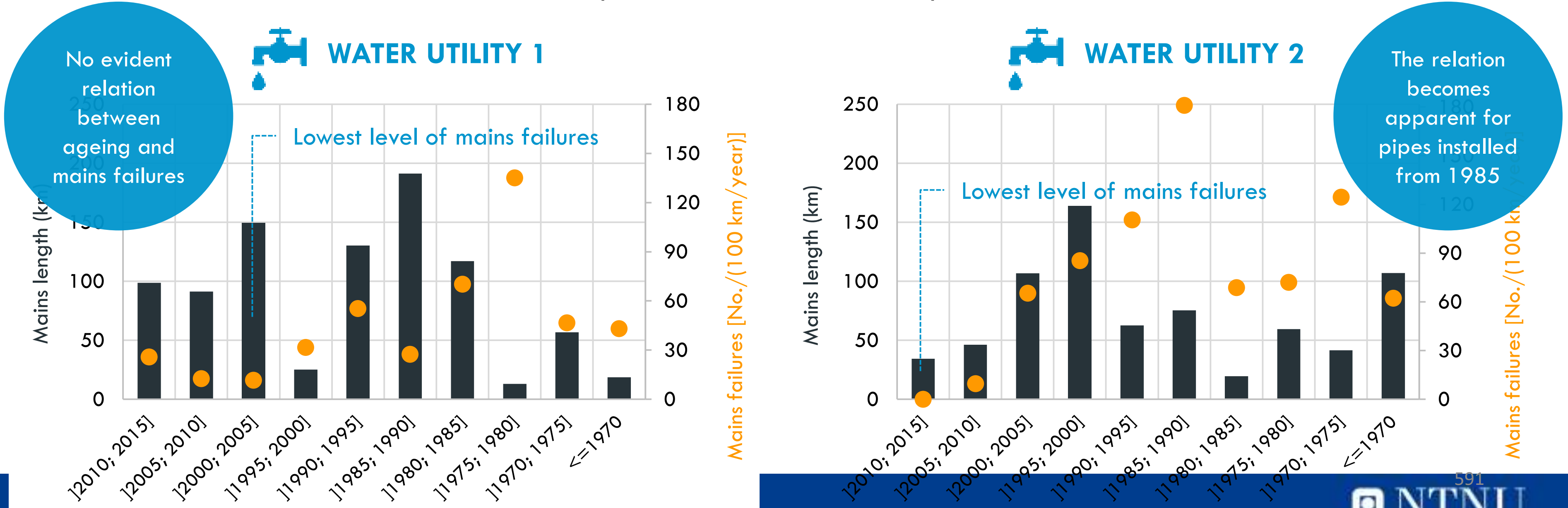

4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

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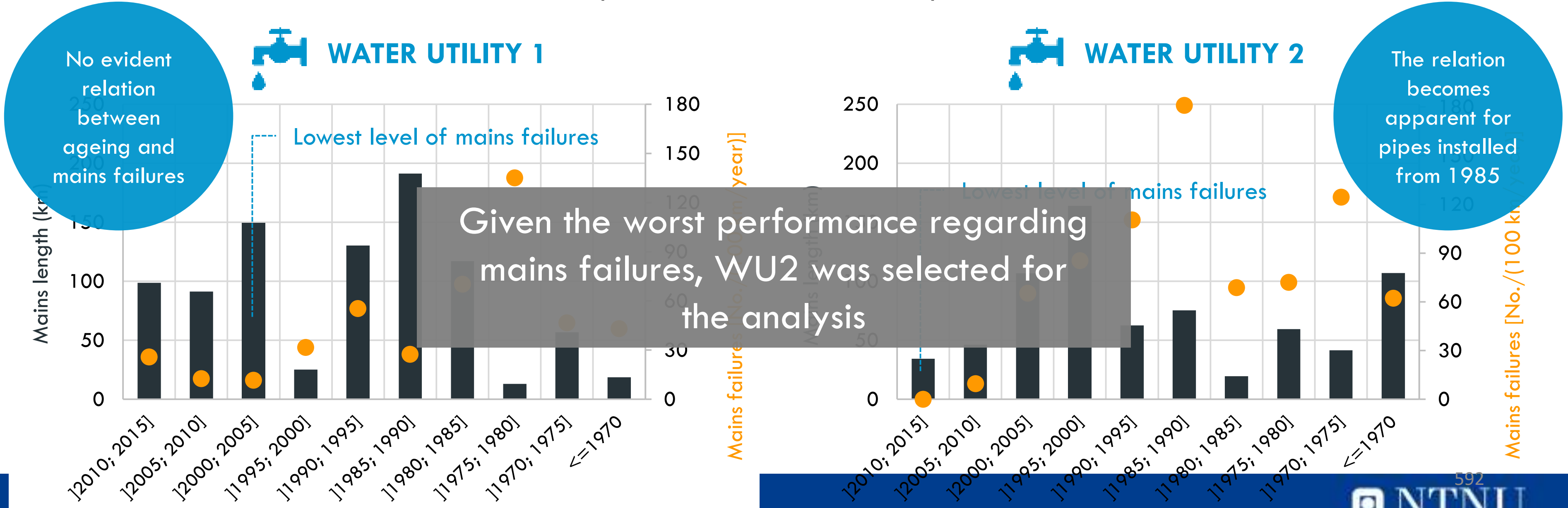


4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

AGS

STEP 2: ADJUSTING ASSETS' USEFUL LIFE AND COMPUTING IVI

Mains failures were computed by cluster of material and installation period (5-year intervals). It was possible to link to each asset the mains failures of its cluster and to apply the presented criteria to adjust each asset useful life and, thus, to compute an adjusted IVI

Two **alternatives** were considered:

1. Maintaining the current rehabilitation rate policy of 0.55% *

2. Adjusting the rehabilitation rate to target a stable IVI of 0.50

Capital expenditures were assessed for both alternatives

* Computed according with the Portuguese regulatory performance indicator

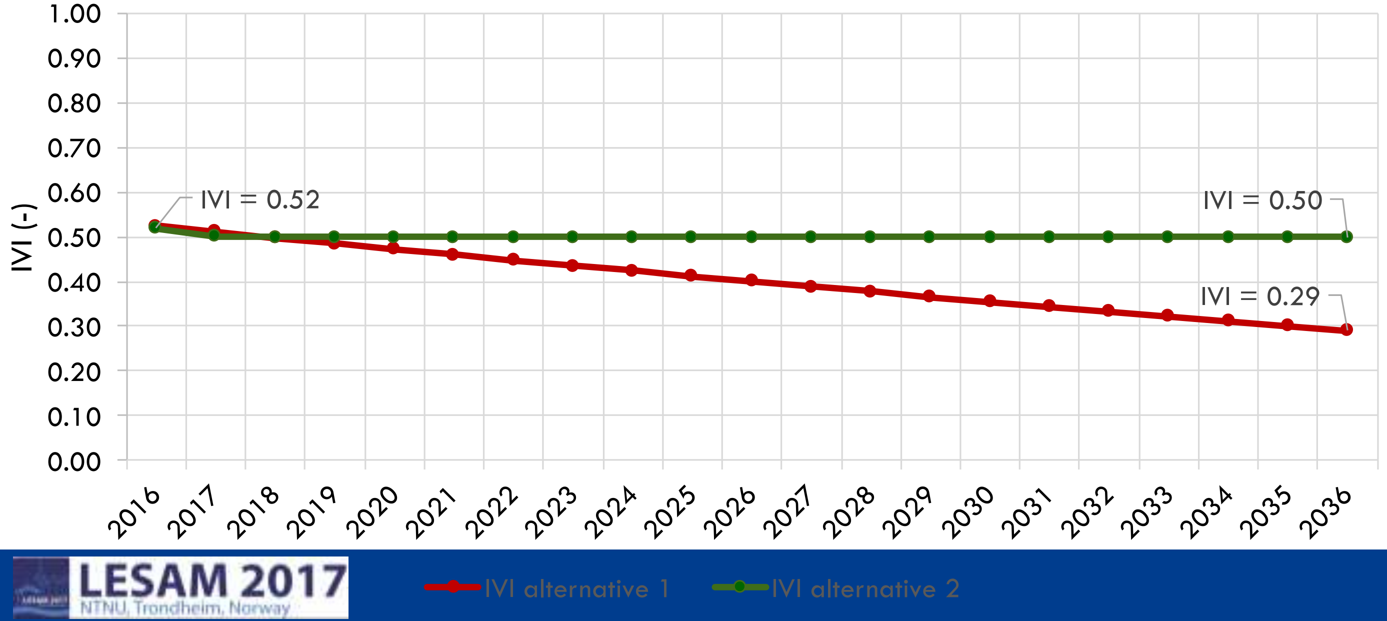
4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

RESULTS | **IVI EVOLUTION**

IVI was computed considering **commonly used useful lives** (continuous lines)

1 Maintaining current rehabilitation rate (0.55%)

2 Adjusting rehabilitation rate to target a stable IVI of 0.50



- With commonly used useful lives, initial IVI will result in 0.52, indicating a stable network
- Maintaining a rehabilitation rate of 0.55% will result in an IVI of 0.29 (poor index level)

4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

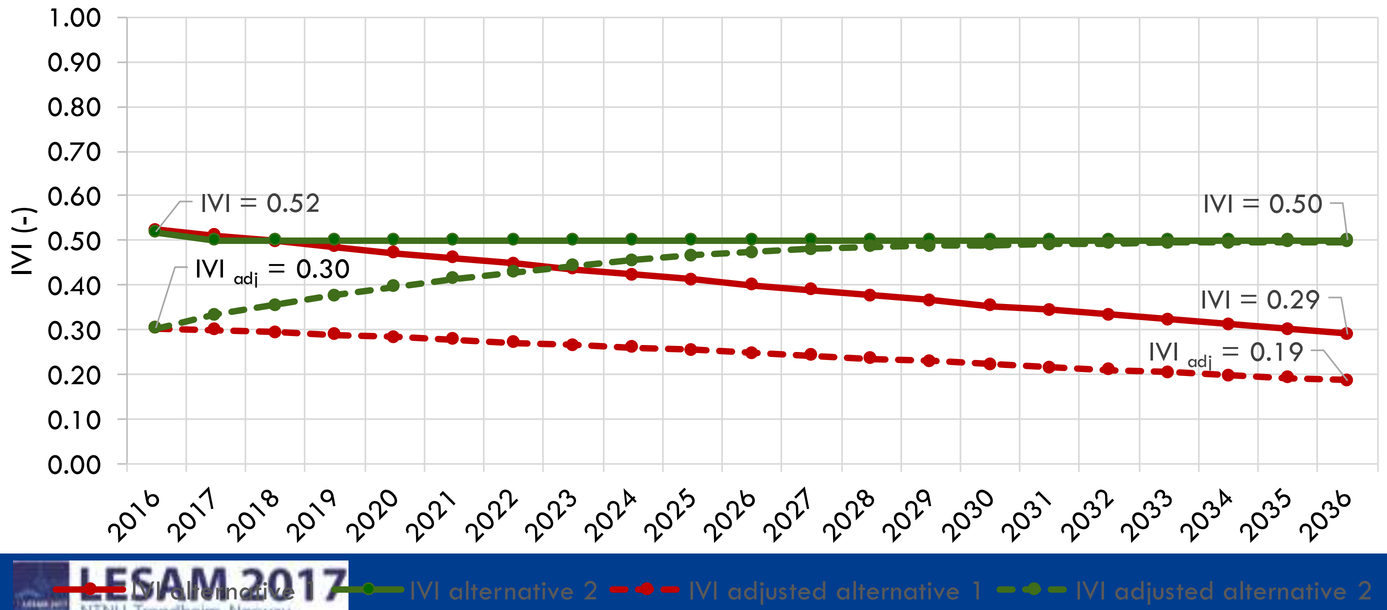
AGS

RESULTS | **IVI EVOLUTION**

IVI was computed considering **adjusted useful lives** (dashed lines)

1 Maintaining current rehabilitation rate (0.55%)

2 Adjusting rehabilitation rate to target a stable IVI of 0.50



With adjusted useful lives, initial IVI will result in 0.30, indicating to some extent an aged network. Adjustment resulted in decreasing IVI from 0.52 to 0.30

Maintaining a rehabilitation rate of 0.55% will result in an IVI of 0.19 (extremely aged network)

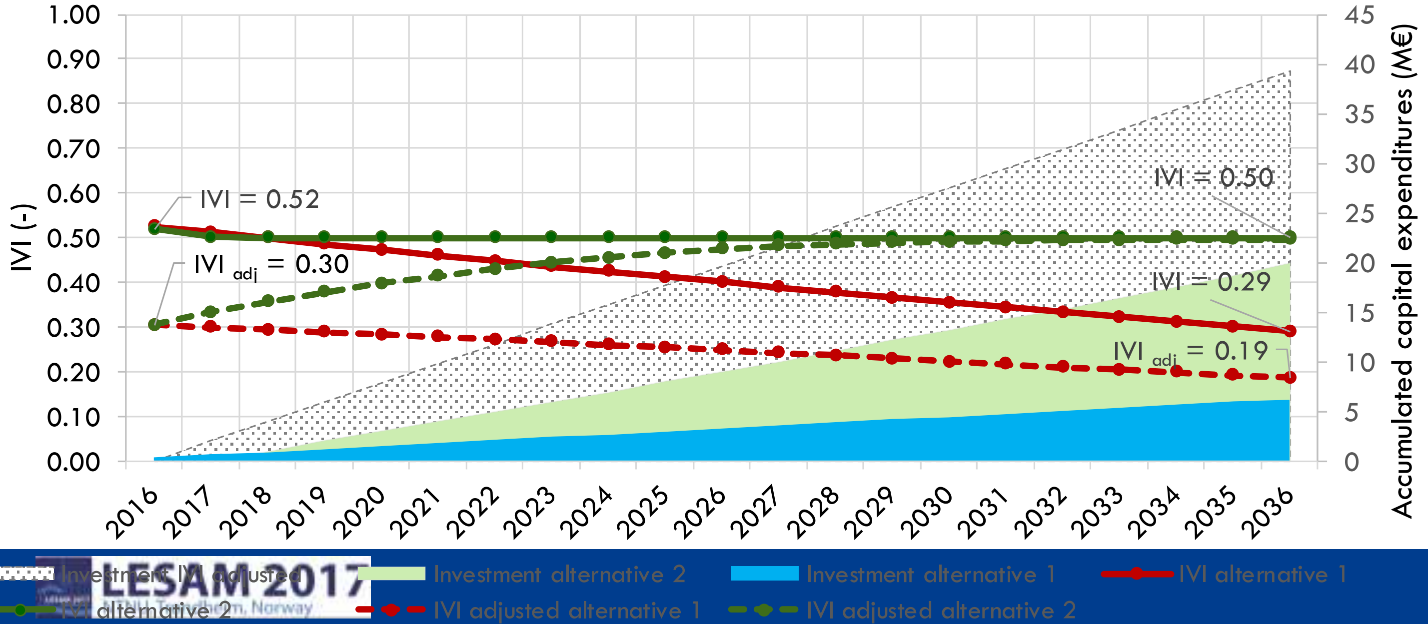
4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

RESULTS | CAPITAL EXPENDITURES

The **capital expenditures** required **to maintain an IVI of 0.5** were assessed

1 Maintaining current rehabilitation rate (0.55%)

2 Adjusting rehabilitation rate to target a stable IVI of 0.50



To maintain IVI around 0.5 (considering commonly used useful lives), the utility must increase CAPEX up to **20 M€** (constant prices @ 2016) in the next 20 years

To maintain IVI around 0.5 (considering adjusted useful lives), the utility must increase CAPEX up to **40 M€** (constant prices @ 2016), doubling the investment effort

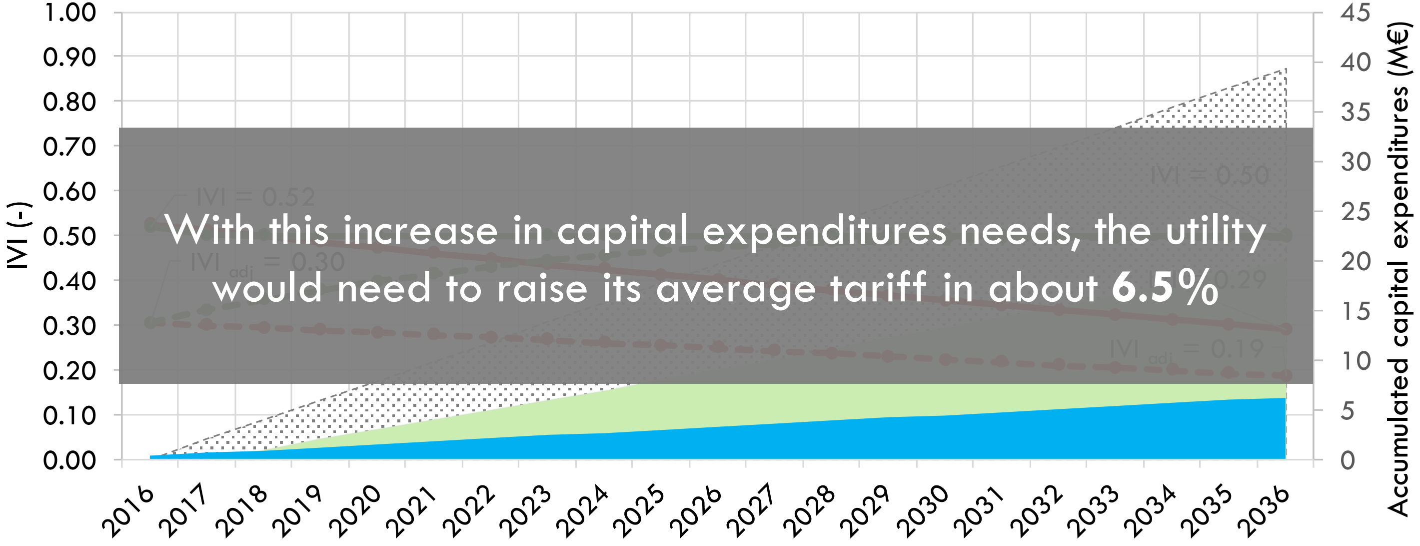
4. Case-study: Estimating rehabilitation needs in water utilities based on network performance

RESULTS | CAPITAL EXPENDITURES

The **capital expenditures** required **to maintain an IVI of 0.5** were assessed

1 Maintaining current rehabilitation rate (0.55%)

2 Adjusting rehabilitation rate to target a stable IVI of 0.50



With this increase in capital expenditures needs, the utility would need to raise its average tariff in about **6.5%**

To maintain IVI around 0.5 (considering commonly used useful lives), the utility must increase CAPEX up to **20 M€** (constant prices @ 2016) in the next 20 years

To maintain IVI around 0.5 (considering adjusted useful lives), the utility must increase CAPEX up to **40 M€** (constant prices @ 2016), doubling the investment effort

5. Final remarks

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5. Final remarks

AGS

- Sustainable management must be supported by reliable information. **Work orders data** can contribute decisively by enabling to assess networks' infrastructure condition

- For **macro-planning purposes**, mains failures can provide useful information by incorporating a utility specific criteria in IVI computation and to **estimate adjusted capital expenditures needs in rehabilitation**

- Useful life adjustment by incorporating the performance dimension in a Portuguese water utility revealed a **significant gap** in the long-term rehabilitation **capital expenditures**, showing that when **neglecting short-term biases**, relevant **long-term** financial **impacts can be hidden**

- In WU2, this represented an **increase** of about **20 M€ in capital expenditures** in 20 years (doubling the investment effort). To cope with these needs, the utility would need to **increase** its **average tariff** in about **6.5%**

- **Further work** should be developed to improve adjusted useful lives criteria to have **more robust reference values**

Rehabilitation needs in water utilities – asset useful life adjustment and Infrastructure Value Index assessment

LESAM 2017

IWA Leading Edge Conference on Strategic Asset Management of Water and Wastewater Infrastructures

Trondheim - June 2017

Presentation 6

Sean Kerwin: Optimal intervention program determination of a water distribution system

ETH zürich

Optimal intervention program determination of a water distribution system

LESA NTNU, Trond

Institute of Construction and Infrastructure Management

NTNU

Contents

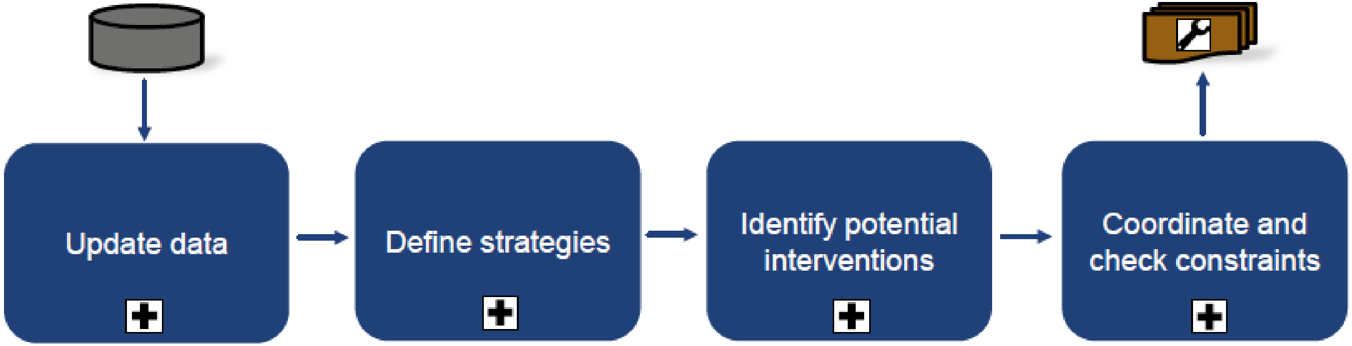
- Context
- Planning of intervention programs
- Methodology
- Example
- Future work

Example water utility

- Zurich
  - Users: 530,000
  - Pipe network: 1,550 km
  - Water treatment facilities: 4
  - Pumping stations: 29
  - Reservoirs: 21

  - Annual investment: 33.3 M USD (2015)

Planning of intervention programs



- Infrastructure objects
- Condition data
- Complaints and failures

- Expert knowledge
- Manufacturer recommendations

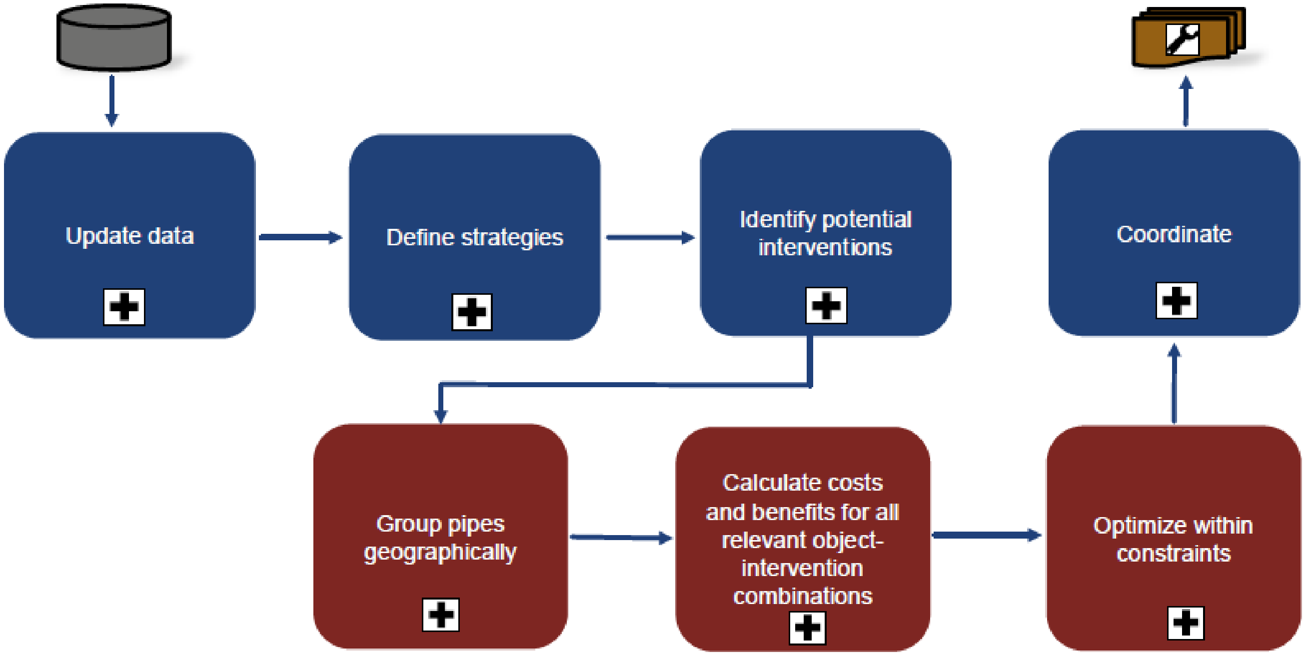
- Object based
- Constraints not considered

- Internal coordination (water utility)
- External coordination
- Check constraints

Potential for improvement

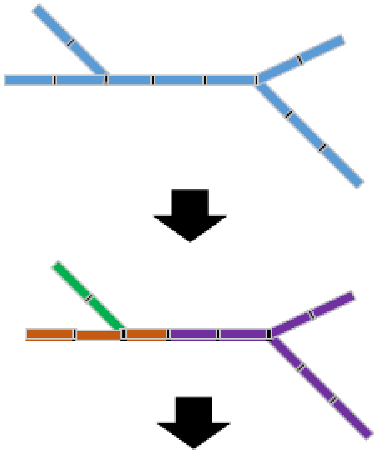
- Very dependent on expert knowledge
  - Bias
  - Information loss
- Consequences of failures ignored
- Impacts of interventions ignored
- No geographical grouping

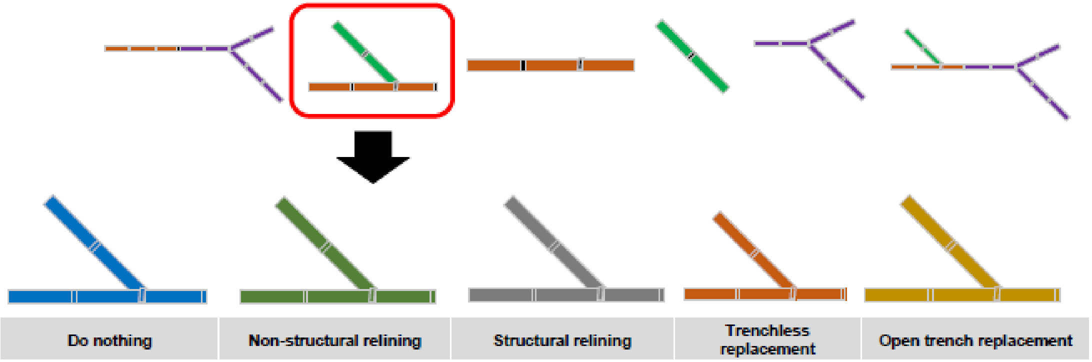
Optimized methodology



Group pipes

Grouping of pipes with same:
- Material
- Diameter
- Age





Calculate costs and benefits of interventions

- *Costs = intervention + loss of service + reduced traffic*

- *Calculated using historical utility data + geographical info.*

Calculate costs and benefits of interventions

- *Risk = Probability x Consequence*

$$Risk = P_{fail}(n,i,t,X) \cdot C_{fail}(n,i,X)$$

- *Benefits = Reduction of risk due to executing intervention*

$$b_{n,k} = F_{n,k} \cdot r_n$$

Failure consequence	Stakeholder	Object
Repair cost	Utility	All
Clean-up cost	Utility	All
Water loss	Utility	All
Worker safety	Utility	Facilities
Loss of service	Public	All
Flooding	Public	All
Traffic disruption	Public	Pipes
Potential water contamination	Public	Pipes

Optimize within constraints

- Objective: maximize net benefit, *Z*, while respecting constraints

$$\max Z = \sum_{n=1}^{N}\sum_{k=1}^{K}\sum_{t=1}^{T}(b_{n,k_{coor},t} - c_{n,k_{coor},t}) \cdot x_{n,k,t}$$

- *b*, benefit of intervention
- *c*, cost of intervention
- *x*, decision variable,

object (*n*), intervention (*k*) and time-step (*t*)

Optimize within constraints

- *Coordination interventions*: interventions coordinated with other networks
- *F_c*, *F_b* modify costs and benefits of interventions executed in coordination areas

$$c_{n,k_{coor},t} = F_{c_{coor},t} \cdot c_{n,k,t} \qquad 0 \leq F_{c_{coor},t} \leq 1$$

$$b_{n,k_{coor},t} = F_{b_{coor},t} \cdot b_{n,k,t} \qquad 1 \leq F_{b_{coor},t} \leq 2$$

Optimize within constraints

- *Priority interventions*: interventions that must be executed ASAP
- Constraint allows input of infrastructure manager.

$$\sum_{k=1}^{K}\sum_{t=1}^{T} x_{n_{included},k,t} = 1, \forall n_{included}$$

Optimize within constraints

- Financial and operational constraints

Annual budget

$$\sum_{n=1}^{N}\sum_{k=1}^{K}\sum_{t=1}^{T} ic_{n,k,t} \cdot x_{n,k,t} \leq \beta_t$$

Max intervention length

$$l_{n,k,t} \leq \Omega, \forall n$$

Minimum renewal length

$$\sum_{n=1}^{N}\sum_{k=1}^{K}\sum_{t=1}^{T} l_{n,k,t} \cdot x_{n,k,t} \geq \Phi_t$$

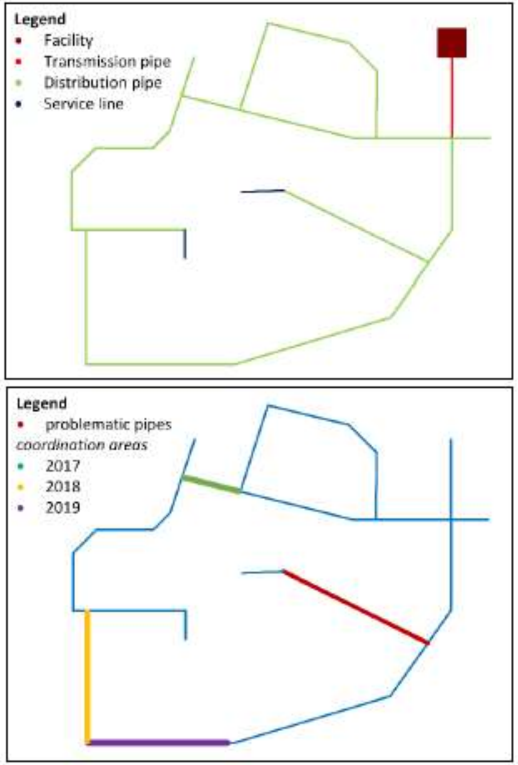
Object constraint

$$\sum_{k=1}^{K}\sum_{t=1}^{T} x_{k,t} \leq 1, \forall n$$

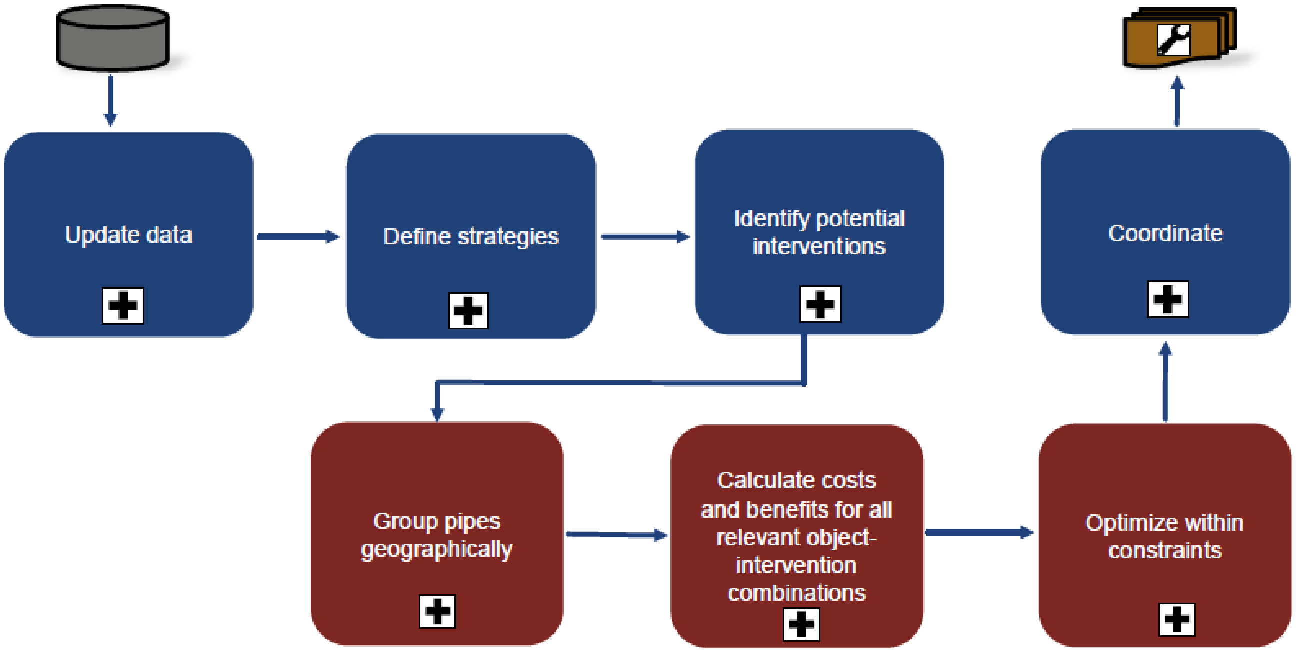
Example network

Component	Dimension
Pipe network	4.6 km
Reservoirs	23'200 m^3 (2)
Pumps	45 L/s (4)

Environment	Description
Zoning	Residential, agricultural
Traffic	low, no public transit
Soil	Clay, silt

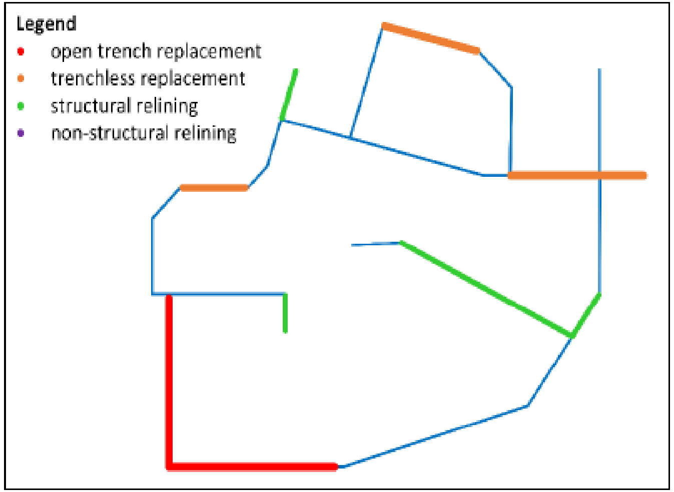


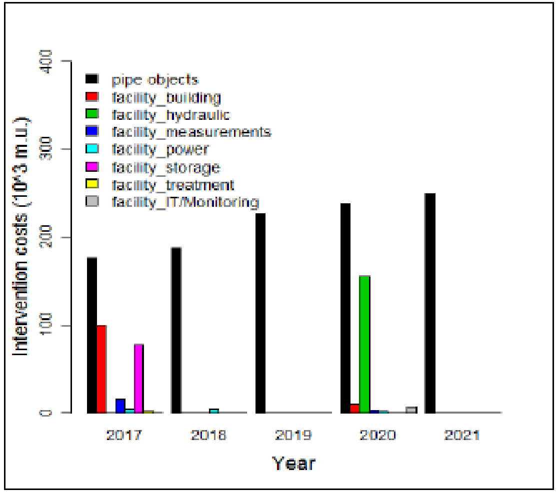
Methodology



Intervention program 1

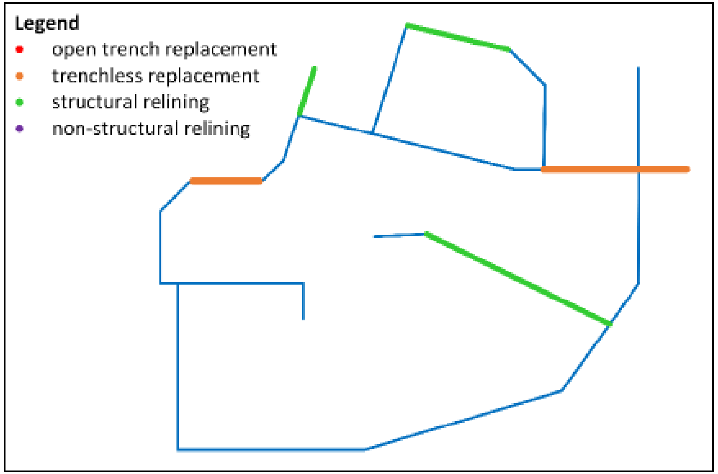
Program	Annual Budget (GE)	Time period (a)	Max. construction site length (m)	Intervention costs (m.u.)	Net benefit (m.u.)
1	unlimited	5	600	1'463'416	1'540'265

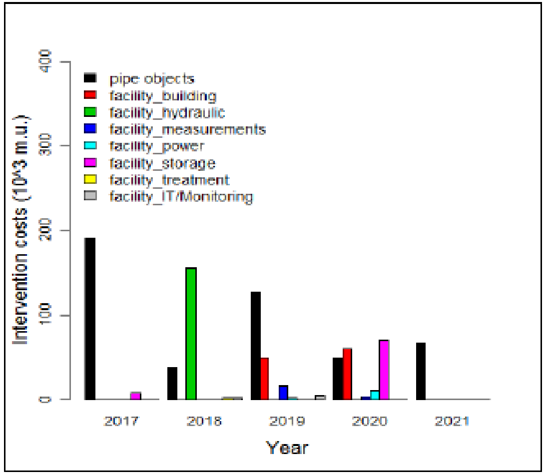




Intervention program 2

Program	Annual Budget (GE)	Time period (a)	Max. construction site length (m)	Intervention costs (m.u.)	Net benefit (m.u.)
2	200'000	5	600	937'988	943'612





Next steps

- Increase scale of model to city-level
- Sensitivity analysis

Thank you

Presentation 7

Annika Malm: Every water utility in Sweden will have a rehabilitation plan for the water and wastewater networks by 2018 - a tool to fulfil the mission

EVERY WATER UTILITY IN SWEDEN WILL HAVE A REHABILITATION PLAN FOR THE WATER AND WASTEWATER NETWORKS BY 2018 - A TOOL TO FULFIL THE MISSION

För ett hållbart och konkurrenskraftigt Sverige

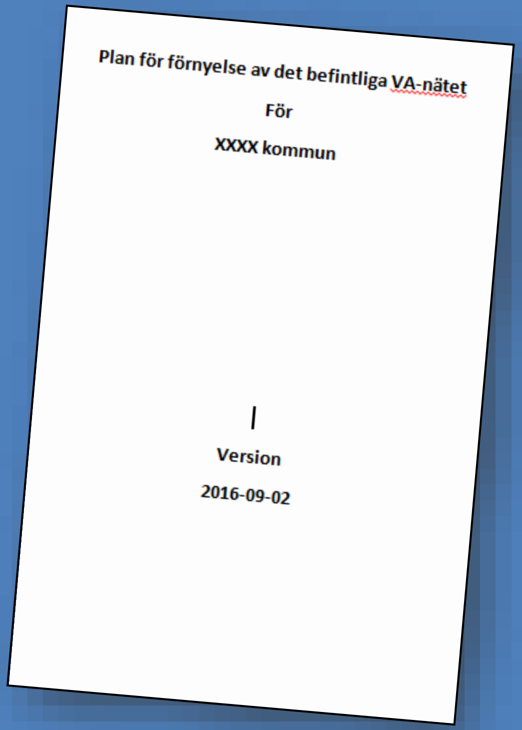
Annika Malm, Anne Adrup, Hans Bäckman

LESAM 2017 Trondheim

Research Institutes of Sweden

HÅLLBAR SAMHÄLLSBYGGNAD
ENERGI OCH CIRKULÄR EKONOMI

Svenskt Vatten


Plan för förnyelse av det befintliga VA-nätet

För

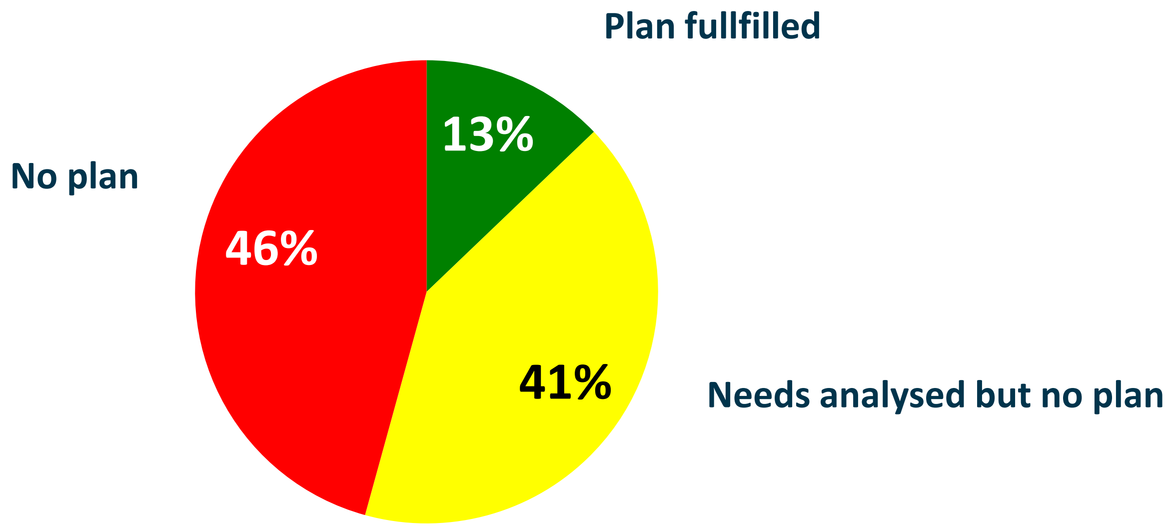
XXXX kommun

Version

2016-09-02

A project 2008-2011 resulted in three reports

Swedish municipalities pipe network planning



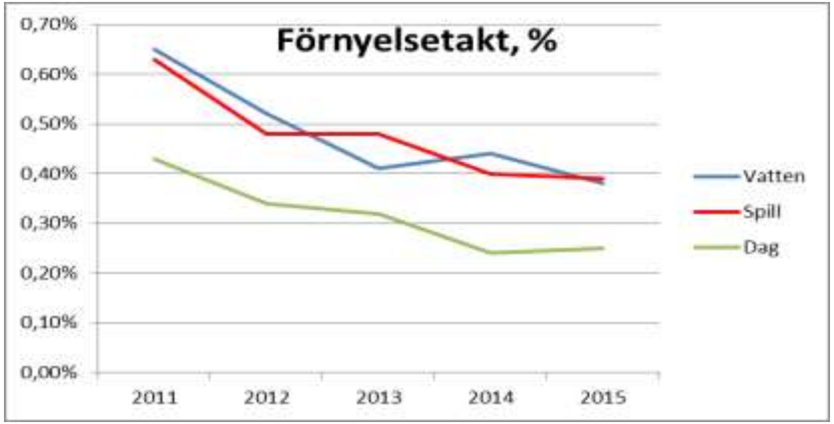
Svenskt Vatten

Data from Svenskt Vatten, 2016

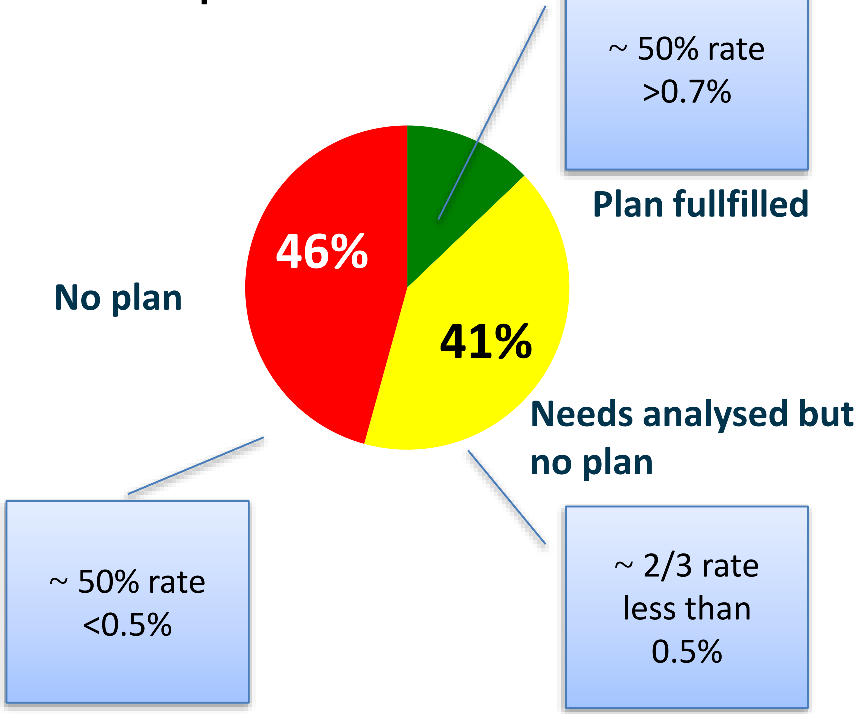
Why do they not start?

Why is planning so important?

- Rehabilitation rate needs to be increased by 40%

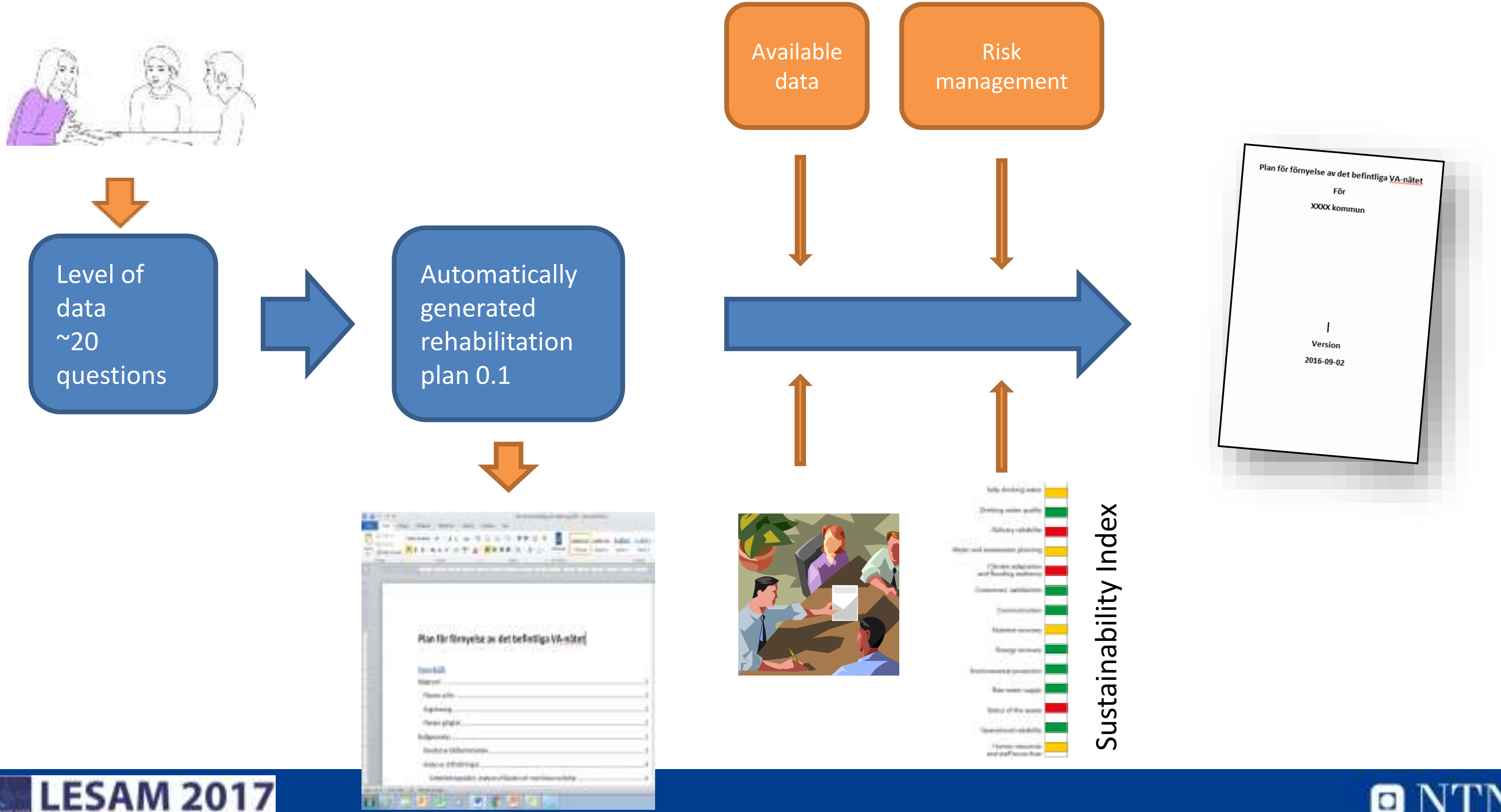


- No plan – less done!

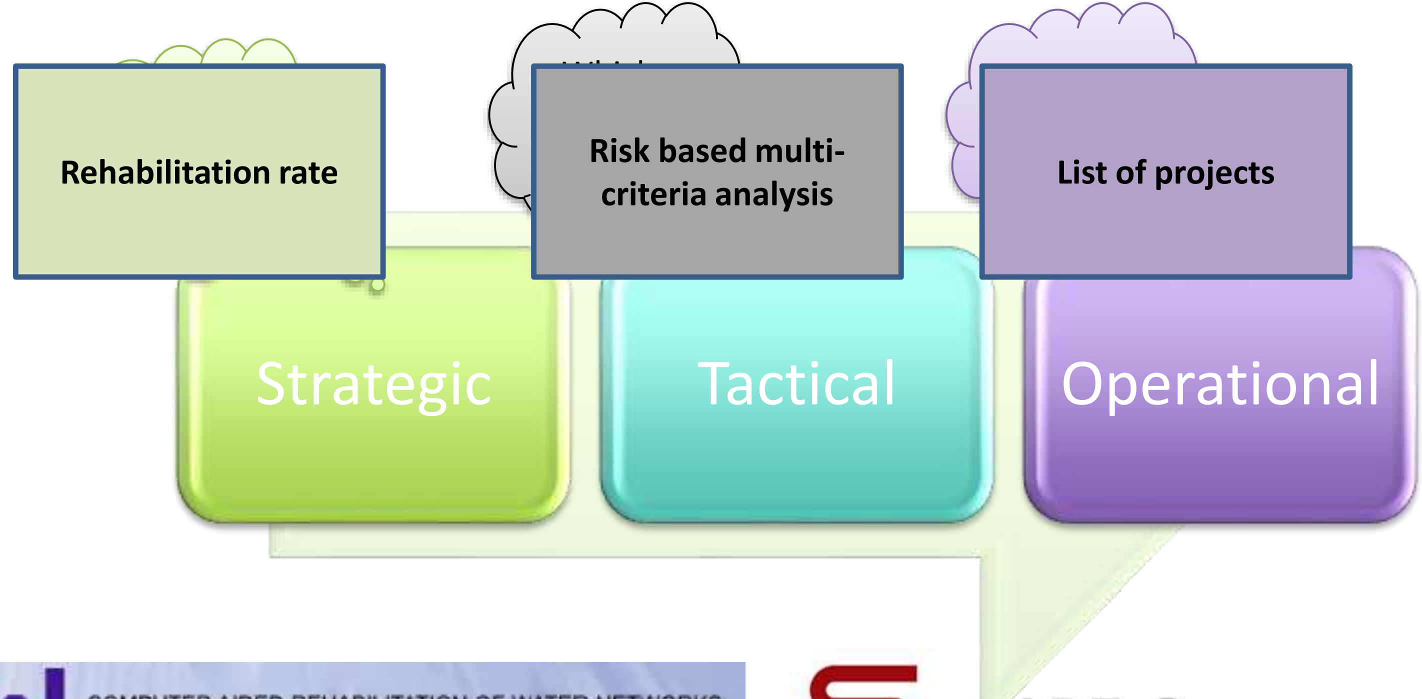


Svenskt Vatten

Data from Svenskt Vatten, 2016


Available data
Risk management
Level of data ~20 questions
Automatically generated rehabilitation plan 0.1
Sustainability Index
Plan för förnyelse av det befintliga VA-nätet
För
XXXX kommun
Version
2016-09-02

The concept were built on previous research



Structure and content of the rehabilitation plan

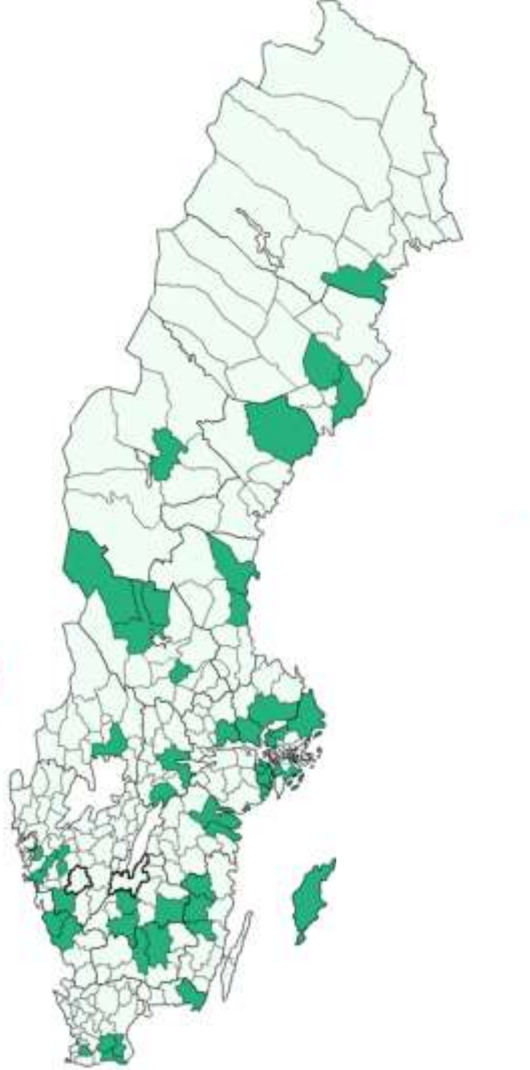
1. Introduction *Purpose, delimitation, validity of the plan*
2. Analysis of present state
   - Results from Swedish Sustainability Index
   - Analysis of failures (if documented)
   - Analysis of present capacity (if needed)
   - Assessments of needs based on a climate change
   - Estimates of needs based on city developments and changes in infrastructure
3. Aims *How to design effective goals?*
4. Strategic needs *How much assets do we need to rehabilitate?*
5. Priority principles (incl. Risk analysis) *Area based planning or pipe based?*
6. Todo-list regarding planning *E.g. Updates of GIS database, identifying pipes high in consequences*
7. List of rehabilitation projects *Time frames, cost, human resources needed*

What is new about this?

- The approach – if no local data is available – national data can give the rehabilitation rate only using total pipe km. Example
- The structural help – the plan is filled in with text as far as possible
- Investigation/documentation shortcomings ends up in a todo-list in the plan
- You see the results the day you start

Course plan

- 2+1 days course
- Prepared by
  - Data as much as they have
  - Bringing own computers to the co
  - Some skills in Word & Excel
- Teaching and showing and owr
- Time for discussions
- About 20 % of the municipalitie far



Reflections from the courses

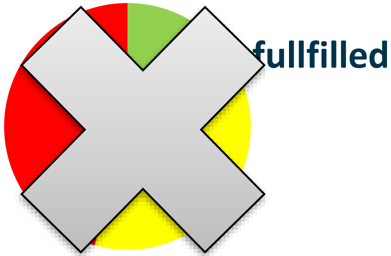
- Too fast for one day
- Too much work on their own/too little work in their own
- Need the course to get a start
- All documents attached are good help
- The analysis should be aimed to be done directly in the GIS-map

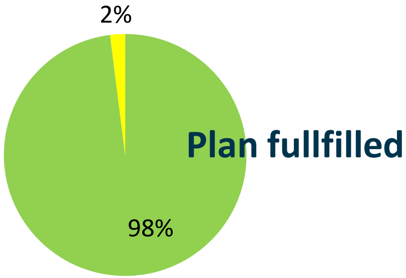
The future

Swedish guideline

More courses

Not yet – but soon!





THANK YOU!

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Research Institutes of Sweden

HÅLLBAR SAMHÄLLSBYGGNAD
ENERGI OCH CIRKULÄR EKONOMI

LESAM 2017
NTNU, Trondheim, Norway

Presentation 8

Stian Bruaset: Rehabilitation practices and strategies of Norwegian water utilities

Rehabilitation practices and strategies of Norwegian water utilities

PhD candidate *Stian Bruaset*
MSc *Martin Okstad*
MSc *Håkon Rygg*
Professor *Sveinung Sægrov*

Norwegian University of Science and Technology

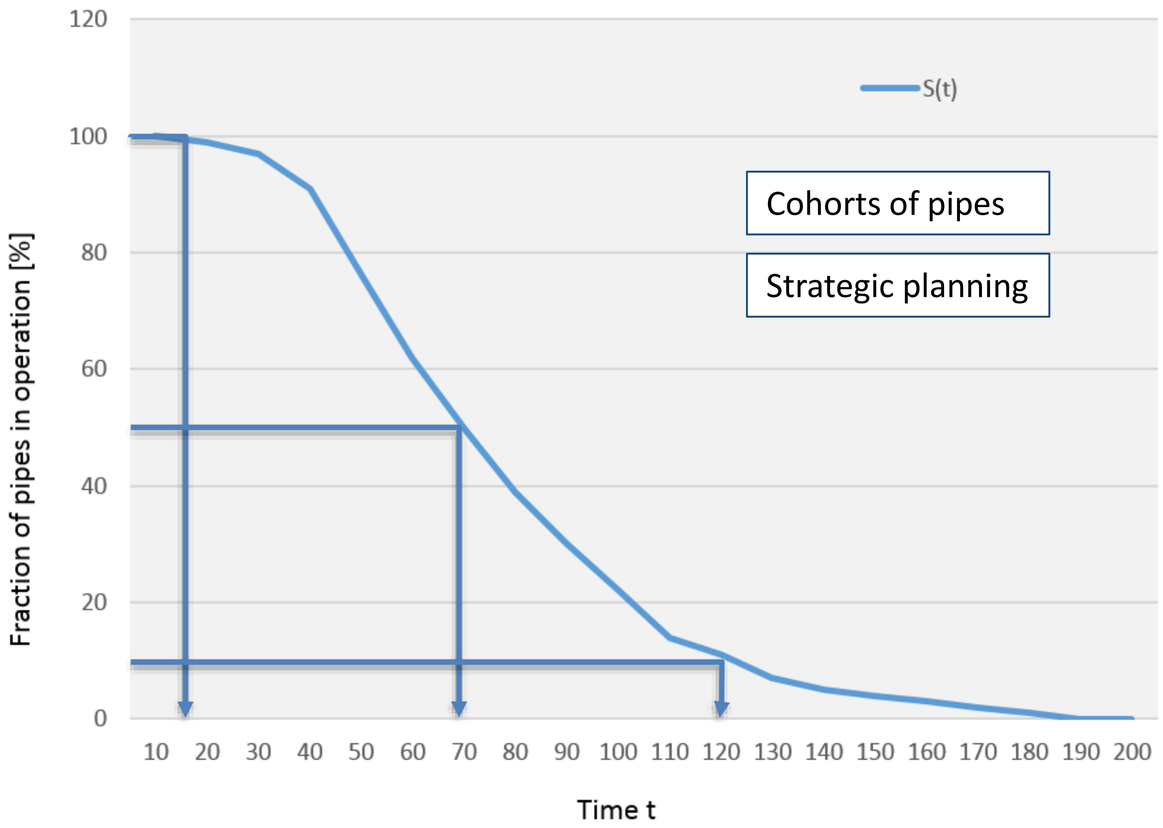
stian.bruaset@ntnu.no

Backdrop

- Survival functions is the main topic of investigation
  - Survival functions are used for cohorts of pipes in long term planning.
  - Survival functions are considered to construct a more realitsic ‘image’ of reality of the service life of pipes than for example average expected lifetimes (see Renaud et al. 2014).
- Two case studies:
  - Calibration of survival functions
  - How to measure sustainability impact of rehabilitation strategies

RENAUD, E., BREMOND, B. & LE GAT, Y. 2014. Water pipes: why ‘lifetime’is not an adequate concept on which to base pipe renewal strategies. *Water Practice and Technology,* 9, 307-315.

Survival functions short intro



Case study 1

Problem description

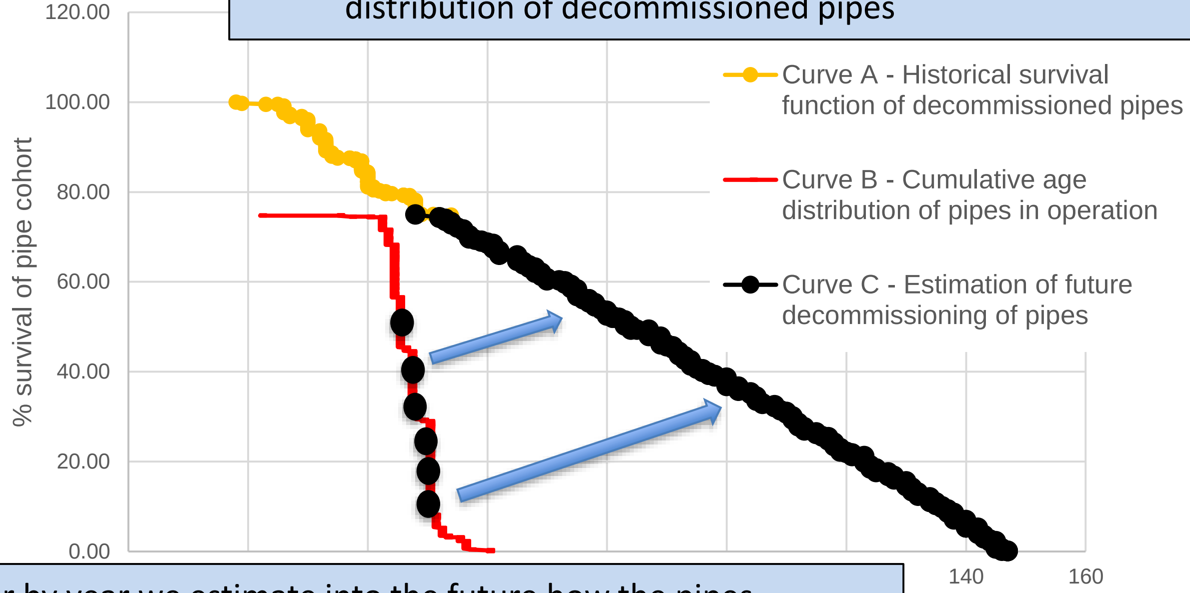
- The biggest challenge of using survival functions is the lack of using empirical data when constructing them

- Expert knowledge and research experience is often used when constructing input values to survival functions

- How about applying historical data on decommissioning ages to calibrate survival functions?

Calibration of survival functions – paper being published

How are pipes decommissioned in the future? –
- What is their age and their age distribution?
- We estimate this distribution based on historical age distribution of decommissioned pipes



Year by year we estimate into the future how the pipes currently in operation are decommissioned

For more information see, BRUASET, S., SÆGROV, S. & UGARELLI, R. 2017. Performance-based modelling of long-term deterioration to support rehabilitation- and investment decision in drinking water distribution systems. *Urban Water Journal*.

What did we do?

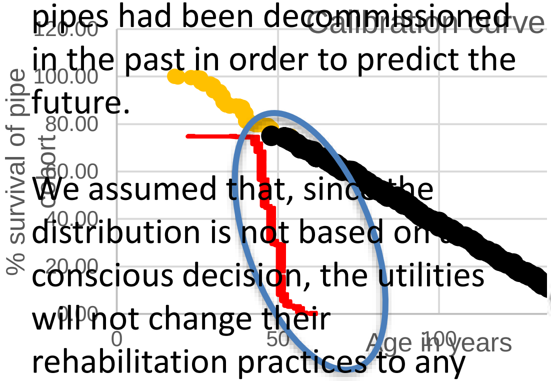
- We collected data from three municipalities about their practices concerning the age of pipes at decommissioning and the total age distribution of these pipes

- We analysed this data to look for patterns and to create rules for the *selection process*.

- *Selection process* = estimation of future annual decommissioning. Pipes are selected once a year from pipes currently in operation.

Case study 1 – age distribution of decommissioned pipes – 3 cities

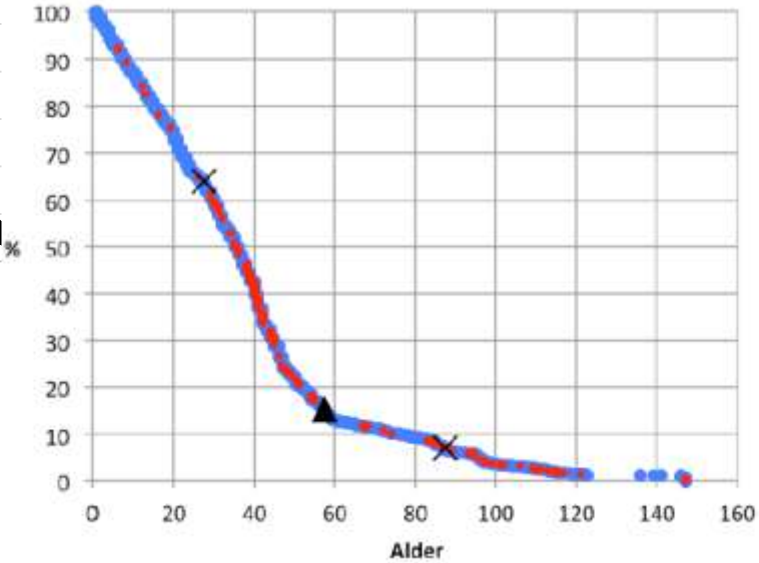
- We wanted to recreate how pipes had been decommissioned in the past in order to predict the future.



- We assumed that, since the distribution is not based on a conscious decision, the utilities will not change their rehabilitation practices to any major extent.

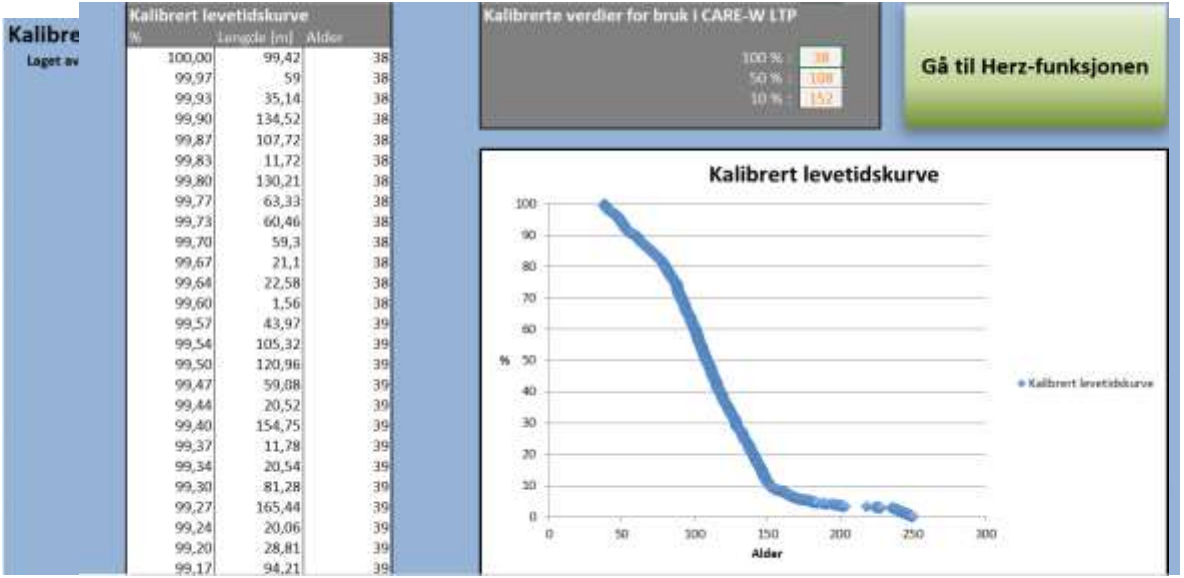
- Analysis is based on 15 years of data

- Average age and Standard deviation used as a measure of the age distribution – based on normal distribution of data



Automated calibration function

Automatically calculates a calibration curve for a cohort of pipes



%	Lengde [m]	Alder
100,00	99,42	38
99,97	59	38
99,93	35,14	38
99,90	134,52	38
99,87	107,72	38
99,83	11,72	38
99,80	130,21	38
99,77	63,33	38
99,73	60,46	38
99,70	59,3	38
99,67	21,1	38
99,64	22,58	38
99,60	1,56	38
99,57	43,97	39
99,54	105,32	39
99,50	120,96	39
99,47	59,88	39
99,44	20,52	39
99,40	154,75	39
99,37	11,78	39
99,34	20,54	39
99,30	81,28	39
99,27	165,44	39
99,24	20,06	39
99,20	28,81	39
99,17	94,21	39

Okstad, M. *Modellering av langtidsbehov for fornyelse av drikkevannsledninger.* Master Thesis, NTNU, 2017,

Case study 2

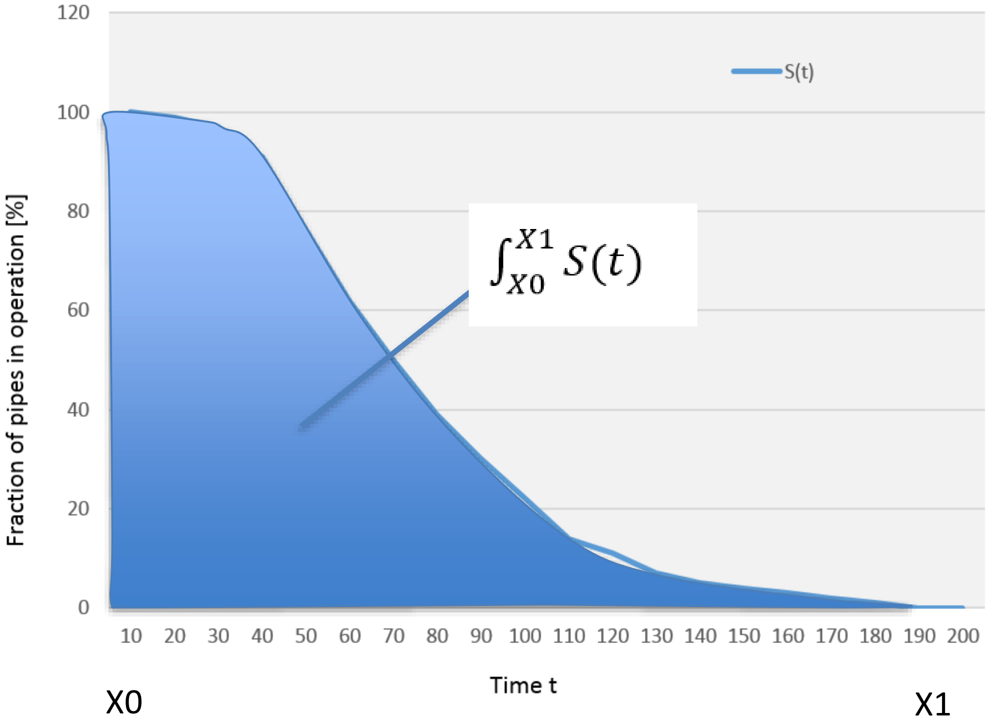
Problem description

- The sustainability of rehabilitation projects are often based on single projects and short to medium - term aspects with regards to service lives of pipes.

- Due to the short time aspect of analyses:
  - long-term sustianability impacts are ignored
  - The expected lifetime of the rehabilitation methods are not fully incorporated into analyses

- This case study presents some ideas on how to compare rehabilitation methods on a strategic level, over their life cycles by
  1. **Defining life cycle for cohorts of pipes**
  2. **Normalizing rehabilitation methods to each other with regards to their different service lives**
  3. **Correcting sustainability analyses on the basis of the total service life of a rehabilitation method**

Idea; Survival functions as life cycles for a rehabilitation method



X0: Inception of the service provision of the rehabilitation method
X1: End of the service provision of the rehabilitation methods

Life Cycle Factor (LCF)

- The area covered by the survival function is calculated by its integral. We refer to the area as the LCF:

$$LCF = \int_{X0}^{X1} S(t)$$

- The LCF normalizes rehabilitation methods to each other with regards to service provision of the specific method, i.e. its total lifetime of all pipes in a cohort.

Norwegian case study

- When we had defined the life cycle of cohorts, we performed a Norwegian based case study
- Data from 20+ Norwegian water utilities to create survival functions.
- Data from 5 Norwegian water utilities on rehabilitation strategies
- Coordination hypoteses from Pericault et al. (2017) was used to construct coordination curves for water+sewer and for water+sewer+roads.

PERICAULT, Y., BRUASET, S., UGARELLI, R., SÆGROV, S., VIKLANDER, M. & HEDSTRÖM, A. 2017. Coordinated Long Term Planning of Sewer and Water Mains Rehabilitation. *LESAM 2017*. Trondheim.

Life Cycle Factors (LCF) for rehabilitation methods/approaches (Norwegian data)

Rehabilitation method	LCF
Replacement (Reference Method – best available method)	125.25
Replacement coordination water and sewer	111.33
Structural no-dig	104.32
Replacement coordination water, sewer and road	99.02
Non-structural no-dig	52.32
Semi-structural no-dig	49.55

How do we use the LCF?

- Sustainability performance based on for example the calculation of indicators are ‘corrected’ with the LCF for the relevant rehabilitation method.
  - Rehabilitation methods can be combined into different strategies

- **This gives the user a possibility to compare the sustainability impact of different rehabilitation strategies based on their life cycles.**

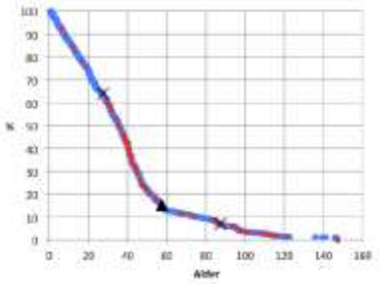
- **Since the LCF corrects sustainability impact for the expected service life of a rehab method, it gives results which are more ‘fair’ than when the LCF is not applied**

Case study results – 15 indicator values assessed for the renewal of Trondheim

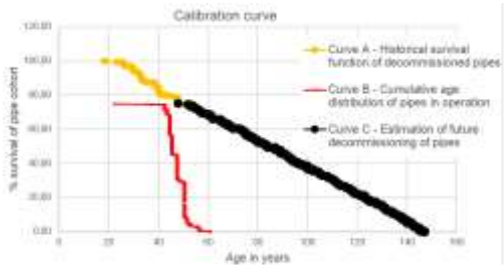
	Strategy 1	Strategy 2	Strategy 3
Description	5 % no-dig, 95 % replacement	30 % no-dig, 70 % replacement	50 % no-dig, 50 % replacement
Penalty points	27486	25305	23558
Normalized	1,17	1,07	1
Total cost	9.918 mill NOK	9.522 mill NOK	9.204 mill NOK

- No-dig reduces negative impact on sustainability, but not as much as traditionally thought when you consider its life cycle.
- What then, if you include coordination of replacement activities where sustainability impact will be reduced by 30-40 %?
- And what if, you include the evolution and impact of electric trucks in the analysis (which will be well within the market within the next 20-30 years).

Overall process summary



Historical age distribution of decommissioned pipes used to improve calibration process



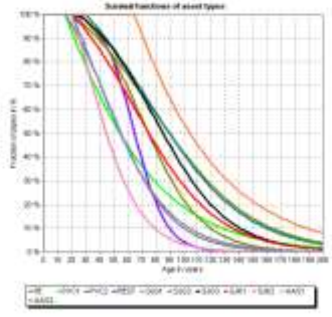
Calibration should be used to improve survival functions

LCF
imp
equ

The link between the two case studies was not explored, meaning we did not calibrate the survival functions used in building the LCF

Rehabilitation method	LCF
Replacement (Reference Method – best)	125.25
Replacement coordination water and sewer	111.33
Structural no-dig	104.32
Replacement coordination water, sewer and road	99.02
Non-structural no-dig	52.32
Semi-structural no-dig	49.55

functions can be used to identify life cycles of rehabilitation strategies



Thank you

Presentation 9

Franz Tscheikner-Gratl: On the potential of integrated multi-utility asset management in urban water management

ON THE POTENTIAL OF INTEGRATED MULTI-UTILITY ASSET MANAGEMENT IN URBAN WATER MANAGEMENT

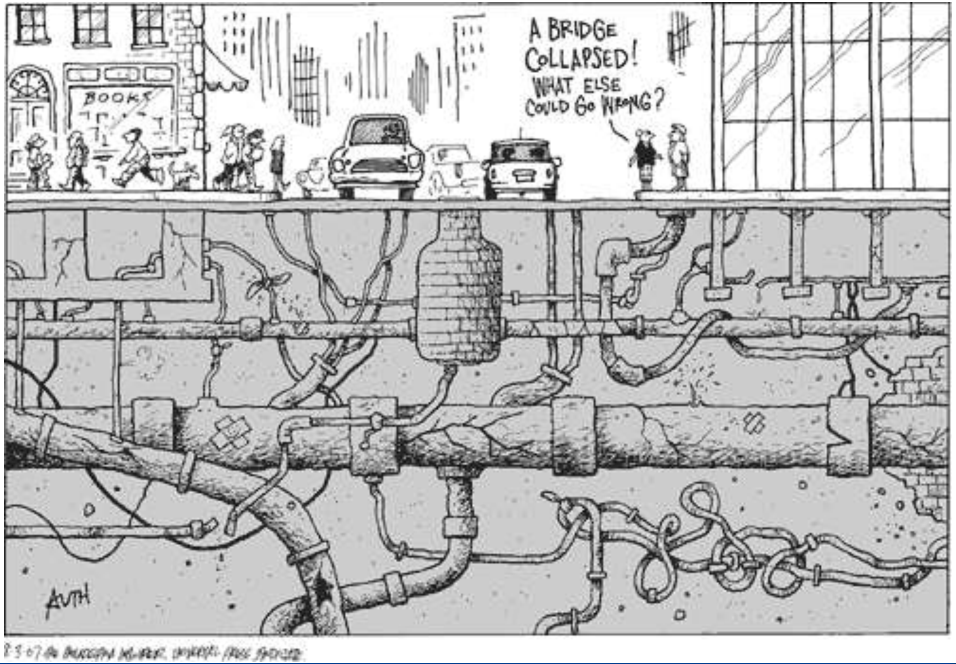
Franz Tscheikner-Gratl
Michael Mair, Wolfgang Rauch,
Jeroen Langeveld, Manfred Kleidorfer

LESAM 2017
NTNU, Trondheim, Norway

Outline of the presentation

Outline of the presentation

- Motivation



Outline of the presentation

- Motivation
- Integrated approach

Source: Margerison-McCann (2015)

Outline of the presentation

- Motivation
- Integrated approach
- Challenges and example application

Source: NewGrowth Consulting (2015)

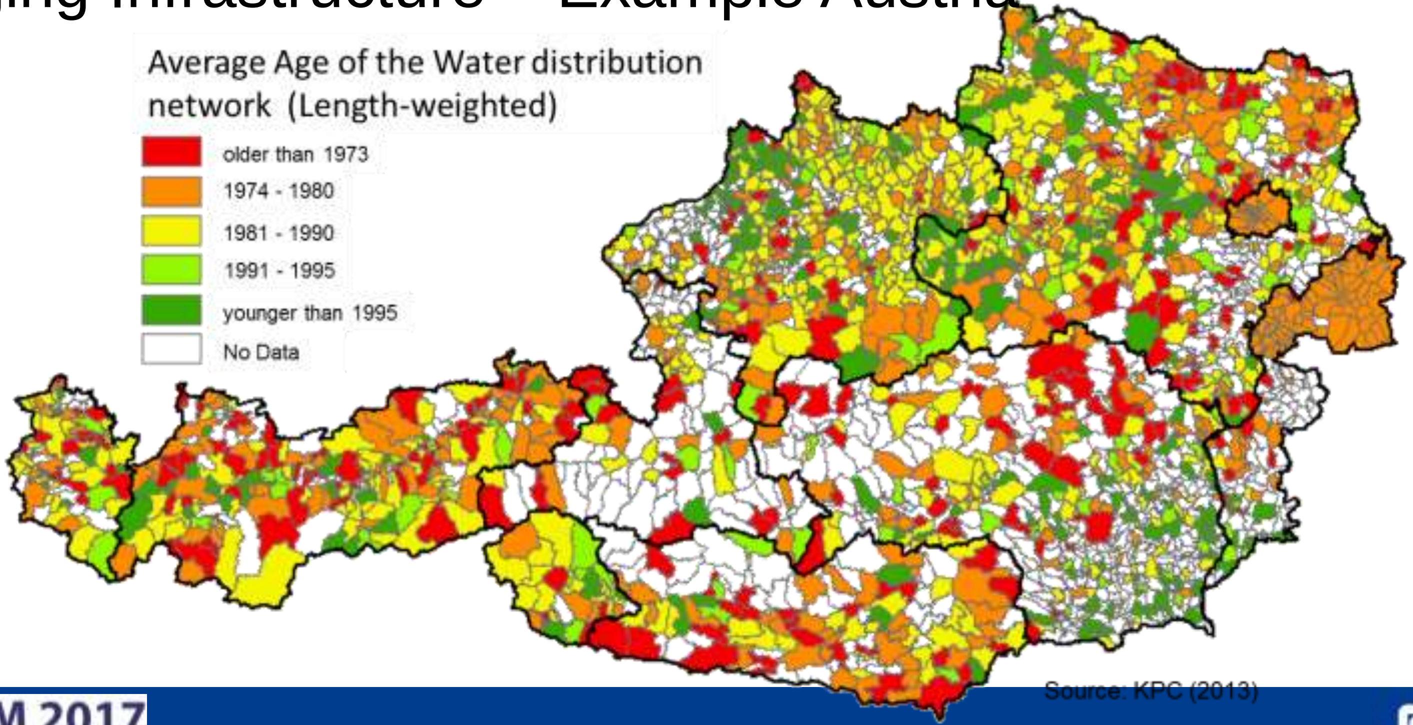
Outline of the presentation

- Motivation
- Integrated approach
- Challenges and example application
- <u>Conclusion</u>

Source: Walt Disney (1963)

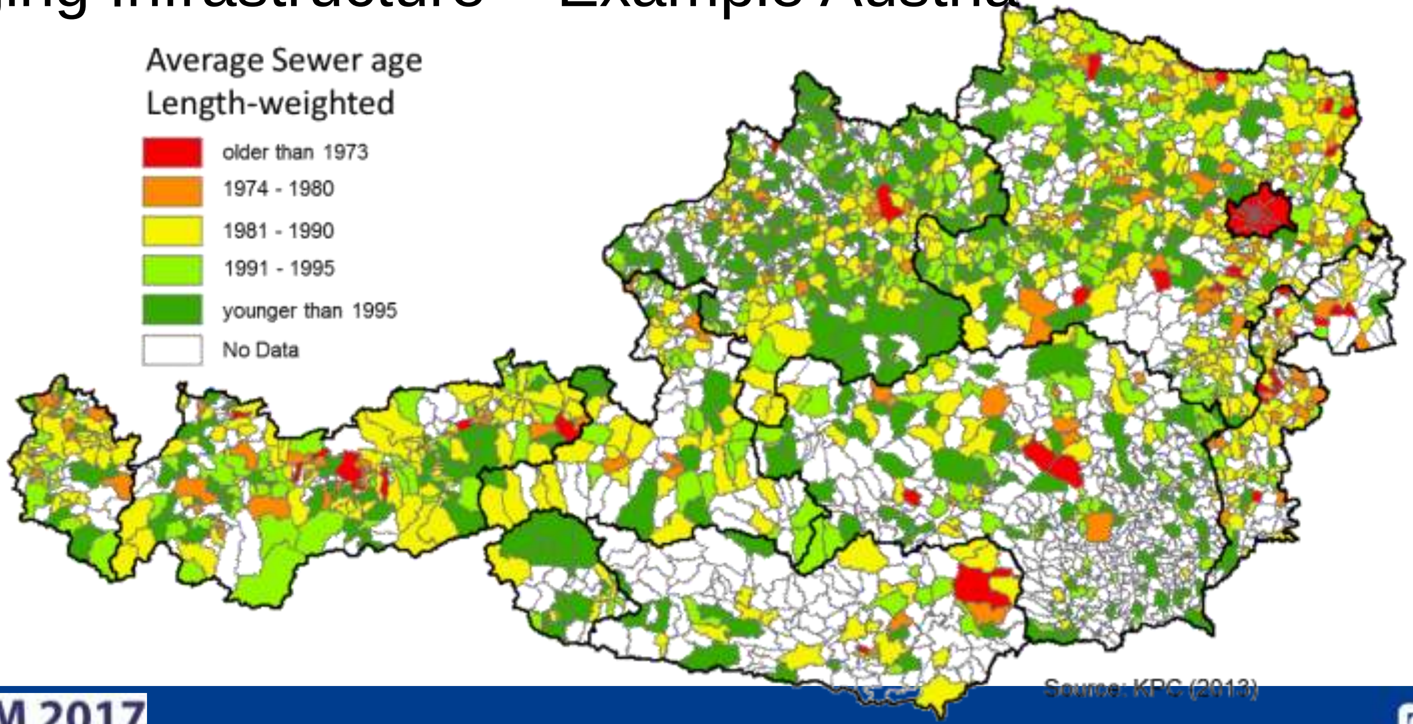
Motivation

- Aging Infrastructure – Example Austria



Motivation

- Aging Infrastructure – Example Austria



Motivation

- Rehabilitation Status Quo – Example Austria
  - Rehabilitation rates are low
    - Current rehabilitation rate for sewers in Austria 0.07% - life expectancy of 1500 years (Breindl 2013)
    - Average rehabilitation rate for water distribution systems in Austria 1.45% (Tscheikner-Gratl et.al. 2015)
  - Investments into water infrastructure are too low
    - In Austria 2016 - 736 Million € will be invested (KPC 2013)
    - 2 billion € should be invested (Cashman & Ashley 2008)

Motivation

- Missing public interest

Source: Vonach (2013)

Source: Hitzfelder (2015)

Source: Kleidorfer (2012)

Source: Egger (2015)

Motivation

- Missing public interest


Source: FF Völs (2013)


Source: Bezirksblatt (2007)

Source: Standard (2015)


Source: ORF Tirol (2015)

Motivation

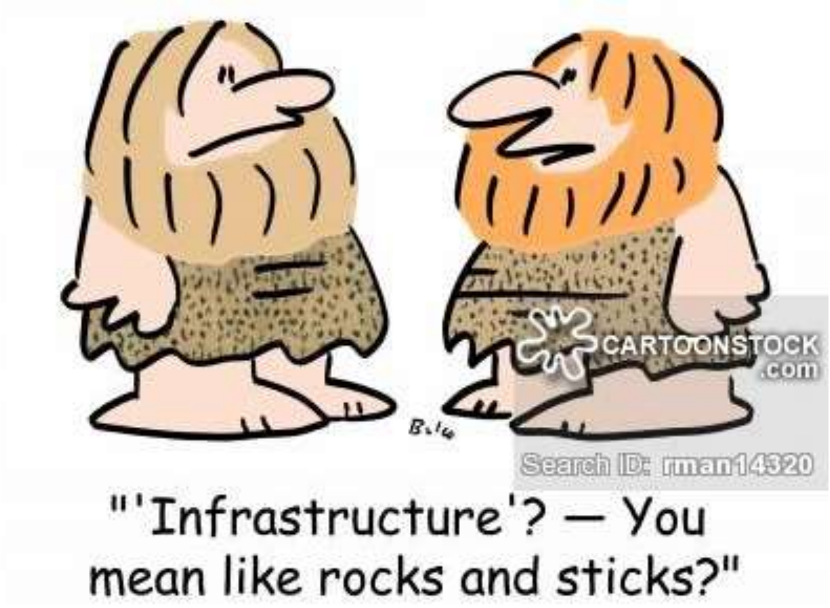
- Missing public interest

Source: GWT (2012)

Source: National Geographic (2010)

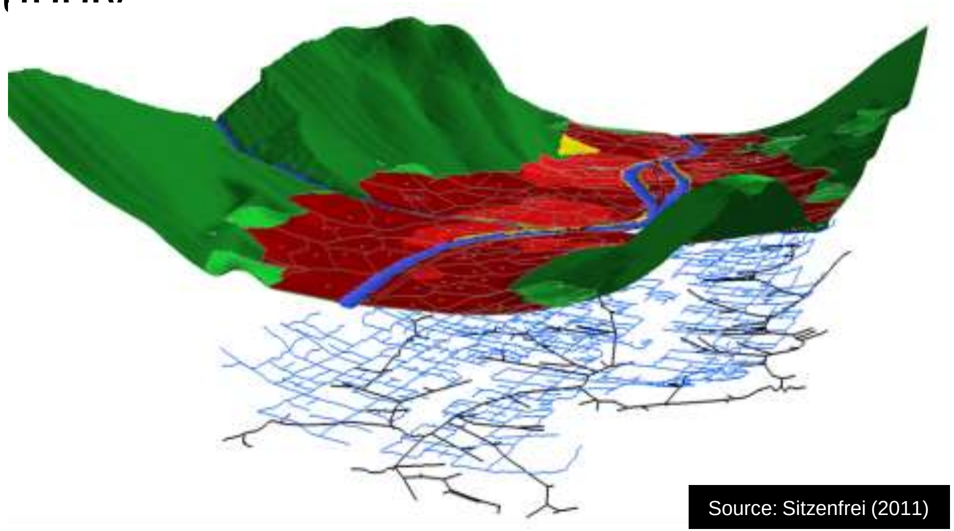
Integrated approach

Integrated approach



Integrated approach

- Pipe networks
  - Sewer / Drainage
  - Water supply
  - Gas



Source: Sitzenfrei (2011)

Integrated approach

- Pipe networks
  - Sewer / Drainage
  - Water supply
  - Gas

Source: Stadt Wien (2013)

- Other networks
  - Traffic facilities (roads, railways)
  - Electrical grids
  - Telecommunication grids
  - District heating

Integrated approach

- Pipe networks
  - Sewer / Drainage
  - Water supply
  - Gas

- Other networks
  - Traffic facilities (roads, railways)
  - Electrical grids
  - Telecommunication grids
  - District heating

Similarities

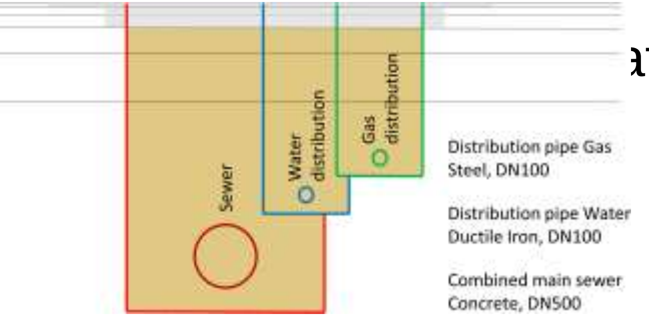
- Essential infrastructure
- Similar layout
- Aging
- Need to be adapted

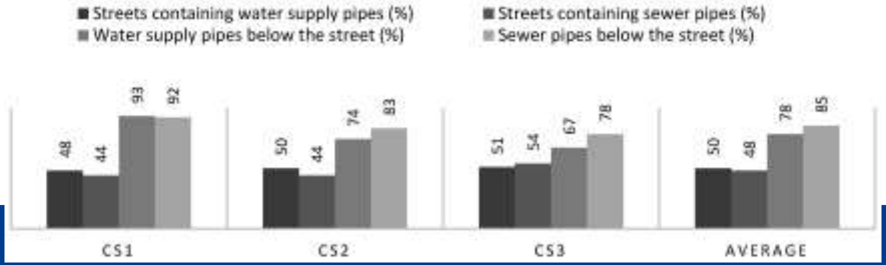
Integrated approach

- Idea:
  - Street sections as container for multiple infrastructure
  - Savin ation

Tscheikner-Gratl (2016)

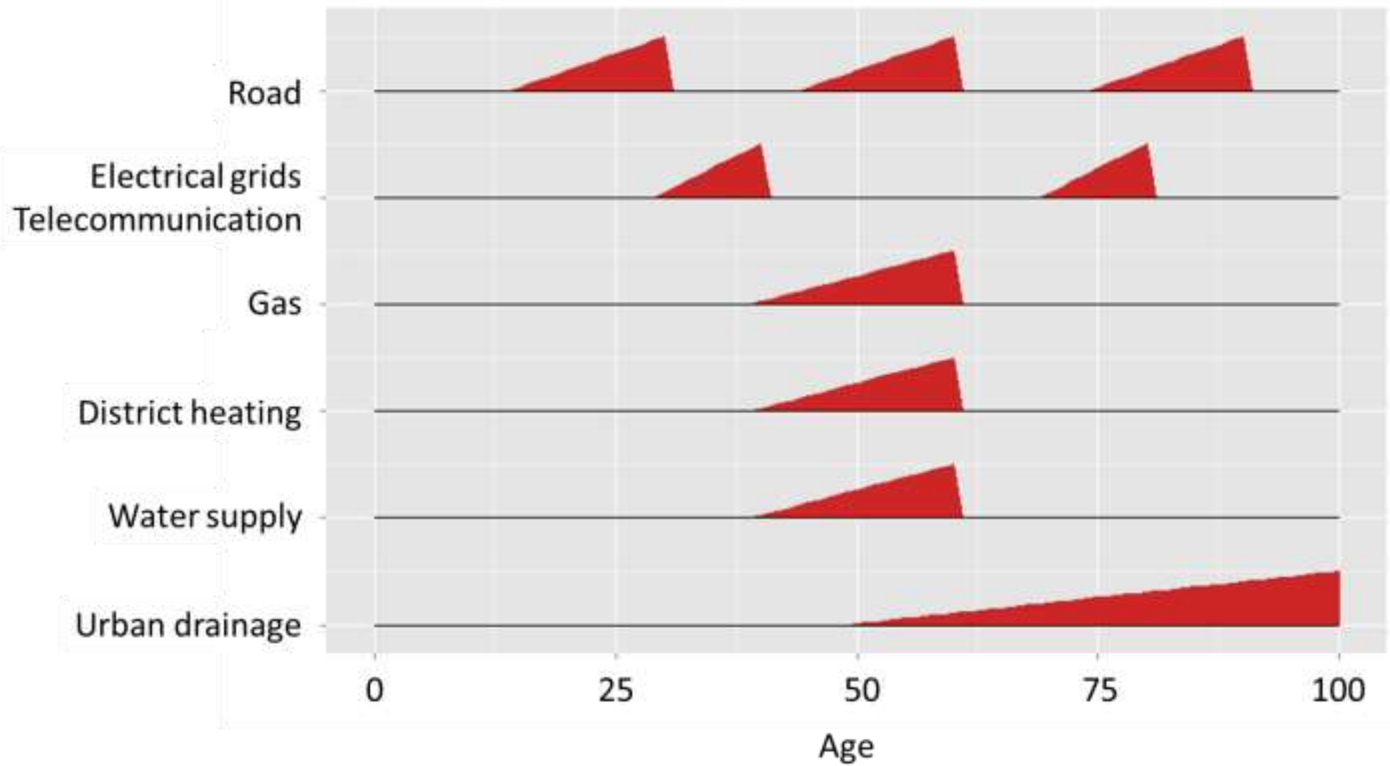
Mair et.al. (2017)





Integrated approach

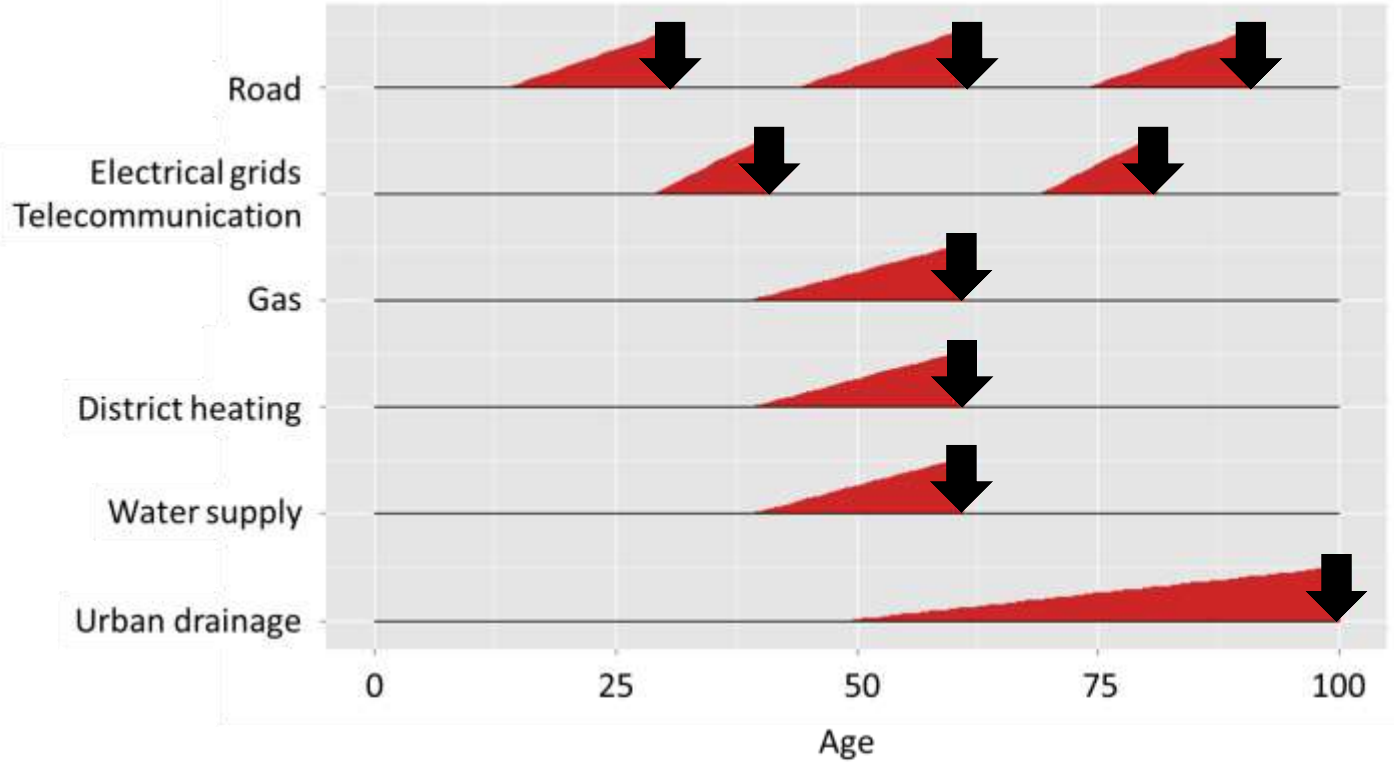
Tscheikner-Gratl (2016)



Life expectancies range from LAWA (2012)

Integrated approach

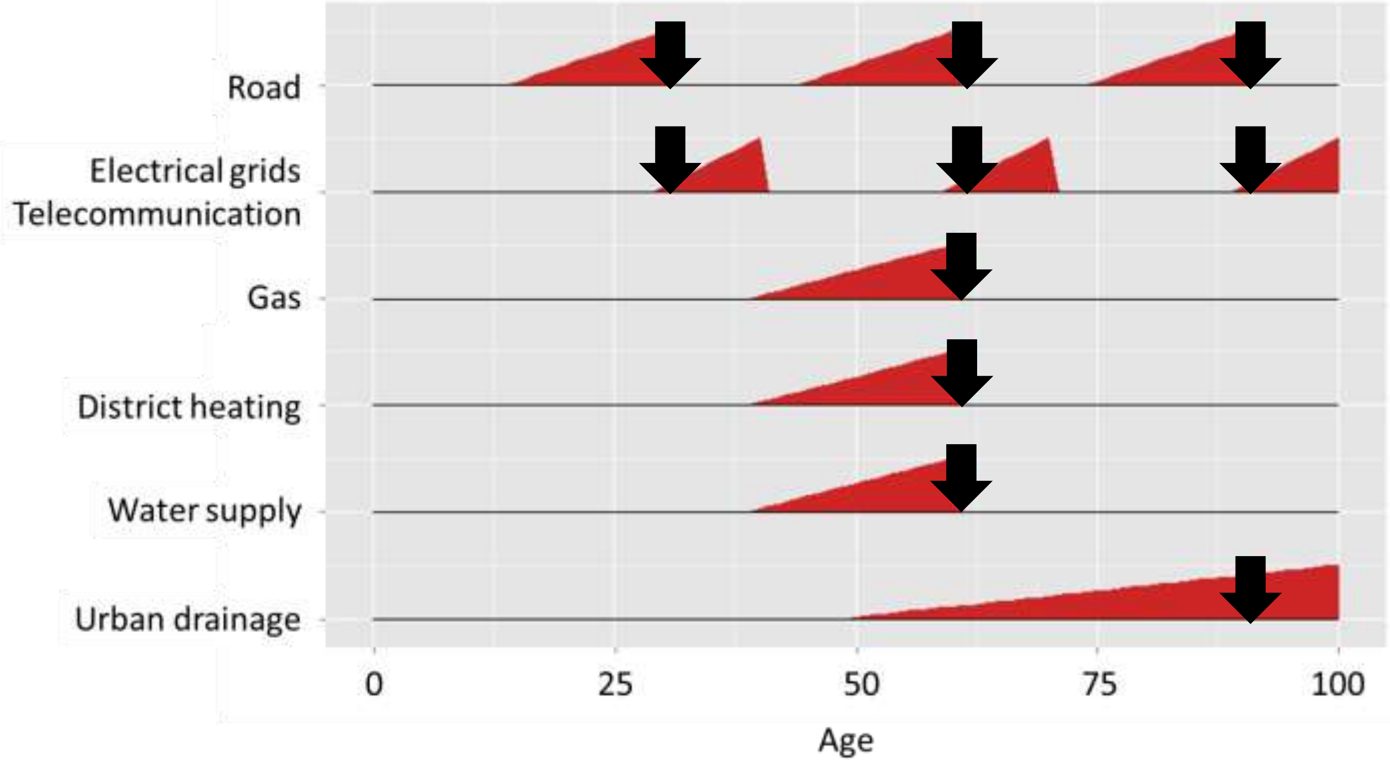
Tscheikner-Gratl (2016)



6 times construction sites

Integrated approach

Tscheikner-Gratl (2016)



3 times construction sites

Challenges

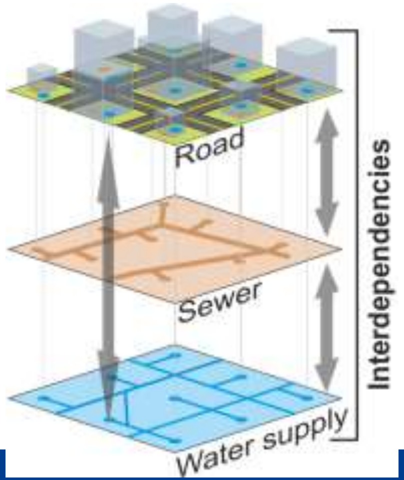
Challenges

- Different goals for the different stakeholders involved

Loucks et.al. (2017)

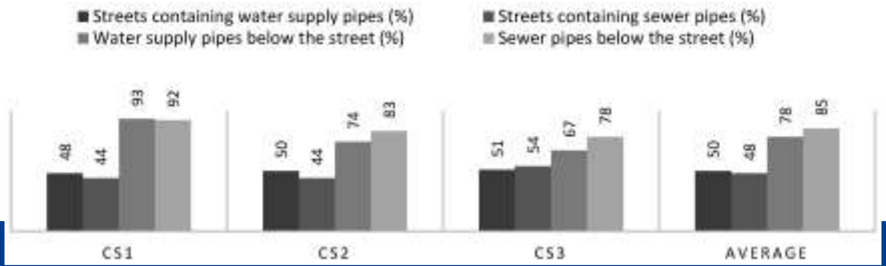
Challenges

- Different goals for the different stakeholders involved
- Interdependencies between the different infrastructures are not completely known and implementable



Challenges

- Different goals for the different stakeholders involved
- Interdependencies between the different infrastructures are not completely known and implementable
- Spatial context: Where in the street section? What about the 20% outside?



Mair et.al. (2017)

Challenges

- Different goals for the different stakeholders involved
- Interdependencies between the different infrastructures are not completely known and implementable
- Spatial context: Where in the street section? What about the 20% outside?
- Influences on the deterioration of adjacent infrastructure

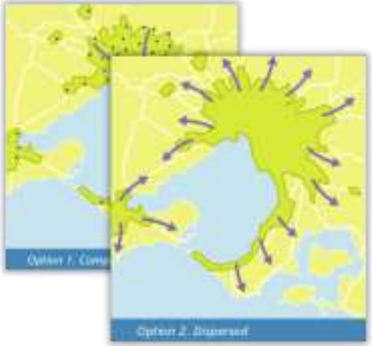
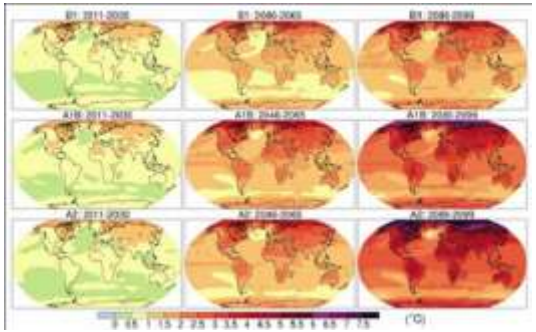
Challenges

- Data management and data quality

Tscheikner-Gratl et.al. (2015)

Challenges

- Data management and data quality
- Changing environmental influences (e.g. urban development)

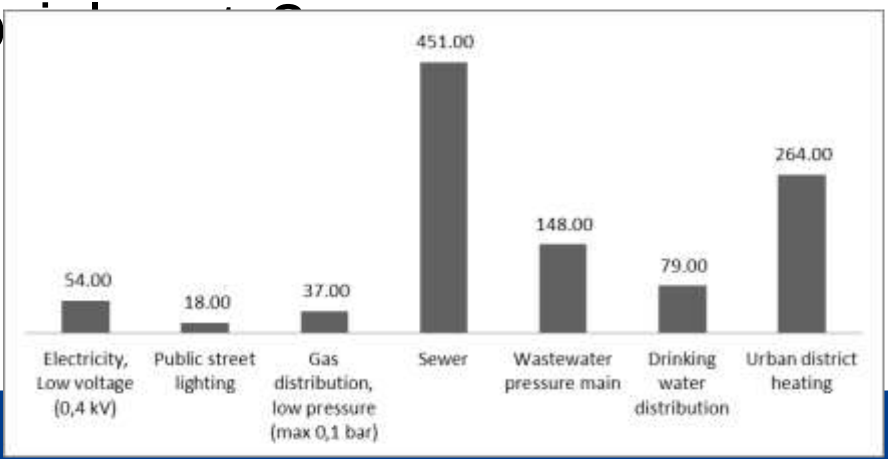



Kleidorfer et.al. (2014)

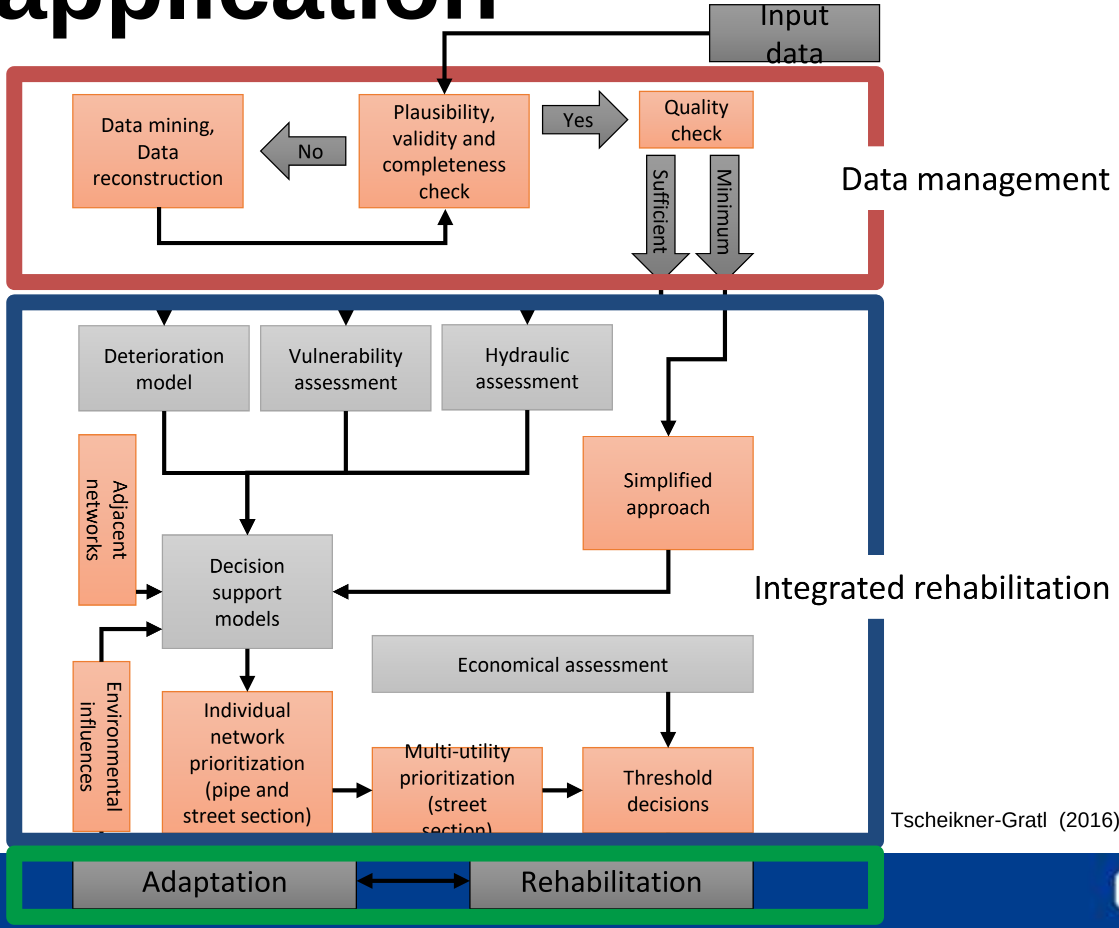
Challenges

- Data management and data quality
- Changing environmental influences (e.g. urban development)
- Economic factors: what are the savings for different infrastructure? So

Typical cost values for construction of different infrastructure in the Netherlands

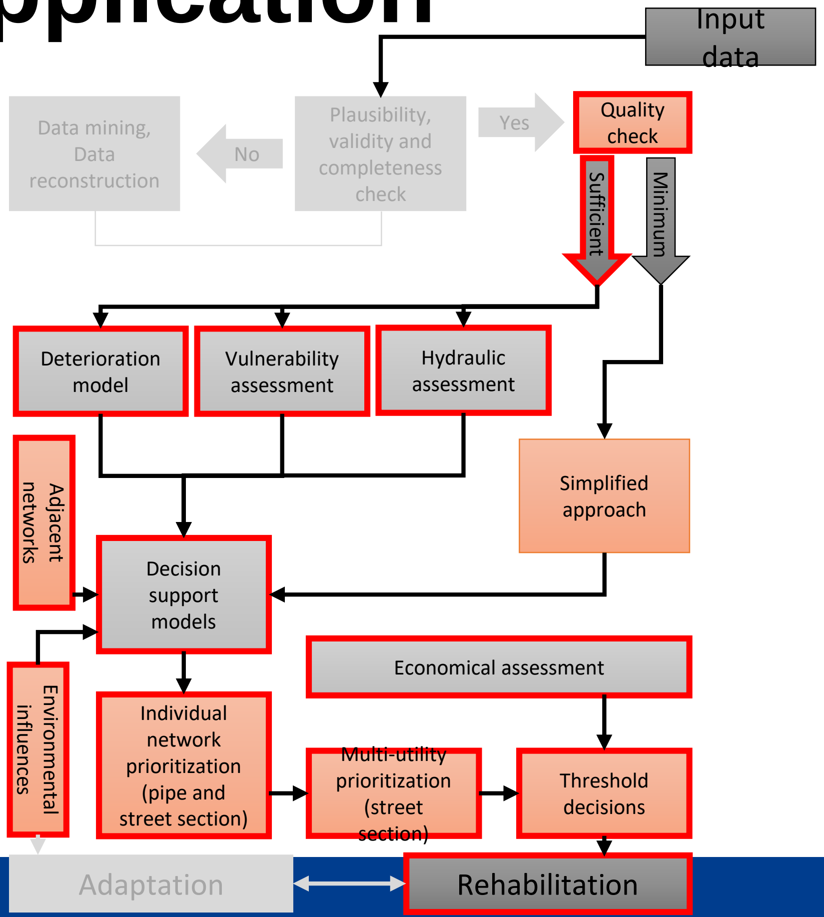


Example application



Tscheikner-Gratl (2016)

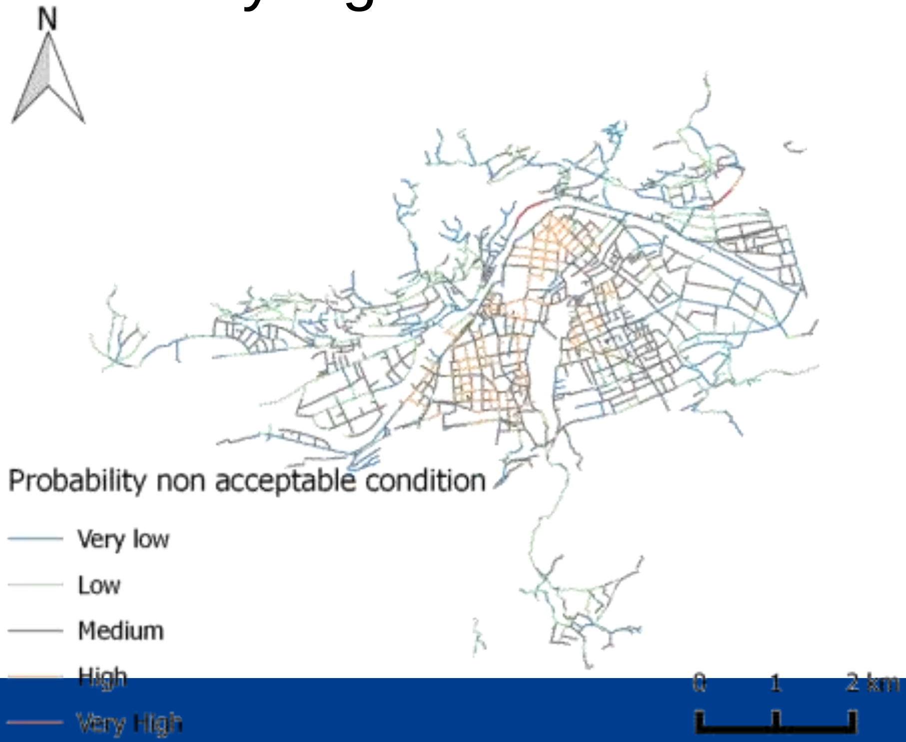
Example application



Tscheikner-Gratl (2016)

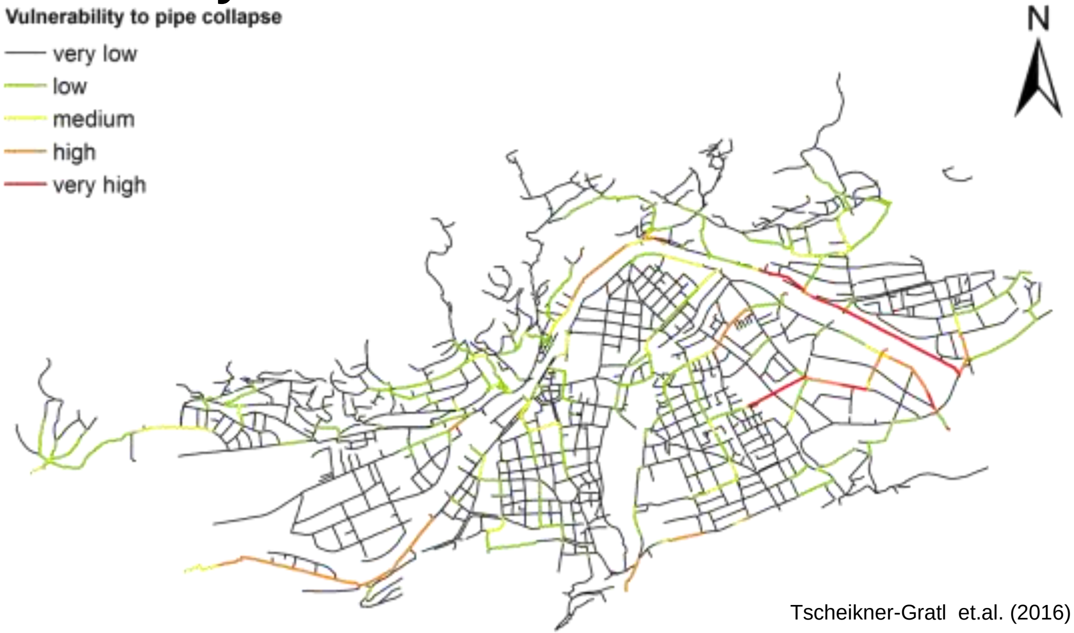
Example application

- Sewer condition → Binary logistic model



Example application

- Sewer Vulnerability → Achilles model



Tscheikner-Gratl et.al. (2016)

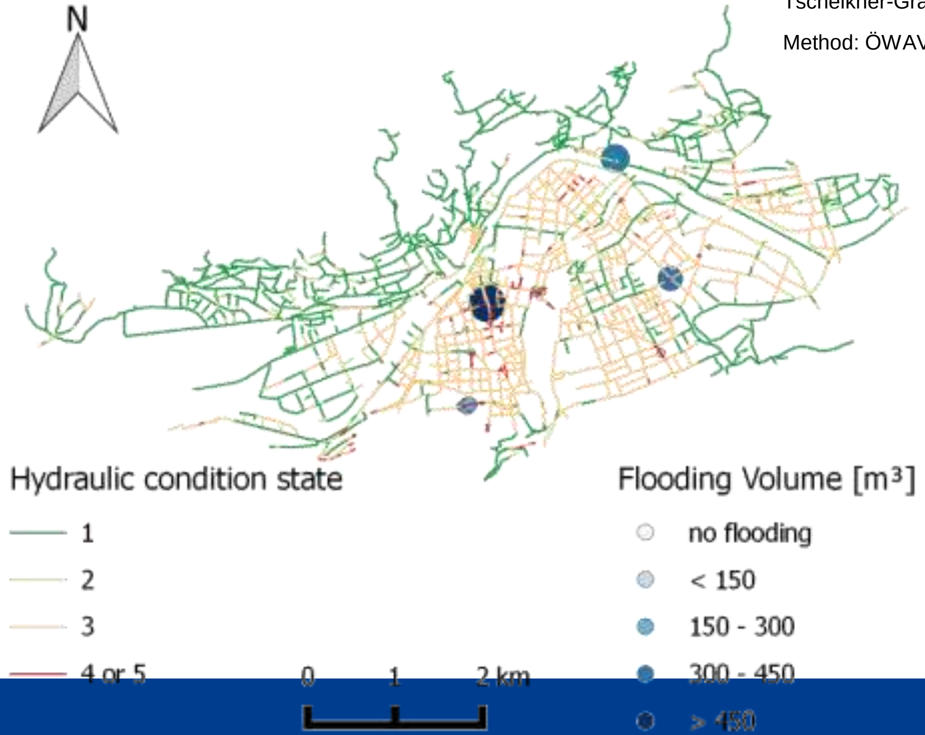
Method: Möderl et.al. (2009)

Example application

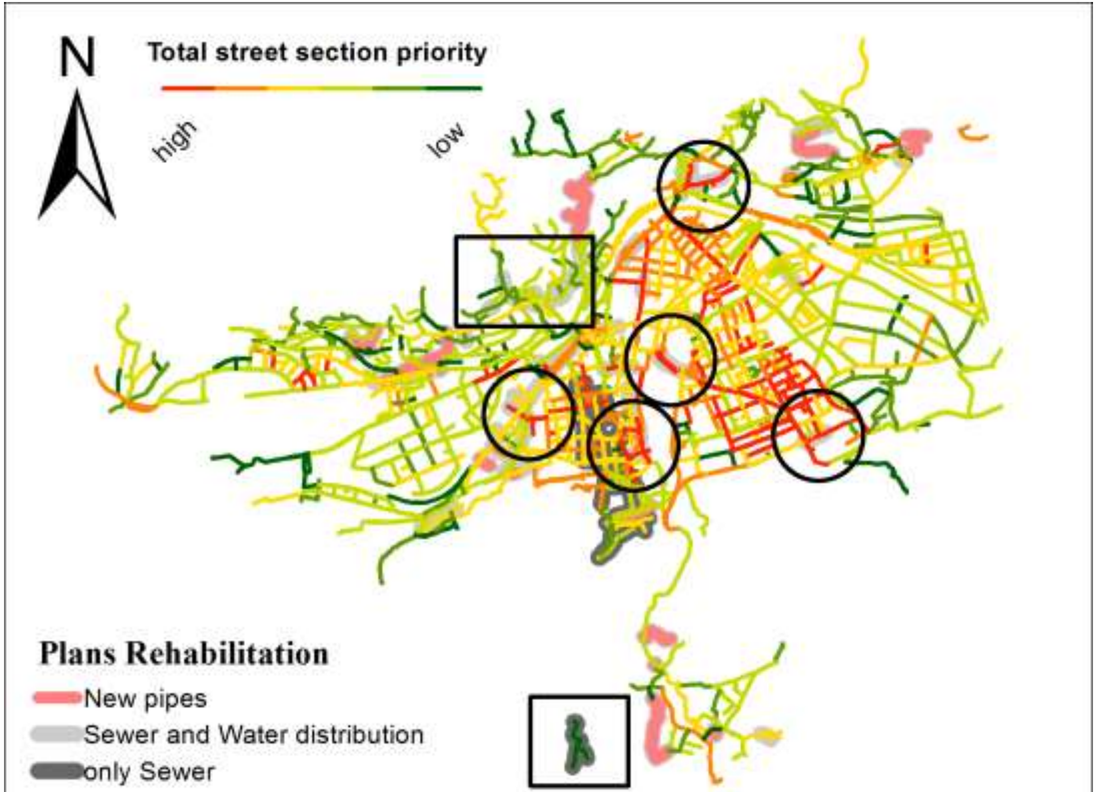
- Sewer hydraulic condition state

Tscheikner-Gratl (2016)

Method: ÖWAV-RB 22 (2015)



Example application



Tscheikner-Gratl et.al. (2016)

Conclusion

- Integrated rehabilitation management is a simple idea with a manifold of challenges.

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- An integrated approach can make sense for most applications. The way of the operators should lead from coexistence over coordination to cooperation.

Conclusion

- Integrated rehabilitation management is a simple idea with a manifold of challenges.
- An integrated approach can make sense for most applications. The way of the operators should lead from coexistence over coordination to cooperation.
- Finding, valuing and implementing of interdependencies into the rehabilitation management process is one of the main challenges

Further Information

Tscheikner-Gratl, F. (2016) Integrated Approach for multi-utility rehabilitation planning of Urban Water Infrastructure, innsbruck university press. ISBN: 978-3-903122-05-5.

Tscheikner-Gratl, F., Sitzenfrei, R., Rauch, W., and Kleidorfer, M. (2016) Integrated rehabilitation planning of urban infrastructure systems using a street section priority model. Urban Water Journal, 13(1), 28–40. DOI: 10.1080/1573062X.2015.1057174.

Tscheikner-Gratl, F., Sitzenfrei, R., Stibernitz, C., Rauch, W., and Kleidorfer, M. (2015) “Integrated rehabilitation management by prioritization of rehabilitation areas for small and medium sized municipalities” in World Environmental and Water Resources Congress 2015: Floods, Droughts, and Ecosystems - Proceedings of the 2015 World Environmental and Water Resources Congress. DOI: 10.1061/9780784479162.201.

Mair, M., Zischg, J., Rauch, W., and Sitzenfrei, R. (2017) Where to Find Water Pipes and Sewers? — On the Correlation of Infrastructure Networks in the Urban Environment. Water, 9(2), 146–161. DOI: 10.3390/w9020146.

Thank you for your attention!

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LESAM 2017
NTNU, Trondheim, Norway

Presentations

Session 3:

Best practices in IAM

Short and long-term planning

Norwegian University of Science and Technology

Presentation 1

Maryam Beheshti: Sustainability analysis of the sewer networks by Dynamic Metabolism Modeling

Sustainability analysis of the sewer network of Trondheim City in Norway by Dynamic Metabolism Modeling

Maryam Beheshti; Sveinung Sægrov

Norwegian University of Science and Technology (NTNU)

Maryam.beheshti@ntnu.no

Leading Edge Sustainable Asset Management of Water and Wastewater Infrastructure
June 20 – 22, 2017, Trondheim, Norway

Introduction

- Sustainability is expanding to all aspects of human life and Urban water system (UWS) are not deprived of this concept.

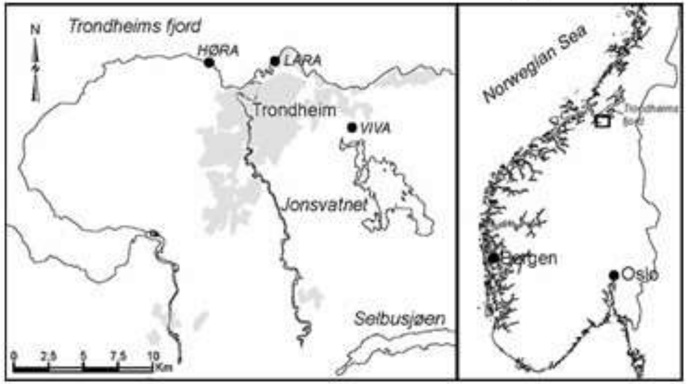
- The wastewater transport system has not been considered by itself in previous sustainability studies.

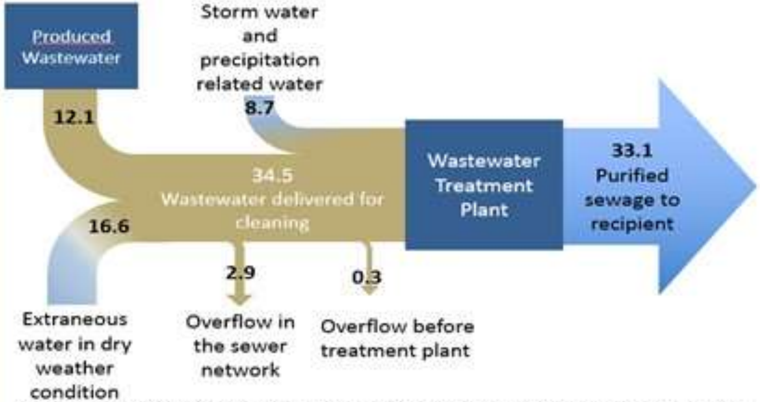
- Sewer networks deputize a high value in water infrastructure assets and it is essential to consider aging and manage them by determined sustainable plans.

- In this study, the metabolism of wastewater transportation system in Trondheim is analyzed from the sustainability point of view by Dynamic Metabolism Model (DMM) to demonstrate a methodology for evaluating different directions toward a sustainable management of wastewater systems.

Source: www.melbournewater.com.au

Case study





Water balance 2009-2011 (million m^3/year), Trondheim, Norway

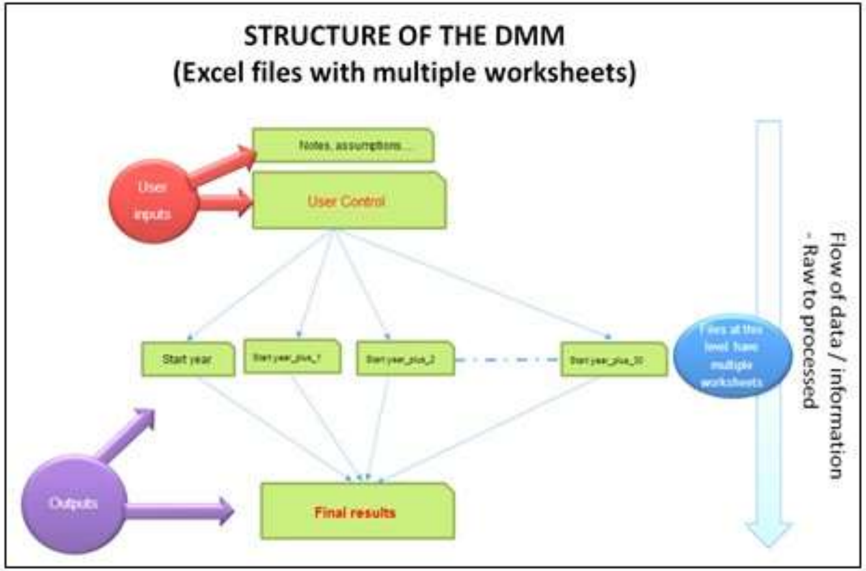
- Trondheim city is the third largest town in Norway by population.
- The wastewater transport system of Trondheim is about 1200 km with the average age of 30 years.
- 51.7% of the total length of the foul sewer network is separated, and 48.3% of them are combined sewers.
- 54 pumping stations
- The amount of infiltration and inflow of extraneous water in to the sewer system in dry weather condition is about 48% of the water which is delivered to the wastewater treatment plant.

Methodology

- **DMM (**Dynamic Metabolism Model**)** is a metabolism-based model, derived from methods of material flow analysis (MFA) and life cycle assessment (LCA). This model is based on analysis of material inflow to the UWS and outflow of them in the context of energy and GHG and byproducts from the system in the life cycle of the material.

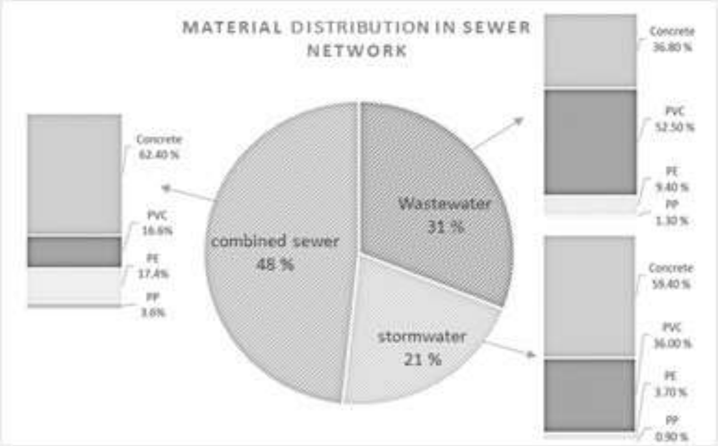
- This model consists of different section of UWS: *Raw water sources*; *Water treatment*; *Water distribution*; ***Wastewater transport***; *Wastewater treatment*

- The flow of material and resources to wastewater transport network has been exploited as DMM model inputs

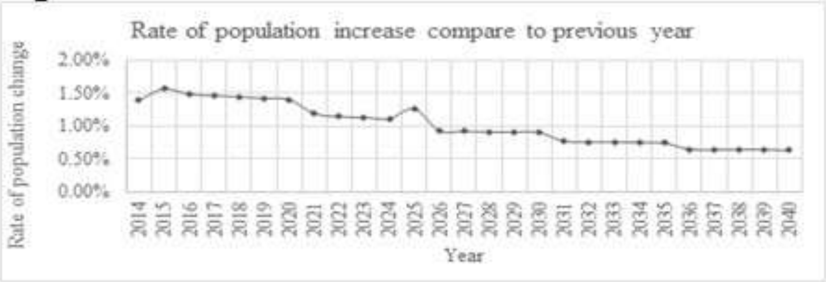


Reference: WM² & Dynamic Metabolism Model – Testing on Oslo's water and wastewater system; 2014

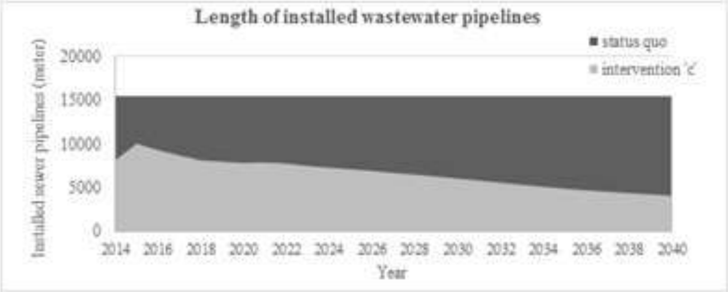
Data and Model inputs



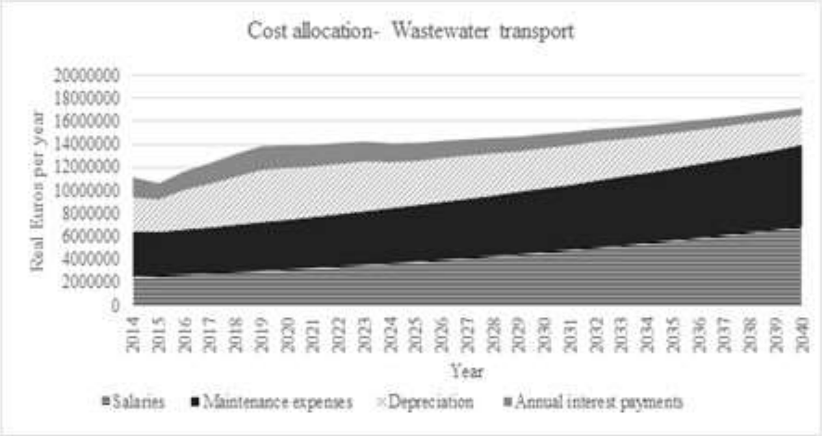
Trondheim municipality sewer pipeline material at the end of 2013



Population growth forecast for Trondheim



Length of installed pipelines



Investment Plan sewage transportation system Trondheim for 2013-2040

Risk factors and interventions of wastewater transportation system

- The impacts of various risk factors have been examined and compared with 'status quo' with a constant development of the wastewater network as average of 2005-2013.

- Four different scenarios and interventions regarding population growth, asset deterioration, network development and energy management have been defined and analyzed until 2040.

Interventions	Risk factors			
	Population growth	Sewer asset deterioration	Energy consumption	Climate change
a: Reduction of Infiltration and inflow		■	■	■
b: Increase of rehabilitation rate		■		
c: Extension of WW transportation network	■			
d: Energy management			■	
a+b		■	■	■
a+c	■	■	■	■
a+d		■	■	■
b+c	■	■		
b+d		■	■	
c+d	■		■	
a+b+c	■	■	■	■
a+b+d		■	■	■
a+c+d	■		■	■
b+c+d	■	■	■	
a+b+c+d	■	■	■	■

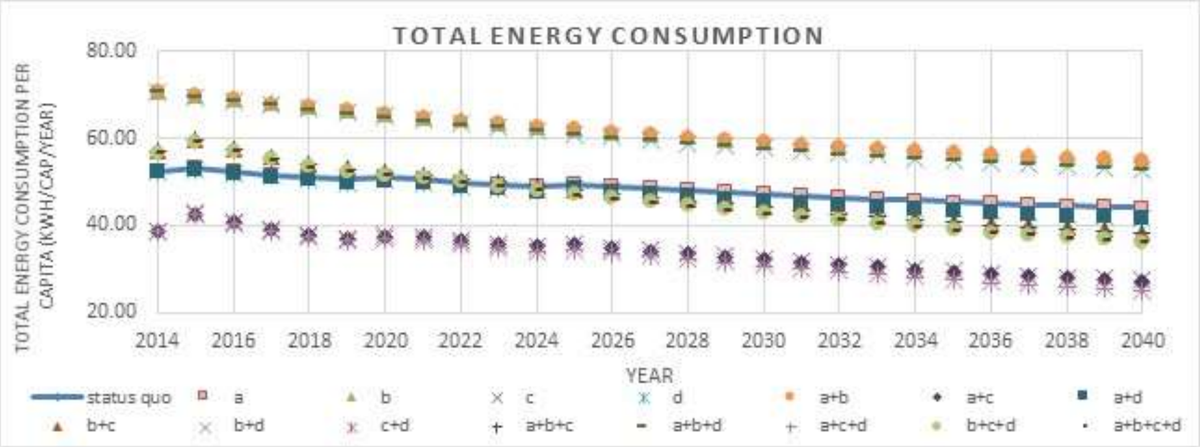
Results and Discussion

Percentage of decrease in comparison with status quo	Color of desirable changes	Color of undesirable changes
0-1 %		
1-10%		
10-20%		
20-30%		
30-40%		
40-50%		
50-60%		
>50%		

Color-codes of indicators' change in comparison with status quo in %

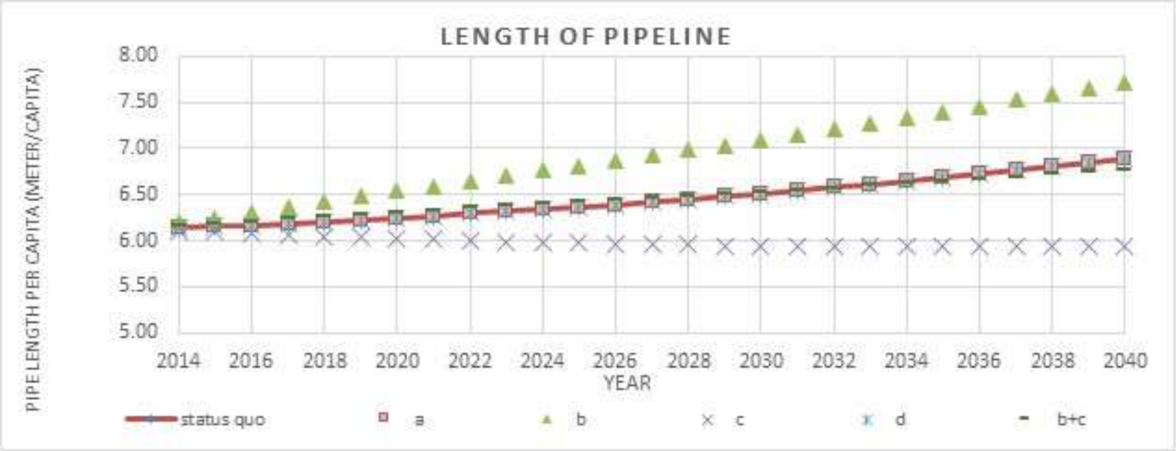
Indicators		Environmental		Physical & Functional		Economic	
		GHG emissions per capita (kg CO2-eq per cap/y)	Total energy consumption per capita (kWh per cap/y)	Length of pipelines per capita (km per cap)	Wastewater treated per cap per year (m^3 per cap)	O&M expenses per capita (Euros per cap/y)	Capital expenditure per capita (Euros per cap/y)
Increase **desirable? (Y/N)**		N	N	Y-N	N	N	Y-N
Interventions in 2040	a	-0.3	-0.55	0.0	-9.4	1.01	0.0
	b	29.9	24.9	12.1	-6.7	3.11	254.3
	c	-40.1	-37.6	-13.8	0.0	-4.6	-44.2
	d	-4.3	-5.0	0.0	0.0	0.08	0.0
	a+b	29.5	24.4	12.1	-16.1	4.11	254.3
	a+c	-40.4	-38.2	-13.8	-9.4	-3.6	-44.2
	a+d	-4.6	-5.6	0.00	-9.4	1.09	0.00
	b+c	-10.2	-12.6	-1.6	-6.7	-1.5	238.6
	b+d	25.6	19.9	12.1	-6.7	3.2	254.3
	c+d	-44.4	-42.6	-13.8	0.00	-4.56	-44.2
	a+b+c	-10.5	-13.2	-1.63	-16.1	-0.52	238.6
	a+c+d	-44.7	-43.2	-13.8	-9.35	-3.55	-44.2
	a+b+d	25.3	19.4	12.1	-16.1	4.19	254.3
	b+c+d	-14.5	-17.6	-1.6	-6.7	-1.45	238.6
	a+b+c+d	-14.8	-18.2	-1.6	-16.1	-0.44	238.6

Changes of selected indicators in percent in 2040 for Trondheim wastewater transport system in comparison with 'status quo'



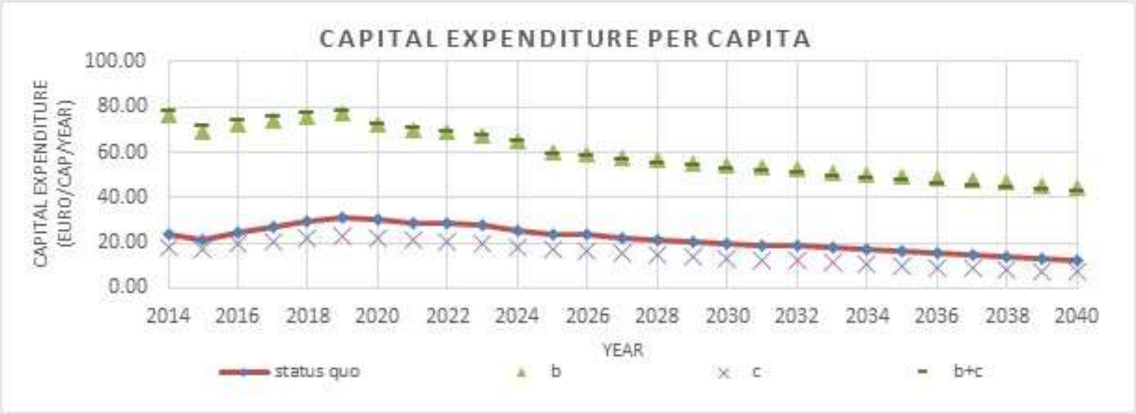
General overview of changes in total energy consumption per capita

Change in GHG emissions per capita (status quo, ‘a’, ‘b’, ‘c’, ‘d ’)



Changes in length of pipeline per capita

Changes in wastewater treatment volumes per capita



Changes in capital expenditure per capita

Change in operation and maintenance expenses per capita

Conclusion

- The results of this type of sustainability analysis of wastewater systems can enlighten the way for decision-makers in wastewater section of Trondheim and other cities.

- For obtaining a sustainable infrastructure asset management of sewer network and making decisions, it is indispensable to consider different aspects of sustainability accurately and manage them in a comprehensive system.

- This can lead to strategic and long-term management in wastewater transport system by having more focus on environmental characteristic of sustainable sewer asset management as well as the economic, physical, functional and social features.

‘The more we understand about our assets, the better we can manage them.’

Thanks for your attention!

Presentation 2

Edvard Sivertsen Asset management of nature-based solutions: What information to collect for maintenance management- Application in Trondheim, Norway

Asset management of nature-based solutions: What information to collect for maintenance management – Application in Trondheim, Norway

KLIMA 2050

CONSORTIUM

Private sector

SKANSKA
MESTERHUS
Multiconsult
Finans Norge
SKJÆVELAND GRUPPEN
NORGESHUS
weber
isola
powel

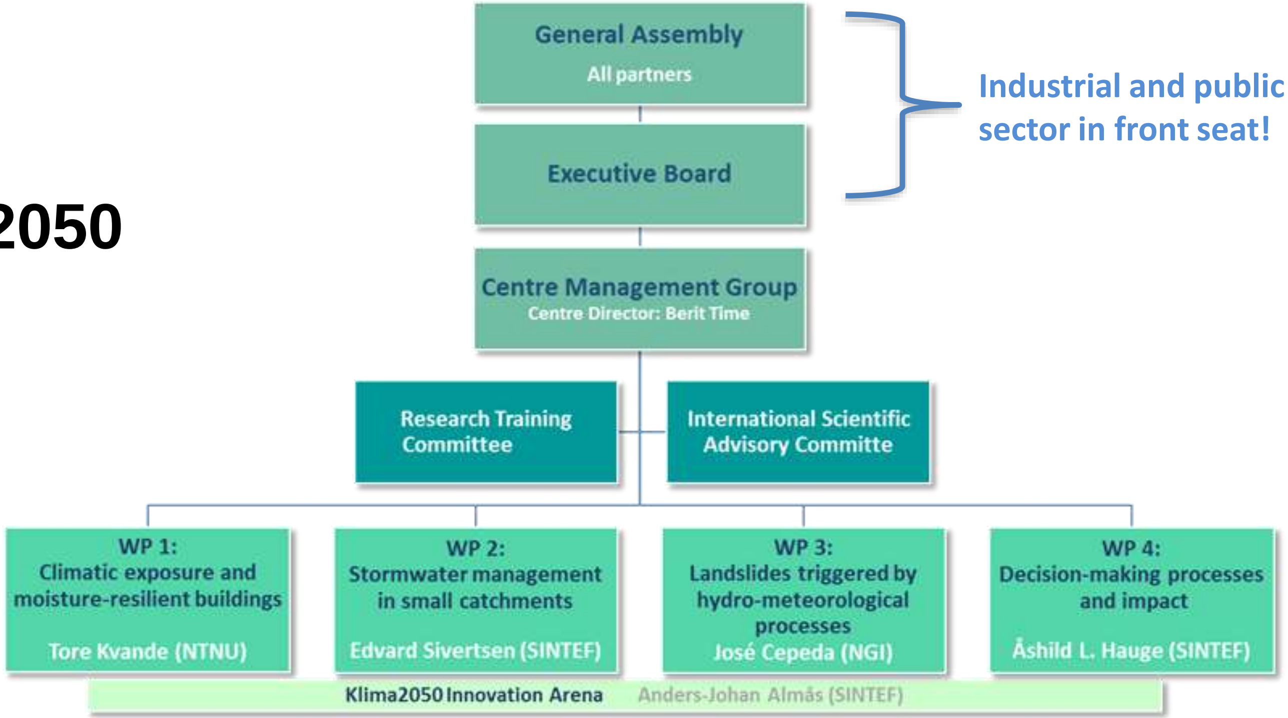
Public sector

Statens vegvesen
NVE
AVINOR
Jernbaneverket
STATSBYGG

Research & education

SINTEF
BI
NTNU
Meteorologisk institutt
NGI

Klima 2050


General Assembly
All partners
Executive Board
Industrial and public sector in front seat!
Centre Management Group
Centre Director: Berit Time
Research Training Committee
International Scientific Advisory Committe
WP 1: Climatic exposure and moisture-resilient buildings
Tore Kvande (NTNU)
WP 2: Stormwater management in small catchments
Edvard Sivertsen (SINTEF)
WP 3: Landslides triggered by hydro-meteorological processes
José Cepeda (NGI)
WP 4: Decision-making processes and impact
Åshild L. Hauge (SINTEF)
Klima2050 Innovation Arena
Anders-Johan Almås (SINTEF)

WP2 Stor[illegible] nt

Background: White paper on stormwater (2015)

1. How large is the problem?

2. How serious is the risk?

3. What can we learn from nature?

4. What do we do with polluted stormwater?

NTNU
Norwegian University of
Science and Technology

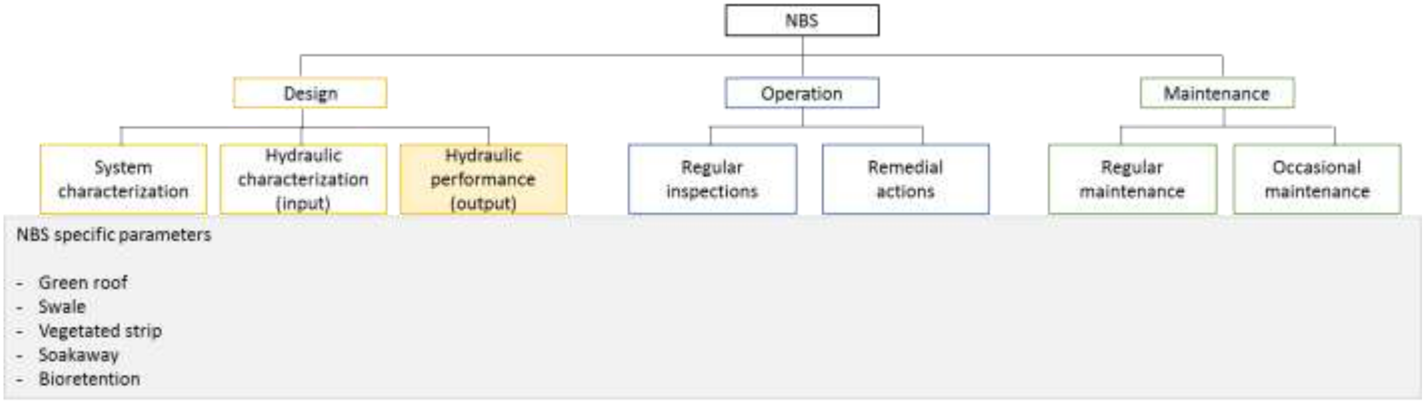
Infrastructure asset management for nature-based solutions (NBS): a guidance for collecting asset information and data for NBS maintenance management Application at Trondheim district (Norway)

Carlos Hidalgo Martínez

Master of Science in Civil and Environmental Engineering
Submission date: July 2016
Supervisor: Rita Maria Ugarelli, IVM
Co-supervisor: Sægrov Sveinung, IVM

Norwegian University of Science and Technology
Department of Hydraulic and Environmental Engineering

NBS data model



How to identify the best combination of NBS solutions to decrease runoff?

A case study from Trondheim:

1. Testing the QuaDEau toolbox
2. Assessing whether the toolbox is useful for Norwegian conditions

QuaDEau toolbox

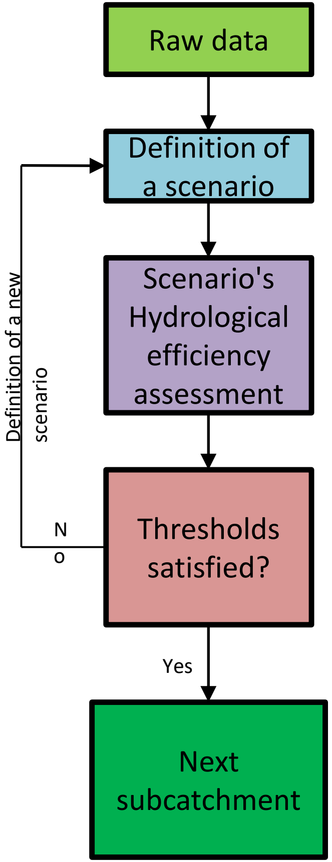
- Toolbox for managing the stormwater at the neighborhood scale
- calculating the infiltrated, evapotranspirated and stored quant
- not limited to the and provides a v

How does it work?

- Decision-support toolbox
- Scaling down the neighborhood according to the user preference
- Each subcatchment consists of some specific surfaces
- Needed information:
- Type of the surface
- Run-off path
- Soil infiltration rate & soil type
- Information about rooftops
- Received flow from upstream

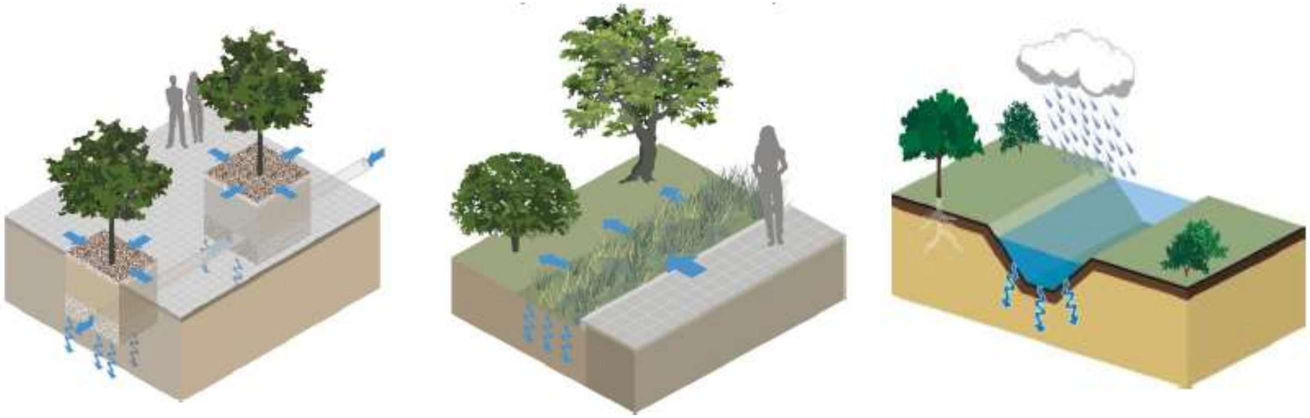
Methodology

1. Information about the subcatchment
2. First scenario about the desired spatial planning:
    - Design rainfall
    - Acceptable outlet flow
    - Dimensions of NBS
    - The precise runoff path in the subcatchment
3. Hydrological water-balance analysis
4. Outlet flow at the end of runoff path
5. If solution's not acceptable, user can modify the scenario!



Choices of NBS

- Wide range of NBS available in the toolbox

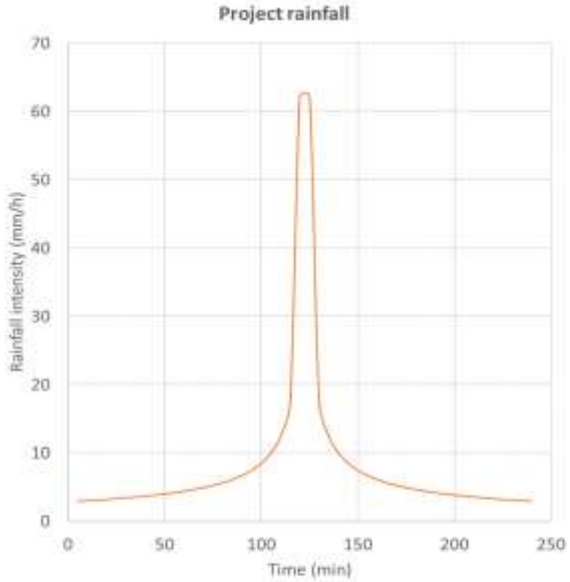


Case study

- Trondheim:
- 3rd Norwegian city
- Monthly precipitation 40 mm to 100 mm during the year.
- Site's run-off coef. 90%
- Elgesetergate towards the city center

Site's characteristics

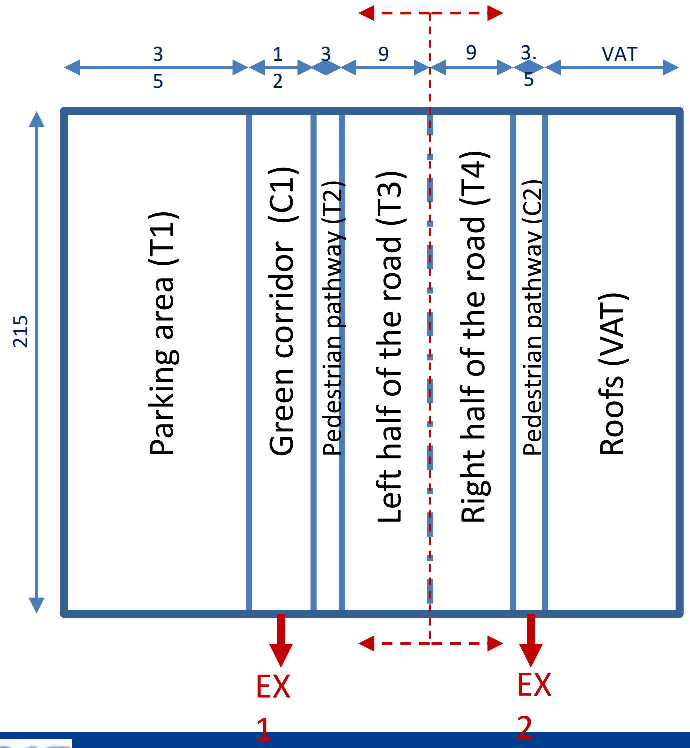
- Design rainfall:
- Return-period 20 years
- Duration 240 mins
- Infiltration rate about 40 mm/h
- Dry initial soil condition



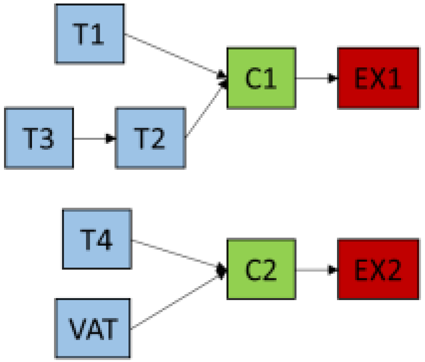
Site's configuration

- One parking area
- Two pedestrian pathways
- One swale
- One avenue and houses

Run-off path



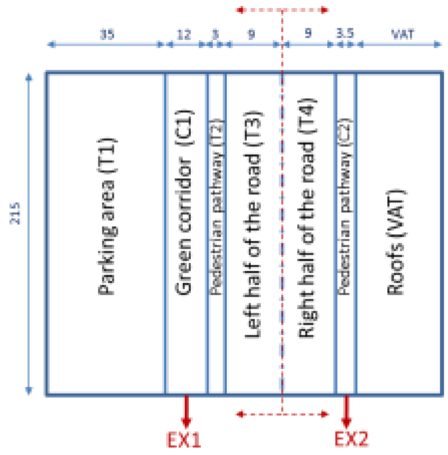
3
5
1
2
3
9
9
3.
5
VAT
215
Parking area (T1)
Green corridor (C1)
Pedestrian pathway (T2)
Left half of the road (T3)
Right half of the road (T4)
Pedestrian pathway (C2)
Roofs (VAT)
EX
1
EX
2



T1
T3
T2
C1
EX1
T4
VAT
C2
EX2

Scenarios

- •S0: baseline scenario
- •Scenarios about C1:
  - S1: Swale with perfect operational condition
  - S2: Swale with 50% of its initial infiltration capacity due to the obstruction/siltation/clogging (20 mm/h);
  - S3: Swale with 38% of its initial infiltration capacity (15 mm/h);
- •Scenarios about C2:
  - S4: 100% pervious surface;
  - S5: Operating under 50% of capacity due to the clogging.
-

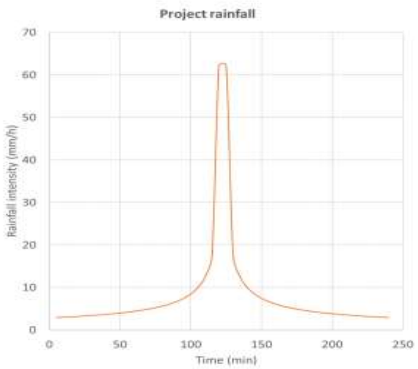


Why asset management for NBS?

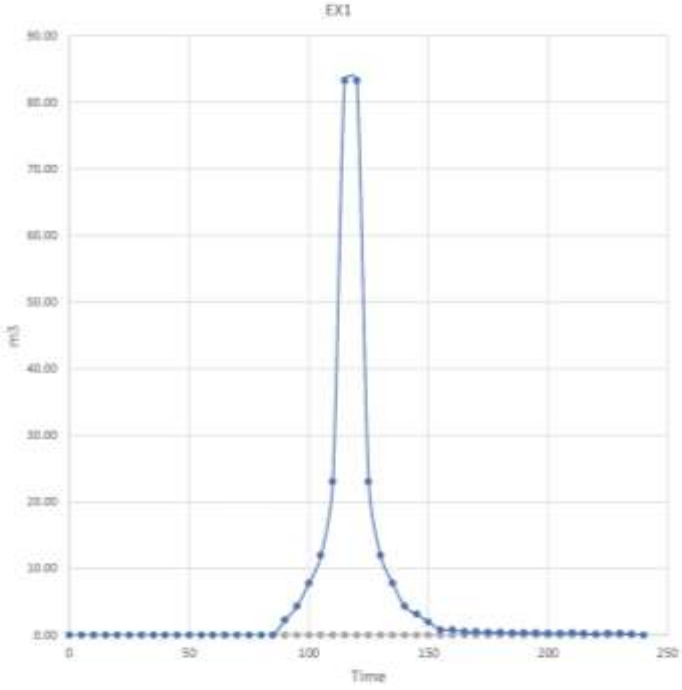
Adapted from Blecken et al., 2017

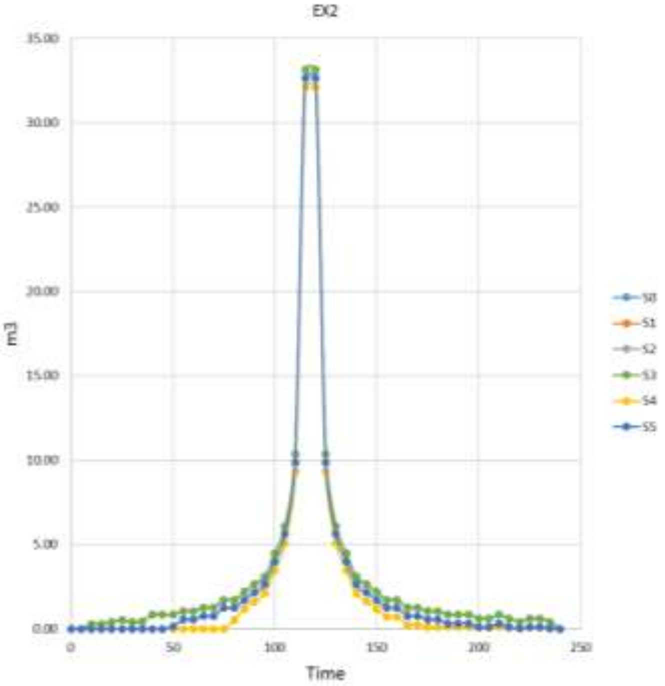
	Left subcatchment (LC)	Right subcatchment (RC)	Whole site
Precipitated volume	432.6 m^3	163.6 m^3	596.1 m^3

Precipitated volume



Res


EX1
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
m3
0
50
100
150
200
250
Time


EX2
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
m3
0
50
100
150
200
250
Time
S0
S1
S2
S3
S4
S5

Next steps

- Possibility of applying different rainfall
- Possibility of modifying initial soil moisture condition
- Implementing the DST into GIS software
    - Studying spatial effects of NBS on the flooding

Presentation 3

Mohammed Reza Mohebbi: Protecting water resources by implementation water safety plans

IWA Leading Edge conference on Strategic Asset Management of water and wastewater infrastructures.

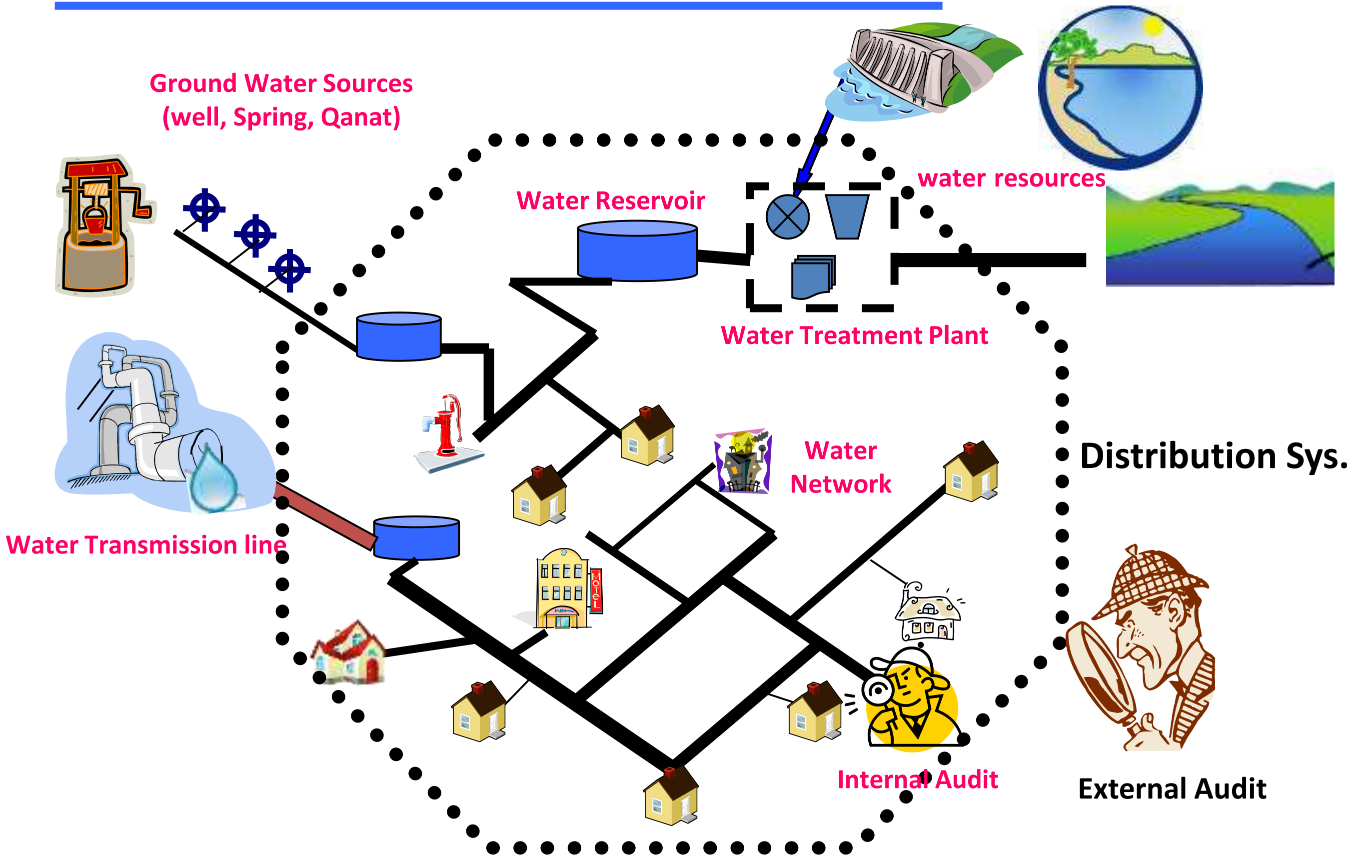
NTNU, Trondheim, Norway, 20 - 22 June 2017

Protecting water resources by implementation water safety plans

MOHAMMAD REZA MOHEBBI

LESAM 2017
NTNU, Trondheim, Norway

WSP Implementation Necessity



End-point Monitoring Approach

Some experiences due to lack of WSP

❖Intentional contamination of drinking water in storage tanks due to lack of appropriate physical protection.

❖Crude oil entering to the intake of water treatment plant with a capacity of 10 m^3/s due to fracture of oil pipeline.

❖Overturned tanker carrying 10000 Liters of MTBE in dam.

❖Viral infection in drinking water in a city with a large number of intestinal disease, despite of negative coliform bacteria test results and appropriate concentration of free residual chlorine in the water distribution network.

Features Of End Point Control System:

- Retrospective instead of prospective
- Just **Identify** the contamination **Not Prevent**
- Just quality control not quality assurance

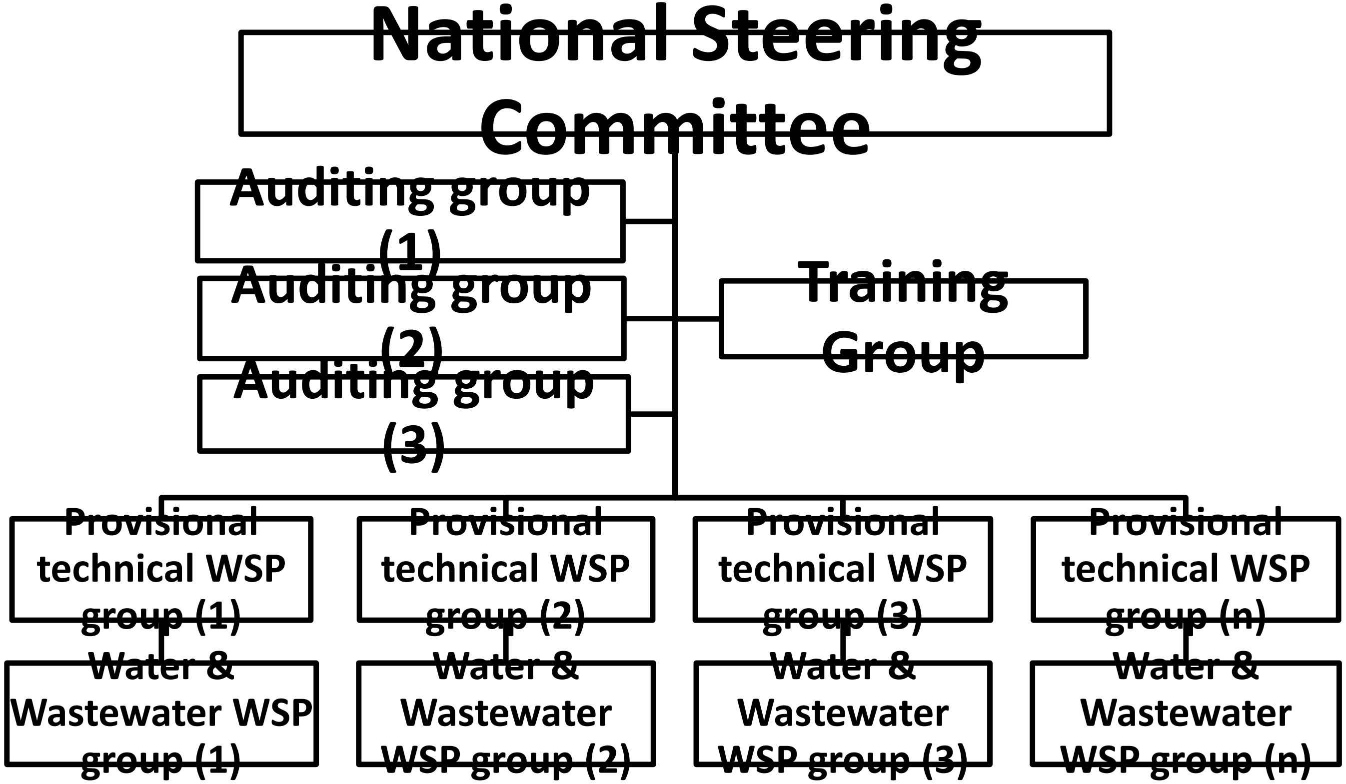
The Most Important Outcome of WSP:

Water safety plan by applying risk management can lead to prevention of pollution and helping to ensure the good quality of water.

Iran's actions to implement steps of WSP:

- Formation of WSP national steering committee.
- Water safety plan as a law.
- Implementing WSP as a Pilot plan in Tabriz.
- Holding Training Courses.
- Preparing Manual for implementing WSP.
- Developing WSP in 14 cities in five steps.
- Organizing 3 auditing groups.
- Starting implementation of the WSP in 16 other cities.

Structure of WSP Implementation



WSP Development

First Step:
1. Tabriz

Second Step:
1. Ahwaz
2. Kashan
3. Esfahan

Total: 15 Cites

Third Step:
1. Zahedan
2. Mashhad
3. Gorgan
4. Rasht
5. Saari
6. Bandar abbas
7. Kermanshah
8. Shiraz
9. Tehran
10. Uremia
11. Karaj

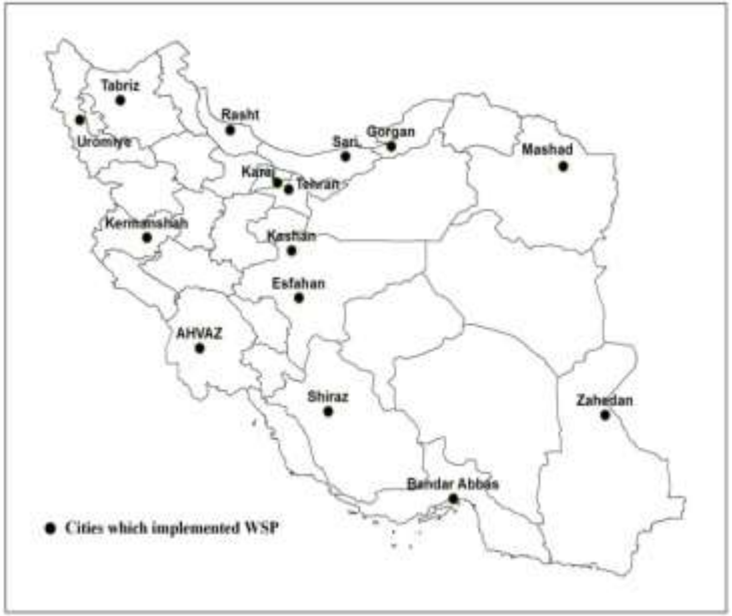


Figure 1: The locations of the cities were selected for implementing WSP

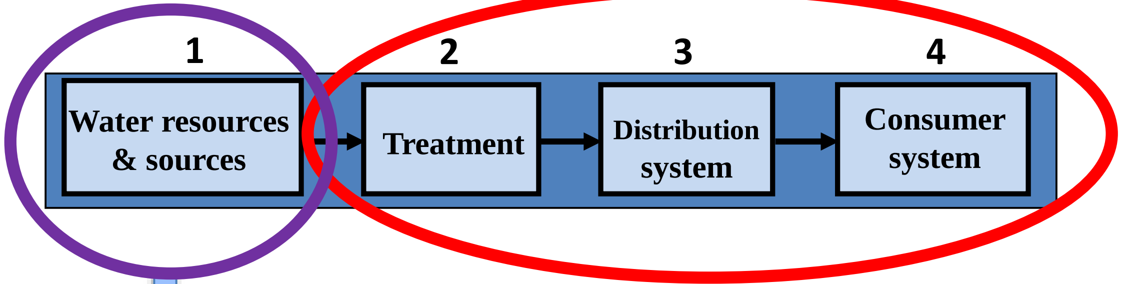
Auditing as an engine for WSP progressing

❖Organizing auditing groups

In order to monitor the progress of the WSP as well as fix problems in the WSP implementing, three auditing groups were formed .

❖The duty of these groups :

- ❖attending in these 15 cities
- ❖ review the documentation of WSP implementation
- ❖ providing guidance to correct mistakes
- ❖ finally reporting progress to NSC



Water & waste water companies

Catchment is under effects of these organizations

Agriculture Affairs	Municipality
Oil Affairs	Industry Affairs
Environmental protection agency	Urban Water & Wastewater Co
Water resources management Co.	Rural Water & Wastewater co.

This group works more on WSP in catchment Due to :

- the most of pollution happens in the catchment
- require greater coordination between the organizations

Lessons learned

Due to diversity of problems that we are facing in catchments; implementation of WSP in catchment areas is far more difficult and more important.

Important points in system description of catchments:

- Agricultural activities (using fertilizers and pesticides in farms)
- Urban activities (wastewater, disposal of solid waste in landfill sites, cemetery, runoff, gas station)
- Industrial activities (untreated wastewater, crude oil transition)
- Development activities (Dam, roads, water transition between basins…)

Implementation of WSP will lead to change in the attitude of end-point monitoring approach for preventing water resources pollution.

Thanks for your attention …

LESAM 2017
NTNU, Trondheim, Norway

Presentation 4

Caty Werey: Research and operational needs to improve the asset management of stormwater control measures

Research and operational needs to improve the asset management of stormwater control measures

D'Arco 2012

Mattar 2016

Caty Werey, Frédéric Cherqui, Nathalie Le Nouveau, Robin Garnier, Tim D. Fletcher, Sylvie Barraud, Pascal Le Gauffre

Still emerging techniques with new organization…

- Going from connected underground networks to natural open areas (drainages lines, wetlands…)
- Managing stormwater from urban areas, reducing threat of flooding
- But also reducing flow to the treatment station and recharging groundwater tables
- depollution capacity
- disconnection programs, regulations …

Still emerging techniques with new organization..

How are they called? (Fletcher et al., 2014)

BMP best management practices

SUDS sustainable urban drainage

WSUD water sensitive design

LID low impact development

And finally :

SCMs STORM WATER CONTROL MEASURES

include 2 dimensions for retention near the source of runoff:

1) structural (wetlands, swales, retention systems…)

2) non structural: practices (residential downs put disconnection programs, regulations …)

O&M already needed because of ageing & damages, with various pathologies

Bourgogne, 2010

Jacopin et Gross, 2010

O&M already needed because of ageing & damages, with various pathologies

Bourgogne, 2010

Many actors…

Decision → **Design/ execution** → **Operation**

- Urban planner,
- Land developer,
- Landscape architect,
- Elected representatives,
- Technical services,
- Etc.

- Engineering offices,
- Drainage services department,
- Urban ecology department,
- Landscaper,
- Etc.

- Drainage services department,
- Garden services dpt.,
- Street sweeping dpt.,
- Road dpt.,
- Etc. ?

And about Asset Management?

Difficult institutional context…

In France: storm/rain water management is not considered as a commercial utility like water or sewer utilities which have and independent budget fed by the water bill. Only combined sewers bring some subsidies from the « general » budget of the collectivity to its sewer utility.

Storm/rain water management has no specific financement, no tax for impervious areas, so maintenance/operating is realized with no specific allocations by the sewer utilities and others…

They are also inexistent in the new GEMAPI competence including flooding and Aquatic environments!

In the opposite, in Australia for example specific «living rivers program » funds up to 50% of investment costs but like in France nothing for maintenance support and ever more for rehabilitation works…

Performance of SCMs

- In France, regarding stormwater management :
  - main function SMCs is hydraulic (flood mitigation)
  - to a lesser extent pollution mitigation but also other rule…

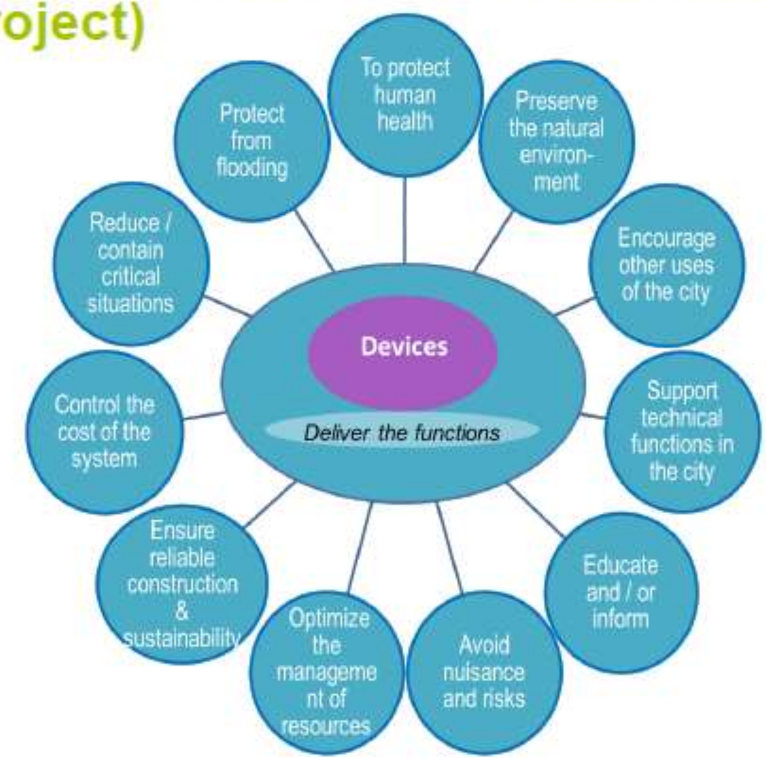
  Infiltration is still difficult in some area and water reuse exist for gardens, at the beginning for houses uses
  Link with " green and blue frames", "Eco district", "Eco campus"

- In other countries:
  - Primary functions also are water quality and flow-regime restoration

- What about the multi functionality of SCMs providing new uses for inhabitants but also a new urban way of building?

- Secondary functions are however explored as shown in the generic program (Micromegas-lyon project) or within urban ecosystem approaches or positives externalities

Performance of SCMs (micromegas-lyon project)



Expected performance of Stormwater Control Measures (Cherqui et al., 2016)

Knowing about costs?

Internal/ direct cost for whom?

Not only for the sewer utility

But also

For road cleaning department

For waste department

For gardens and parks departments…

Concerning many actors, different budgets…

experimentation under way with a full costing approach in Srasbourg Eurometropole and Grand Lyon Metropole utilities

(same methodology as Werey, Cheritat , LESAM poster 2017)

(Externalities valuation for a cost benefit analysis foreseen in 2018)

Example of cost valuation under way

Dry Bassin n°1	unit	quantity	unit cost	total cost
SEWER UTILITY				
direct costs				
material	piece			- €
machines	hours			- €
staff	heures			- €
				- €
...				- €
direct cost for the equipment				- €
indirect costs at annual level (accounting data)				
insurance costs	€			- €
depreciation	€			- €
signalisation	€			- €
oil	€			- €
management staff	€			- €
	€			- €
...				- €
repartition key				
indirect costs for the equipement				- €
Full cost				- €

	unit	quantity	unit cost	total cost
green spaces department				
direct costs				
material	piece			- €
machines	hours			- €
staff	heures			- €
				- €
...				- €
direct cost for the equipment				- €
indirect costs at annual level (accounting data)				
insurance costs	€			- €
depreciation	€			- €
signalisation	€			- €
oil	€			- €
management staf	€			- €
	€			- €
...				- €
repartition key				
indirect costs for the equipement				- €
Full cost				- €

	unit	quantity	unit cost	total cost
waste department				
direct costs				
material	piece			- €
machines	hours			- €
staff	heures			- €
				- €
...				- €
direct cost for the equipment				- €
indirect costs at annual level (accounting data)				
insurance costs	€			- €
depreciation	€			- €
signalisation	€			- €
oil	€			- €
management staff	€			- €
	€			- €
...				- €
repartition key				
indirect costs for the equipement				- €
Full cost				- €

	unit	quantity	unit cost	total cost
road cleaning department				
direct costs				
material	piece			- €
machines	hours			- €
staff	heures			- €
				- €
...				- €
direct cost for the equipment				- €
indirect costs at annual level (accounting data)				
insurance costs	€			- €
depreciation	€			- €
signalisation	€			- €
oil	€			- €
management staf	€			- €
	€			- €
...				- €
repartition key				
indirect costs for the equipement				- €
Full cost				- €

Asset management?
Learning from sewer asset management?

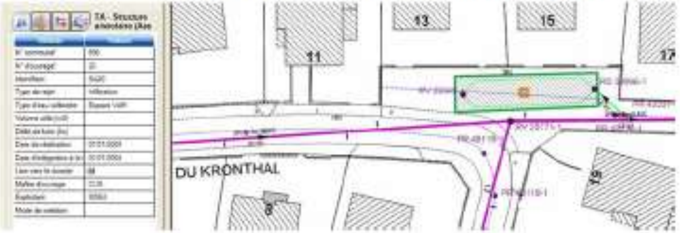
First step knowing the existing infrastructures?

- Making the inventory of the techniques:

Physical description

operating information recording

On GIS with specific description and localisation



Eurométropole de Strasbourg

- Who is the owner, operating, maintaining?
- Public/private area

Next steps: ageing? Impacts when failures? Financement of rehabilitation?

In conclusion, there is still work…

Principal difficulties:

No « Continuum » of the techniques, park of techniques?

Natural or artificial infrastructure?

Performances and actors different from one utility to the other

… but it is necessary to begin now !

By the conception project

The actors and their missions

Expected performances

Means to measure these performances

Means to maintain them properly over the time…

Collect information up to now

Localization and characteristics of the SCMs

Dysfonctionements and interventions

New jobs or multifunction jobs…

New asset management issues for many different SCMs and crossed maintenance…

Thanks for your attention

caty.werey@irstea.fr
frederic.cherqui@gmail.com

Research and operational needs to improve the asset management of stormwater control measures

Caty Werey, Frédéric Cherqui, Nathalie Le Nouveau, Robin Garnier,
Tim D. Fletcher, Sylvie Barraud, Pascal Le Gauffre

Presentation 5

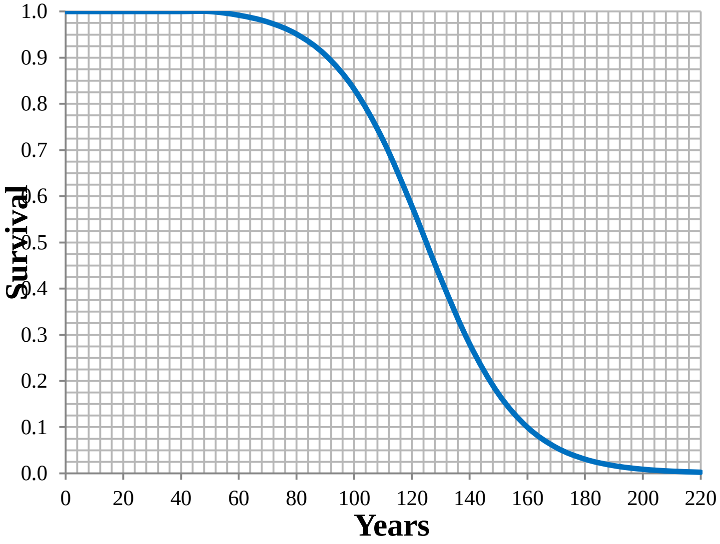
Youen Pericault: Coordinated long term planning of sewer and water mains rehabilitation

Coordinated Long Term Planning of Sewer and Water Mains Rehabilitation

Leading Edge Sustainable Asset Management of Water and Wastewater Infrastructure
June 20 –22, 2017, Trondheim, Norway

Youen Pericault	LTU, Luleå, Sweden
Stian Bruaset	NTNU, Trondheim, Norway
Rita Ugarelli	NTNU, Trondheim, Norway
Sveinung Saegrov	NTNU, Trondheim, Norway
Maria Viklander	LTU, Luleå, Sweden
Annelie Hedström	LTU, Luleå, Sweden

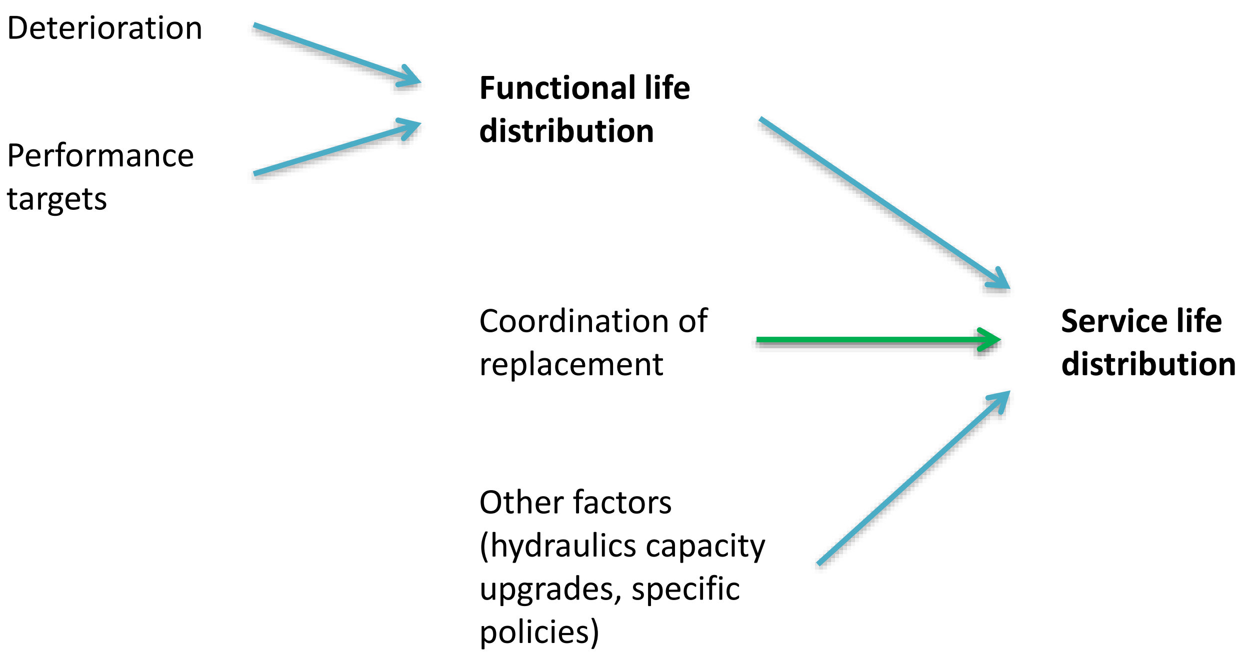
Cohort survival models



Example of Herz survival function

- Pipes grouped into cohorts
- To forecast rehabilitation needs at the network level
- Time horizon 10-50 years
- Implemented in KANEW and CARE-W LTP
- Calibrated on historical decommissioning data

Functional life vs. service life



Research questions

How can we evaluate the impacts of coordinated replacement water-sewer-road on long term replacement costs with CARE-W LTP ?

How do the three following scenarios impact long term replacement costs?

- No coordination
- Systematic coordination water-sewer
- Systematic coordination water-sewer-road

Proposed method

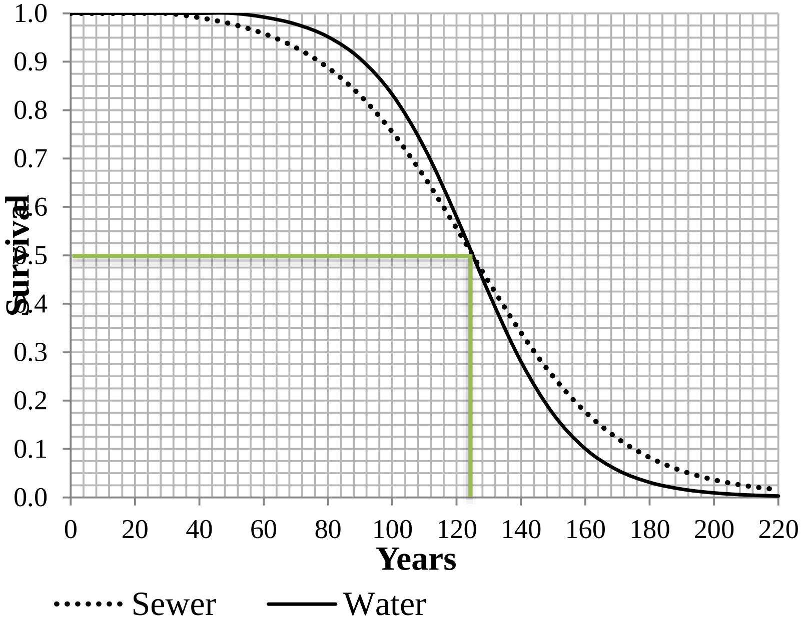
Assumptions:

- Sewer and water survival functions represent the "survival in **functional state**"
- Water **or** sewer pipe needs replacement (end of functional life) ➔ both are replaced (end of service life)

Aim:

- To estimate the survival function (in service) of the system sewer pipe + water pipe

Proposed method



Independent hypothesis:

- No spatial correlation of functional life distributions
- $F_{sw}(t) = S_s(t)*S_w(t)$

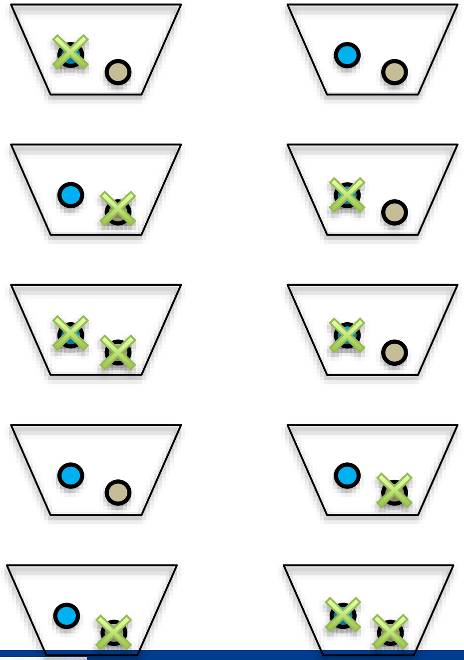
Dependent hypothesis:

- Positive spatial correlation of functional life distributions
- $F'_{sw}(t) = \min[S_s(t);S_w(t)]$

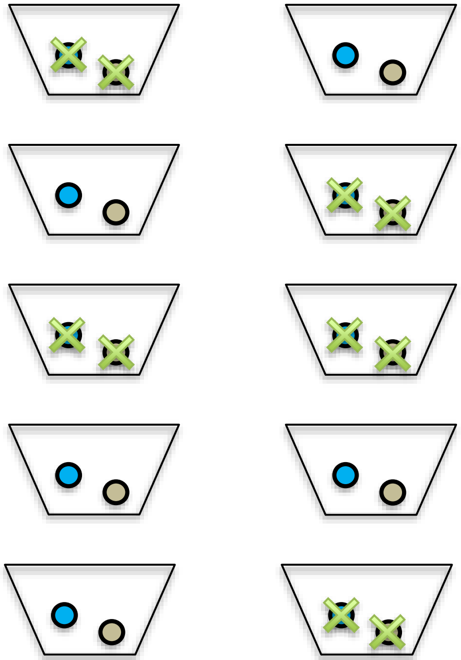
Proposed method

- Water pipe survival probability after 125 years : 50%
- Sewer pipe survival probability after 125 years: 50%

Independent hypothesis:



Dependent hypothesis:



Case study

- Residential area of 1000 residential units in Gällivare projected for 2030
- 7,3km of new sewer, drinking water pipes and roads

- Survival data:

Cohort	Survival time 100%	Survival time 50%	Survival time 10%	Source
New water pipe in PE	50 years	125 years	160 years	(Malm, 2013)
New sewer pipe in PVC	30 years	125 years	175 years	(Malm, 2013)
New road 250-500 v./day	3 years	18 years	53 years	(Svensson, 2014)

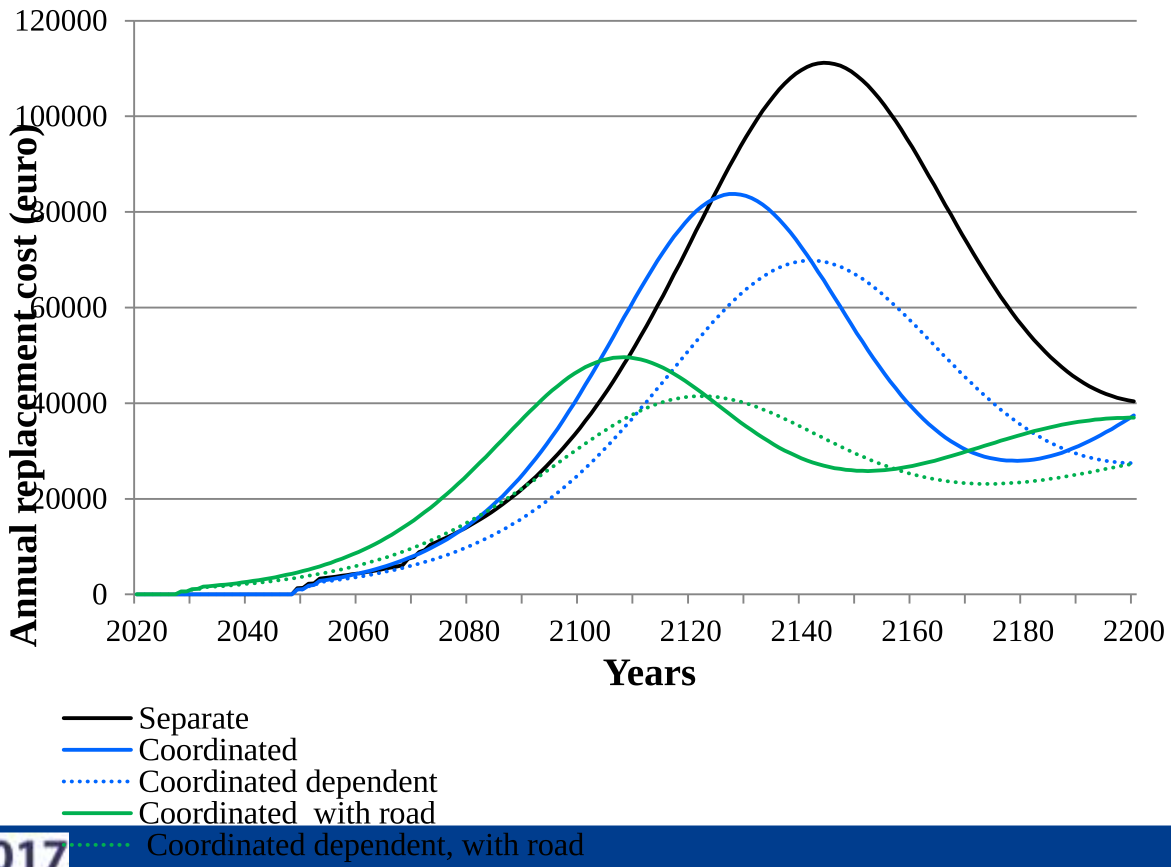
- Cost data

Scenario	Activity description	Cost (euro/m)
Separate	Replacement of water **or** sewer main. Includes road replacement.	550
Coordinated	Replacement of water **and** sewer main. Includes road replacement.	700
Coordinated with road	Replacement of water and sewer main. **Excludes** road replacement.	400

- All scenarios are pro-active

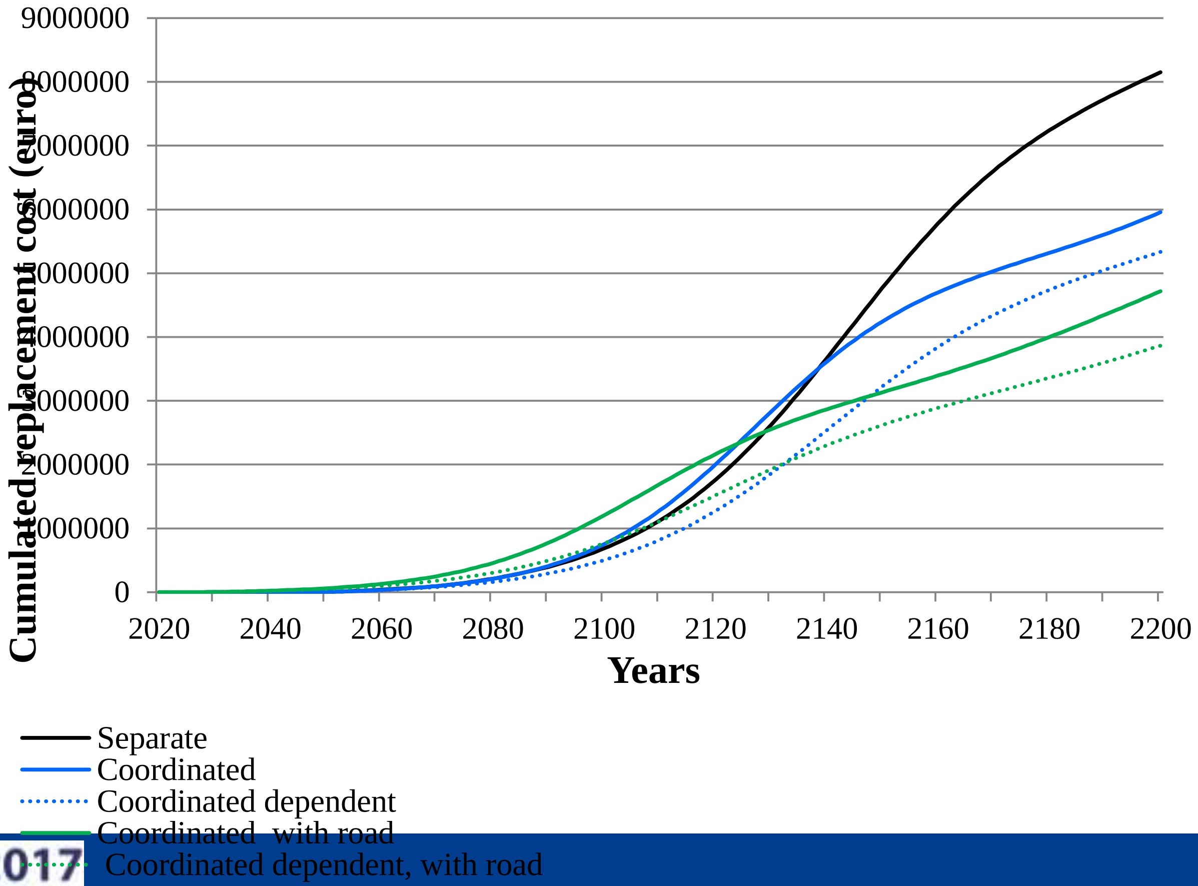
- Coordination with road: pipes systematically replaced in advance to match previous road replacement

Results



120000
100000
80000
60000
40000
20000
0
Annual replacement cost (euro)
2020
2040
2060
2080
2100
2120
2140
2160
2180
2200
Years
Separate
Coordinated
Coordinated dependent
Coordinated with road
Coordinated dependent, with road

Results, cumulated



Conclusion

- A method was proposed to evaluate the impacts of coordination on renewal costs based on survival functions **representing deterioration only.**

- The main advantage (cost sharing) and drawback (**under-utilization of useful life**) of coordination were considered.

- Coordinated scenarios were considerably **cheaper** and the investment **peaks were softened**.

- Considering no spatial correlation of deterioration water-sewer-road (independent assumption), yearly investments for the case of coordination water-sewer-road were **higher than the separated case** during the first 80 years.

- The **extent of the savings** is **dependent** on the level of spatial correlation between sewer and water pipes deterioration (dependent vs dependent hypothesis)➔ specific to cohort type and network.

Thank you for your attention

Questions ?

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LESAM 2017
NTNU, Trondheim, Norway

Presentation 6

Arne Svendsen: Asset management planning delivered through an integrated urban watershed modelling approach

Asset Management Planning Delivered Through an Integrated Urban Watershed Modelling Approach

Arne Svendsen (VCS Denmark)

Per Henrik Nielsen, Annette Brink-Kjær & Justine Henonin (VCS Denmark)
Elliot Gill (CH2M) Lorenzo Benedetti (Waterways)

Agenda

1. VCS & Odense
2. Integrated modelling approach
3. Meeting Good Ecological Status
4. Exploring OPEX
5. Conclusions

VandCenter Syd – VCS Denmark

- Owned by the City Council of Odense & the Local Council of Northern Funen
- Since 1853
- 200 employees
- Drinking water & Waste water

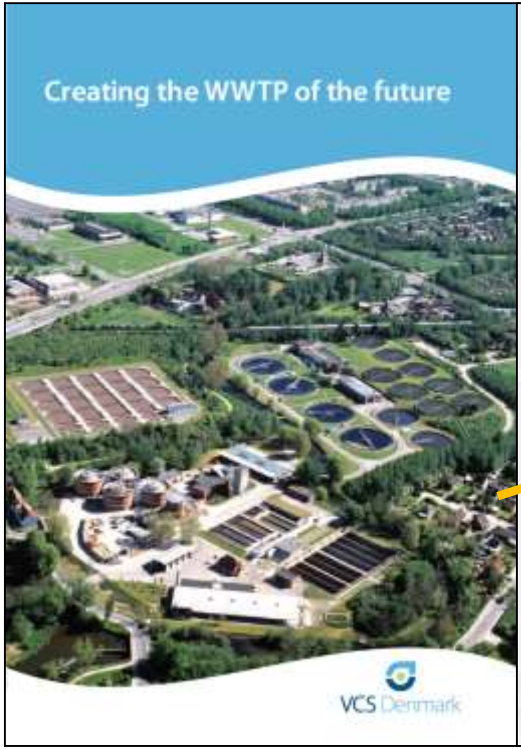
Odense

- 3rd largest city in Denmark
- Ca. 192,000 inhabitants
- Birthplace of H.C. Andersen

Odense wet weather challenges I:
150+ CSOs & 80+ storm water outfalls

Odense wet weather challenges II:

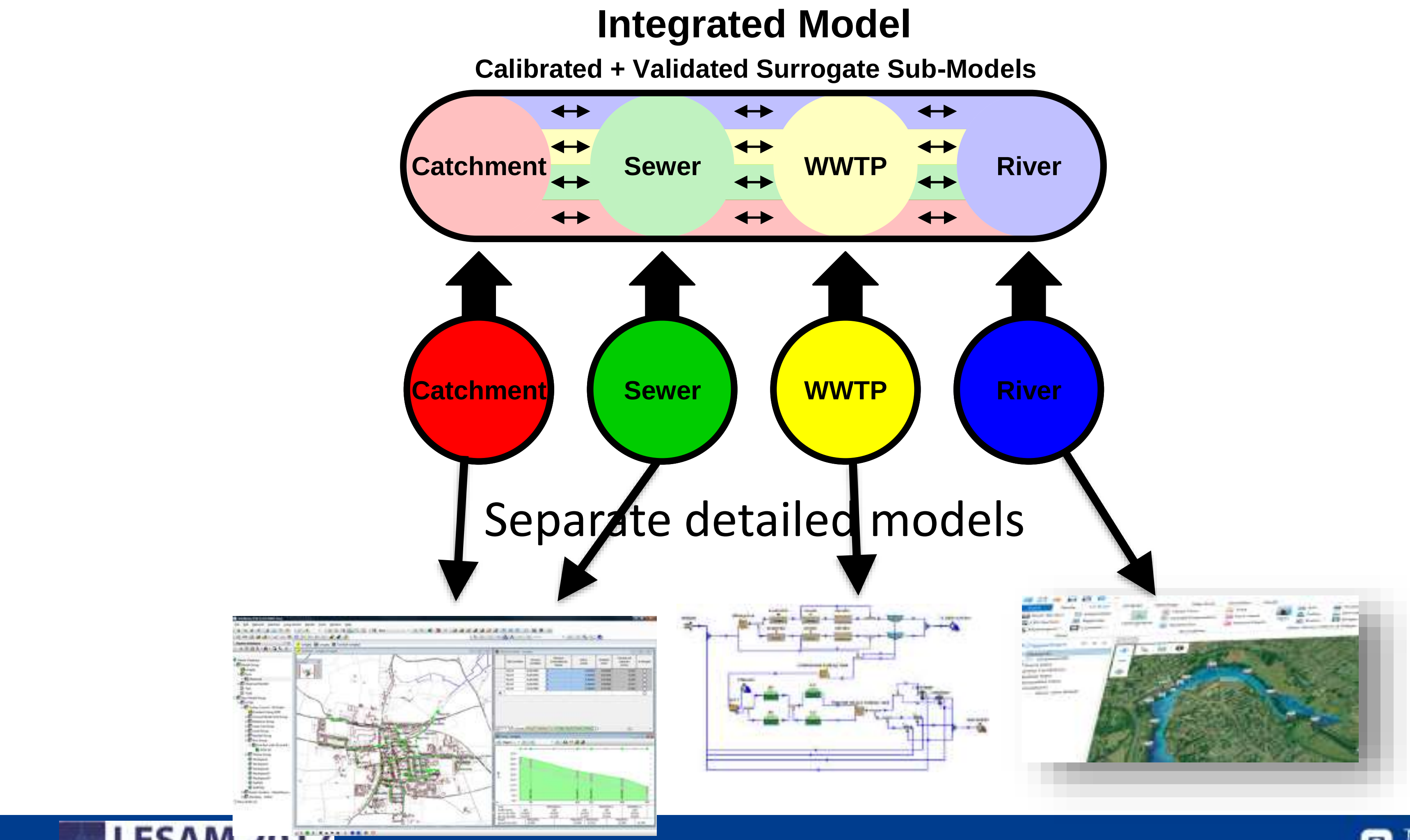
3 WRRF (Water resource recovery facility)



Odense wet weather challenges III: regulation & planning approach

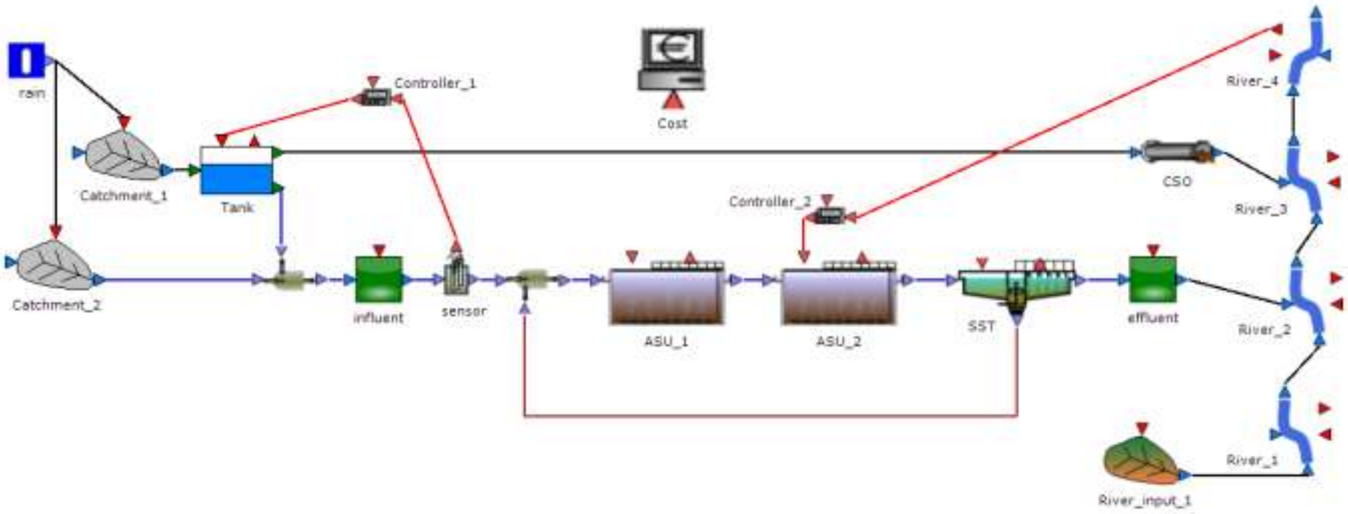
1. Rivers must achieve Water Framework Directive (WFD) Good Ecological Status (GES)
2. Regulator's approach to wet weather permitting
   - Separate consideration of CSO and WFF
   - Annual CSO discharge volume (250m^3/ha)
   - Annual CSO discharge frequency (< 5)

1. Regulator agreement
2. Recognise collection system & WRRF interactions
3. CSO & WRRF impacts on river quality – good ecological status
4. Develop effective & affordable whole life cost strategy

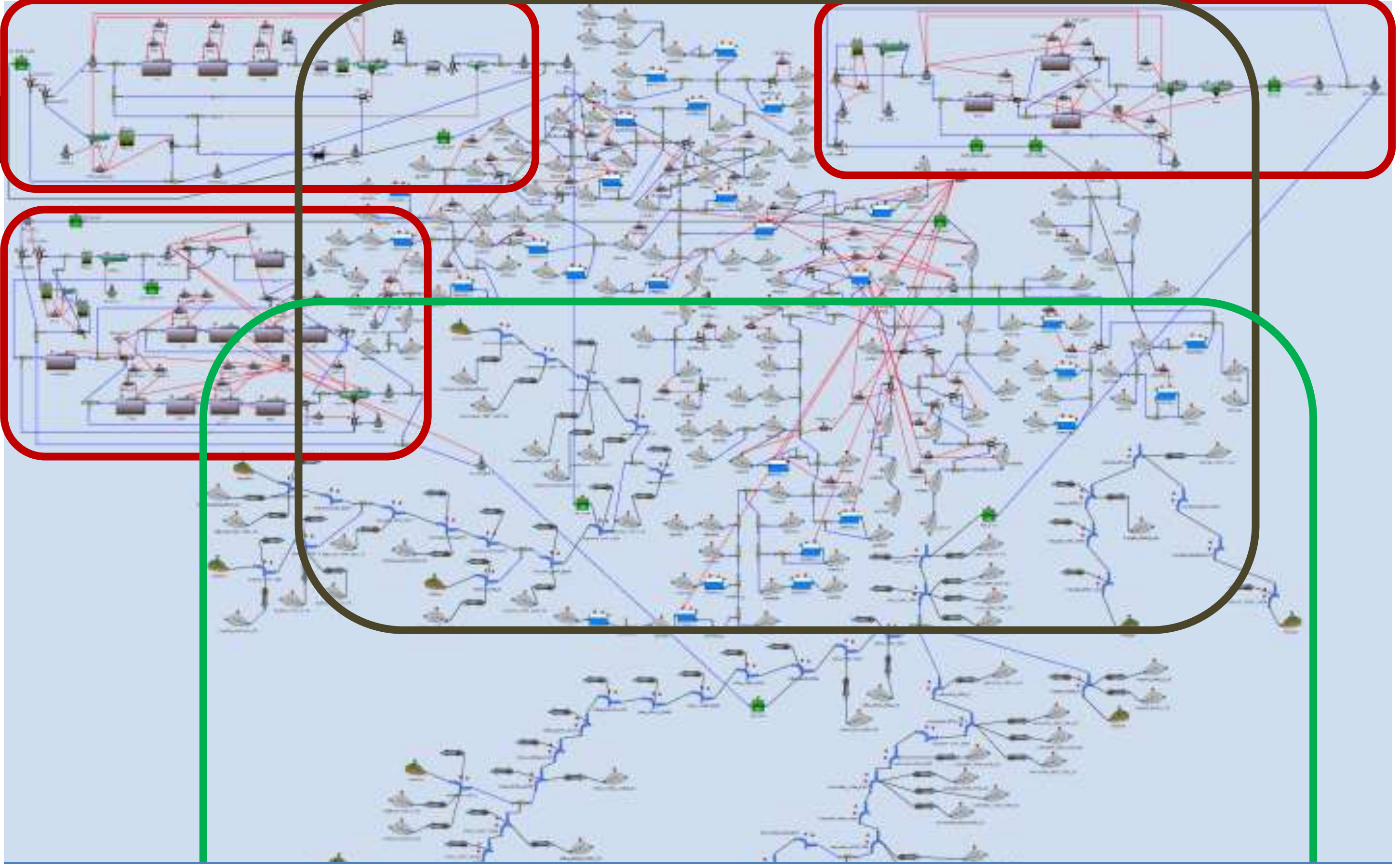


Integrated Model
Calibrated + Validated Surrogate Sub-Models
Catchment
Sewer
WWTP
River
Catchment
Sewer
WWTP
River
Separate detailed models

Simplified integrated model in DHI WEST



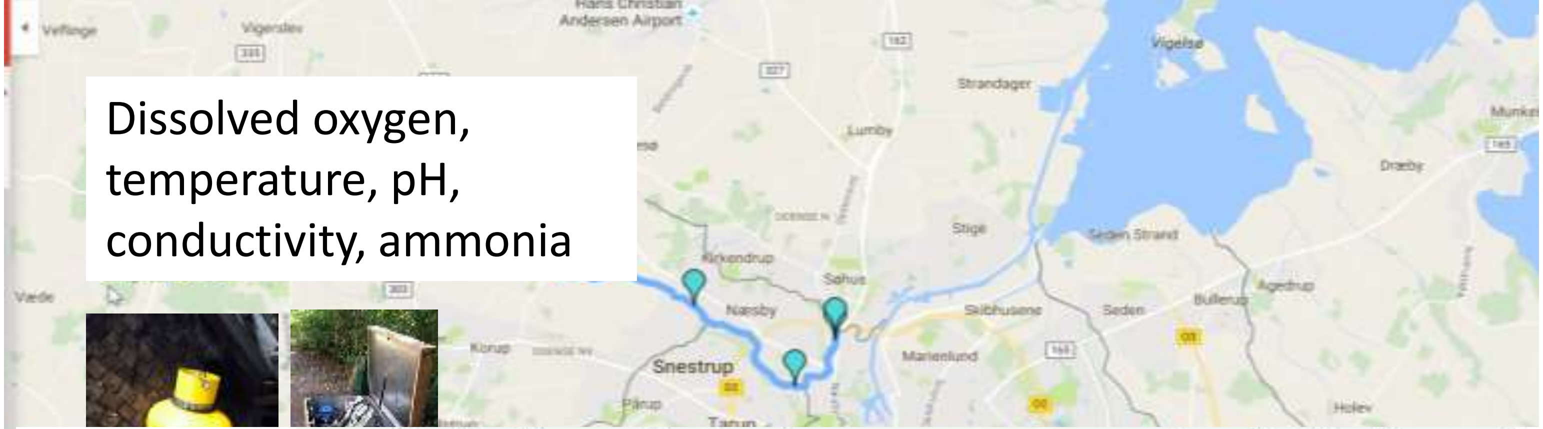
Od

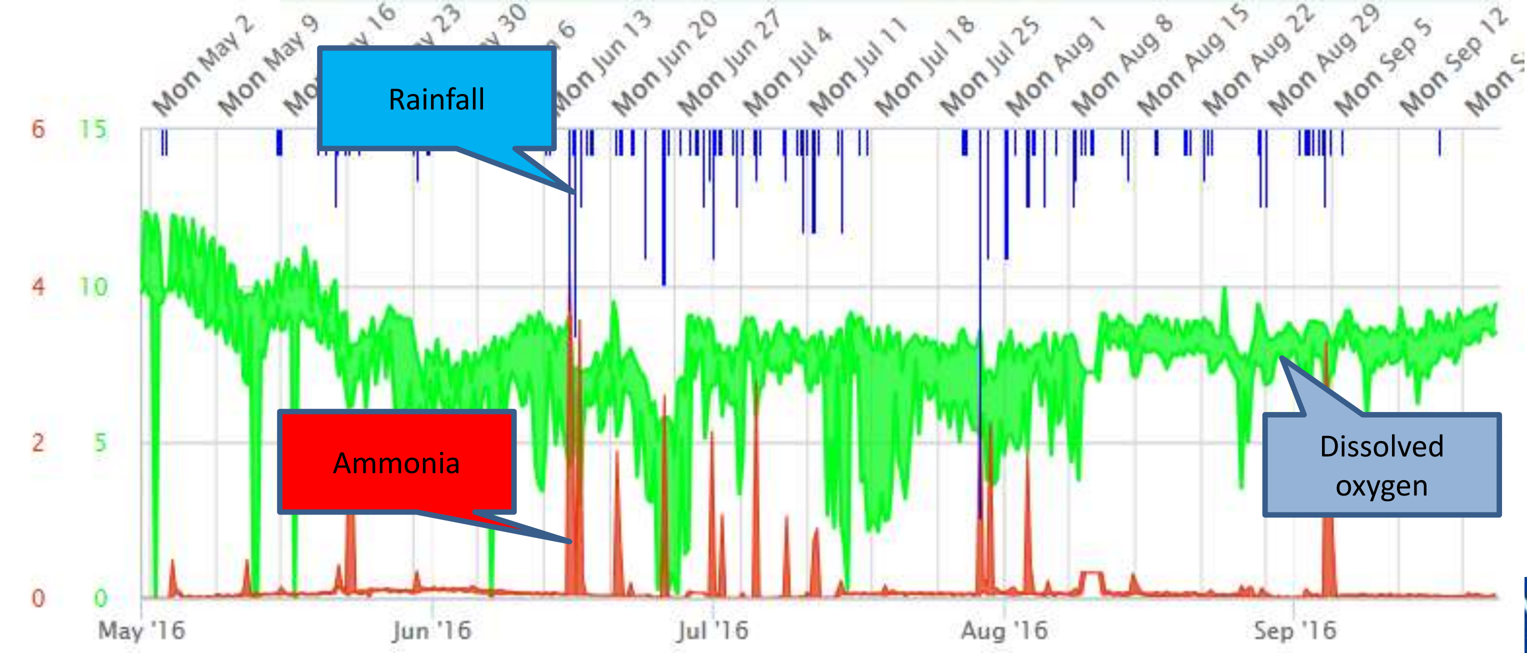


Fast simulator

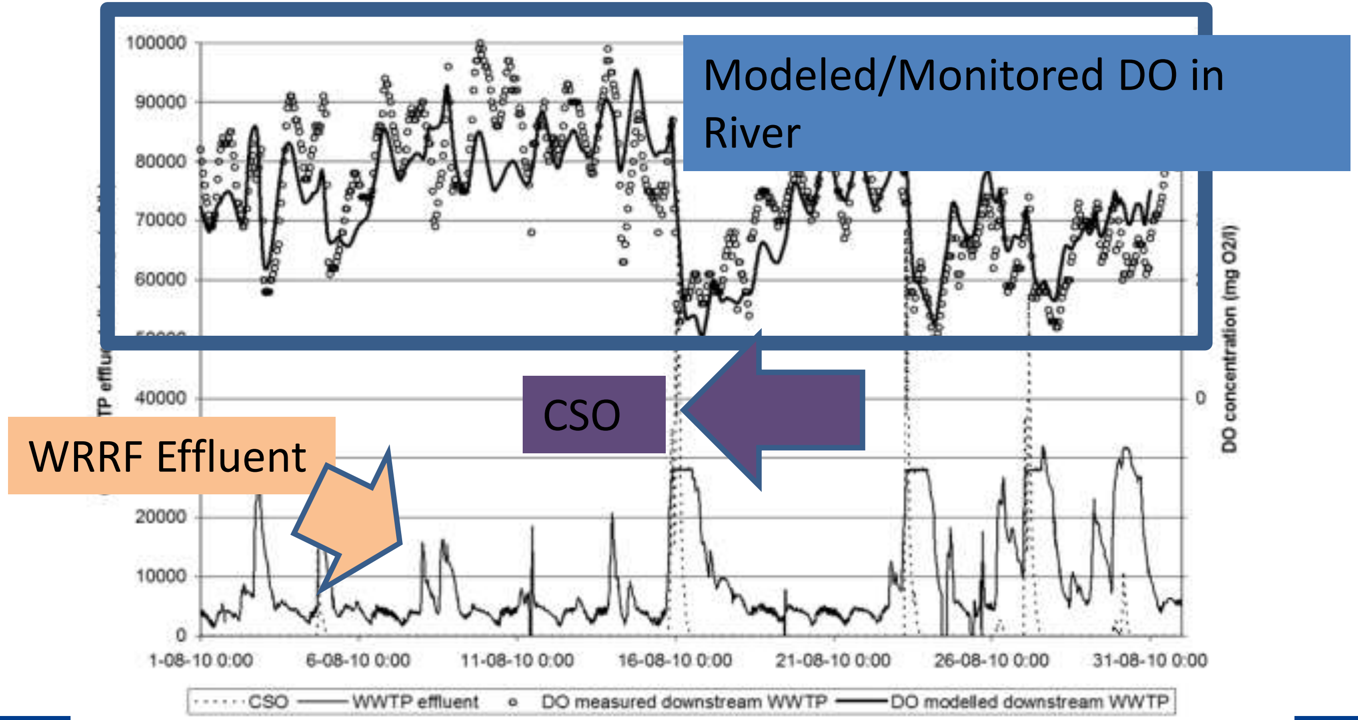
(1 year @ 1 minute timestep in 1.5 hours)

Dissolved oxygen, temperature, pH, conductivity, ammonia





Water quality validation (example)



Urban Pollution Management (UPM)
Environmental Quality Standards (EQS)

					BellAa_3091_0						Bolbro_2782_0					
UIAc salm.	*Duration of the event*															
				24 h												
Tolerated				.018	1	1	1	0.2	1.3	0.2	1	4	1	6.0	24.7	1.3
frequency				.025	1	1	1	0.0	0.0	0.2	1	4	1	1.7	8.4	0.2
per year				).03	1	1	1	0.0	0.0	0.2	1	4	1	0.6	4.7	0.2
DO saln																
				24 h												
Tolerated	12	5	5.5	6	1	1	1	7.1	4.5	0.2	1	1	1	9.0	5.1	0.4
frequency	4	4.5	5	5.5	1	1	1	3.0	0.9	0.2	4	2	1	9.4	4.3	0.2
per year	1	4	4.5	5	3	1	1	1.5	0.2	0.2	5	3	1	8.4	1.9	0.2

1: <80% tolerated frequency

2: >80% <120%

3: >120% <200%

4: >200% <500%

5: >500%

Developing wet weather solutions to deliver Good Ecological Status

- Scenario 0 (current situation)

- Scenario 1 (Regulator's plan using network storage)
  - 9,300m^3 of new storage at 9 locations
  - 3 upgraded pumping stations

- Scenario 2 (40% cost saving alternative ~ wet weather treatment)
  - 700m3 of new storage at 1 location
  - 11 upgraded pumping stations
  - Enhanced wet weather treatment at 1 WWRF
    (full biological treatment up to 2,500m^3/hr then settling/filters up to 10,000m^3/hr)

UIAc salm.	*Duration of the event*				curr					
		1 - 5 h	**6 - 24 h**	**> 24 h**						
Tolerated	**12**	0.065	0.025	0.018	1	3	1	4.0	16.0	2.0
frequency	**4**	0.095	0.035	0.025	1	4	1	0.0	8.0	2.0
per year	**1**	0.105	0.04	0.03	1	5	2	0.0	5.0	1.0

DO salm.	*Duration of the event*									
		1 - 5 h	**6 - 24 h**	**> 24 h**						
Tolerated	**12**	5	5.5	6	1	1	1	5.0	7.0	3.0
frequency	**4**	4.5	5	5.5	1	4	1	2.0	8.0	2.0
per year	**1**	4	4.5	5	4	5	2	3.0	7.0	1.0

1: <80% tolerated frequency

2: >80% <120%

3: >120% <200%

4: >200% <500%

5: >500%

Wet weather performance not delivering Good Ecological Status

Ammonia peaks & oxygen sags too severe & frequent

UIAc salm.	Duration of the event				curr						sc1					
		1 - 5 h	6 - 24 h	> 24 h												
Tolerated	**12**	0.065	0.025	0.018	1	3	1	4.0	16.0	2.0	1	2	1	0.0	11.0	2.0
frequency	**4**	0.095	0.035	0.025	1	4	1	0.0	8.0	2.0	1	1	1	0.0	2.0	1.0
per year	**1**	0.105	0.04	0.03	1	5	2	0.0	5.0	1.0	1	4	2	0.0	2.0	1.0

DO salm.	Duration of the event															
		1 - 5 h	6 - 24 h	> 24 h												
Tolerated	**12**	5	5.5	6	1	1	1	5.0	7.0	3.0	1	1	1	2.0	6.0	2.0
frequency	**4**	4.5	5	5.5	1	4	1	2.0	8.0	2.0	1	3	1	2.0	5.0	1.0
per year	**1**	4	4.5	5	4	5	2	3.0	7.0	1.0	2	4	2	1.0	4.0	1.0

1: <80% tolerated frequency

2: >80% <120%

3: >120% <200%

4: >200% <500%

5: >500%

Wet weather performance not delivering Good Ecological Status

Ammonia peaks & oxygen sags too severe & frequent (but improved)

UIAc salm.	Duration of the event				curr						sc1						sc2					
		1 - 5 h	6 - 24 h	> 24 h																		
Tolerated	**12**	0.065	0.025	0.018	1	3	1	4.0	16.0	2.0	1	2	1	0.0	11.0	2.0	1	1	1	1.0	7.0	1.0
frequency	**4**	0.095	0.035	0.025	1	4	1	0.0	8.0	2.0	1	1	1	0.0	2.0	1.0	1	1	1	0.0	1.0	1.0
per year	**1**	0.105	0.04	0.03	1	5	2	0.0	5.0	1.0	1	4	2	0.0	2.0	1.0	1	2	2	0.0	1.0	1.0

DO salm.	Duration of the event				curr						sc1						sc2					
		1 - 5 h	6 - 24 h	> 24 h																		
Tolerated	**12**	5	5.5	6	1	1	1	5.0	7.0	3.0	1	1	1	2.0	6.0	2.0	1	1	1	2.0	3.0	1.0
frequency	**4**	4.5	5	5.5	1	4	1	2.0	8.0	2.0	1	3	1	2.0	5.0	1.0	1	1	1	2.0	1.0	1.0
per year	**1**	4	4.5	5	4	5	2	3.0	7.0	1.0	2	4	2	1.0	4.0	1.0	4	2	2	2.0	1.0	1.0

1: <80% tolerated frequency

2: >80% <120%

3: >120% <200%

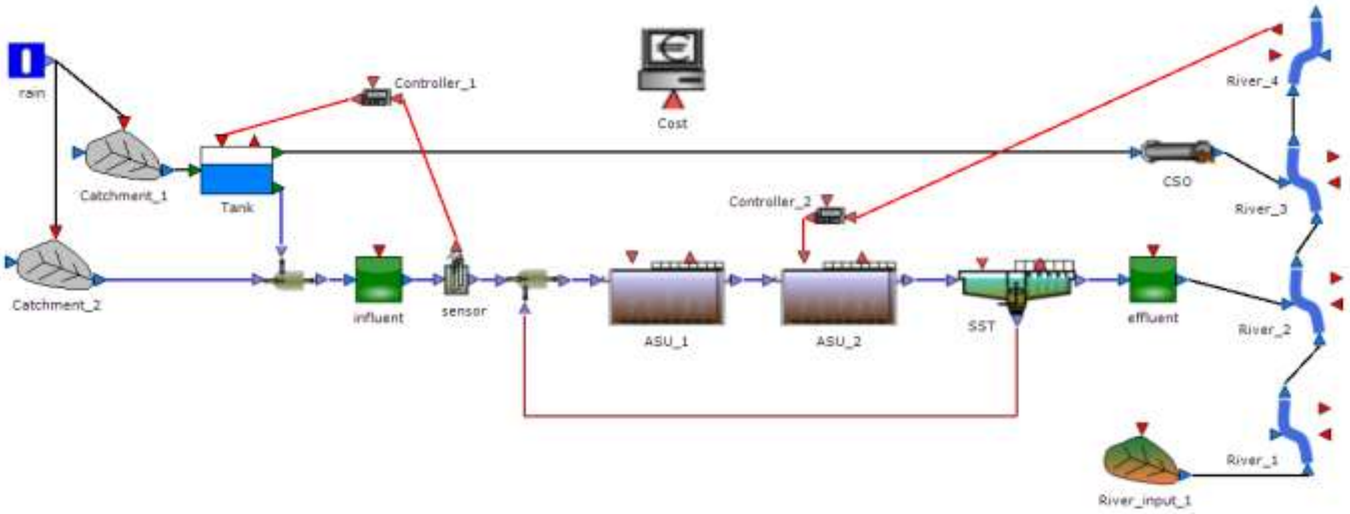
4: >200% <500%

5: >500%

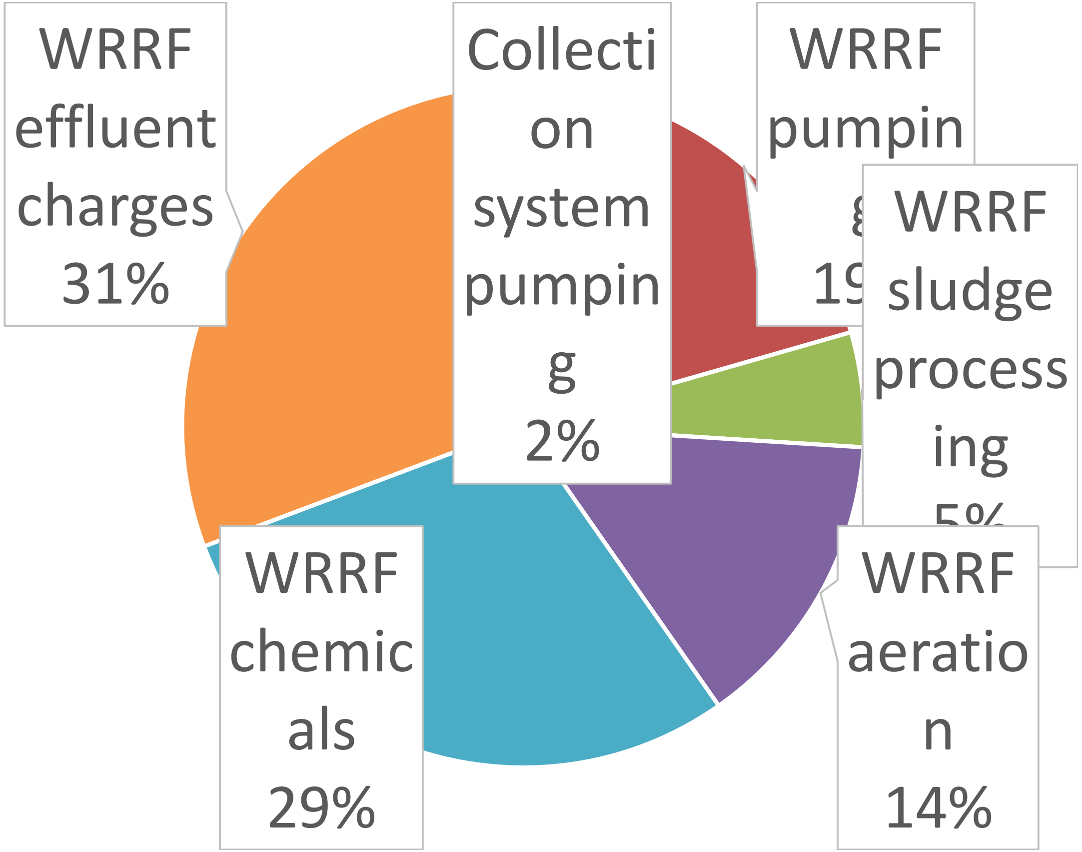
Wet weather performance protecting Good Ecological Status

Ammonia peaks & oxygen sags generally within limits

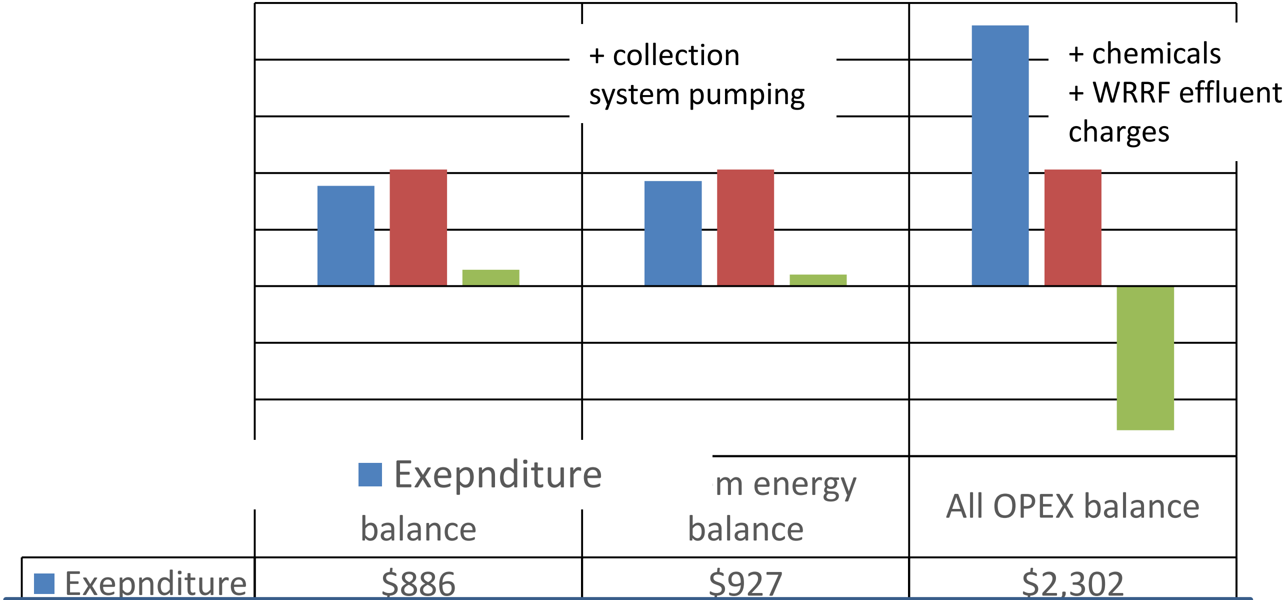
Simplified integrated model in DHI WEST



Odense system OPEX (baseline)

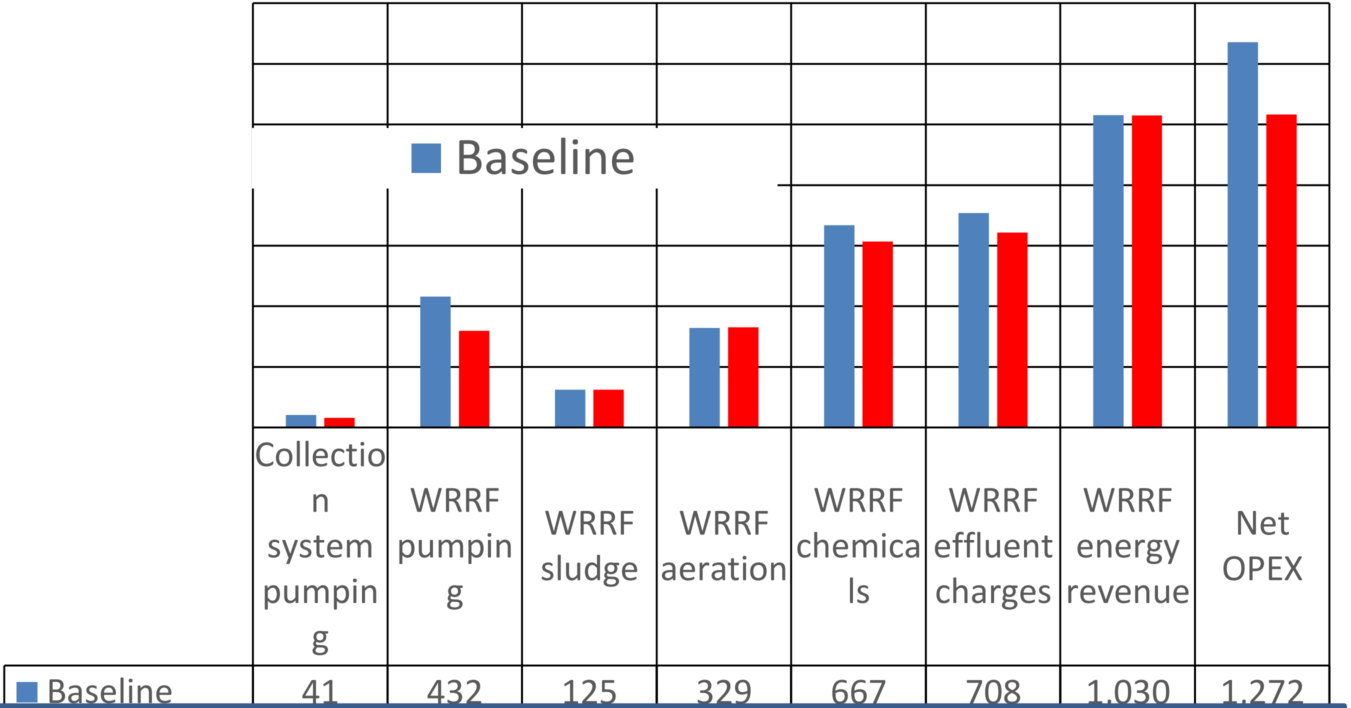


Does <u>system</u> cost money or generate revenue?



Using integrated model to understand costs of running system

Odense system OPEX (alternatives comparison)



Using integrated model to understand costs of different asset management strategies

Conclusions

- Systems approach to asset management planning to deliver water quality outcomes
- Use of an integrated model to develop strategies and communicate with stakeholders
- Planning approach brings people together: sewers, treatment, regulators

Presentation 7

Frederic Cherqui: Trusting CCTV reports? An exploratory study of operators’ ability to detect and recognize defects

CAN WE TRUST CCTV REPORTS?

An exploratory study of operators' ability to detect and recognize defects

LESAM 2017
NTNU, Trondheim, Norway

Image: Bradley Garrett

Frédéric Cherqui, Claudia Gutiérrez-Silva, Mehdi Ahmadi, Jean-Baptiste Aubin, Pascal Le Gauffre

Content

- Why do we need visual inspection?
- What are the biases in visual inspection?
- What factors are affecting visual inspection?
- Can we assess the reliability of CCTV reports?
- Preparatory method / application on a case study
- Preliminary conclusion

Why … eed visual inspection?

- Visual inspection is a very old method
- Technology has been improved

- Its use has been normalized

Why do we need visual inspection?

CCTV is by far the most used investigation method…

- To rehabilitate or not
- To decide how to rehabilitate
- To elaborate deterioration models
- To estimate budget
- …

CCTV is the key element of asset management, however

CCTV has been chosen because of cost, <u>not reliability</u>…

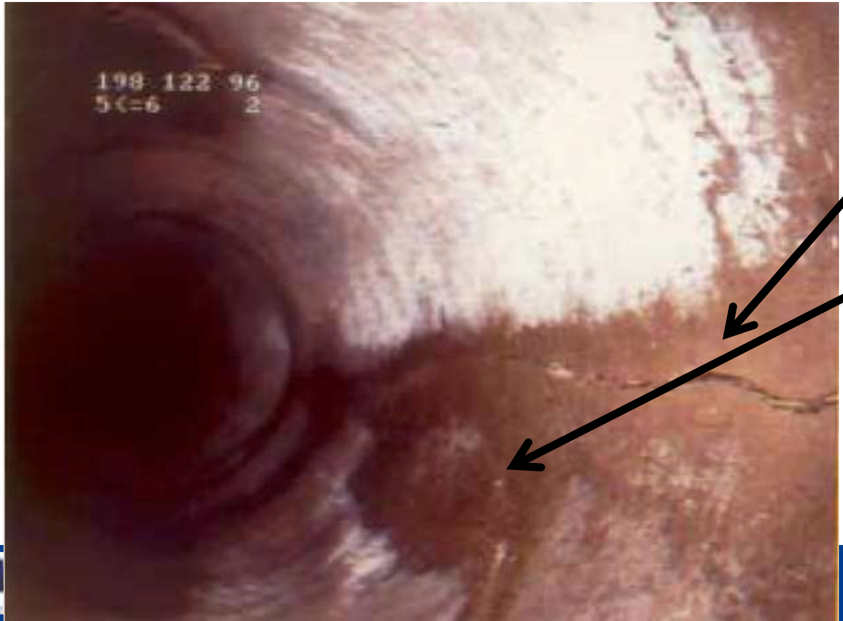
So, what about CCTV reports?

- The visual inspection process

Detection of a defect → Recognition of the defect → Description of the defect

Adapted from Dirksen *et al.*, 2013

- Example for the EN 13508-2 standard



Longitudinal fracture

Attached deposits

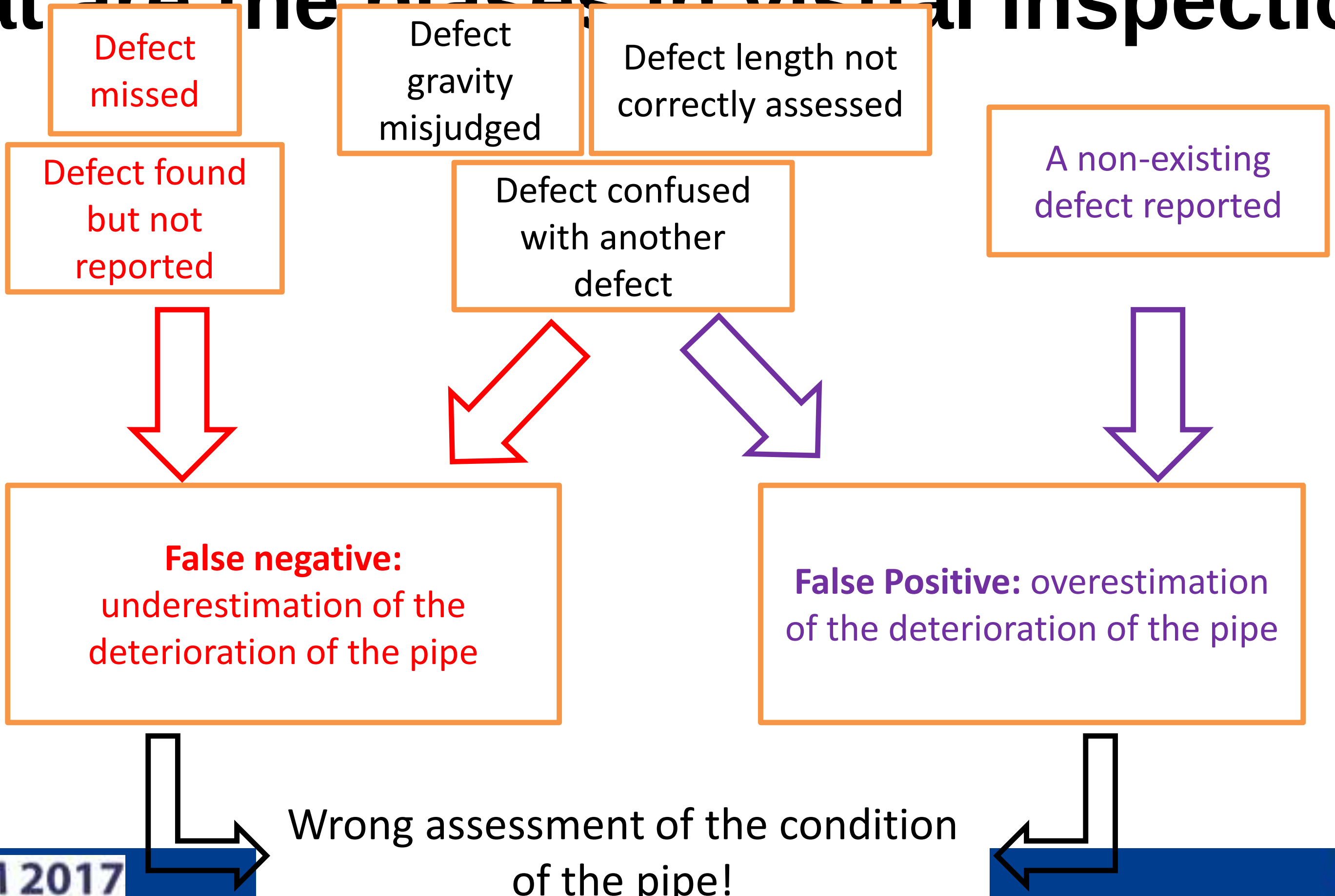
? Longitudinal crack

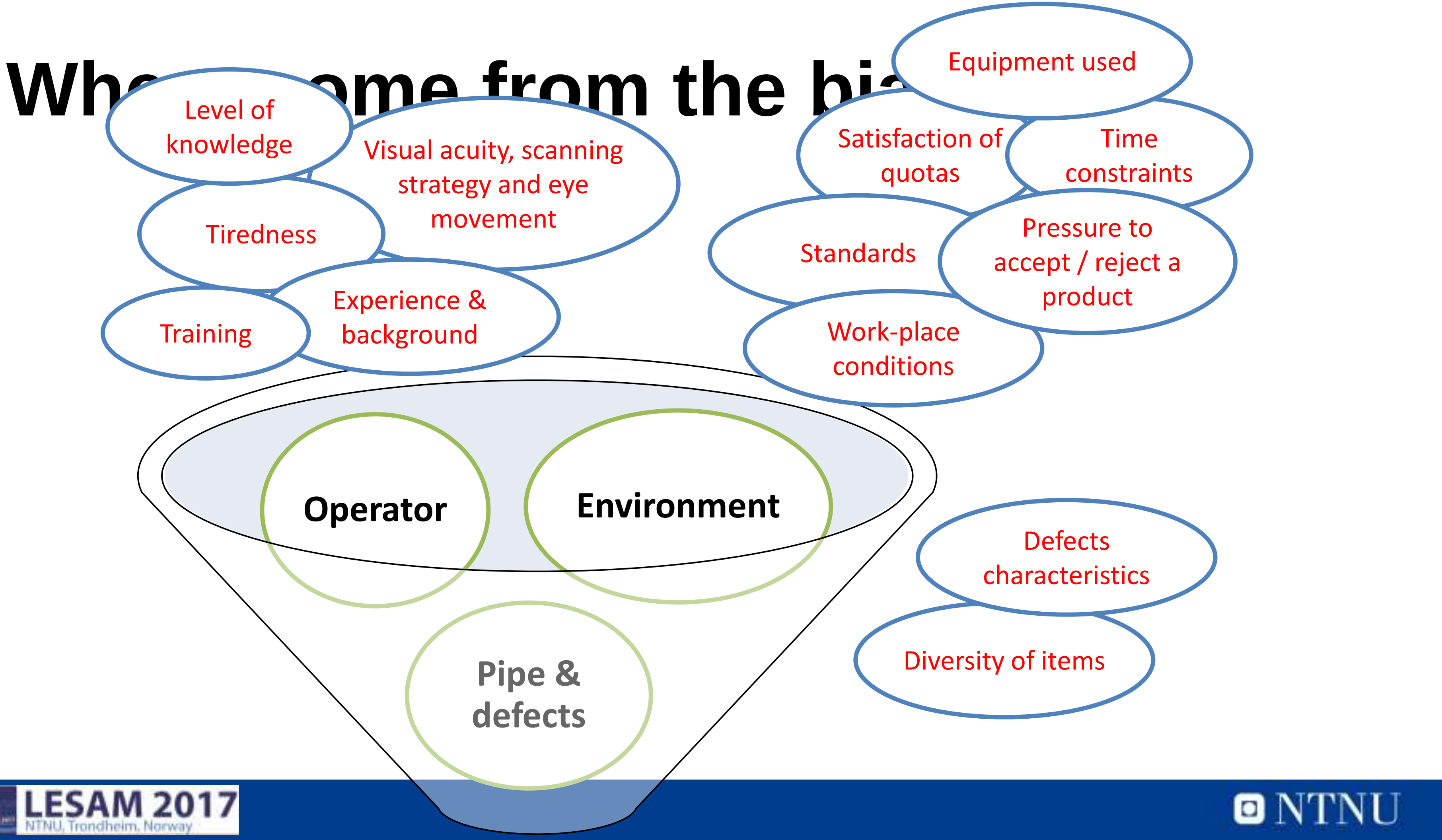
What are the biases in visual inspection?

(Few) publications address the unreliability of sewer investigation: Caradot *et al.*, 2017; Dirksen *et al.*, 2013; Korving and Clemens, 2004; van der Steen *et al.*, 2014

- But there is an important literature related to visual inspection: Baudet *et al.*, 2013; Gallwey *et al.*, 1986; Garrett *et al.*, 2001; Gramopadhye *et al.*, 1997; Hassan *et al.*, 2010; Heidl *et al.*, 2013; Hollnagel *et al.*, 1991; Laofor and Peansupap, 2012; Latorella and Prabhu, 2000; Megaw, 1979; Mellow *et al.*, 2000; Newman and Jain, 1995; *etc*.

What are the biases in visual inspection?




Wh… ome from the bi…
Level of knowledge
Visual acuity, scanning strategy and eye movement
Tiredness
Experience & background
Training
Equipment used
Satisfaction of quotas
Time constraints
Standards
Pressure to accept / reject a product
Work-place conditions
Operator
Environment
Pipe & defects
Defects characteristics
Diversity of items
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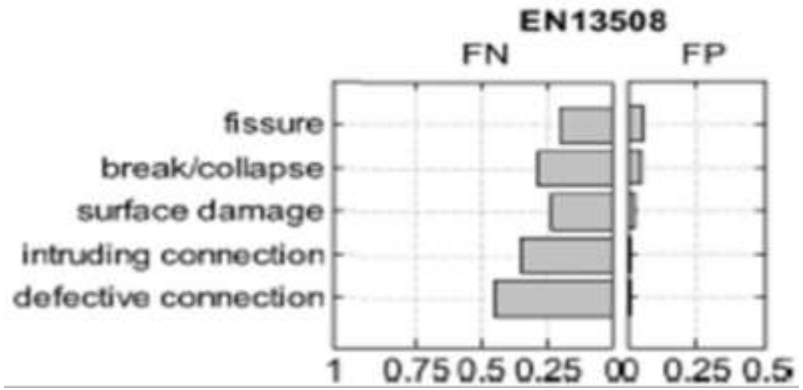
NTNU, Trondheim, Norway
NTNU

Can we assess reliability of CCTV reports?

It is mandatory to compare operators' behavior

- Case 1: several operators assess the same pipe
  - Ideal case but not frequent



Adapted from Dirksen et al., 2013

False negative (underestimation)

>

False positive (overestimation)

- Case 2: only one operator assesses a pipe
  - Every utility database
  - How to learn from this data?

Preparatory method

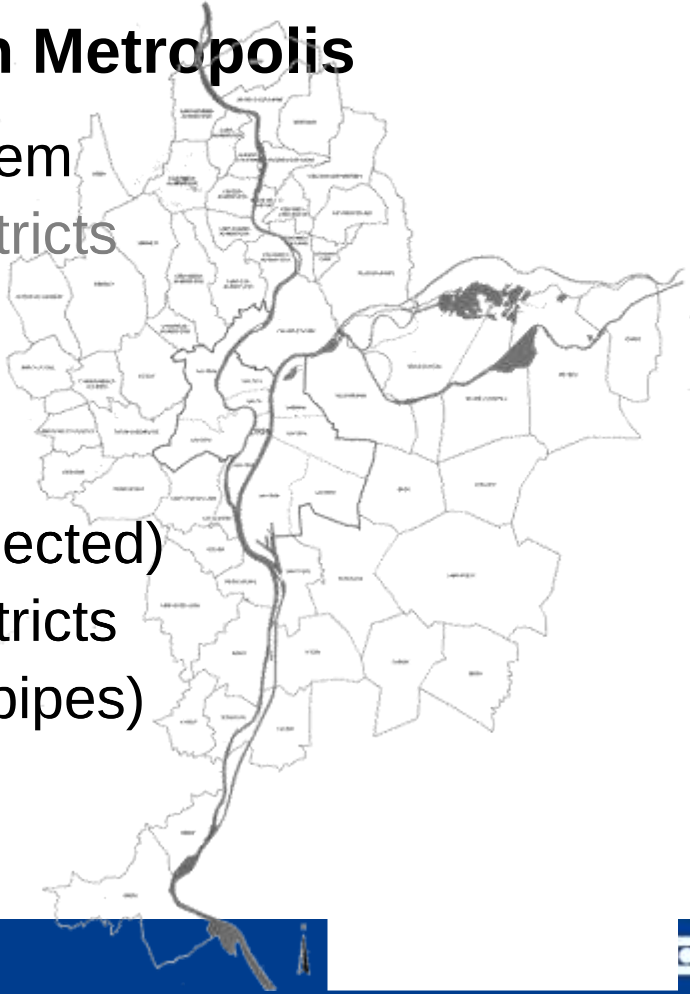
- Material: single reports of each sewer pipe

- Objectives: to elaborate a method in order to
  - Compare the codes that different operators use
  - Identify codes that are never used
  - Identify differences between operators on a same territory
  - Compare results from different utilities / countries

- Main hypothesis:

"If enough pipes have been inspected by the operators on the same district, they should have observed the same defects on the district"

Case study: the Greater Lyon Metropolis



- CCTV ϵ [2007-2011]
- EN 13508-2 coding system
- 58 municipalities + 9 districts
- 11 operators
- 5760 CCTV (pipes)

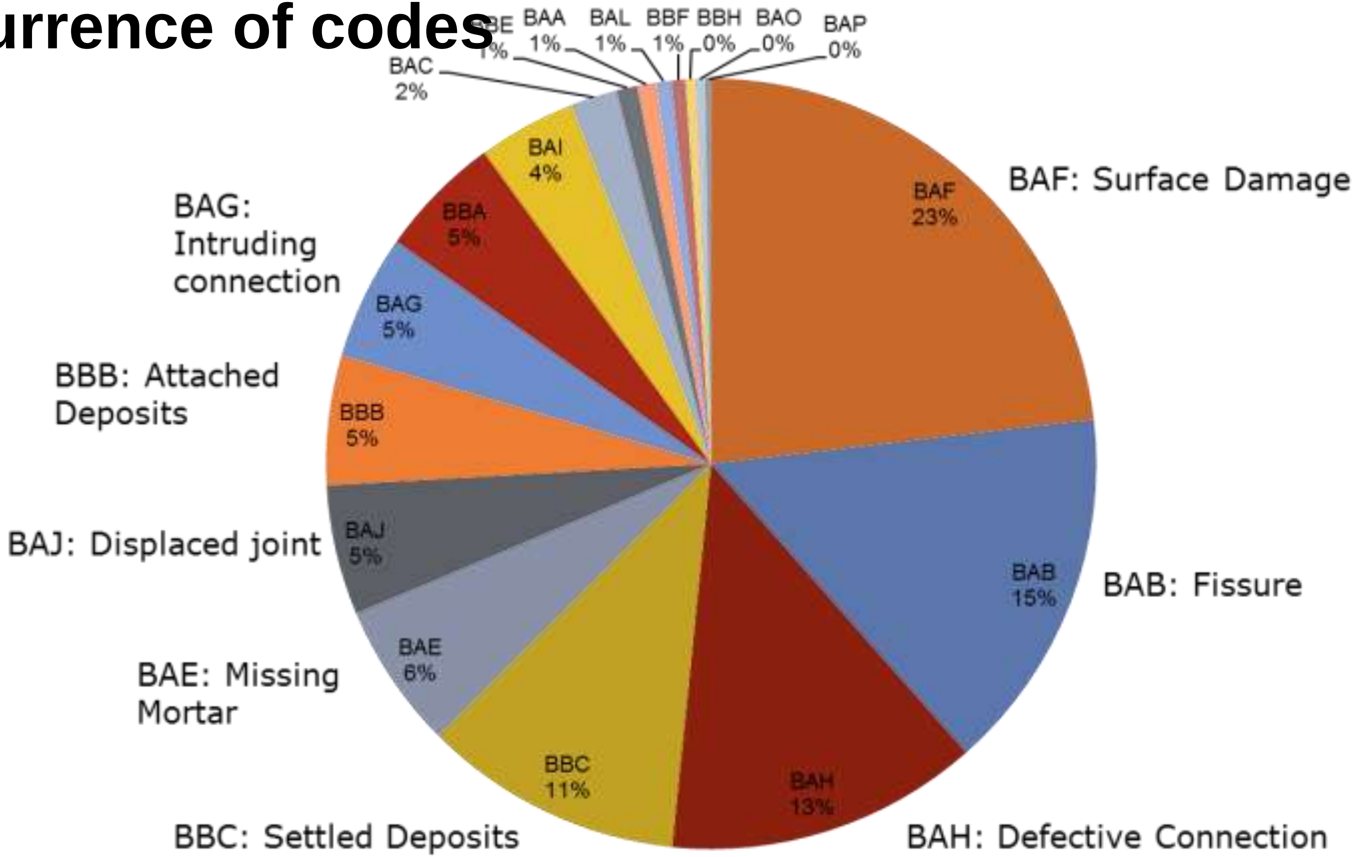
- 7 operators (≥ 4 km inspected)
- 53 municipalities + 9 districts
- 175 km of CCTV (5259 pipes)
- 72 506 863 codes
  - **BA… = structural**
  - **BB… = operational**
  - ~~BC… = inventory~~
  - ~~BD… = other~~

Raw analysis of data

- Almost all codes are used, except:
  - No BAN "Porous pipe"
  - Very few BAD "Defective Brickwork or Masonry"
  - Very few BAM "Weld failure"
  - Very few BBD "Ingress of soil"
  - Few BAK "Lining defect"
  - Few BBG "Exfiltration"

- Almost **20%** of defects have a 1st characterization
  - Z = "other"
  - Empty

Occurrence of codes



Normalization: standard score

$$Z(defect, operator) = \frac{frequency\ of\ defect - mean\ frequency}{standard\ deviation}$$

- Questions
- → Are there some defects subject to high disagreements between operators?
- → Do all the operators have the same behavior?

Normalization: standard score

All municipalities & districts

length insp.	15,9 km	13,9 km	39,6 km	50,0 km	38,6 km	12,5 km	4,6 km
CODE	OP1	OP2	OP3	OP4	OP5	OP6	OP7
BAA	-0,38	-0,58	2,36	0,03	-0,03	-0,73	-0,67
BAB	1,04	1,48	0,65	-1,53	-0,72	-0,55	-0,38
BAC	-0,87	0,91	-0,39	-0,71	0,14	-1,01	1,93
BAD	-0,41	-0,41	2,45	-0,41	-0,41	-0,41	-0,41
BAE	-0,49	-0,58	-0,53	0,06	-0,08	-0,75	2,36
BAF	-0,81	0,52	1,68	-0,83	0,33	-1,46	0,57
BAG	-0,19	-0,56	-1,65	0,30	0,84	-0,46	1,71
BAH	-0,27	-0,05	-0,62	0,01	0,63	-1,59	1,90
BAI	-0,93	-0,48	2,07	-0,68	0,03	0,76	-0,77
BAJ	-0,55	-0,22	-0,22	-0,24	-0,66	-0,52	2,41
BAK	-0,49	2,43	-0,44	-0,42	-0,08	-0,49	-0,49
BAL	0,17	-0,78	-0,46	0,04	2,28	-0,92	-0,33
BAM	-0,41	-0,41	-0,41	2,45	-0,41	-0,41	-0,41
BAO	-0,64	-0,13	-0,64	-0,51	0,17	-0,61	2,35
BAP	0,20	-0,64	-0,84	-0,84	1,26	-0,84	1,69
BBA	-0,49	-0,64	1,27	1,30	-1,73	0,29	-0,01
BBB	-0,40	-0,41	-0,02	-0,10	-0,66	-0,77	2,37
BBC	-0,52	1,86	0,63	-0,41	-0,39	-1,55	0,38
BBD	0,35	0,73	1,76	-0,32	-0,02	-1,25	-1,25
BBE	-0,17	-0,05	-0,15	2,29	-0,12	-1,04	-0,77
BBF	-1,35	0,99	0,87	0,16	1,24	-1,12	-0,80
BBG	-0,19	-0,49	-0,36	-0,42	2,44	-0,49	-0,49
BBH	-0,70	1,69	-0,18	1,27	-0,76	-0,12	-1,20

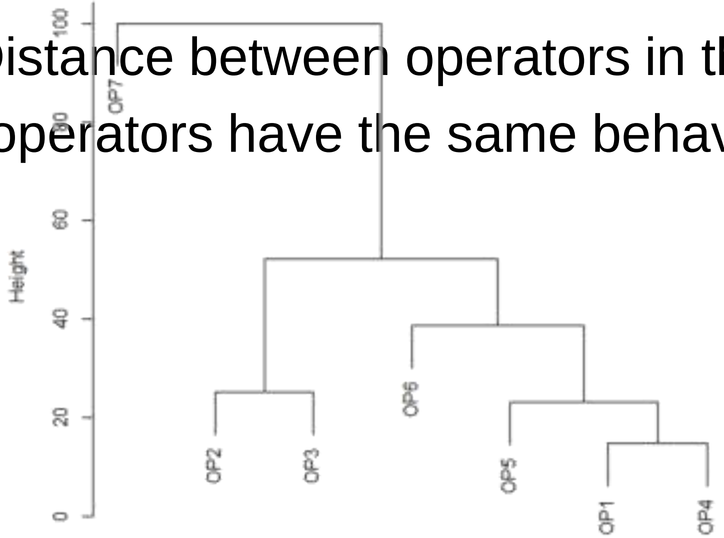
OP6: “fast and furious” or specific mission (connection / infiltration ?)

Dendrogram?

- Hierarchical clustering: calculation of distance between variables
  - Distance between operators in the same municipality

= do operators have the same behavior?

All municipalities & districts



Distance = f(highest frequencies of defect)

On-going work: Principal Component Analysis

Observations → "axis" (variables) to explain the variability in the data

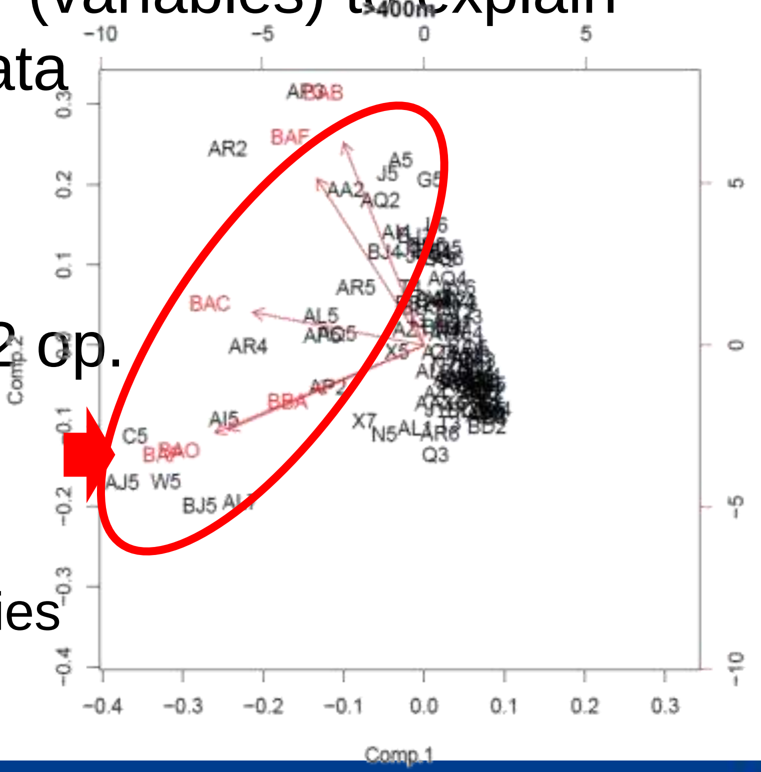
- 32 municipalities

Inspected by at least 2 op.

- 110 points
  - A → BJ: municipalities
  - 1 → 7: operators

Ex: AJ5 = OP5 in "Lyon 9"

Defects driving the difference of operator behavior



Conclusions (regarding the case study)

- First analysis of main codes (BAx or BBx)
- Almost all defects are used!
- Many BAF (surface damage) and BAB (fissure)
  - BAB: “close” fissure and “open” fissure seems difficult to distinguish
- Difference of behavior between operators are noticed
  - Variability of frequency of observed defects
  - Writes all defects ≠ writes only major defects…

- A lot of data not used yet!

- *To be continued…*

Presentations

Session 4:

Advanced data management

Innovative technologies

LESAM 2017
NTNU, Trondheim, Norway

Presentation 1

Didier Sinapah: Pressure analytics in asset management applications

Pressure Dynamics and Asset Management (“Straw that breaks the camel’s back”)

LESAM-2017

Trondheim, Norway

Didier SINAPAH
Deputy Divisional Manager
Distribution Technical Centre
SUEZ

Dr Ivan STOIANOV
Senior Lecturer (Associate Professor) in
Water Systems Engineering
IMPERIAL COLLEGE LONDON

June-2017

“Preserving water resources is our mission…

82,500		Employees worldwide
70		Countries worldwide
15,2	Billions	Turnover in 2016

…we have been working as an operator to improve water systems performance for more than 150 years “

300 000	km	Water Network pipes
60	Millions	People served

Innovation ecosystem, multi-local and open…

€74 000 000
devoted to R&I

6
research centers

>200
analysis laboratories

>400
experts and researchers

65
research programs

283
families of patents

2 000
national patents in 70 countries

CTD: Delivering water distribution expertise

Dynamic

International

Agile

Holomorphic

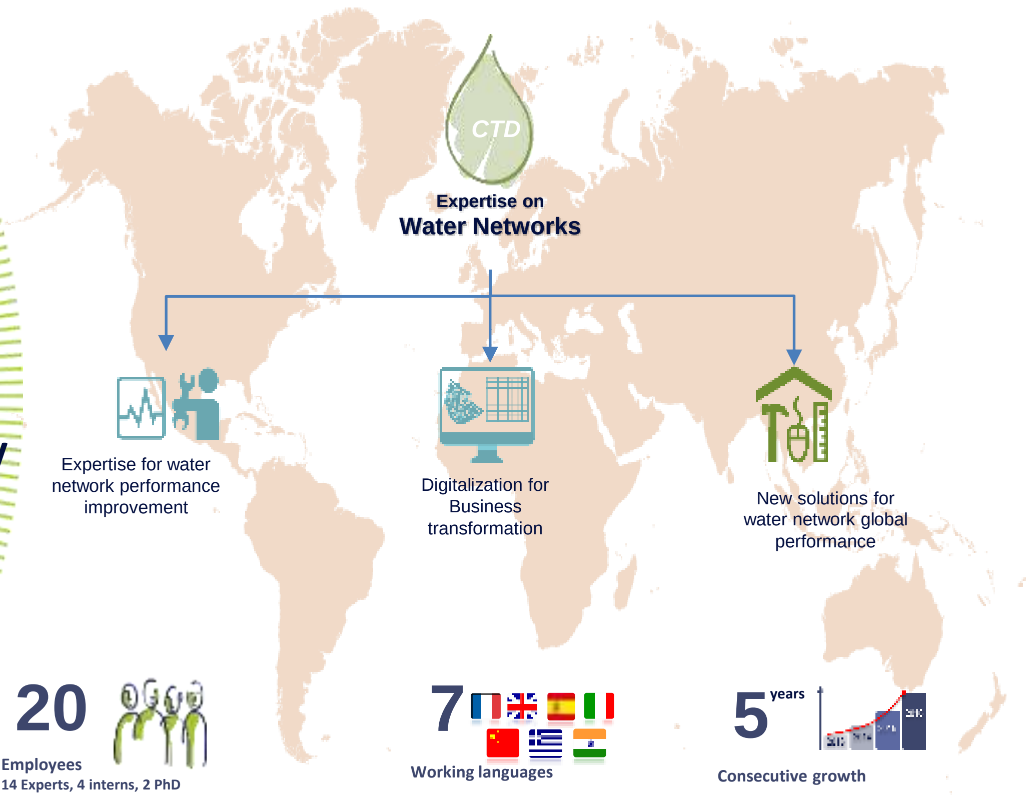
Multidisciplinary

Ambitious

Sparkling

Innovative

Expert



- Introduction-Prevoir

PREVOIR™ Suite
Decision-Support Tool Box for Asset Performance Prediction
and Optimization of Asset Renewal / Investment with Advanced Statistical Methods

Drinking water network | **Wastewater network** | **Plants**


Mains


Connections


Meters


Sewage pipes

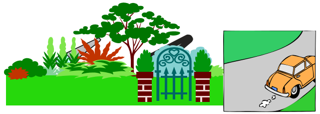

Pumps, valves, …

- Provides optimal assets renewal strategies under financial and technical constrains and objectives
- Predicts pipes and assets failure probabilities for medium to long term
- Improves the knowledge on the deterioration rates of assets
- Enables optimal OPEX versus CAPEX decisions in order to provide reliable water supply services at a minimum cost

• How it works

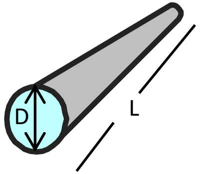
Data

<u>Environment</u> :
Soil, traffic,
pressure…



<u>Burst records</u>

<u>Asset characteristics</u>
material, length, diameter,
year of installation…



<u>Simulator data</u>
repair cost,
replacement cost,
replacement rules…

Modeling

- Prediction model
- Burst severity evaluation

Simulation

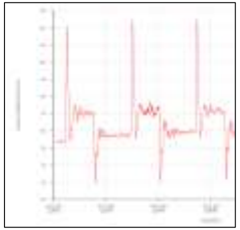
Risk = f (probability, severity)

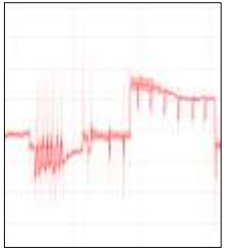
- Pipe priorization
- Renewal strategies assessment

- "Straw that breaks the camel's back"
- Impact of Dynamic Pressure on Pipe Deterioration and Failure

Internal Loading:
[Flow Dynamics]
Pressure Transients & Pressure Variations

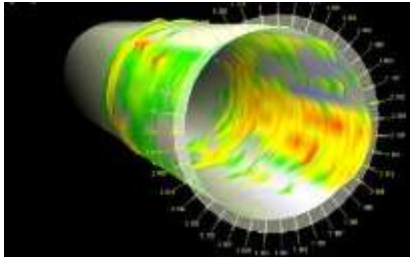
- **Manufacturing Flaws**
- **Internal Loading**
- **External Loading: *soil, installation, traffic***
- **Corrosion**
- **Human & Installation Errors**

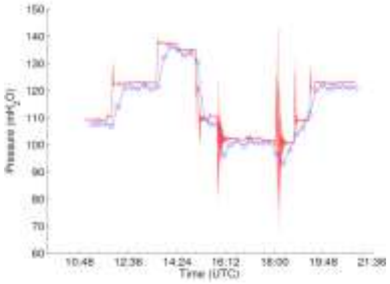


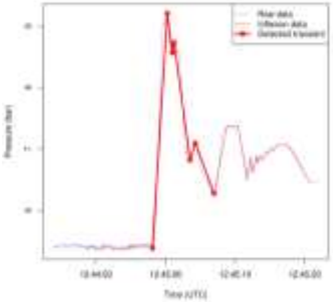


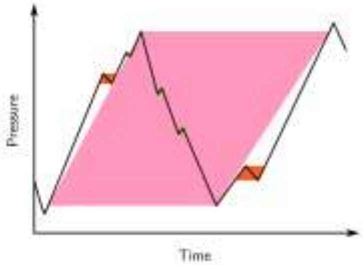
- Cumulative Pressure Induced Stress [CPIS™]

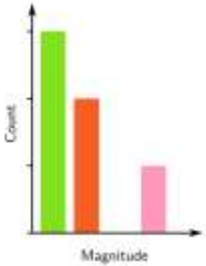
- Continuously Monitoring and Accounting for the Dynamic Pressure Variations [Patent Pending]

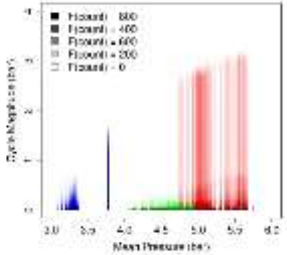








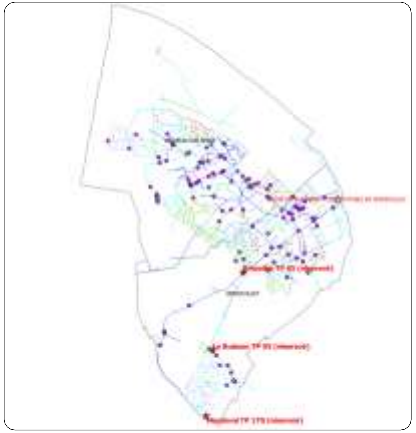




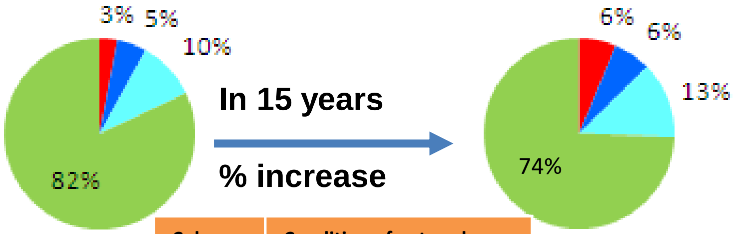
Pressure Cycle Characterisation → Cumulative Pressure Induced Stress

Application of PREVOIR

- **Pilot zone**: 40 km from Paris
- **Network pipe length**: 110 km
- **Typology**: 3 major pressure zones
- **Material**: 44% ductile iron + 26% cast iron + 22% PE
- **Leak rate**: ~ 6 leak/100km/year
- **Average pipe age** : 39 years



- Prediction model



Color	Condition of network
	Worst
	Poor
	Average
	Good

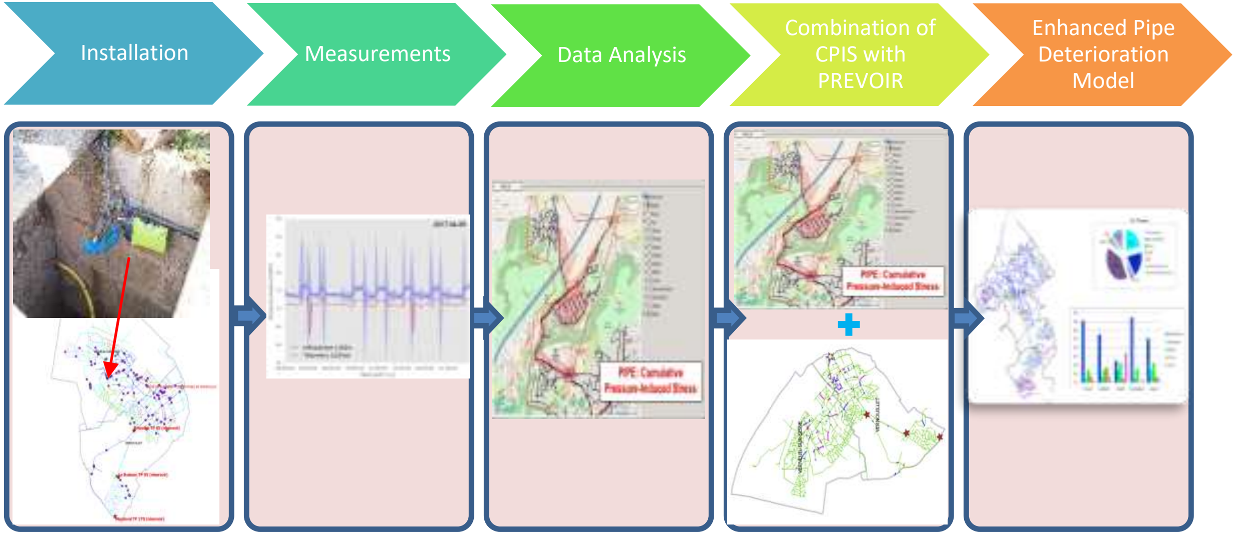
- Continuous Pressure Monitoring at 128S/s
- InflowSense™ (Inflowmatix Ltd)

42 InflowSense devices
SR: 128S/s
Time sync: 2ms
100% reliability and data integrity

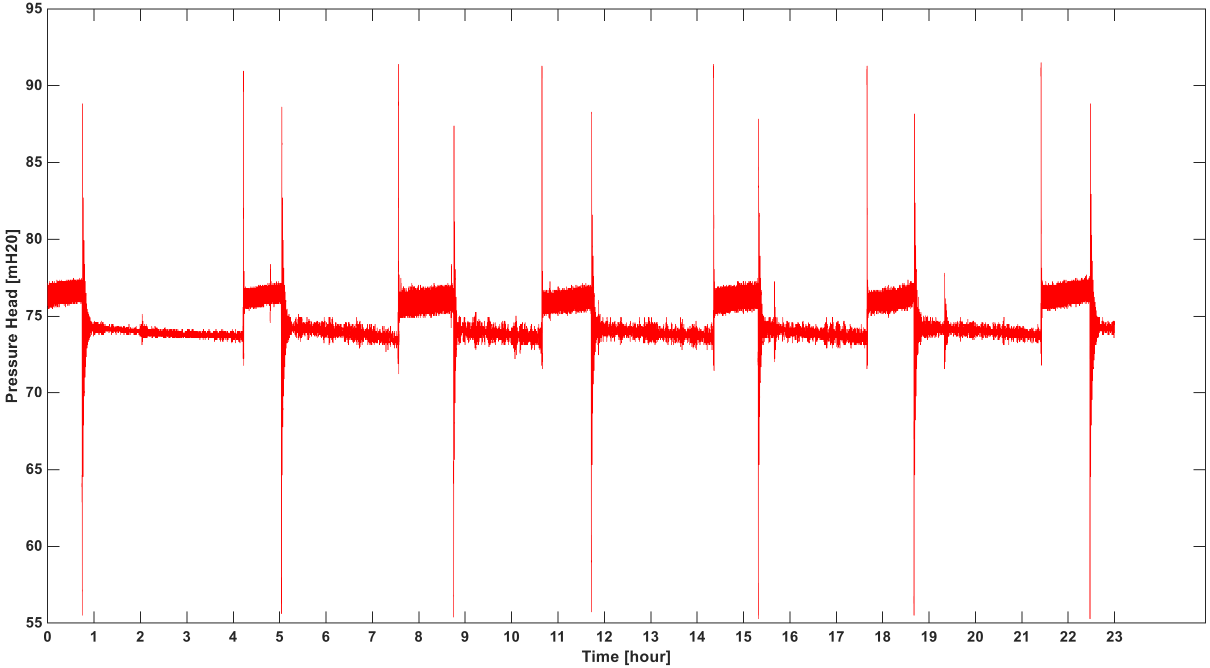
inflowmatix

• Template of acquiring and integrating CPIS™ in PREVOIR™

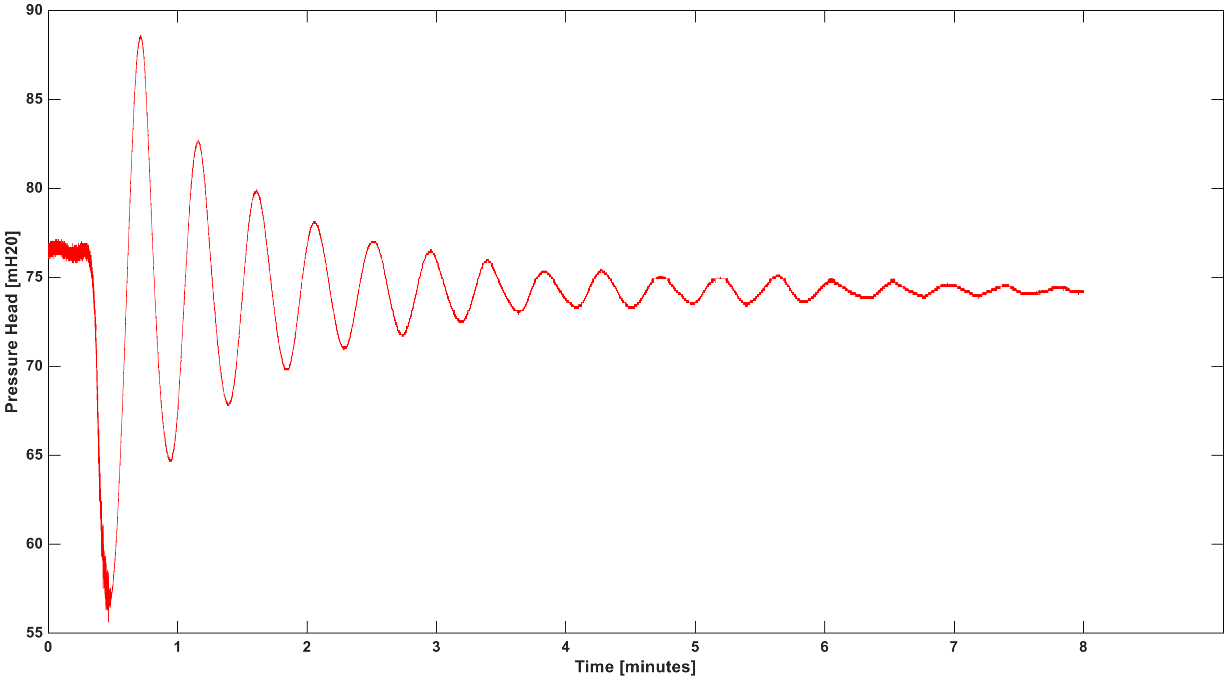
- Capture the complex pressure load history for each pipe
- Account for the fatigue effects of pressure loadings
- Sensing technology and analytics developed by Imperial College London (licensed to & further developed by Inflowmatix Ltd, UK)
- CPIS: A nover metric to enhance pipe deterioration models and their application.



- Example of the Dynamic Hydraulic Conditions

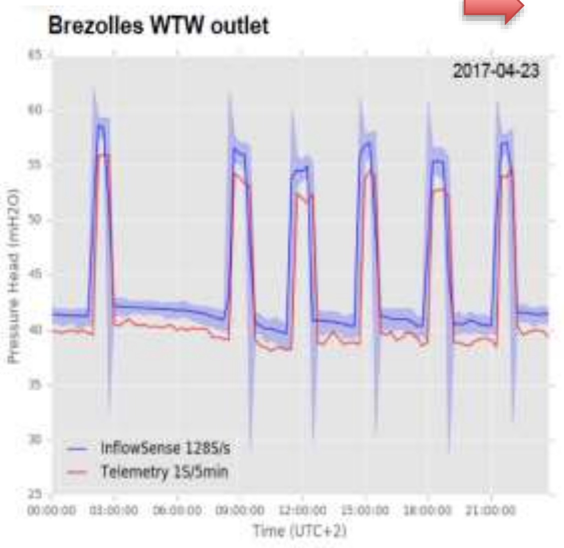


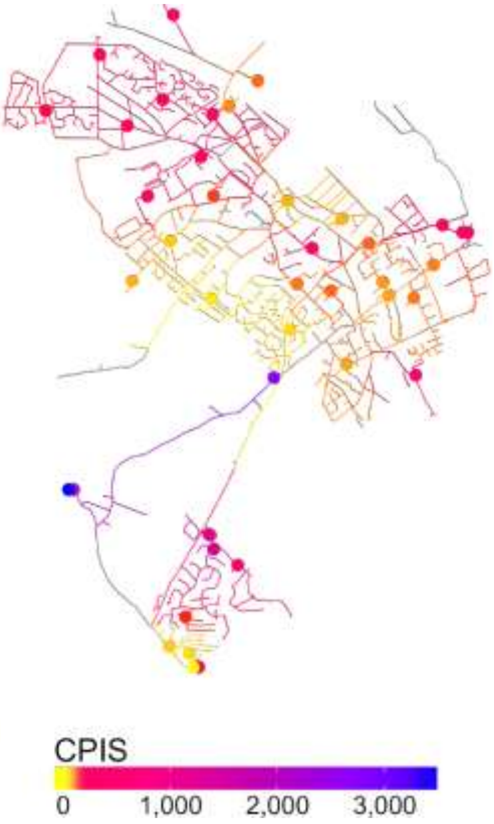
- Example of the Dynamic Hydraulic Conditions



• CPIS™ analysis for the pilot zone

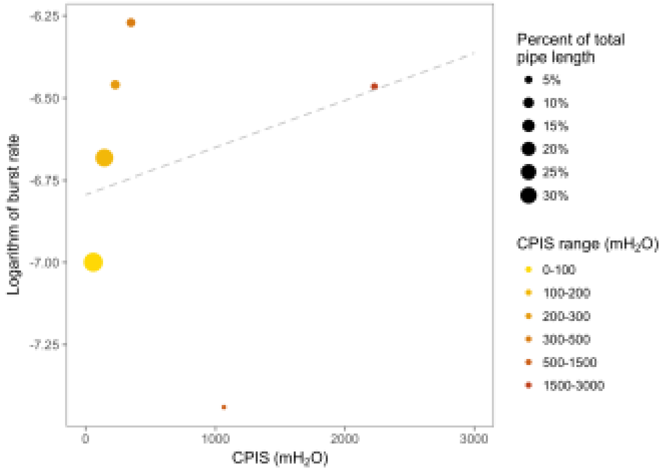
- 42 InflowSense devices (~ 1d/ 2.8km of pipe)
- Analytics to derive CPIS scores for each pipe
  - Energy dissipation and graph theory





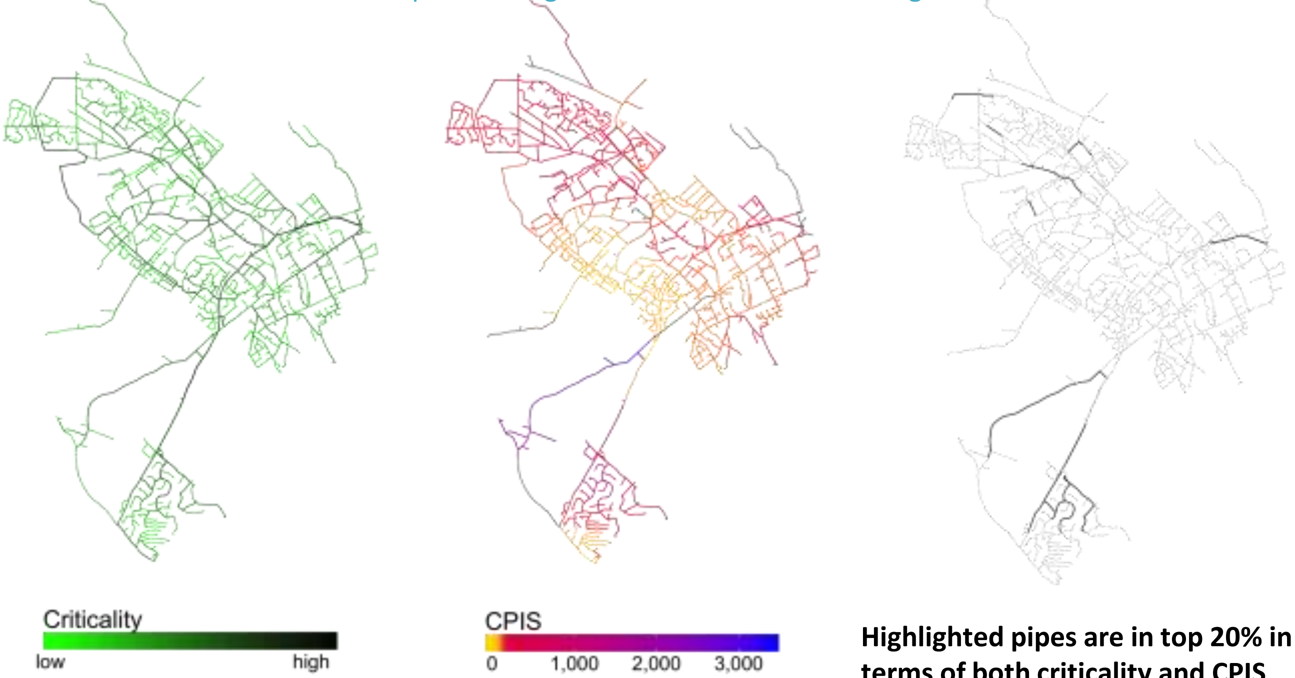
• Bursts versus CPIS™

- Positive correlation between dynamic pressure and pipe failures
- Small sample size (an initial validation of a processing template)



• The addition of CPIS™ in Prevoir™

- A positive correlation between pipe bursts and CPIS™ for individual pipes
- CPIS™ as a co-variate to trace the complex pressure loading history of an asset in Prevoir™
- Enables a more reliable and optimal integration of asset and risk management



Highlighted pipes are in top 20% in terms of both criticality and CPIS score

Conclusion

- A novel approach to monitor and characterise the complex pressure loading of assets based on:
  - Fundamental science in pipe fracture mechanics
  - Novel low-cost technology for the continuous monitoring of pressure (unique spatial and temporal resolution data)
  - Novel analytical methods
- The case study was selected to investigate a robust data acquisition and analytical template
- Further work to apply the proposed template to large scale networks
- Novel & unique method to account for the IWA's aspiration to capture the impact of pressure transients ("Straw that breaks the camel's back") within the broader concept of calm networks.

Thank you

Acknowledgements:

Dr Vasilis Kontis, Robin Bell, Dr Mike Williams (Inflowmatix Ltd)

Huan Yin, Satish Vegi, Andrea Rossi (Suez)

Presentation 2

Tiia Lampola : Automated Image Learning to Improve Sewer Pipeline Inspections

Automated Image Learning to Improve Sewer Pipeline Inspections

Tiia Lampola, Helsinki Region Environmental Services Authority

Purely better, every day

Basic task	We produce and organise water services, waste management services and environmental regional information
Customers	Residents and business companies in the Helsinki Metropolitan Area
Member municipalities	Espoo Helsinki Kauniainen Vantaa

Core tasks of HSY Water services

Clean water

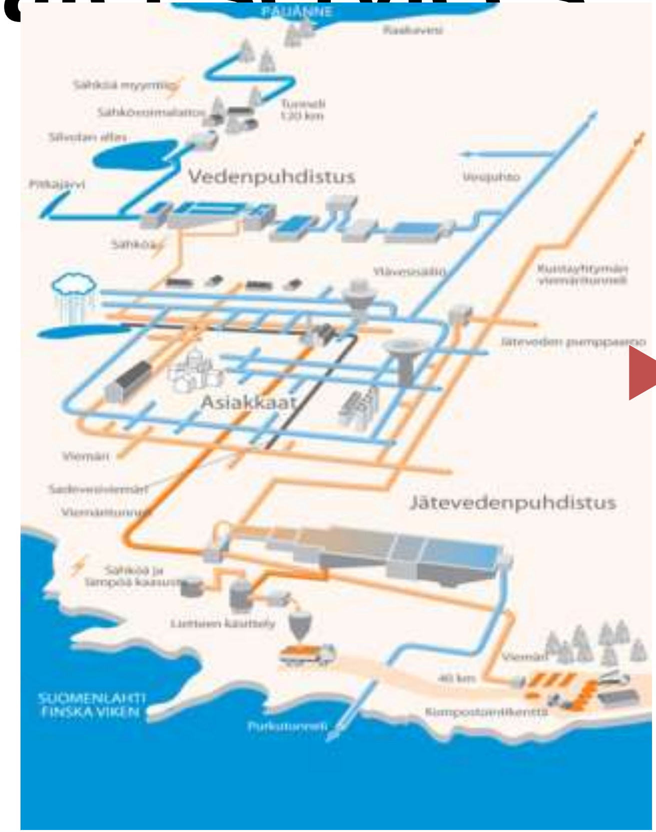
Comfortable environment

Developing community

Acquisition, cleaning and supply of high-quality domestic water

Sewage collection, treatment and discharge into the sea

Production of water management services that correspond with the growth of communities



Key figures for the water supply network

WATER SUPPLY NETWORK	Total length of network	New built in 2016	Old renovated in 2016
Water pipes	3 073 km	30 km	8.8 km
Wastewater and combined sewers	2 877 km	27 km	6.2 km
Storm drains	2 372 km	31 km	1.9 km
Total	**8 322 km**	**88 km**	**16.9 km**

Key figures for HSY Water services in 2016

New connections	**approx. 965 per year**
New residents	**approx. 14 361 per year**
Population 31 December 2012	**1 138 708**
Connected to the network	**approx. 1 112 400**
Outside networks	**approx. 12 200**
Connection fee	**98.9%**

Smart Water -project

- Started in January 2015, ends in December 2017
- Total budget 600 000 €, from which Tekes (the Finnish Funding Agency for Technology and Innovation) provides 50 %

- Concentrating on the networks

Goals of the Smart Water project

- In the project a new (one or more) way of working in public-private-cooperation

- Data improvement
  - GIS data (75 000 connections and manholes)
    - From 1890’s
  - SCADA (550 pumping stations)
- Integration of systems
  - Open inferfaces
- In pipelines (networks)
  - Leakages
  - Inflow and infiltration
  - Breakages
  - Need for renovation

Sewer Pipeline Inspections in HSY

- Total length of approx. 2 800 km
- Only a fraction of the network (less than 0.5 % of total length) is renovated annually
- Traditional video inspection (CCTV inspections)
  – Annually approx. 120 km
- Manual fault observation and reporting
  – Slow process
  – Interpretation varies depending on the operator
  – Information is not objective
- Need to get the CCTV inspections in this millennium
  – Faster turnaround time
  – Objective interpretation

Smart Water project in HSY

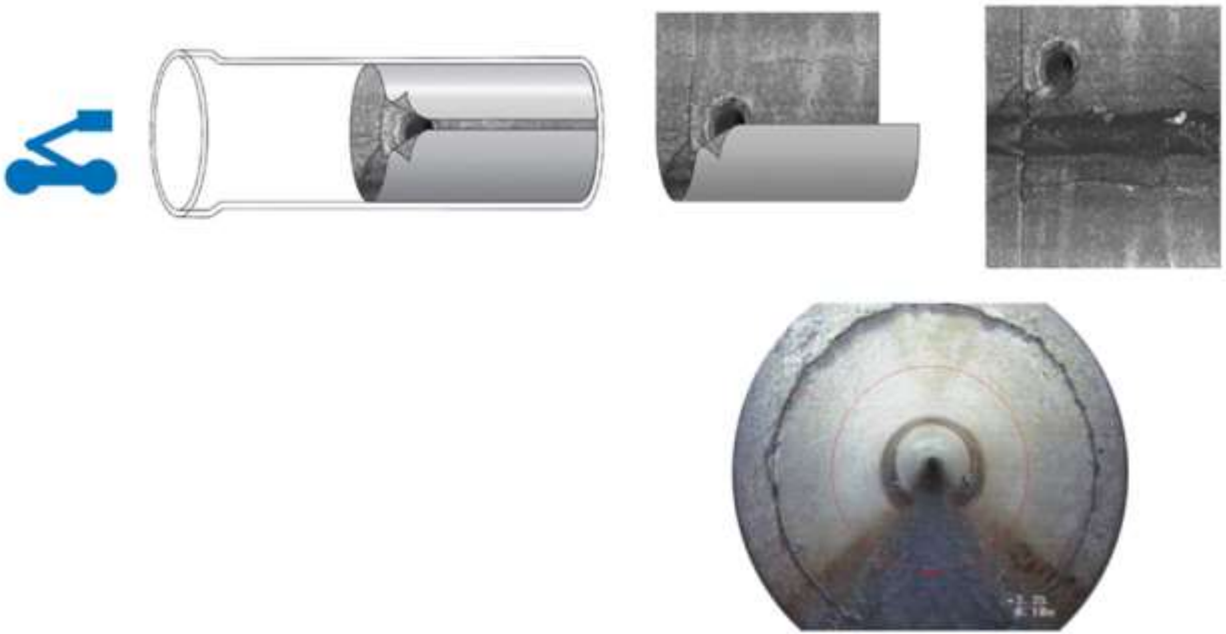
- Survey of current situation (Sakari Kuikka, Oy DigiSewer Ltd.)
  - Reports from Europe and USA/Canada
  - Interests of possible partners of cooperation
  - Surveying the current inspection methods
- In 2016 in HSY
  - Two PoC's of machine learning
  - Pilot project of approx. 13 km of sewer pipelines
  - Different materials, ages, conditions
- In 2017
  - Further development of image learning process from digital images of sewer pipelines

Digital material from sewer inspections

- Image learning process
  - Fast
  - Objective
  - Homogeneous material
- Principles of analyses
  - Instructions of interpretations
    - Non-profitable/parent organisations (such as FIWA)
  - Pipelines with/without observable problems/faults
  - Classification of faults
- A new approach to make CCTV-inspections
  - Different approach with more possibilities
  - From single faults to better knowledge of condition

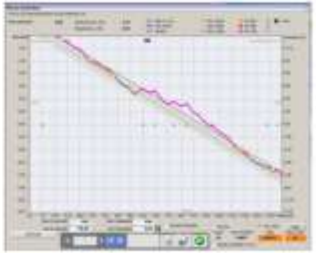
Digital images from sewer inspections (1/2)

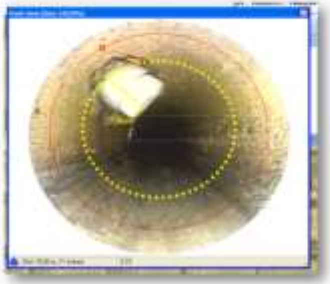
- DigiSewer® Laser

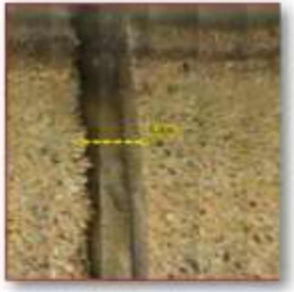


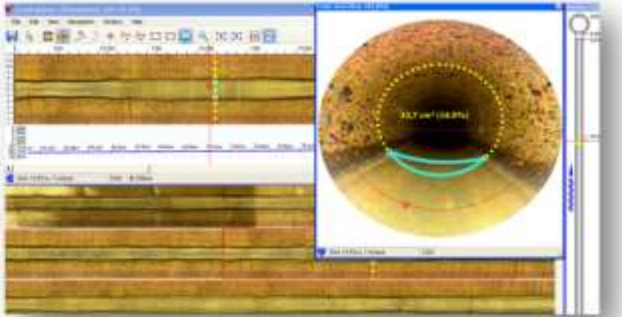
Digital images from sewer inspections (2/2)

- DigiSewer® Laser; mittausta, kuvia









Presentation 3

Mauritz Maks: An autonomous inspection robot for underground water mains

Design of an inline, autonomous inspection robot for underground water pipes

Maurits Maks, Peter van Thienen, Doekle Yntema

21 June 2017

LESAM, Trondheim

Project Information

- Collaboration between Wetsus and KWR (BTO)
  - **Wetsus: *European centre of excellence for sustainable water technology***
  - **KWR: Research institute of the Dutch (and one Flemish) drinking water companies; mission: *bridging science to practice***
  - **BTO: Joint research program of the Dutch drinking water companies**
- Project advisors: experts on drinking water, inspection and sensors.

- September 2015, burst water pipe Amsterdam.

Goal of project

- Not only to reduce incidents

- Also cost effective pipe replacement
  - More efficient replacement strategy
  - Bad pipes first
  - Good pipes can wait

- Many more possibilities not yet defined
  - Water quality monitoring
  - Leakage detection

Pipe network

- Primary
  ≥300mm
- Secondary
  <300mm
  ≥160mm
- Tertiary
  <160mm

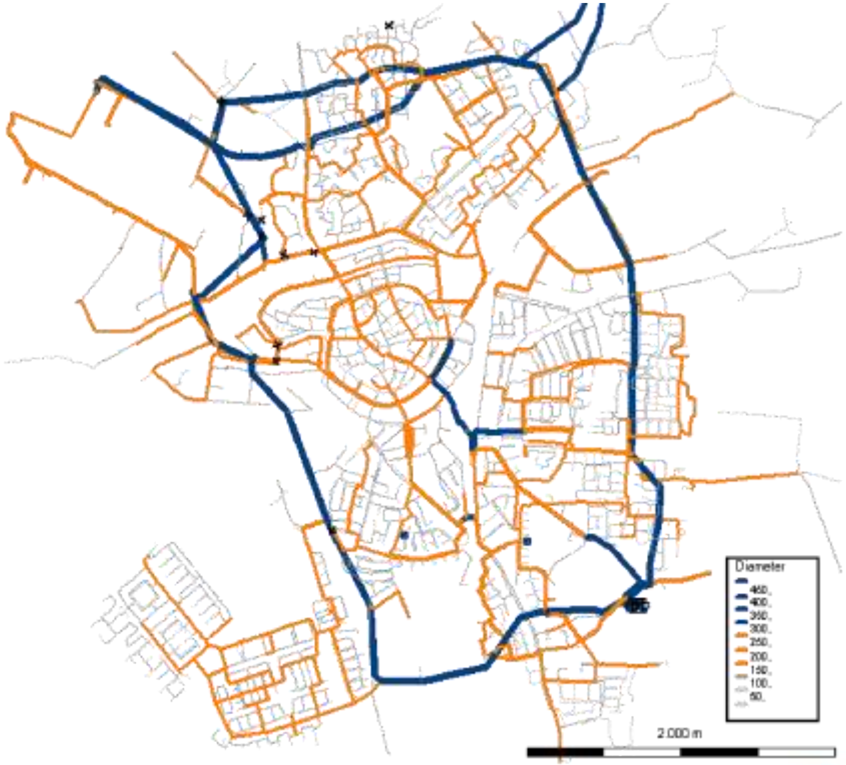


Image source: Ontwerpen secundair leidingnet – KWR – april 2011

Pipe network

- Many bends, T-joints and valves
- Network is looped
  - Flow can be in both directions

Image source: Ontwerpen secundair leidingnet – KWR – april 2011

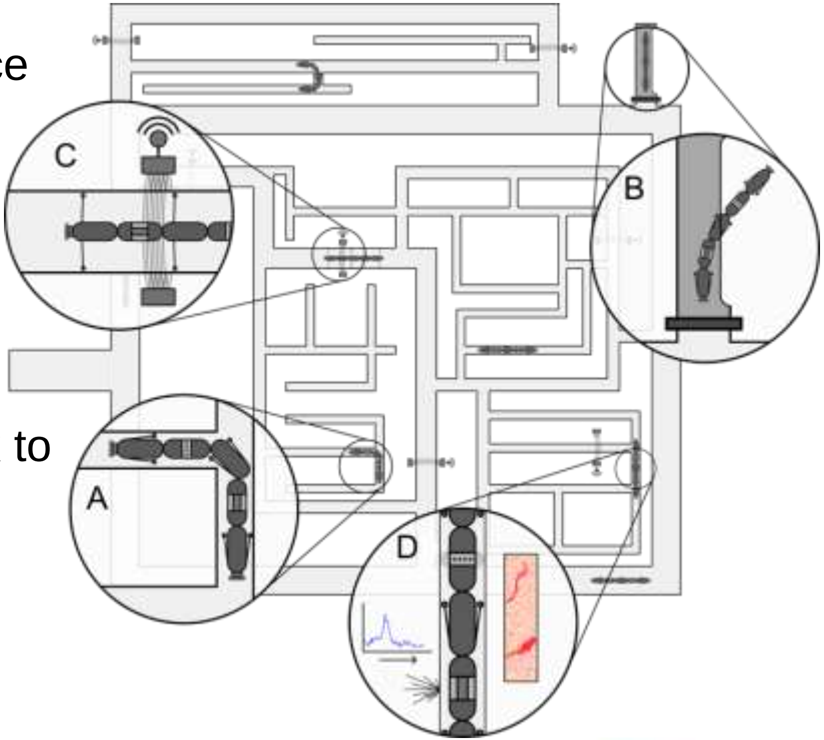
Pipe network

- Different sizes and materials
  - Mainly asbestos cement and PVC in the Netherlands
  - ~~Grey cast iron, steel, PE are also used~~
  - Diameters range from 40 – 1500mm
  - An operational life of 60 years is not uncommon

http://www.blomcivieletechniek.nl/drinkwatertransportleidingliof

Vision autonomous pipe inspection

A. Passing T-joints
B. Access for maintenance
C. Charge point
D. Inspection pipe



Goal: Inspect pipe network to reduce failure and reduce replacement costs by knowing what pipes to replace.

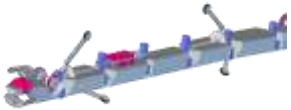
Vision autonomous pipe inspection

- Inspect pipe quality
  - Without system downtime
  - While water stays drinkable
  - Fully automated

http://www.colleranenvironmental.com/water-purifiers/

Inspection techniques compared



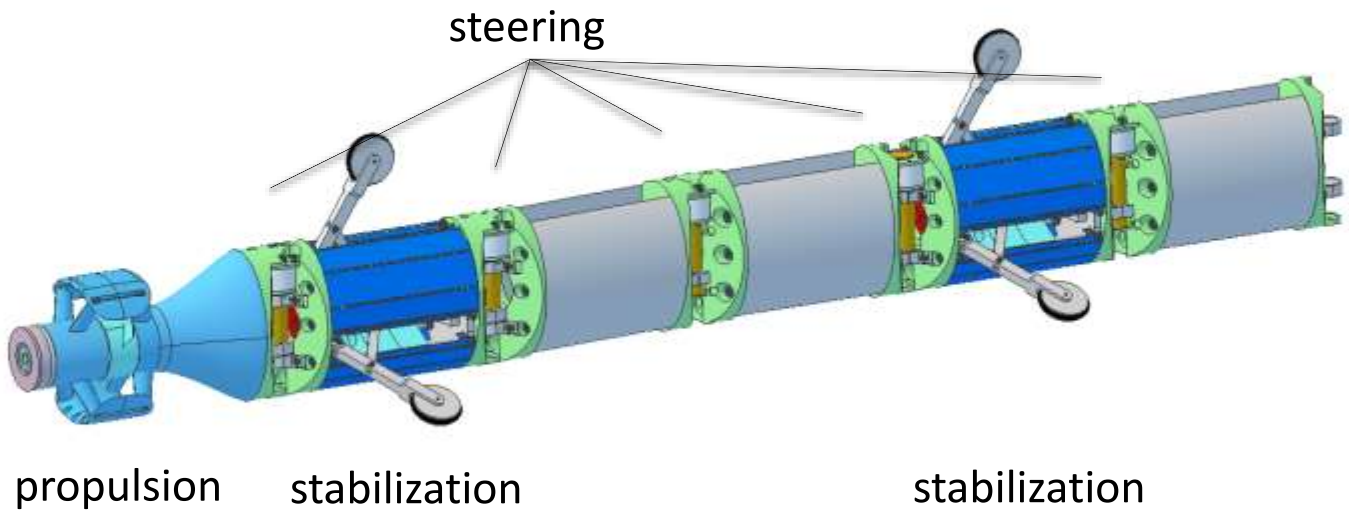



	Crawler	PIG	Floater	AIR
inspection single section	+	++	+	+
bends	+/-	++	++	++
multiple sections at once	--	--	+/-	++
T-joints	-	--	+/-	++
network uptime	--	--	+	++
accuracy	++	++	+/-	+
speed	+	++	+/-	+/-

Concept generation

- Multiple concepts generated
  - Feasibility check
  - Discussed with experts

Chosen concept



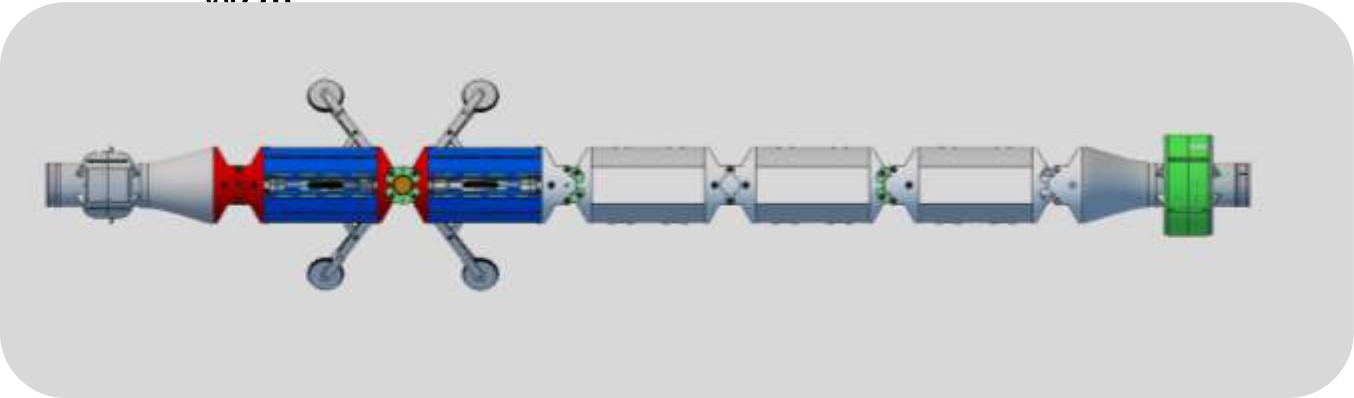
Empty modules for electronics, batteries and sensors.

Design decisions

- Propulsion with propeller
  - Water stable factor, state of the pipe wall not
  - Camera and sensor on f
  - Simple to construct

Design decisions

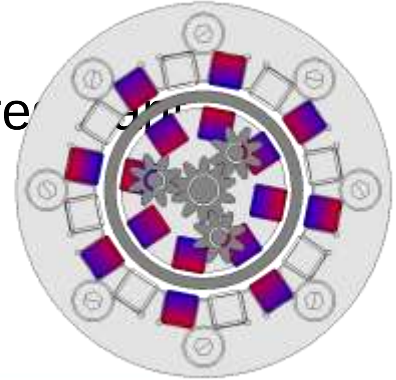
- Stabilization with centering module
  - Straight path for wall condition sensors
  - Aligns sensors perpendicular to wall



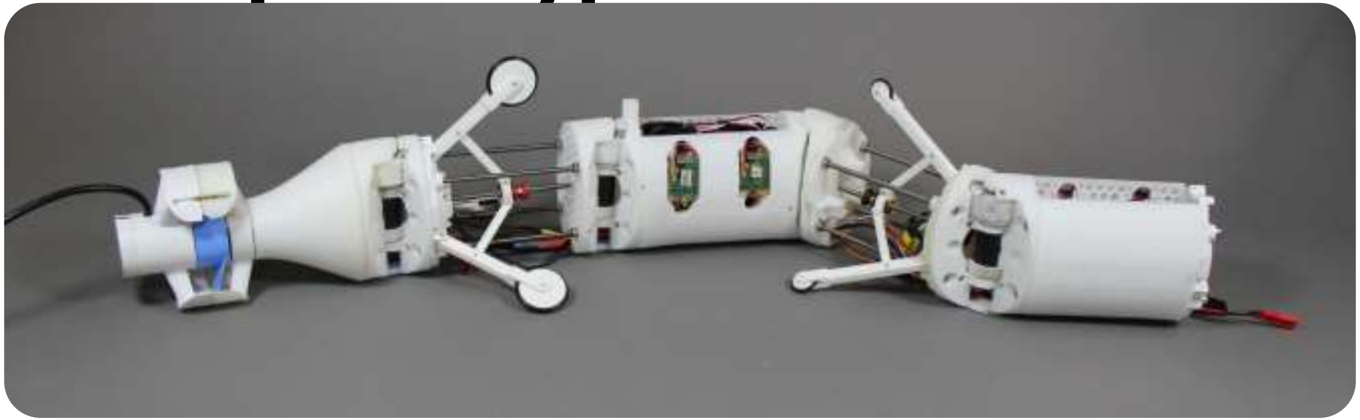
Design decisions

- Actuators for steering
  - Controlled passing of obstac
  - Stability for sensors

  - Hygienic
  - Watertight
  - Pressure re



The prototype



- Most parts 3D-printed
- Free space for:
  - Sensors
  - Energy storage
  - Navigation systems

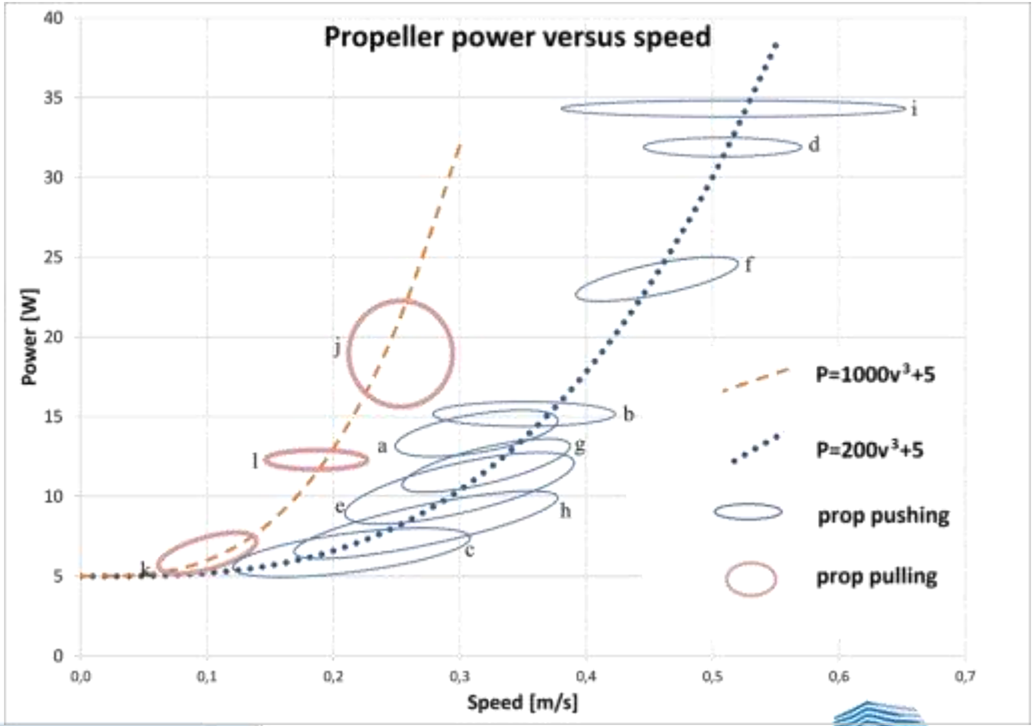
Passing T-joint

Propulsion

- 13m 150mm I.D. pipe
- Power and control by cable

Propulsion

- Power consumption propeller
- Slow
  - 0,2m/s
  - 6W
- Fast
  - 0,5m/s
  - 34W



Conclusion

- With autonomous inspection we aim to:
  - Determine instead of estimate the condition of pipes, in order to replace the right pipe at the right time
  - Thus reducing failure rates and replacement investments
  - And also reducing leakage rates
- A prototype was engineered:
  - 3D-printed
  - Water resistant
  - Hygienic
- Tests have been performed:
  - Passing a T-joint
  - Power consumption propulsion

Thank you for your attention!

Presentation 7

Michael Pöhler: Advanced method to assess wastewater pump

ADVANCED METHOD TO ASSESS THE ASSET WASTEWATER PUMP

Michael Pöhler | TU Berlin | LESAM 2017

Motivation

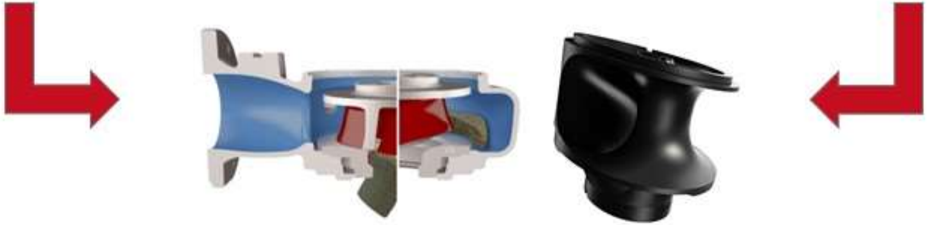
Sydney: each year 500 tons of wet wipes

New York

- spent 18$ mill. last five years
- screening material has doubled

Motivation

How to choose the right wastewater pump?



Current assessment of wastewater pumps

- Assessed according to DIN EN ISO 9906
- Load of fibrous/ solid material not quantified or considered






Testing procedures
Artificial wastewater

Wastewater class	Specific fibre content in g/m^3	Fibre composition	Form	Size in cm
Clear water	0	n.a.	n.a.	n.a.
Low contamination	95	Synthetic	25 $wipes/m^3$	21 x 30
Medium contamination	190	Synthetic	50 $wipes/m^3$	21 x 30
High contamination	380	Synthetic	100 $wipes/m^3$	21 x 30

Testing procedures
Functional performance test

- Defined volume of wastewater with specific fibre content
- Results in Degree of Functional Performance

Testing procedures
Long-term Functional performance test

- Defined time with specific fibre content
- Results in Degree of Long-Term Functional Performance

Assessment of functional performance

Definition Degree of **Functional Performance D_F** (Range 0..1):

$$D_F = \frac{pumped\ textiles\ [g]}{tot\ amount\ of\ textiles\ [g]}$$

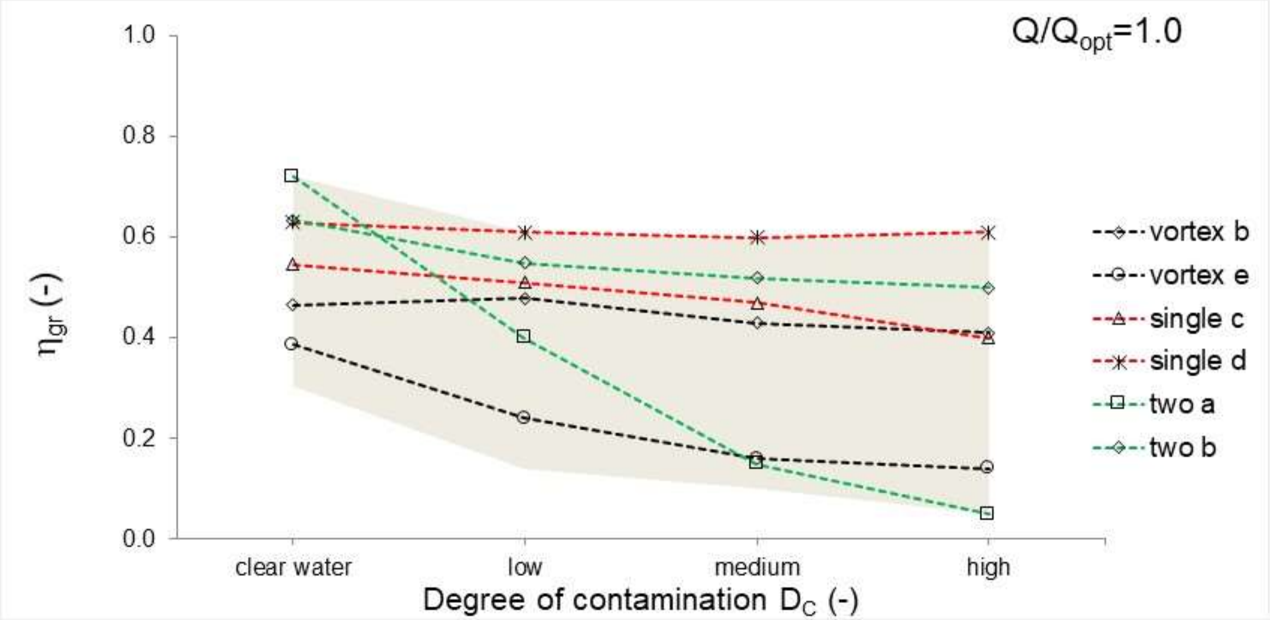
Definition Degree of **Long-term Functional Performance D_{LTF}** (Range 0..1):

$$D_{LTF} = \frac{1}{2}\frac{efficiency\ between\ 0-60\ min.[\%]}{clear\ water\ efficiency[\%]} + \frac{1}{2}\frac{tot\ amount\ of\ textiles\ [g] - residues\ in\ impeller\ [g]}{tot\ amount\ of\ textiles\ [g]}$$

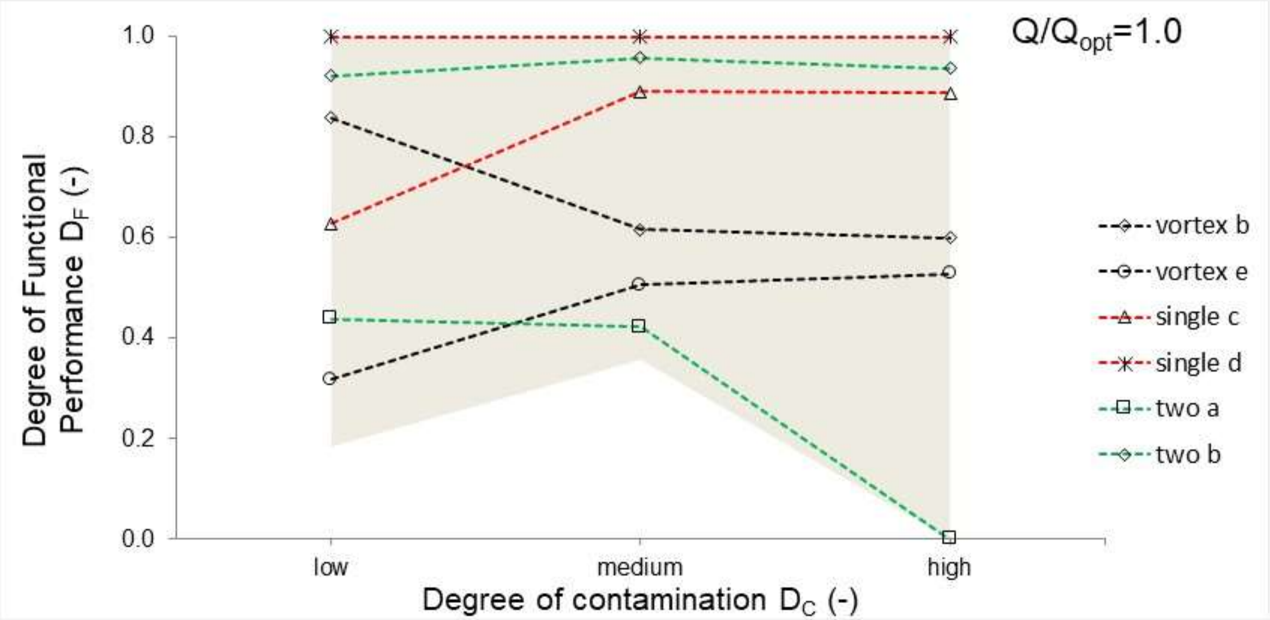
Definition **Functional Efficiency Index FEI** (Range 0..1):

$$FEI = (1/2 \cdot D_F + 1/2 \cdot D_{LTF}) \cdot \frac{\rho \cdot g \cdot H \cdot Q}{P}$$

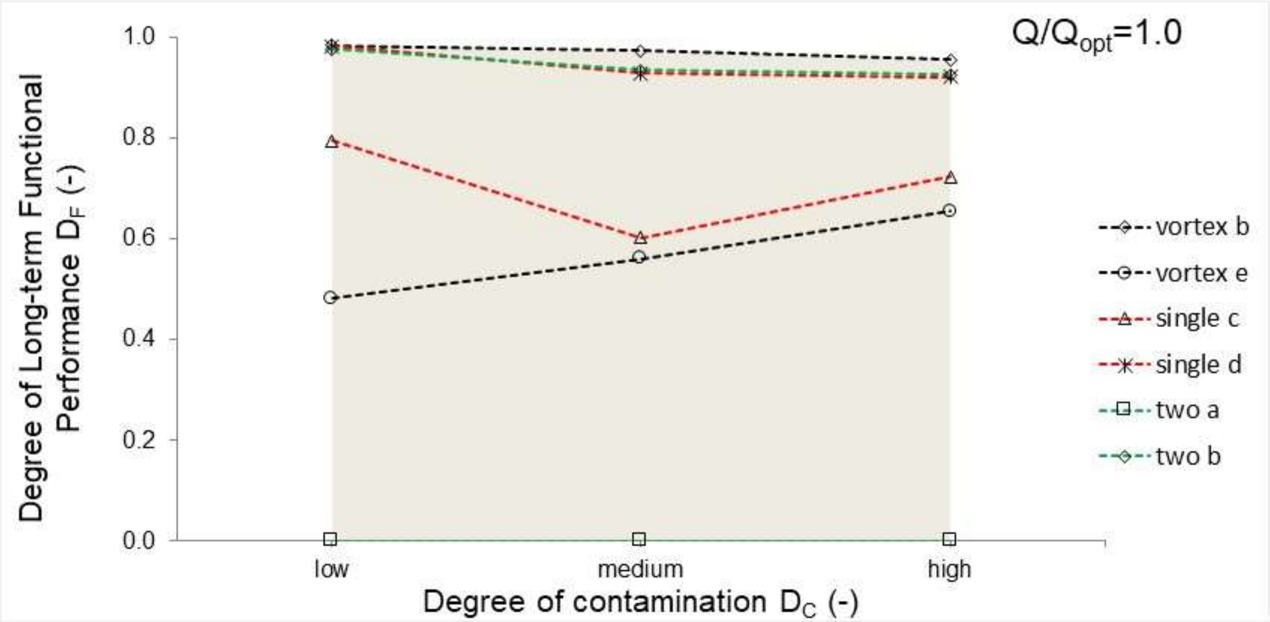
Wire-to-water Efficiency



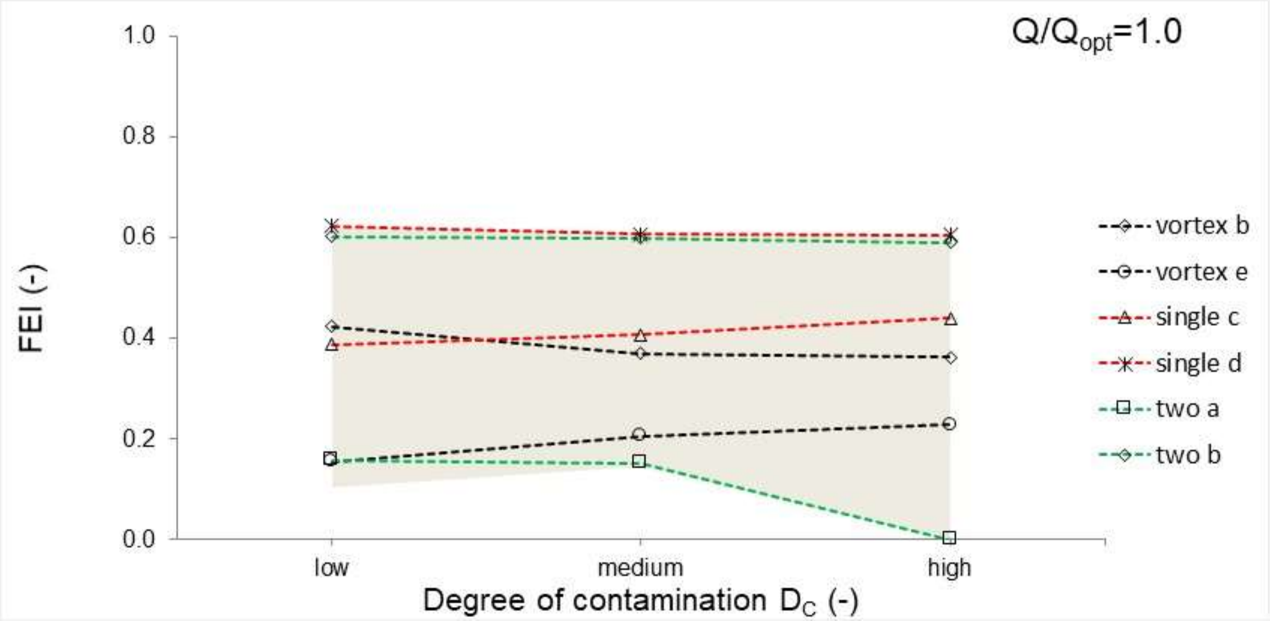
Degree of Functional Performance



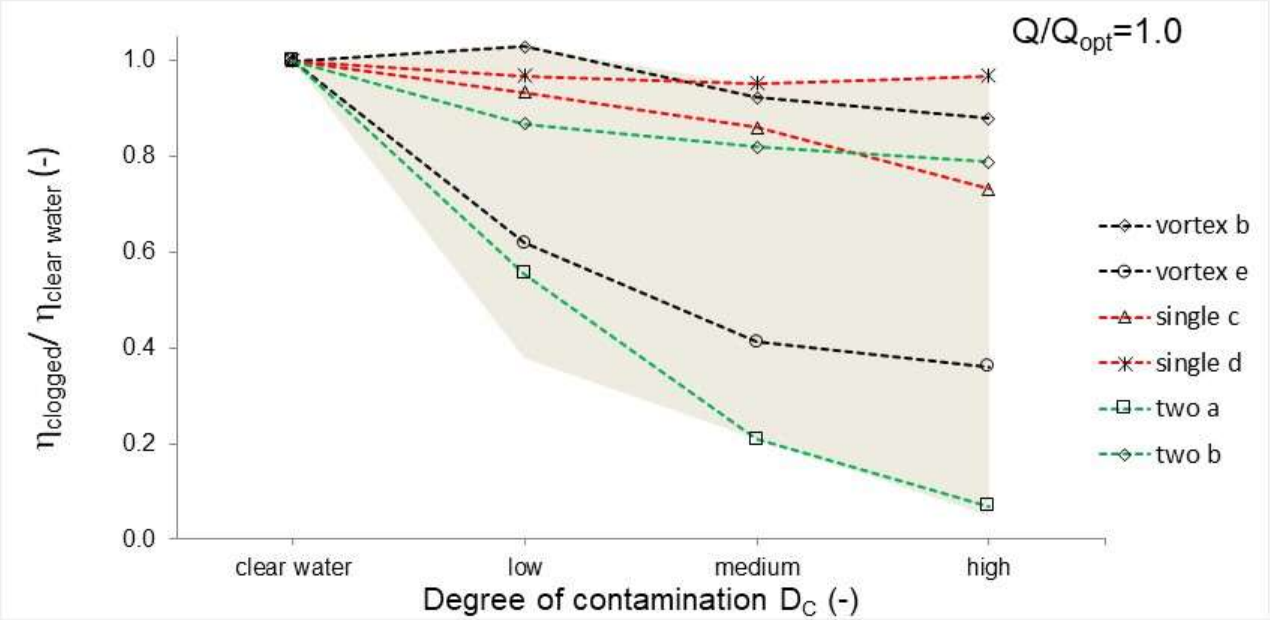
Degree of Long-term Functional Performance



Functional Efficiency Index

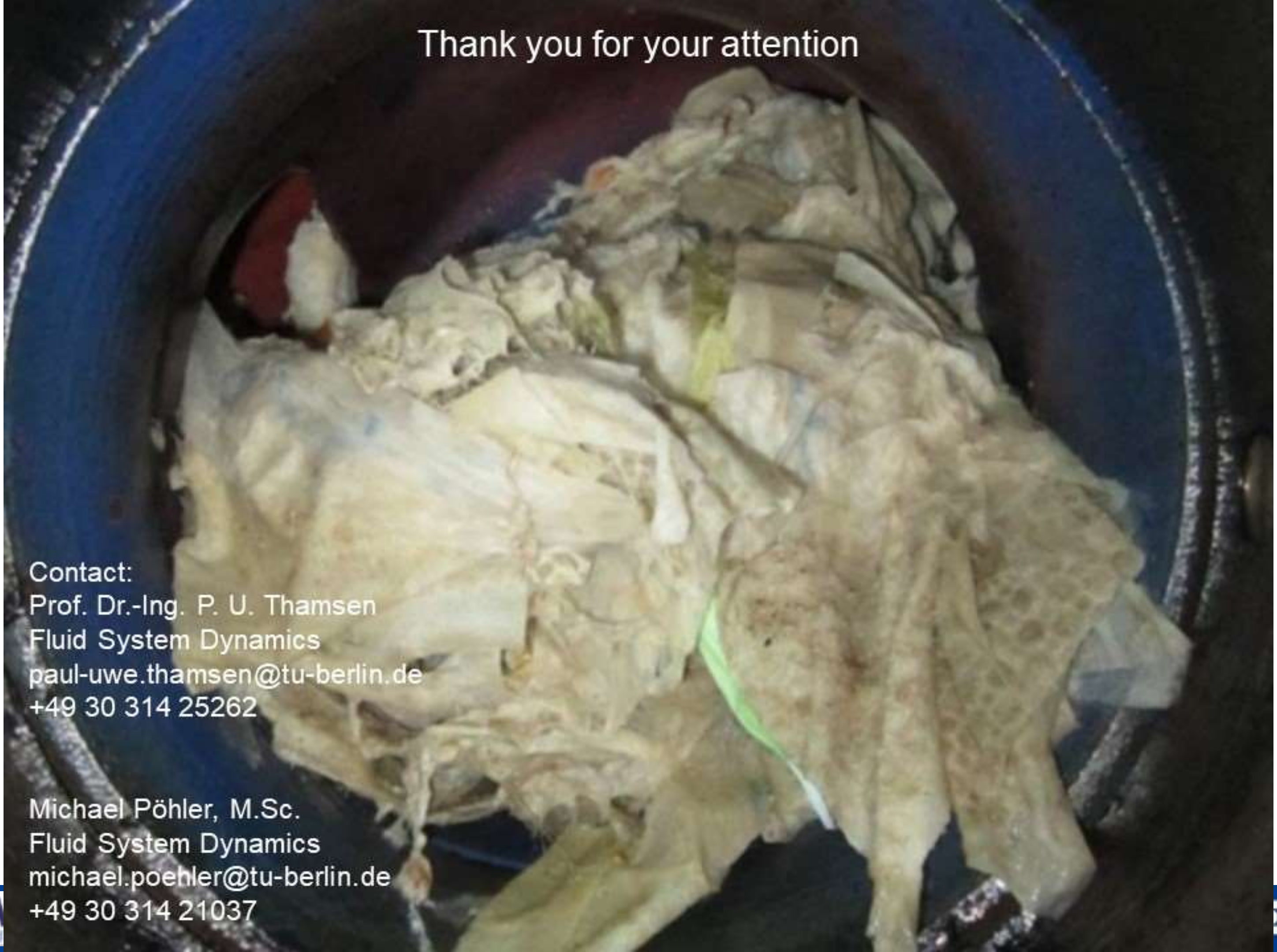


Normalised degradation in wire-to-water efficiency



Conclusions

- Goal: Prolong mean time between failures and maintenance
- Clear water efficiency is not a good indicator
- Developed testing procedures and assessment allow the comparison of functional performance of pumps
- Functional performance is not dependent on impeller technology
- Each impeller shows specific behaviour (own specifics and advantages/ shortcomings)



Thank you for your attention

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Presentations

Session 5:

Water and wastewater utility energy management

Short and long-term planning

Norwegian University of Science and Technology

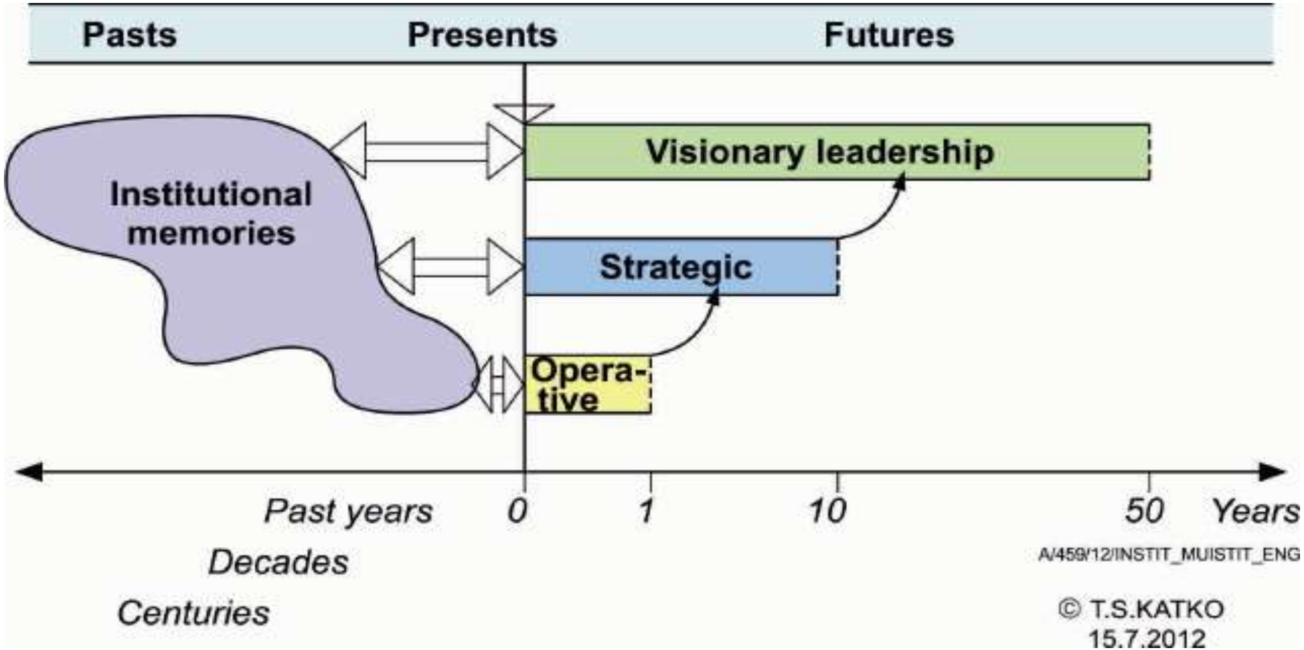
Presentation 1

Tapio Katko: Strategic thinking needed for tackling the challenge of aging water services infrastructure

Strategic Thinking Needed for Tackling the Challenge of Aging Water Services Infrastructure

Tapio S. KATKO, **Adjunct Professor; UNESCO Chairholder in Sustainable Water Services**
Tampere University of Technology (TUT), Finland
Co-authors: J.J. Hukka and P.S. Juuti (TUT)

2. Time frames (Katko 2016)

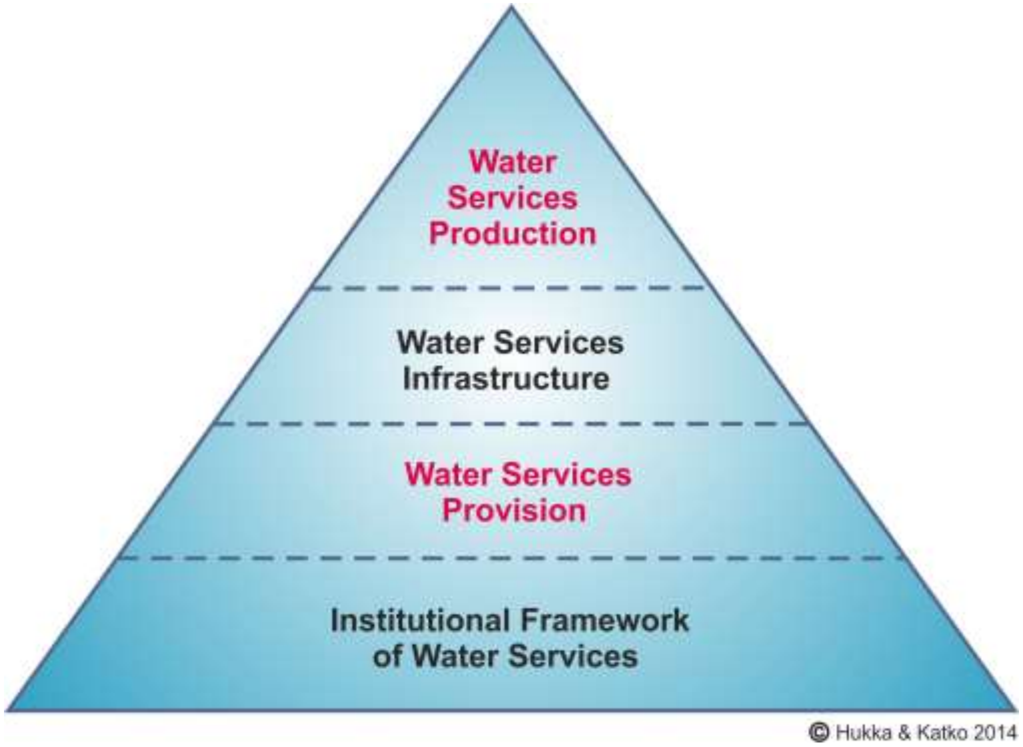


3. Estimated investment gap in water services infrastructure in four OECD countries

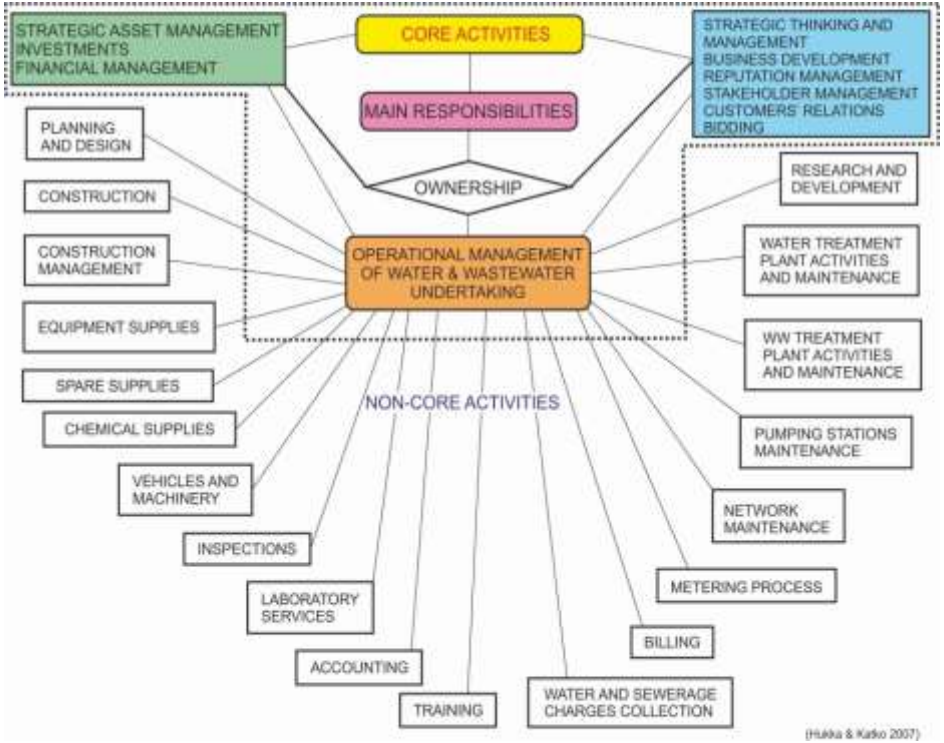
Country	Population (millions)	State of water services infrastructure (scale high to low)	Estimated current funding gap (billions USD)	Estimated funding gap per population (USD/hd)
Canada	35.182	Good (Very good–very poor)	72.1	2,050
Finland	5.426	7 (10–4)	6.58	1,210
Norway	5.043	Water networks 3; sewers 2 (5–1)	18.12	3,590
USA	320.051	D (A–E)	556.8	1,740

Karst formation with stalactites? (Katko 2016, 99)

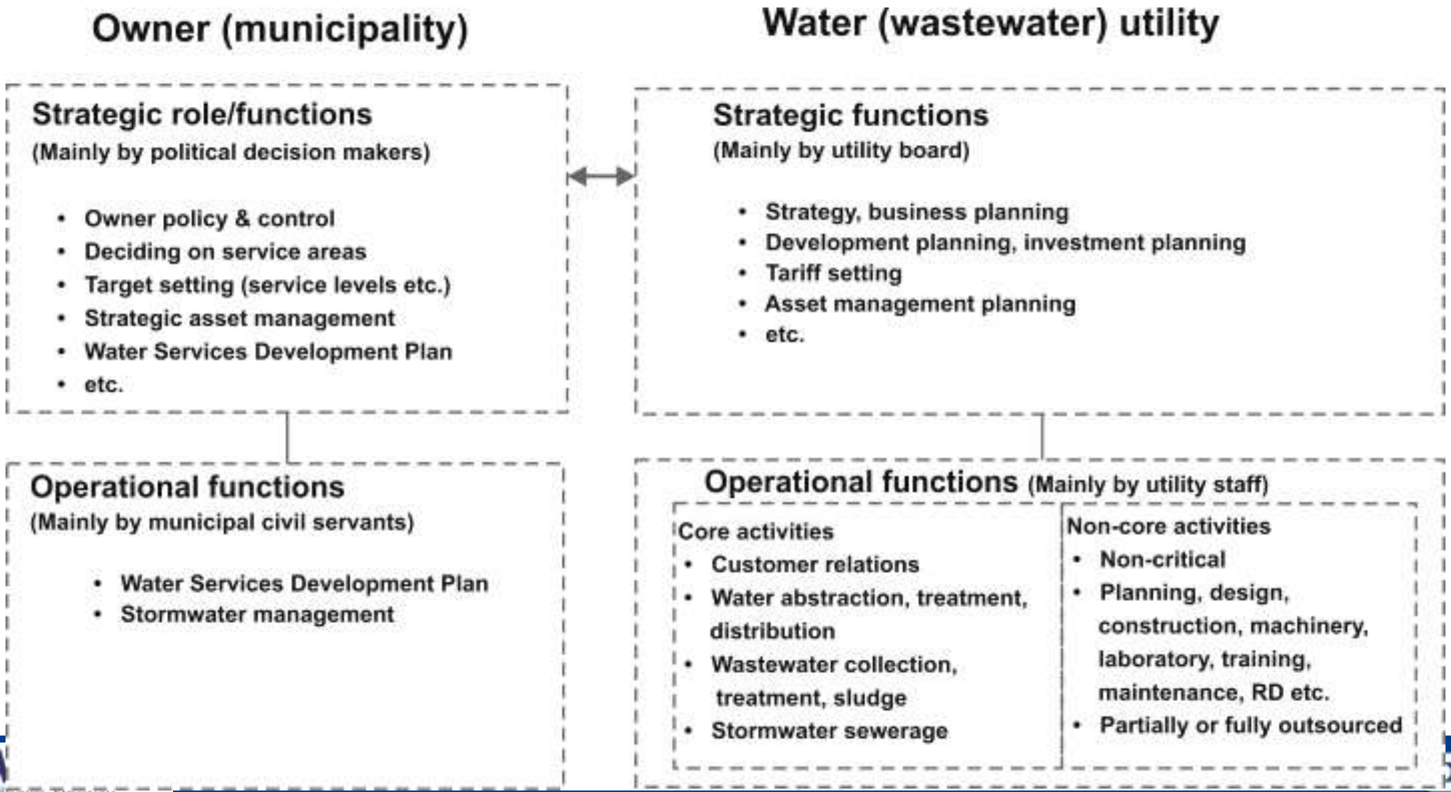
More Structured Approach (Katko & Hukka 2015)



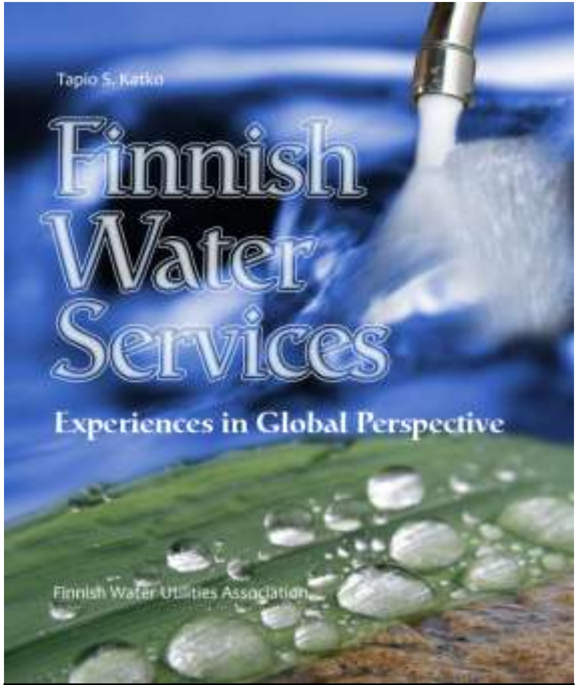
4. Core and none-core activities (Katko & Hukka 2016)



5. Key *strategic roles and functions* of municipality and urban water utility in Finland



6. Role of institutions



- www.finnishwaterservices.fi

D.C. North´s soccer-analogy:

- Institutions = formal and informal rules of the game
- Players = organisations

4. Conclusions

- **At least Strategic time frame is needed**
- **Investments gaps for rehabilitation are obvious everywhere**
- **Service provision vs. production**
- **Core and none-core activities → Key *strategic roles and functions* of municipality and water utility: These to be included in education and RDI activities**

- **-----------------------------**
- **Thanks very much tapio.katko@tut.fi**

5. Selected sources

- Heino O.A, Takala A.J. & Katko T.S. 2011. Challenges to Finnish water and wastewater services in the next 20–30 years. *E-Water*. EWA. http://www.ewaonline.de/portale/ewa/ewa.nsf/C125723B0047EC38/60CAFA191D51F6CDC1257876002699C6/$FILE/Challenges_A_TAKALA_OH_Final.pdf
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- Hukka J.J. & Katko T.S. 2015. Resilient Asset Management and Governance for Deteriorating Water Services Infrastructure. 8th Nordic Conference on Construction Economics and Organization*. Procedia Economics and Finance. 21: 112–119. http://www.sciencedirect.com/science/journal/22125671/21*
- Katko T.S. & Hukka J.J. 2016. Institutional Development is the Key for Sustainable Water Services in the Built Environment. CIB World Building Congress 2016. May 30-June 3, 2016. Tampere, Finland https://www.baufachinformation.de/Institutional-Development-is-the-Key-for-Sustainable-Water-Services-in-the-Built-Environment/ulcib/2016111000365
- Katko T. 2016. Finnish Water Services – Experiences in Global Perspective. www.finnishwaterservices.fi
- Seppälä O.T. 2004. Visionary management in water services: Reform and development of institutional frameworks. Doctoral dissertation. TUT, Publications 457. 300 p. See more: http://www.cadwes.com/publications/

Presentation 2

Helena Alegre: Exploring assessment systems for water loss and energy diagnosis and prioritisation of analysis areas

EXPLORING ASSESSMENT SYSTEMS FOR WATER LOSS AND ENERGY DIAGNOSIS AND PRIORITISATION

Ana Poças, Dália Loureiro, Aisha Mamade, Helena Alegre

National Laboratory of Civil Engineering (LNEC), Lisbon, Portugal.

EXPLORING ASSESSMENT SYSTEMS FOR WATER LOSS AND ENERGY DIAGNOSIS AND PRIORITISATION

Ana Poças, Dália Loureiro, Aisha Mamade, Helena Alegre

National Laboratory of Civil Engineering (LNEC), Lisbon, Portugal.

Inês, borne on 17 June 2017, prevented Ana to participate…

Table of contents

- The iPerdas approach
- Exploring assessment systems for water loss and energy diagnosis and prioritisation
- The case-study
- Results and discussion
  - System diagnosis and prioritisation
  - Accomplishment of the objectives and identification of intervention tactics
- Take-home message

The iPerdas approach

- Capacity-building project for the development of management plans on water loss and energy efficiency
- Plan-Do-Check-Act (PDCA), in compliance with ISO 55x standards on asset management and 50x on energy
- Continuous improvement of the quality of the provided service
- Implementation of metrics to allow the analysis and support future investments and decision-making

Main objectives

- To discuss prioritisation as a tool for the diagnosis and ranking of analysis areas
- Comparison of assessment systems using different metric subsets
- Highlight of the main issues raised through system diagnosis and prioritisation

Exploring assessment systems for water loss and energy diagnosis and prioritisation

- Traditional metrics used for diagnosis
  - non-revenue water by volume – IWA Fi46
  - real losses per connection – IWA Op27
  - standardised energy consumption – IWA Ph5)

- Utilities went further in selecting metrics that address their own particularities (through water and energy balance calculations and interpretations, overall water meter error, and experience)

The case-study

- The utility
  - abstraction and distribution systems
  - input volume of ca. 6 million m^3 of water
  - average monthly consumption of ca. 90 m^3
  - ca. 40% of non-revenue water

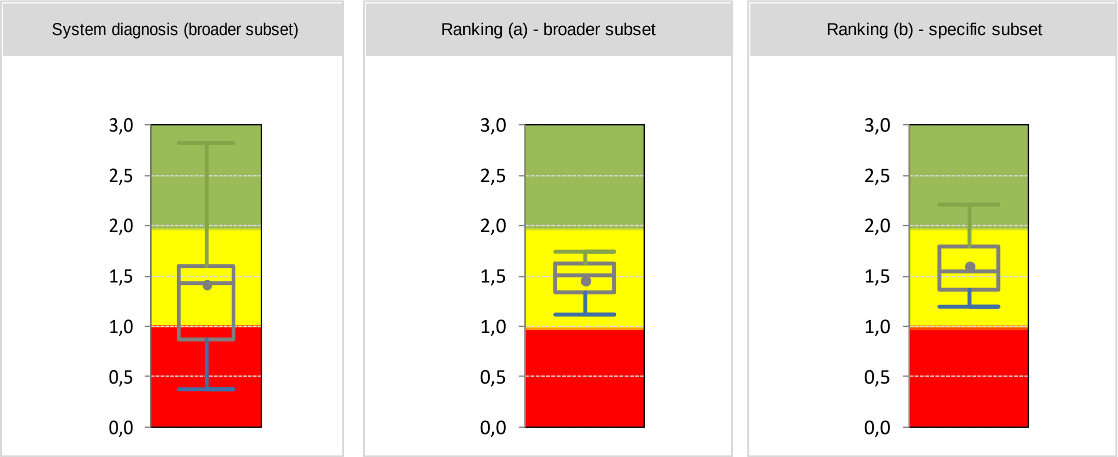
- The objective: to discuss information provided by the application of different assessment systems: (a) with the same broader subset of the metrics than the one used for system diagnosis (i.e., with more aggregated information) and (b) with a more specific subset (i.e., with more detailed information)

Metrics

Metrics	Description	Objective	Assessment system
Mains rehabilitation (AA10ab, ERSAR*)	Percentage of mains length with more than 10 years rehabilitated in the last 5 years	Obj.1 - to ensure infrastructural sustainability	system and (a) subset
Mains failures (Op31, IWA**)	Average number of mains failures per 100 km of mains and per year		(b)
Non-revenue water by volume (Fi46, IWA)	Percentage of the system input volume that corresponds to non-revenue water	Obj. 2 – to ensure economical sustainability	system and (a) subset
Water meters above 12 years (LNEC**)	Percentage of household water meters with age above 12 years		(b) subset
Apparent losses (Op25, IWA)	Percentage of the water provided to the system that corresponds to apparent losses		(b) subset
Ratio of the total energy in excess (E3, LNEC)	Ratio of the theoretical energy in excess in comparison to the minimum required energy (calculated from the consumer side)	Obj. 3 - to promote the efficient use of energy	system and (a) subset
Standardised energy consumption (Ph5, IWA)	Average pumping energy consumption in the system per 1 m^3 at 100 m of head		(b) subset
Real losses per connection (Op27, IWA)	Real losses, expressed in terms of the average daily volume lost per connection	Obj. 4 - to promote the efficient use of water	system, (a) and (b) subsets
Safe water (AA04, ERSAR***)	Percentage of water controlled and of good quality, in compliance with sampling frequencies and the parametric values defined by Decree-Law	Obj. 5 - to ensure the quality of the provided service	system and (a) subset
Interruptions per connection (QS14, IWA)	Average number of interruptions per service connection per year		(b) subset

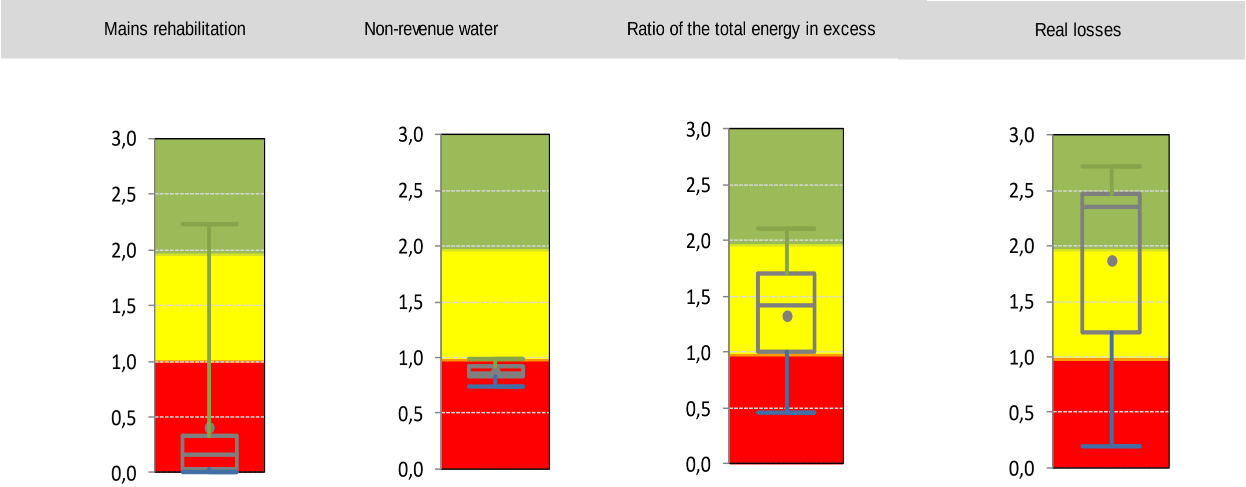
Assessment system results

- Assessment system (a) showed a more narrowed rank than (b)
- (b) was considered to be more differentiating for ranking the areas analysis



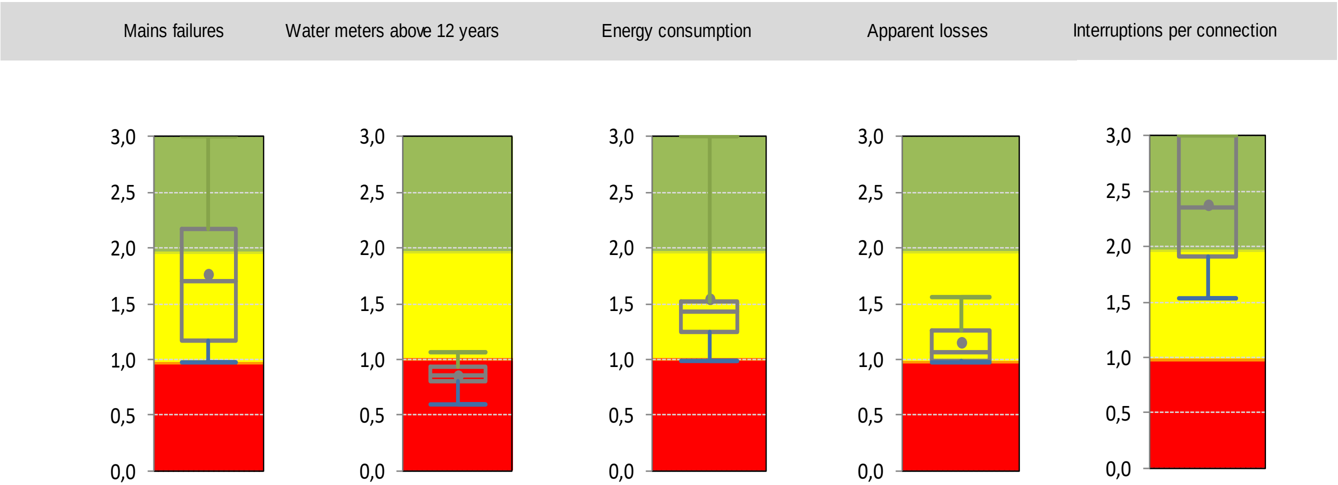
Performance results: (a) subset

Subset (a): non-revenue watering was the only metric crosswise to all analysis areas in terms of unsatisfactory performance level. Mains rehabilitation showed poorer overall average result. Results are consistent with those obtained from the system diagnosis.



Performance results: (b) subset

Subset (b): only water meters above 12 years showed an overall average result under the unsatisfactory level, but with results on apparent losses also close to that level.



Overall results

- mains failures, real losses, interruptions per connection and ratio of the total energy in excess showed to be more differentiating
- standardised energy consumption was the only specific metric with narrower results than the corresponding ratio of the total energy in excess, considered in the broader subset.
- apparent losses and water meters above 12 years were more differentiating than non-revenue water, particularly the former, along with mains failures that was more than mains rehabilitation.

Accomplishment of the objectives and identification of intervention tactics

- Infrastructural and economical sustainability corresponded to the lowest performances shown for system and analysis areas diagnosis. The quality of the provided service was the objective showing the overall best performance.

- Tactics:
  - to implement water meter plan and invest on information integration and management; to study the network layout and definition of district meter areas, development of a pressure zone program, replacement of water meters with age over 12 years, replacement of pumps and monitoring large consumers; to invest on rehabilitation.

Take-home message

- The use of more specific metrics enabled to identify the main causes of high non-revenue water and excess energy input in priority areas
- The use of a more specific assessment system for prioritisation of analysis areas may be useful to understand in more detail specific issues that may affect some analysis areas
- Comprehensive prioritisation can be used to make decisions over the areas needing immediate intervention

Presentation 3

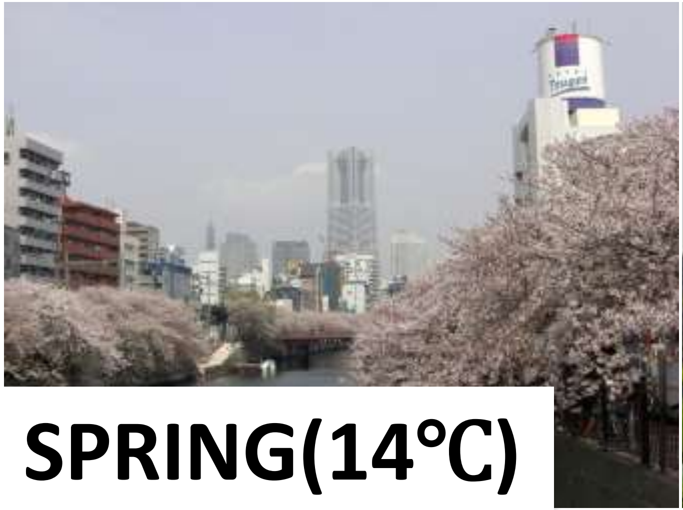
Yusako Shibata: Water Pressure Surveying in Yokohama City for Studying Future Plans

WATER PRESSURE SURveYING IN YOKOHAMA CITY FOR STUDYING FUTURE PLAN

Tomoko Isoyama
Takayuki Konishi
○Yusako Shibata
Noriko Takei
Yokohama Waterworks Bureau (YWB)
JAPAN

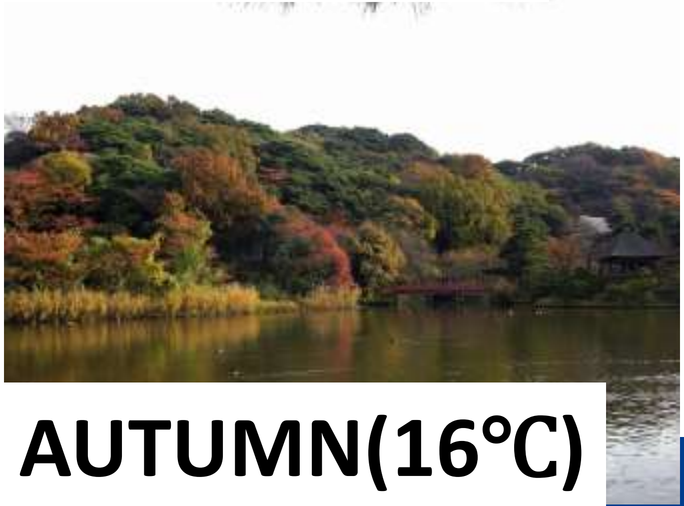
Population: 3.7million People

No.1　JAPAN'S LARGEST CITY



SPRING(14℃)

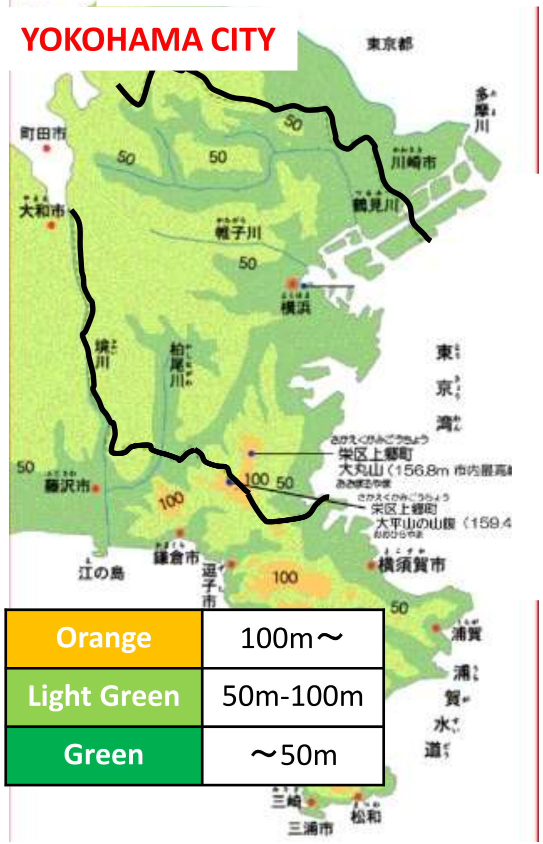
SUMMER(26℃)



AUTUMN(16℃)

WINTER(6℃)

Background 1　Effort to Cutting Operational Costs



Orange	100m～
Light Green	50m-100m
Green	～50m

- Reducing usage of pumps
- Priority use of gravity flow system
- Introducing energy saving equipment

➡ Cutting Operational Costs

Background2 Decreasing Water Supply Amount Increasing Replacing Demand

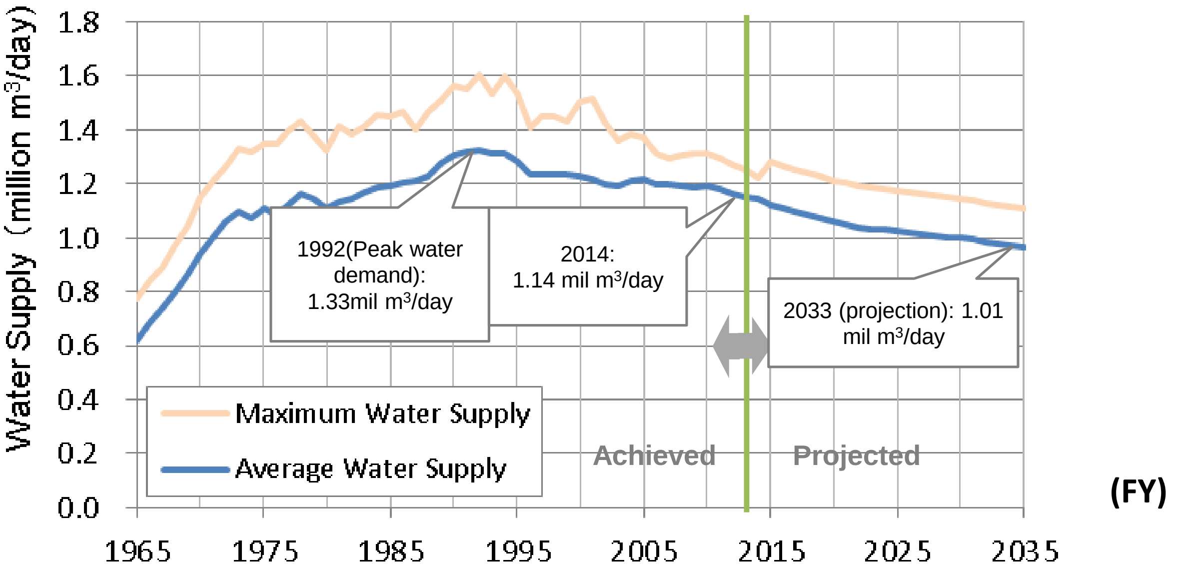


Figure 1. Transition and estimation of average water service per day in Yokohama city

Meet the huge demand for the renewal, cutting the renewal and operational costs

→Renewal on more appropriate facility scale

Research Objectives

Assess the function and capacity of present waterworks facilities

Focus on observed values of water pressure as basic data

Surveyed summer water pressure in 2015

Utilize for the assessment and analysis

1 To find out the current water pressure and to examine the effects of reducing water supply amount on water pressure.

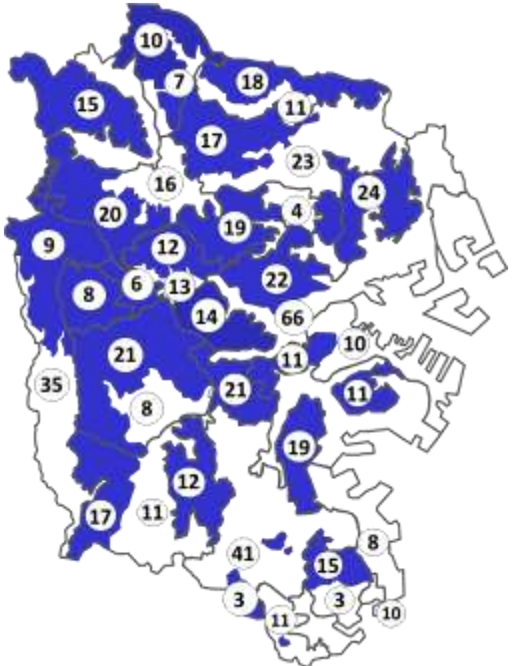


Fig2. Water Distribution Block System

Distribution block border

Pump pressurization system

Gravity flow system

Number of measurements in each block

Water Distribution Blocks

25 Water Distribution Blocks

↓

37 Water Distribution Blocks

- The Gravity Flow System
- The Pump Pressurization System

- Areas where found high pressure
  →Pressure Reducing Valve
- Areas where found low pressure
  →Booster Pump

Distribution block border

Pump pressurization system

Gravity flow system

Number of measurements in each block

Measurement Points

601 measurement points

- Points measured by FY 2008
- Block border and pipe end
- Points with the highest ground height in blocks
- Spots where blocks have changed since FY 2008
- Spots where high pressure was measured in the past

Measurement Methods

Measurement Period

- 2015/7/30-8/20 Fri-Sun or Sat-Mon

Measurement Hours

- 72hours 4 second intervals

• Measurement points of single distribution block were measured simultaneously

Water Pressure Measuring Equipments

Setting on Fireplug

Result of Water Pressure Survey

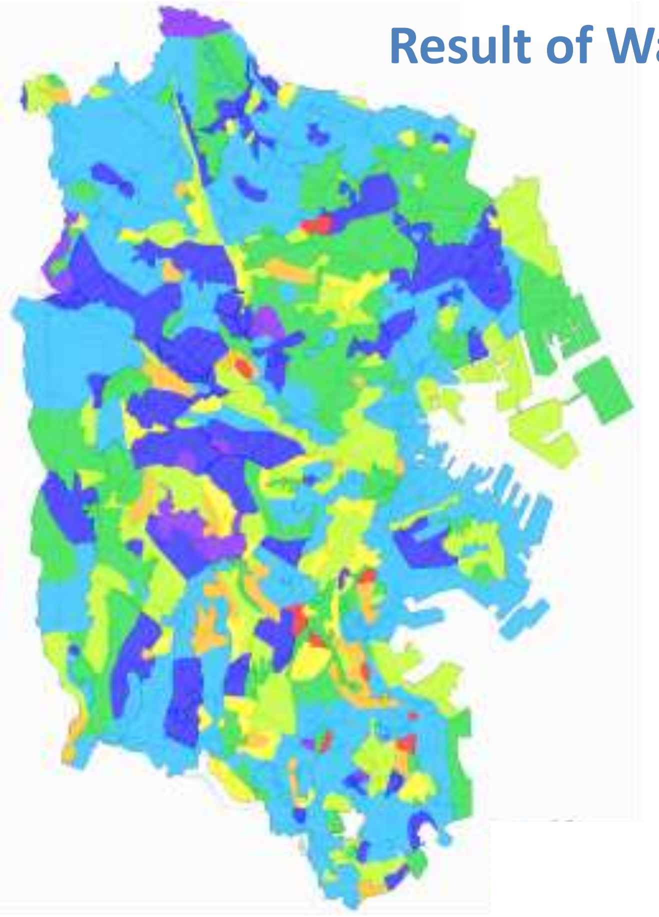


Fig3. Water Pressure Contour Diagram

Ave. Water Pressure at All Measurement Points

0.49MPa

Ave. Water Pressure was Low

→ 12 measurement points

Ave. Water Pressure was High

→ 42 measurement points

Display Color	Water Pressure Division	
	Over 0.850MPa	High
	0.750～0.849MPa	High
	0.650～0.749MPa	Appropriate
	0.550～0.649MPa	Appropriate
	0.450～0.549MPa	Appropriate
	0.350～0.449MPa	Appropriate
	0.249～0.394MPa	Appropriate
	Under 0.25MPa	Low

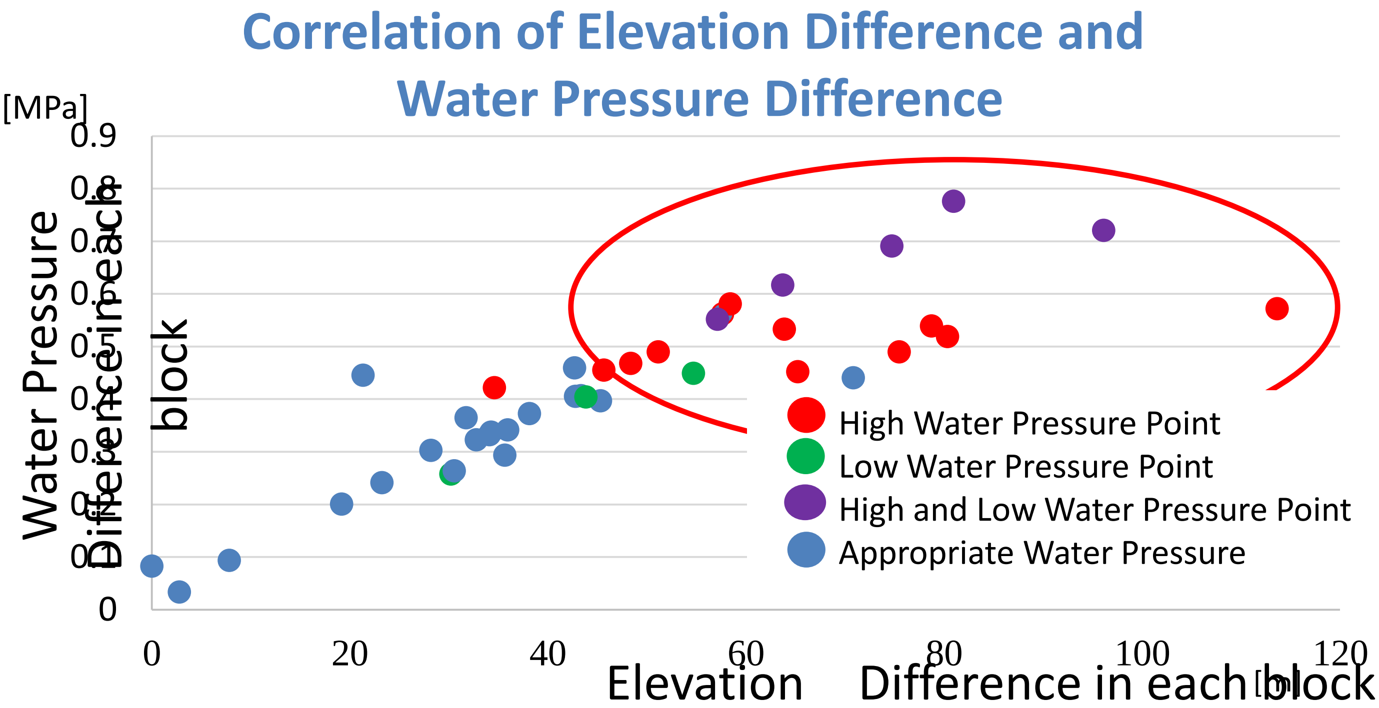
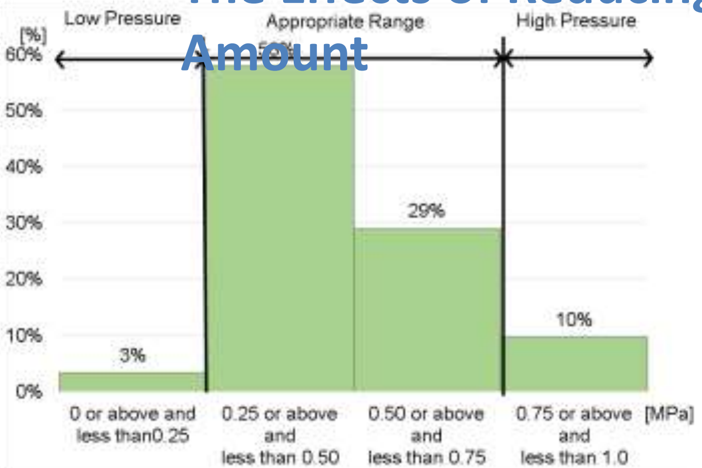


Fig4. Correlation of elevation difference and water pressure difference

The larger the elevation difference is, the larger water pressure difference is, it is found to be difficulty of control.

In that kind of blocks, we could find many low water pressure and high water pressure measurement points.

Analysis 1: Current Water Pressure and The Effects of Reducing Water Supply Amount



N=455

Fig5. Water Pressure Distribution in FY 2008

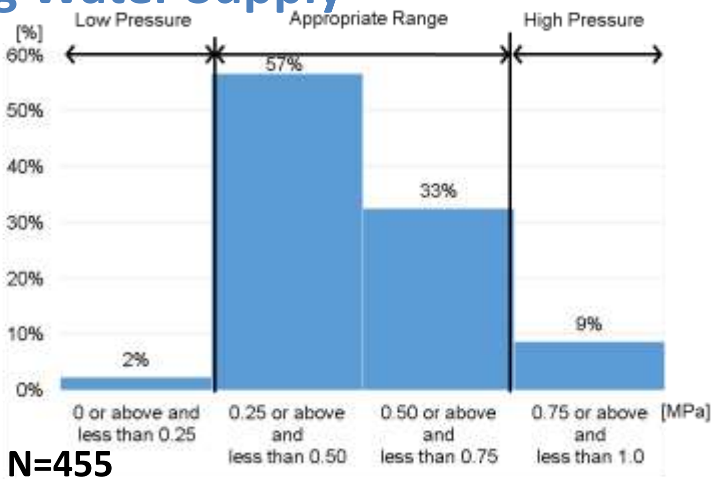


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Fig6. Water Pressure Distribution in FY 2015

Decreasing 64,000m^3

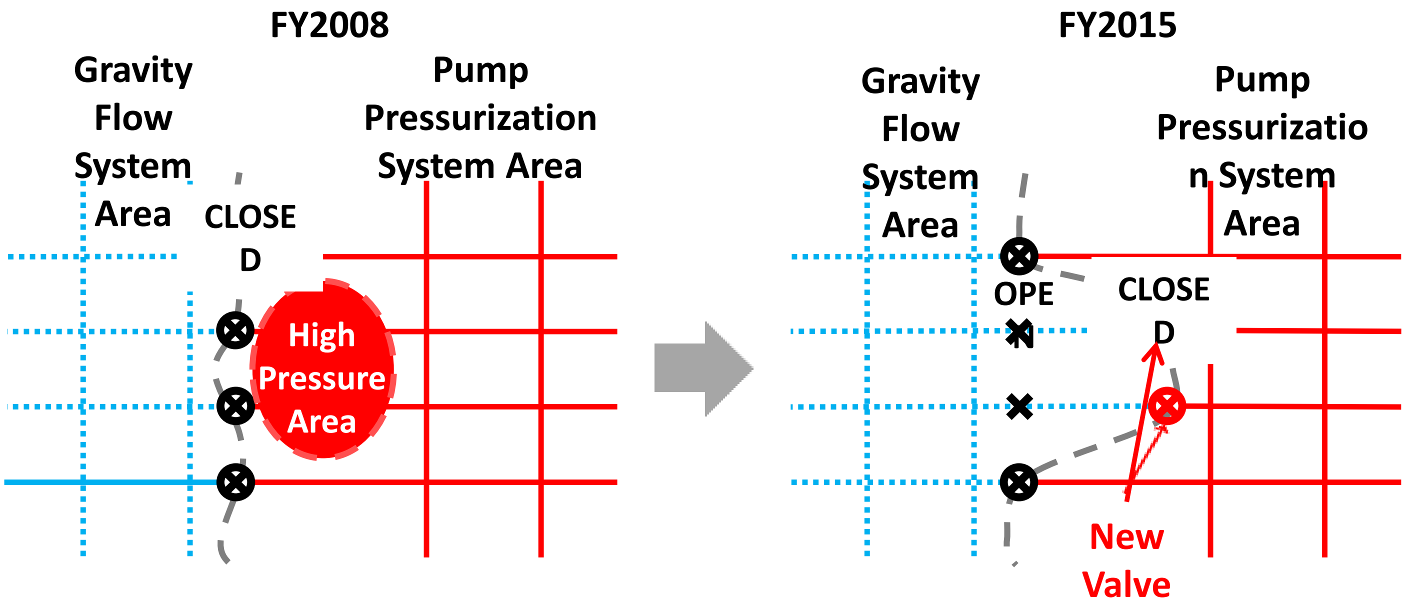
Average Water Supply Amount/DAY FY2008 ➡ FY2015

<u>There is no effect of reducing water supply amount on water pressure.</u>

➡ We have operated to ensure the appropriate water pressure by changing distribution block etc.

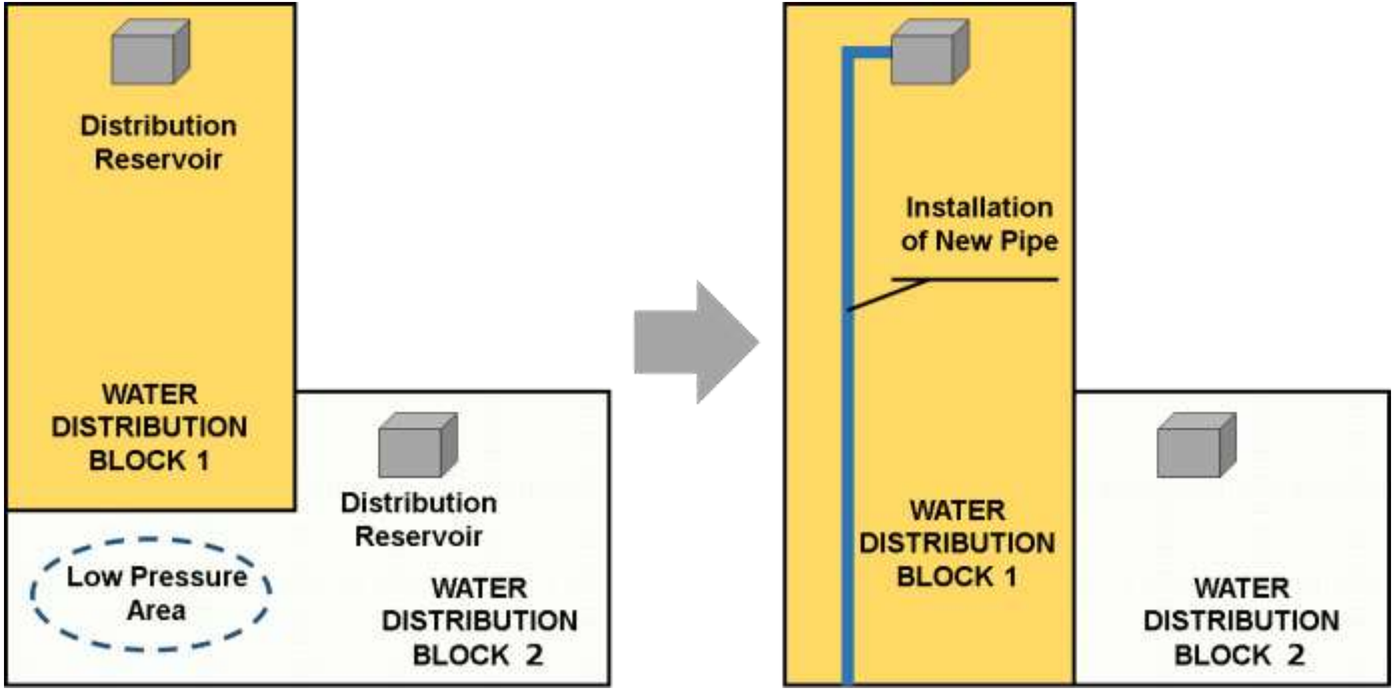
Analysis 2: The Cases Improved Low and High Water Pressure Areas ⊖

- Change of area range in a block



Analysis 3: The Cases Improved Low and High Water Pressure Areas ㊂

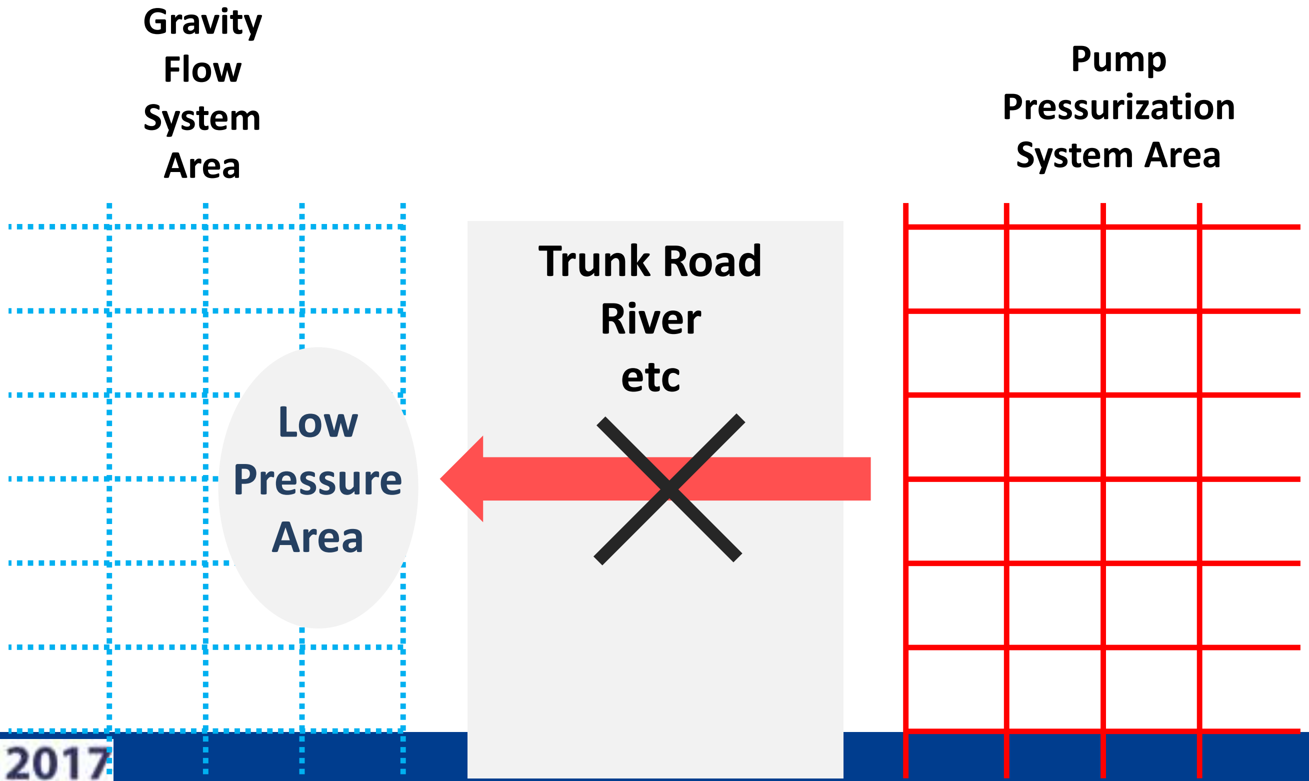
-Pipe network improvement



FY2008 FY2015

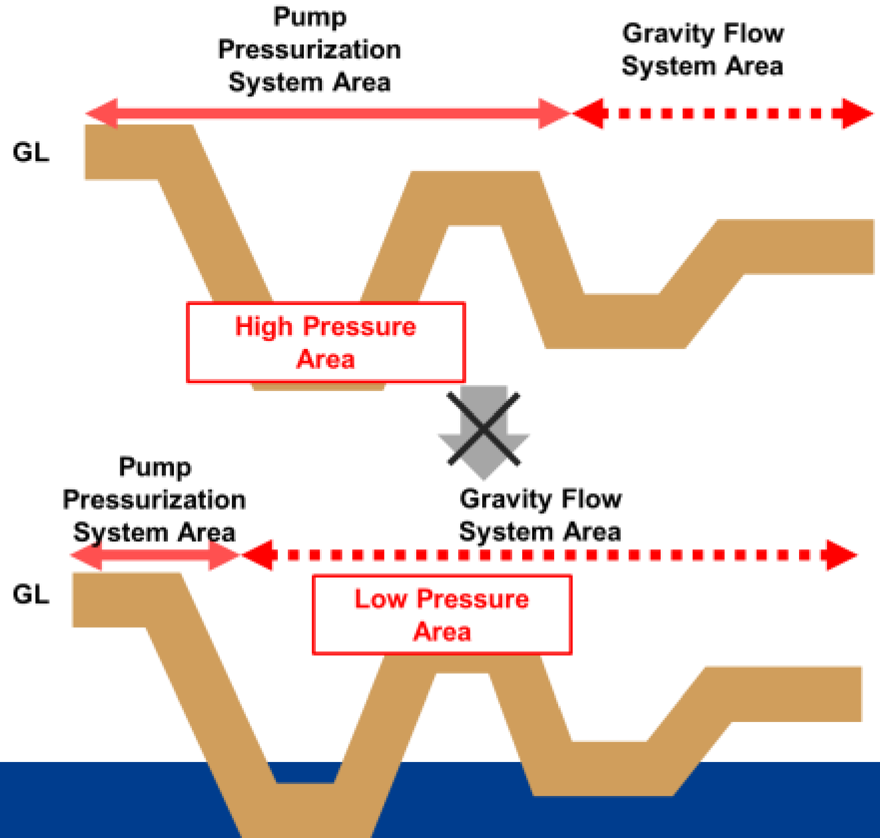
Analysis 4: The Cases not Improved Low and High Water Pressure Areas ⊖

-The restriction of distribution network

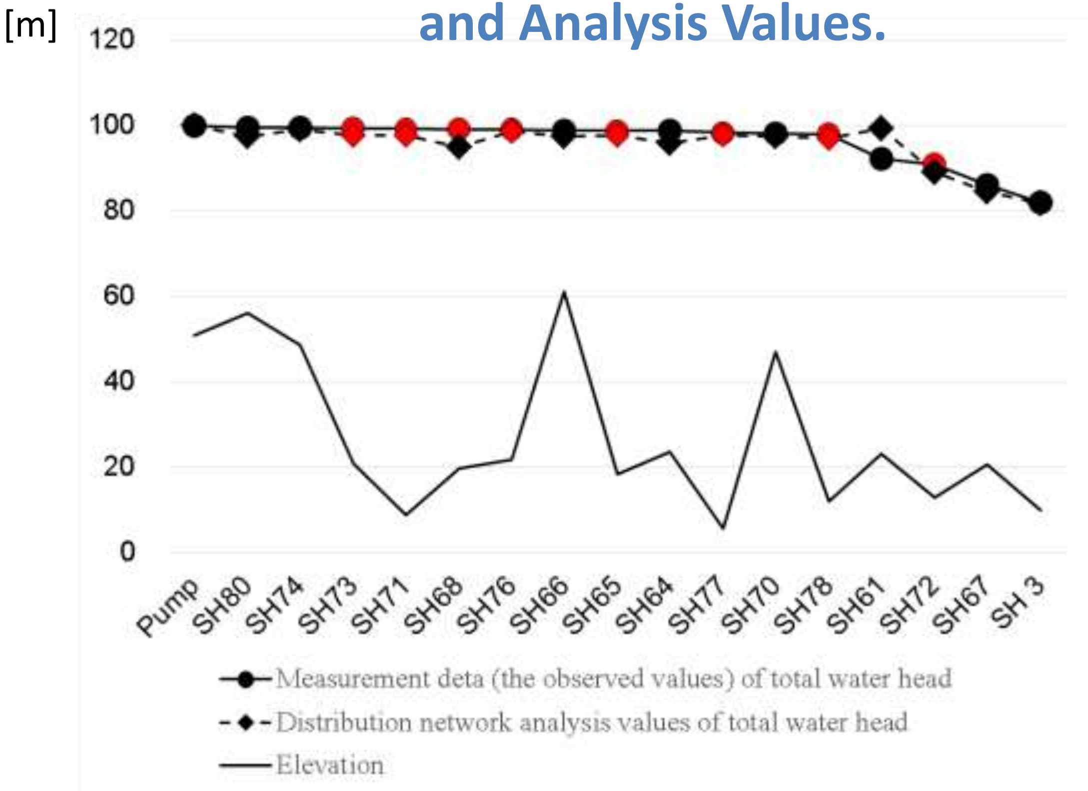


Analysis 5: The Cases not Improved Low and High Water Pressure Areas ☹

-The restriction of terrain characteristics



Analysis 6: Comparison of Observed Values and Analysis Values.



Almost same value with observed values and analysis values

→High accurate analysis

Conclusion

Summer water pressure survey was conducted in FY2015

㊀To clarify current water pressure and the effects of reducing water supply amount on water pressure.

→Water pressure tends to stay within more appropriate range compared with FY 2008

→ Observed values weren’t affected by decreasing water supply amount.

㊁Examined the cases improved or not improved low and high water pressure areas.

→To clarify the issues of not improved low and high water pressure and the solution of improved low and high water pressure.

㊅ Comparison of observed values and analysis values.

→There were no big difference between observed and analysis values

Water supply amount is projected to decrease step by step, therefore we will continue to measure water pressure in the city every few years to reflect the outcome to long term replacement plan


8,157km

研究目的

現状の水道施設の機能・能力を評価する

水圧に着目→基礎データとして評価・解析に活用

2015年に夏季水圧調査を行い
施設更新計画のための基礎データとして活用

㊀水圧の現状と給水量減少による影響を把握
㊁低水圧・高水圧箇所の解消点の検証
㊂実測値と解析値の比較

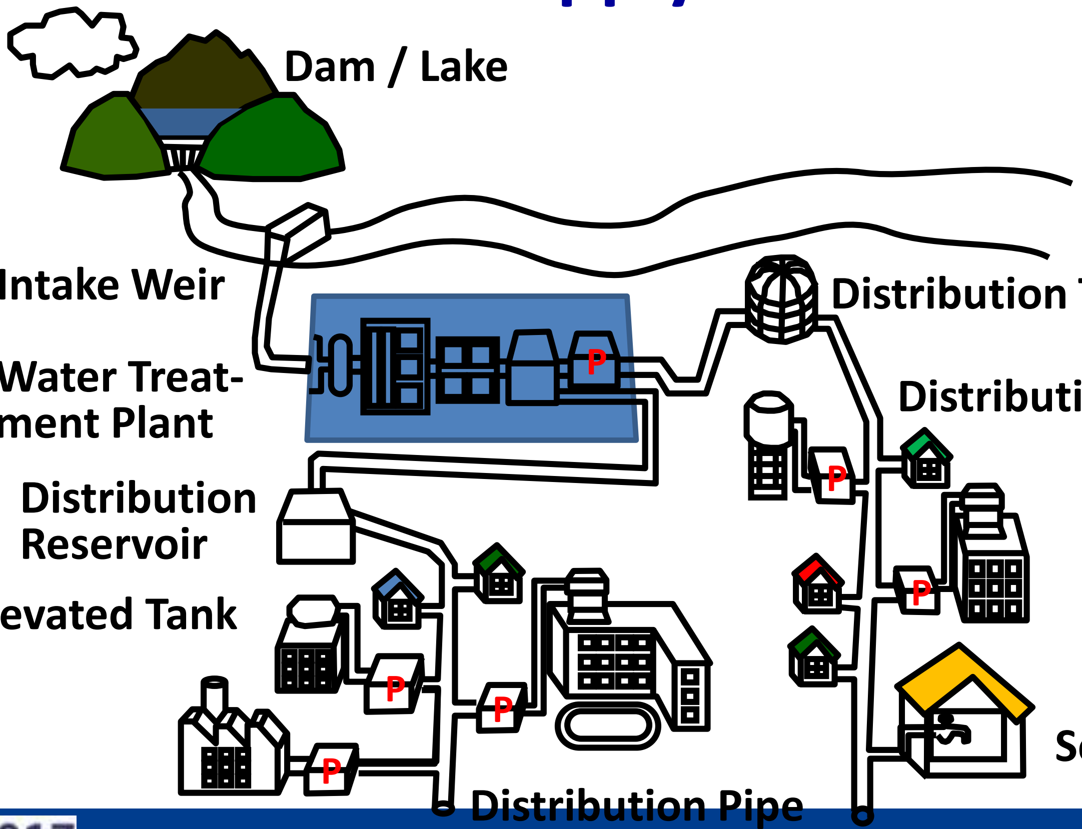
New method of pipe replacement without cut off of the water supply

Tomoko Isoyama
Kazuo Nakai
Noriko Takei
Takayuki Konishi

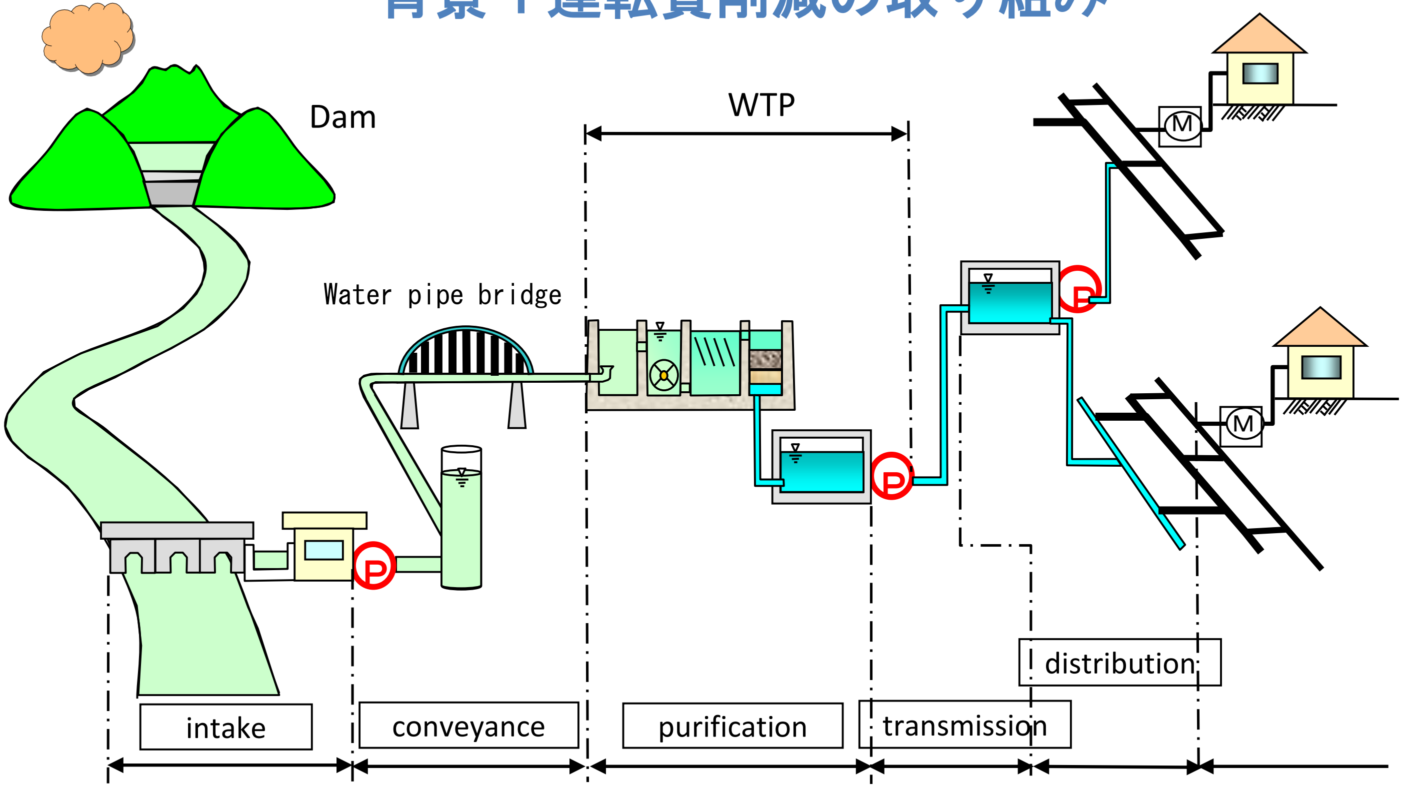
Yokohama Waterworks Bureau(YWWB)
JAPAN

Water Supply Situation in Japan

Water Supply Facilities

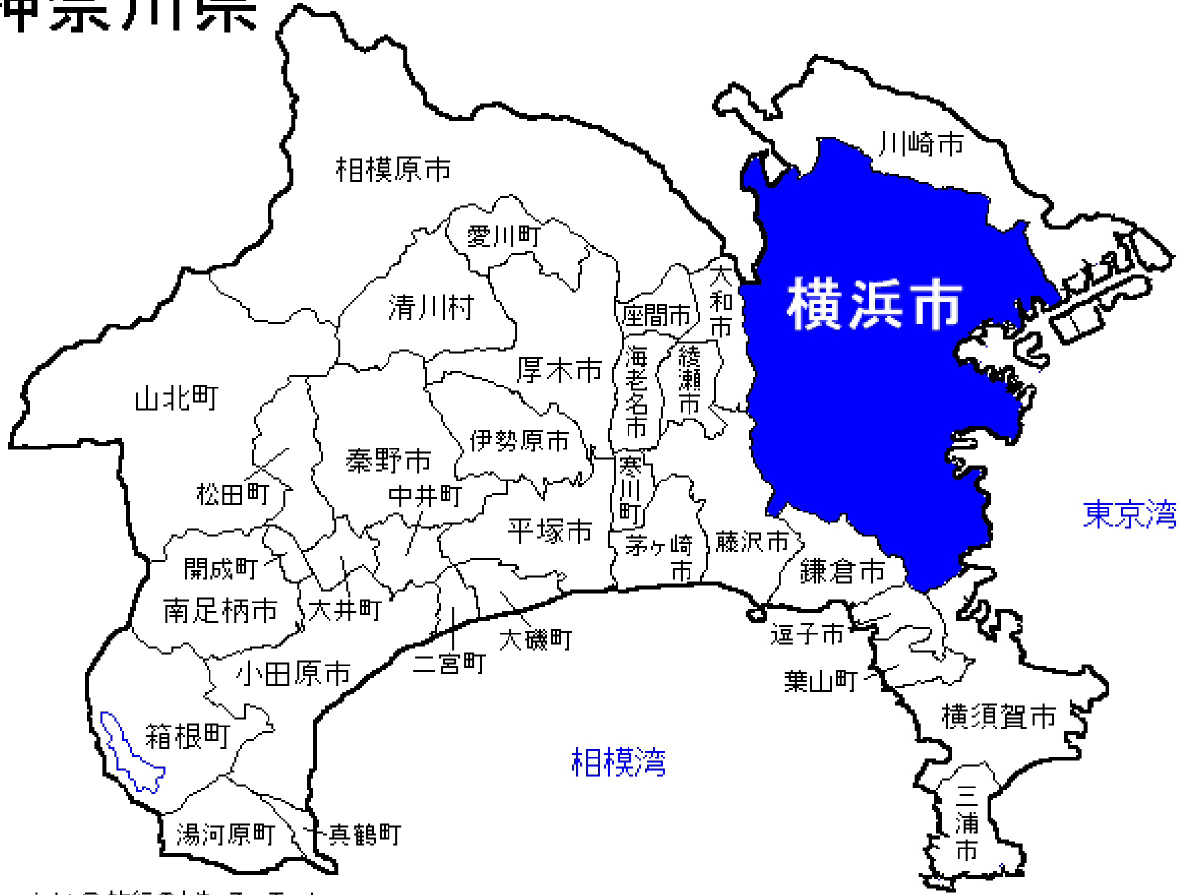


背景１運転費削減の取り組み



Water supply facility

神奈川県


相模原市
愛川町
清川村
山北町
厚木市
座間市
大和市
海老名市
綾瀬市
伊勢原市
秦野市
松田町
中井町
寒川町
平塚市
茅ヶ崎市
藤沢市
開成町
南足柄市
大井町
鎌倉市
大磯町
二宮町
逗子市
小田原市
葉山町
箱根町
横須賀市
湯河原町
真鶴町
三浦市
川崎市
横浜市
東京湾
相模湾

Presentation 4

Helena Alegre: Analysis of energy efficiency solutions in water supply systems

LESAM 2017
NTNU, Trondheim, Norway

Analysis of energy efficiency solutions in water supply systems

Aisha Mamade · Dália Loureiro · Dídia Covas

· **Helena Alegre**

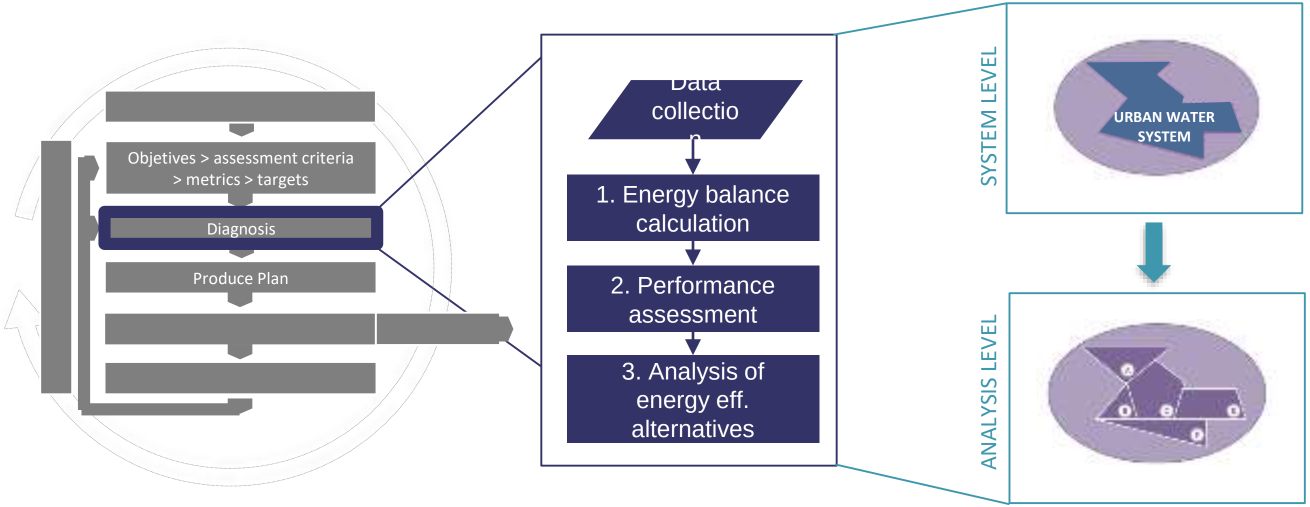
LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL
TÉCNICO LISBOA

Contents

Introduction

- Water supply systems are high energy consumers, with electricity costs varying from 5-30% of total operating costs
- Energy costs also represent the largest controllable operational expenditure of most water utilities
- Objective: present energy efficiency solutions that derive from a capacity building project – iPerdas – whereby 24 water utilities received one-year training on water losses and energy efficiency.
- Previous projects: AWARE-P + national initiatives on Infrastructure asset management
- The result: looking to the energy efficiency problem in an integrated way:
  - 1) combining water and energy losses
  - 2) integrated in an asset management methodology

Methodology



AWARE-P methodology

Methodology

Data collection

1. Energy balance calculation

2. Performance assessment

3. Analysis of energy eff. alternatives

Basic data:

- Inlet water volumes and hydraulic heads at delivery points, storage tanks and pumping stations
- electric energy consumption in pumping stations

Assessment of the main components where energy is consumed:

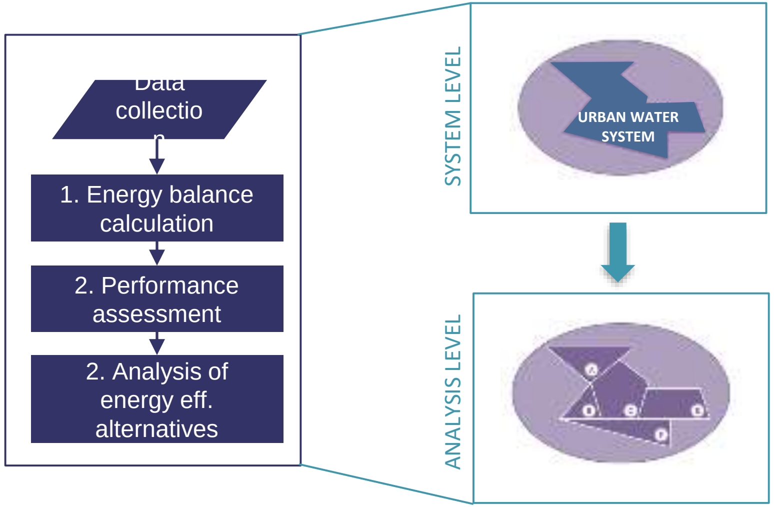
- Minimum energy to supply consumers
- Dissipated energy: pump inefficiencies, water losses

- Ph5-Standardised energy consumption
- E3-Ratio of total energy in excess

Layout | Water losses | Pump efficiency | Pump schedul. | Valve operation | Pipe friction

Typical solutions

Application



28-785 m
elevation difference

1600-163000
Serviced population (exc. transmission syst.)

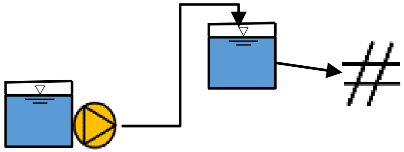
56-1817 km
network length

244-2054
l/(cl.day)
Daily water consumption per client

0.3-0.76
kWh/m³/100m
Stand. energy consumption

+400
Pumping stations

Case-study 1 – Pump scheduling

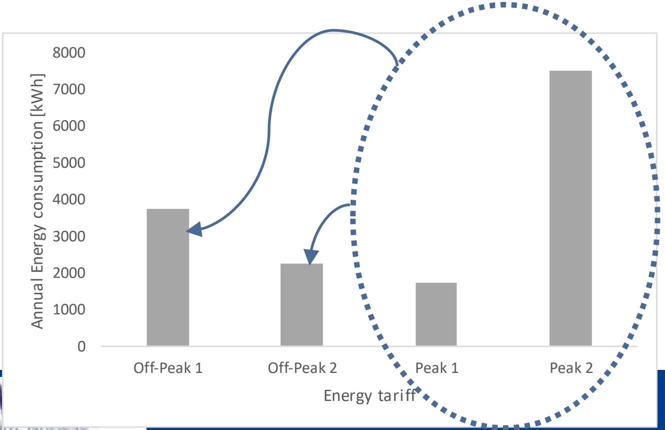


➢ A simple water supply and distribution system with two DMA - only 54% of the total water supplied is consumed

Performance assessment results

Ph5= 0.5 kWh/m³/100m
Equivalent to Ƞ=54%

E3=3.3
Excess energy represents 3.3x minimum energy



➢ High energy in excess (E3=3.3) due to water losses and pump inefficiencies

➢ The tank´s large storage capacity allows an immediate potential for pump scheduling with no investment.

Case-study 2 – Layout change 1

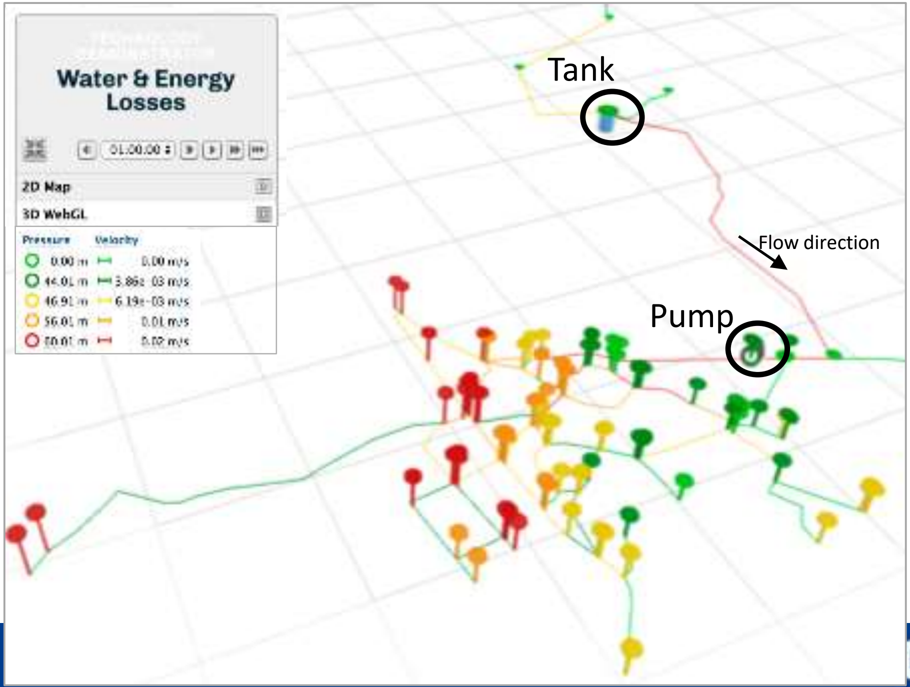
➢ Rural water supply: inefficient pumping station and high pressures in some areas associated with the topography.

Performance assessment results

Ph5= 1.4 kWh/m³/100m
Equivalent to η=19%

E3=4.5
Excess energy represents 4.5x minimum energy

Before…



Case-study 2 – Layout change 1

Alternative solution:

- Gravity-fed water supply
- Energy consumption → 0 kWh
- Adequate serviced pressure
- Water losses reduction

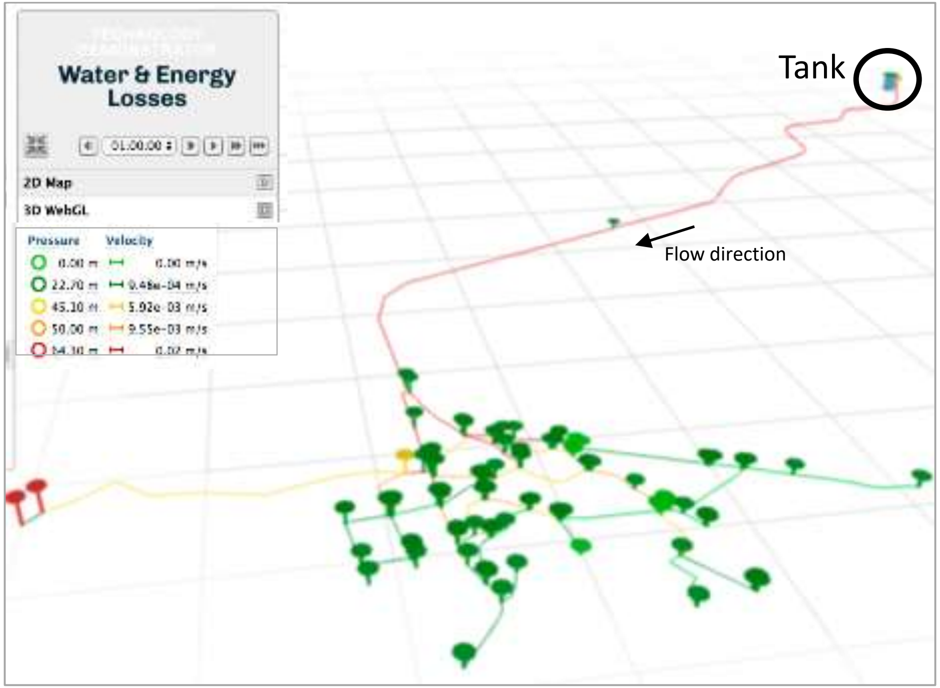
Performance assessment results

Ph5= NA

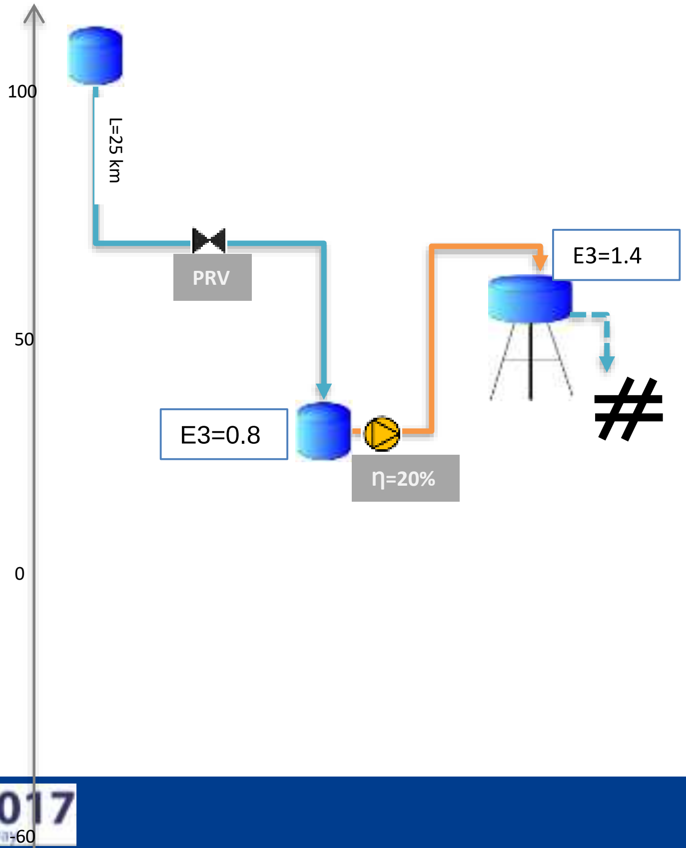
E3=1.9

Excess energy represents 1.9x minimum energy

After…



Case-study 3 – Layout change 2



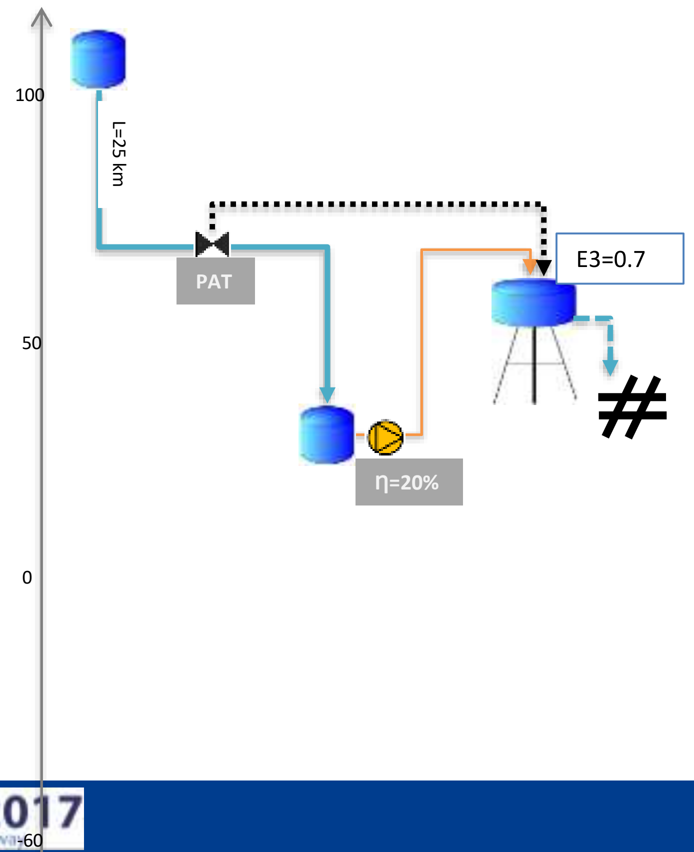
- Transmission main with 25 km that is supplying water to a tank 75 m below the upstream. This tank has a good storage capacity to ensure summer water demand.
- Water is then pumped to another tank, using a pump that has low efficiency (η=20%)
- Installed PRV is dissipating energy that could be recovered using a PAT

Performance assessment results

Ph5= 1.5 kWh/m³/100m
Equivalent to η=20%

E3=1.4 (→)
Excess energy represents 1.4x minimum energy

Case-study 3 – Layout change 2



Alternative solution (⋯➤)
Build alternative layout so that the pumping station is used during peak season only + study the possibility of replacing the PRV by PAT to recover energy.

Performance assessment results

Ph5= 1.5 kWh/m^3/100m
Equivalent to η=20%

E3=0.7
Excess energy is cut by half comparing to the initial solution

Results summary

Case-study	Current solution		Alternative solution				
	Ph5	E3	Ph5	E3	Energy consumption reduction		Invest-ment
	kWh/(m^3.100m)	-	kWh/(m^3.100m)	-	kWh/year	€/year	€
A – Pump scheduling	0.5	3.3	0.5	3.3	0	**2700**	**0**
B – Layout change 1	1.4	4.5	**-**	**0.9**	4422	530	**24750**
C – Layout change 2	1.5	1.4	1.5	**0.7**	22368	3579	(*)

(*) – still to be estimated

- A: Costs' reduction only
- B: Elimination of energy costs and **5x** less excess energy
- C: Excess energy cut into **half**

Next steps

- Improve assessment of investment costs and energy consumption reduction (in *kWh* and costs)
- Development of a decision platform comparing different water-energy efficiency solutions

Presentation 5

Ina Vertommen: Optimization of network blueprints: application of Gondwana to a real-life network

Using Gondwana for the optimization of network blueprints

Ina Vertommen, Peter van Thienen (KWR),

Martin Klein Arfman and Johannes Keizer (PWN)

Network blueprints

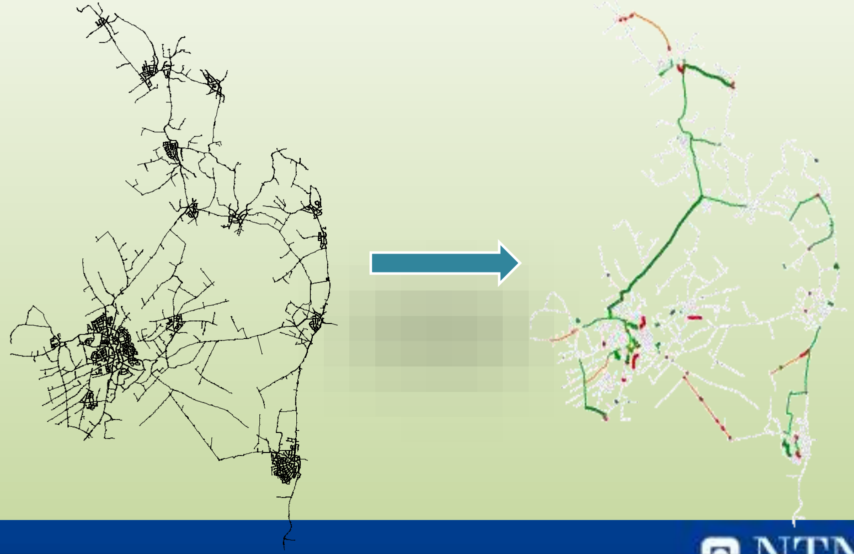
Dutch context:

- Proactive maintenance of the infrastructure:
- Adding and replacing pipes in existing networks is common practice;
- Design of new networks is relatively rare;

➢ Hot topic: design of network blueprints.

BLUEPRINT

Structure to which a current network should evolve to over the coming decades, taking into consideration company-specific objectives and constraints.



Network blueprints

Challeging task:

- Large and complex networks;
- Several constraints (incl. legal requirements)
- Multiple objectives.

Current practice: ***by hand***

- Supported by hydraulic models;
- Time consuming;
- Leads to **one feasible solution**;
- Unfeasible to assess changing conditions and scenar

Scientific publications on optimal design of water distribution networks

Application to the design of network blueprints

Source: Scopus

→ Numerical optimization techniques!

Network blueprints

Challenging task:

- Large and complex networks;
- Several constraints (incl. legal requirements)
- Multiple objectives.

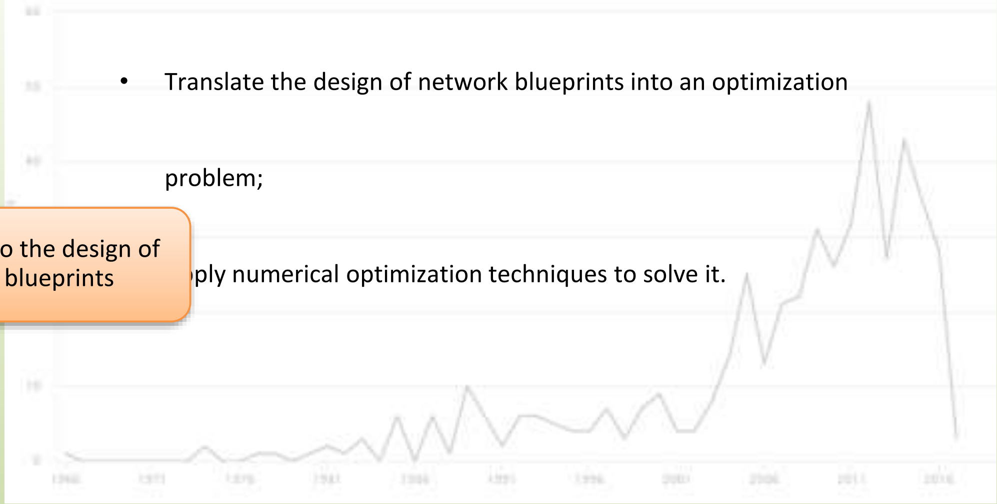
Current practice: ***by hand***

- Supported by hydraulic models;
- Time consuming;
- Leads to **one feasible solution**;
- Unfeasible to assess changing conditions and scenar

Proposed approach:

- Translate the design of network blueprints into an optimization problem;
- ply numerical optimization techniques to solve it.

Application to the design of network blueprints



Source: Scopus

→ **Numerical optimization techniques!**

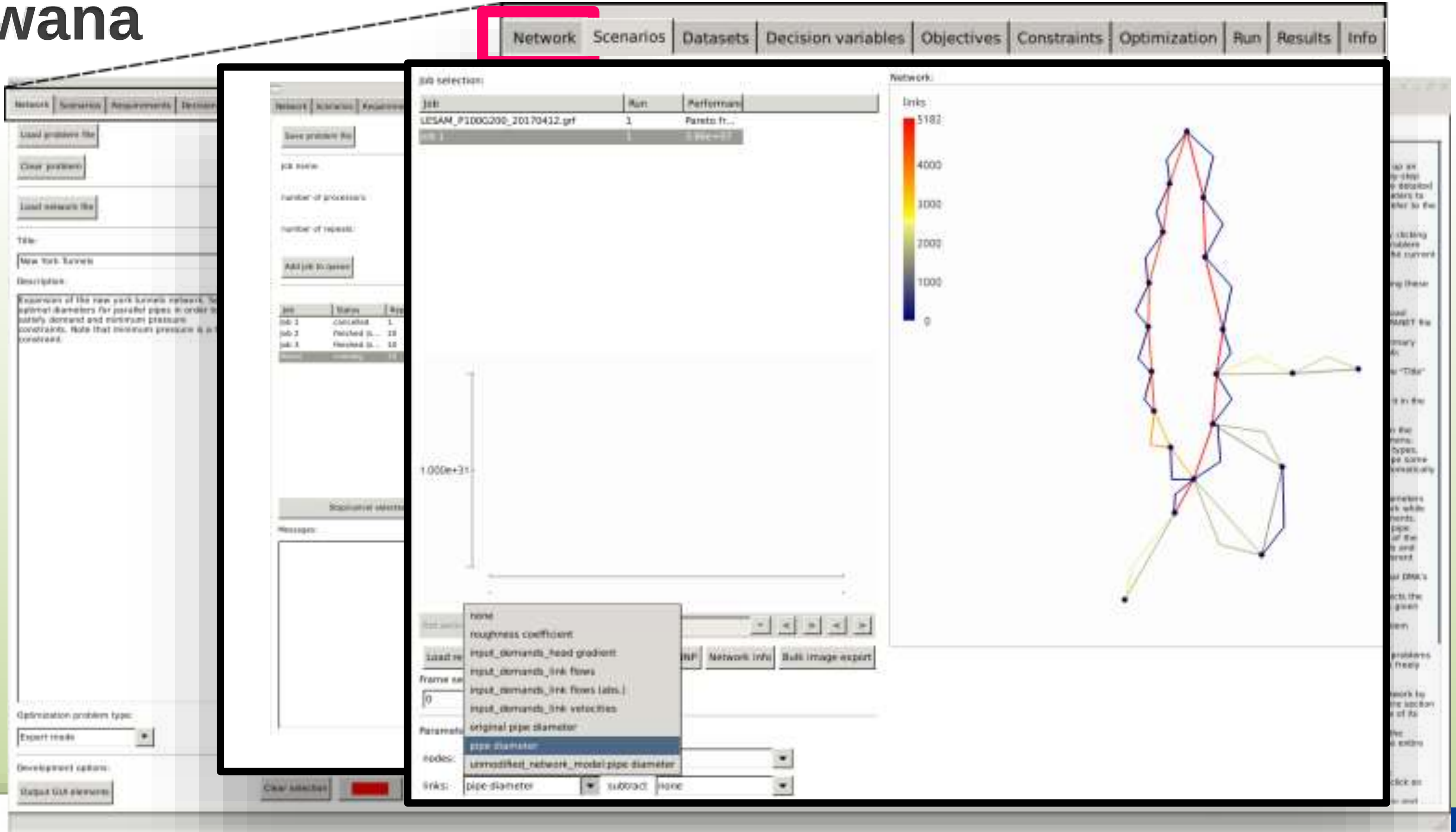
Gondwana

- **Generic software platform for the optimization of water distribution networks** developed by KWR;
- EPANET – hydraulic calculations;
- Inspyred library– metaheuristic optimization methods;

Targets:

- Network design; → Excellent performace on benchmark problems
  van Thienen, P. and Vertommen, I. (2015) *Gondwana: A Generic Optimization Tool for Drinking Water Distribution Systems Design and Operation*, Procedia Engineering 119, 1212-1220.
- Water quality sensor placement;
- Hydraulic sensor placement; → Poster at LESAM
- Network operation;
- DMA design ; → Poster at LESAM
- Design of network blueprint; → This presentation

Gondwana


Network
Scenarios
Datasets
Decision variables
Objectives
Constraints
Optimization
Run
Results
Info
Job selection:
Job
Run
Performance
LESAM_P100G200_20170412.prf
1
Pareto fr...
Network:
links
5182
4000
3000
2000
1000
0
1.000e+31
none
roughness coefficient
input_demands_head gradient
input_demands_link flows
input_demands_link flows (abs.)
input_demands_link velocities
original pipe diameter
pipe diameter
unmodified_network_model:pipe diameter
Network info
Bulk image export
Frame
nodes:
links:
pipe diameter
subtract
none
Load problem file
Clear problem
Load network file
Title:
New York Tunnels
Description:
Optimization problem type:
Expert mode
Development options:
Output GUI elements
Save problem file
Add job to queue
Messages:
Clear selection

Case study

Water distribution network of Texel (Netherlands)

PWN:

- Dutch water company in North Holland
- Serves 787 000 connections

Island Texel

- 14’000 inhabitants

Case study

Water distribution network of Texel (Netherlands)

Network info:

- 1823 demand nodes
- 1584 pipes
- 2 pumpstations
- 2 reservoirs
- 323 valves

- distribution and transport mains

809

Case study

Optimization problem

Multiobjective :

- Min. of network (pipe) volume
- Min. of the average head gradient in pipes

Constrained by:

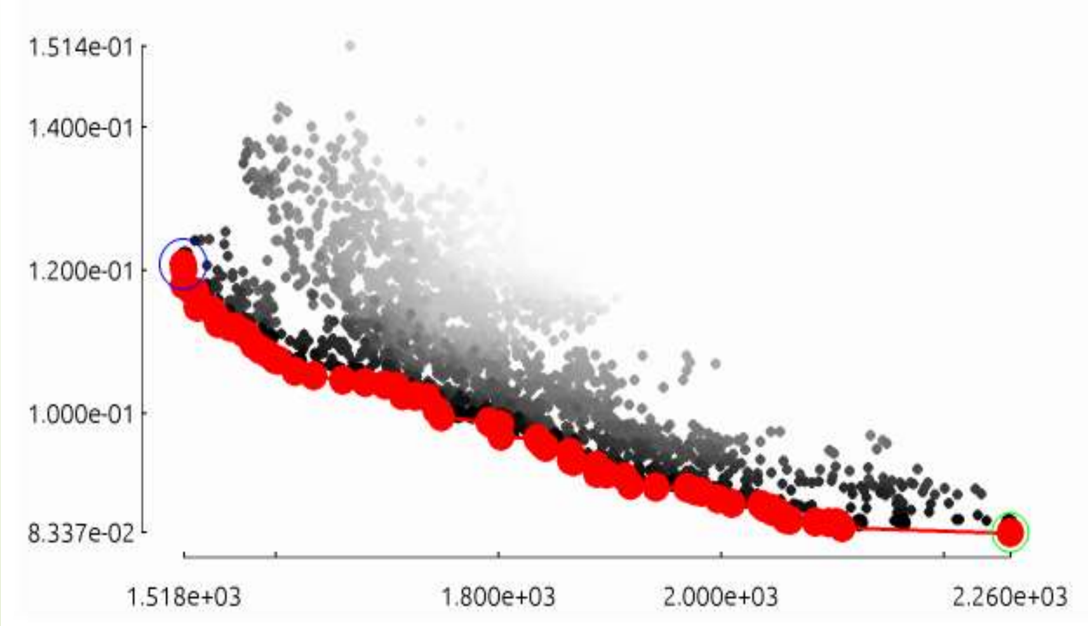
- Minimum pressure 24 m
- Reliability of supply
- Available pipe diameters

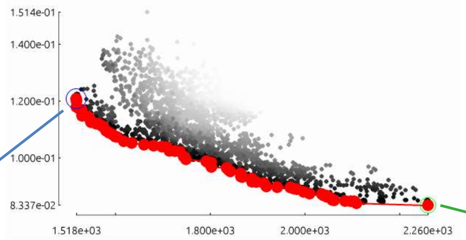
Decision variables:

– Diameters of transport mains

Initial results

Pareto front





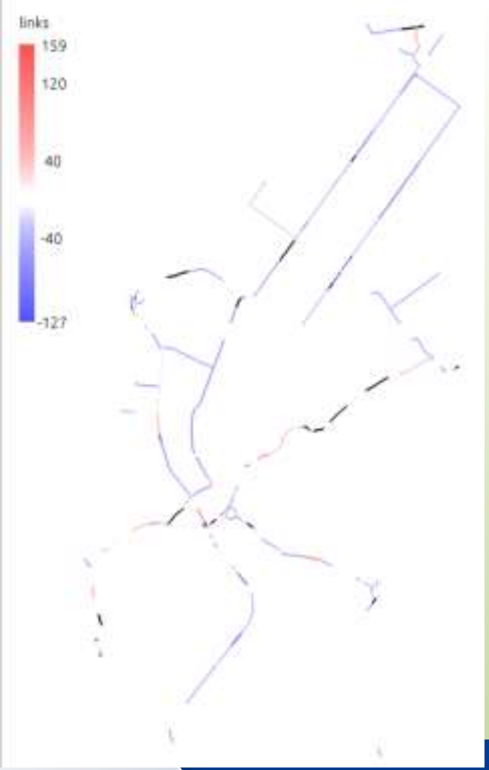
Initial results

Pipe diameters

Solution 1:

Volume: 1518 m^3

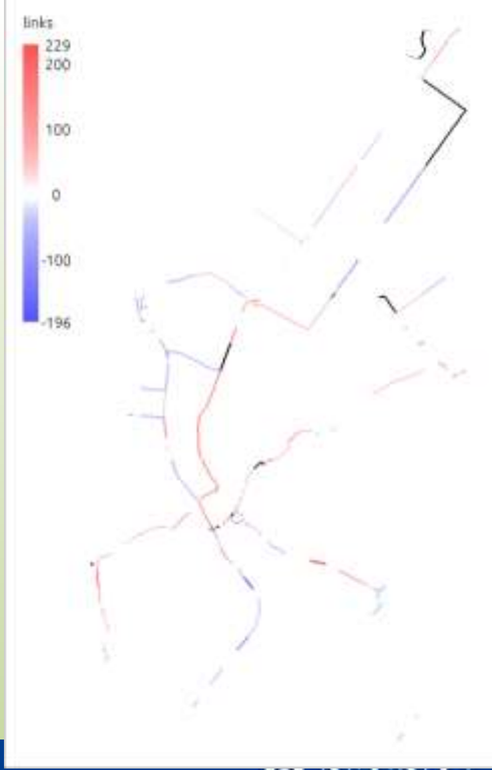
Head gradient: 0.12 m/km



Solution 2:

Volume: 2260 m^3

Head gradient: 0.083 m/km



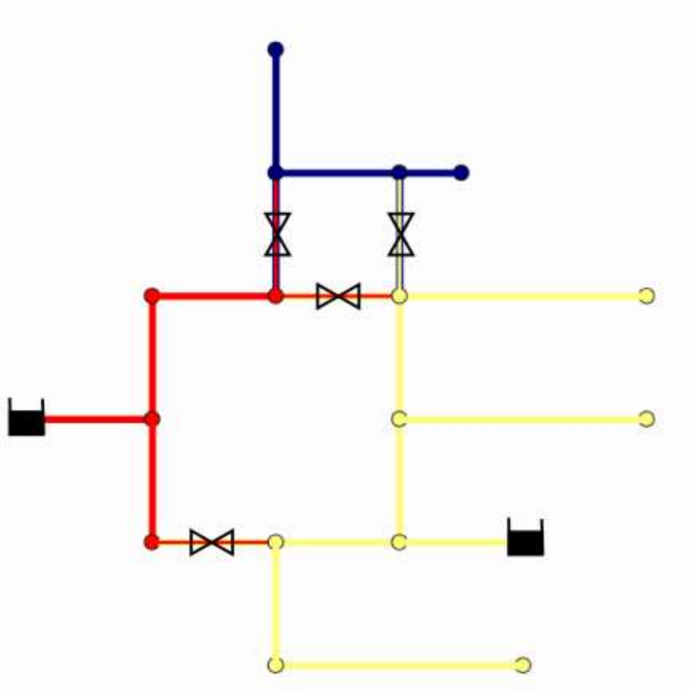
Reliability of supply

Dutch legislation:

- Reliability of supply during section failure

Implementation:

- Creation of valve sections;
- Shutting down valve sections one-by-one;
- Assess pressure requirements in remaining sections (minimum pressure = 15 m);
- Pressure-driven demands.



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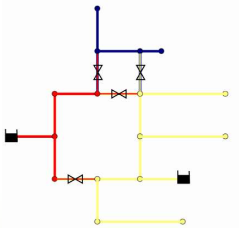

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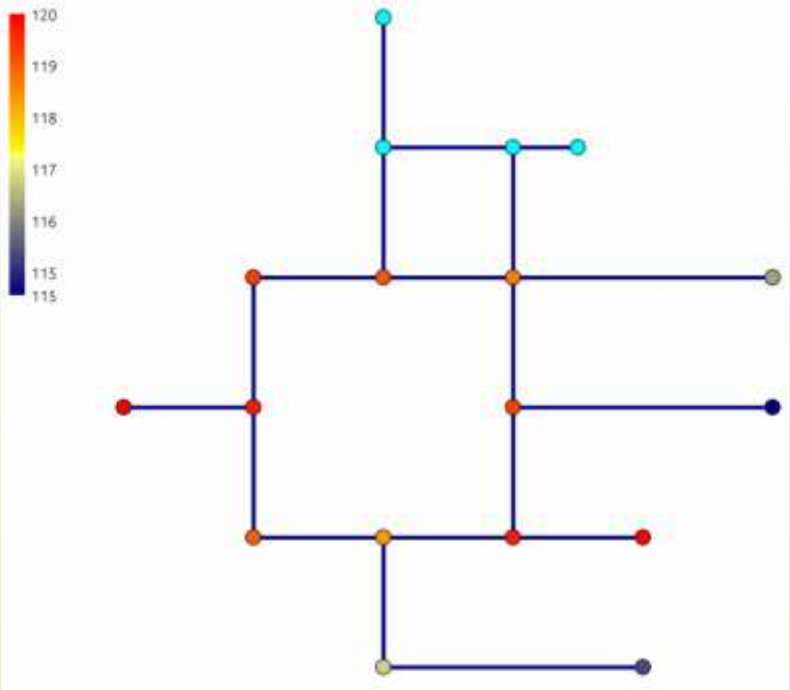

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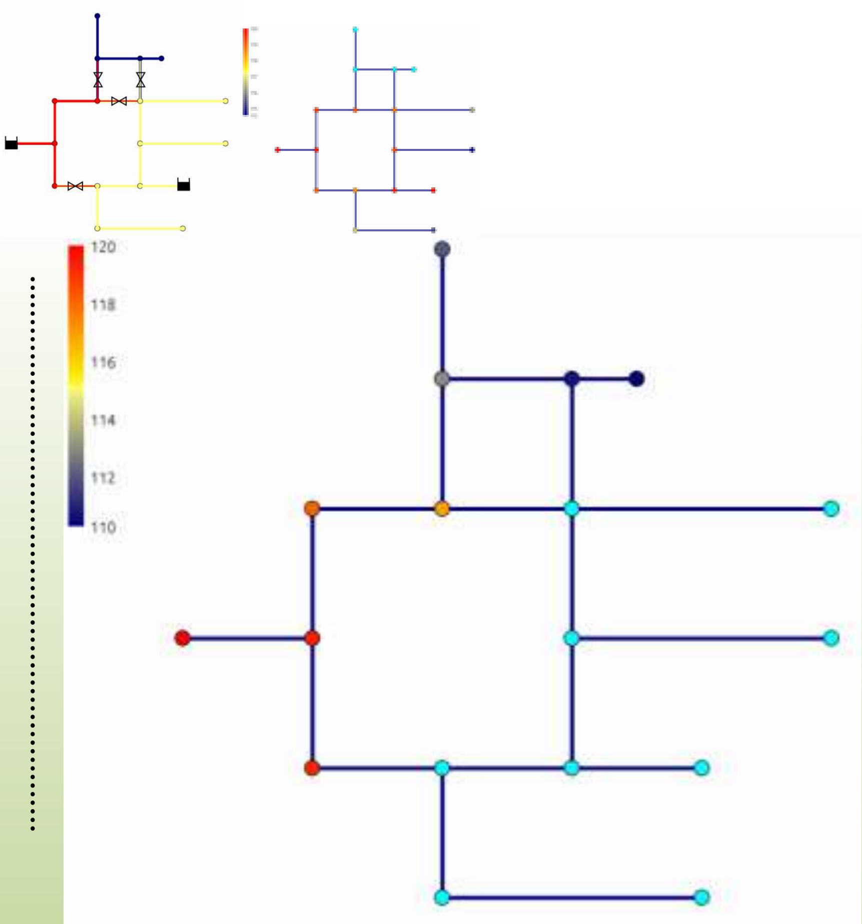
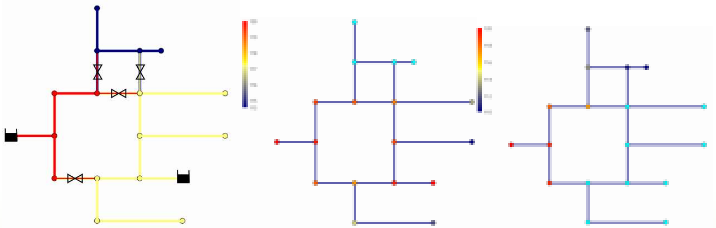


Reliability of supply



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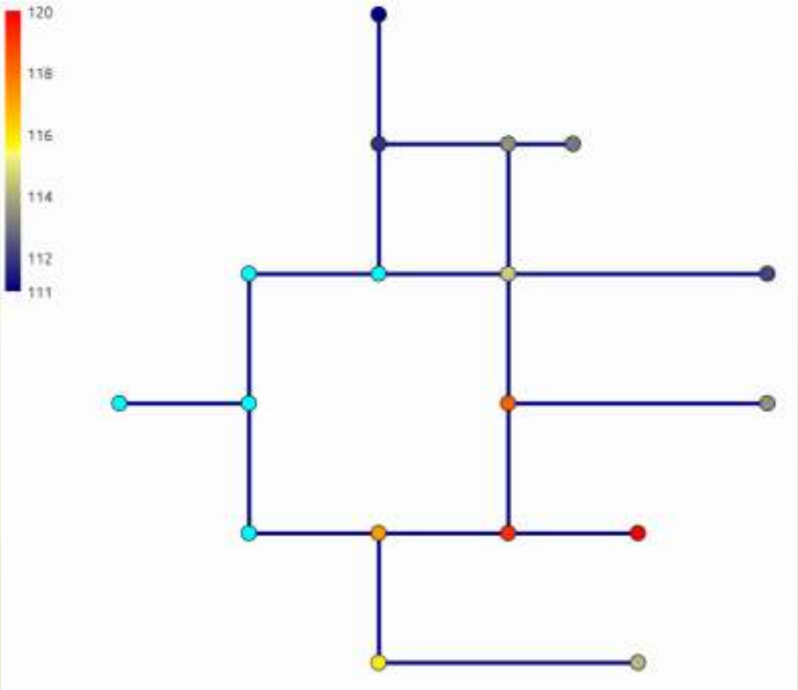
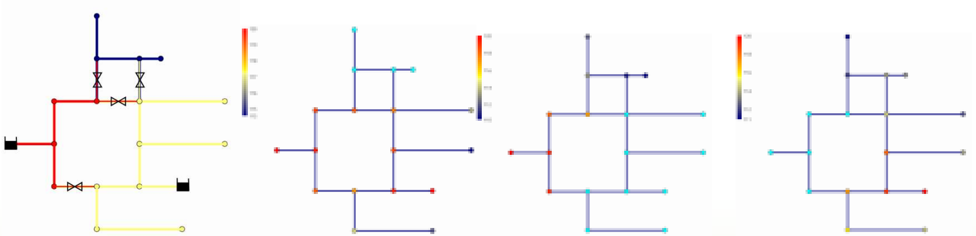
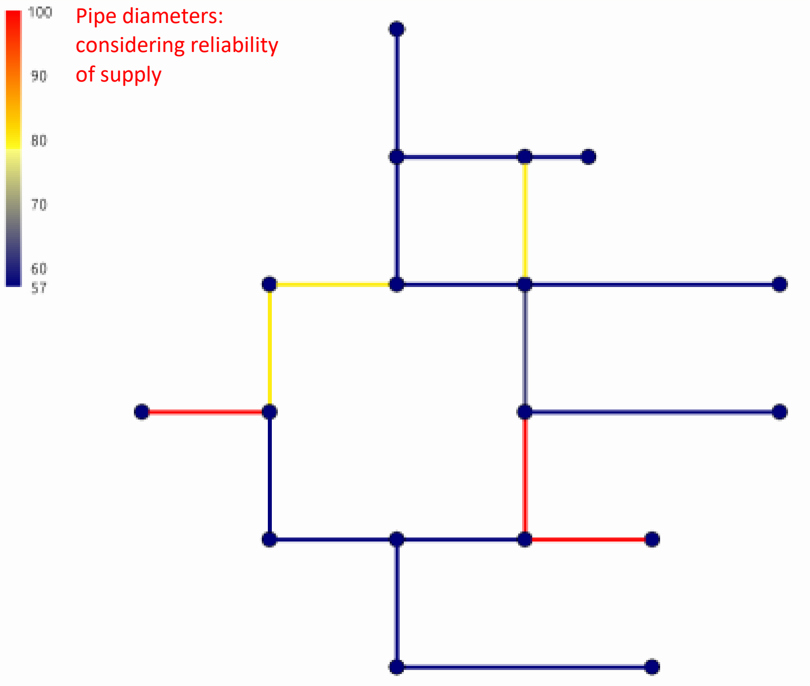
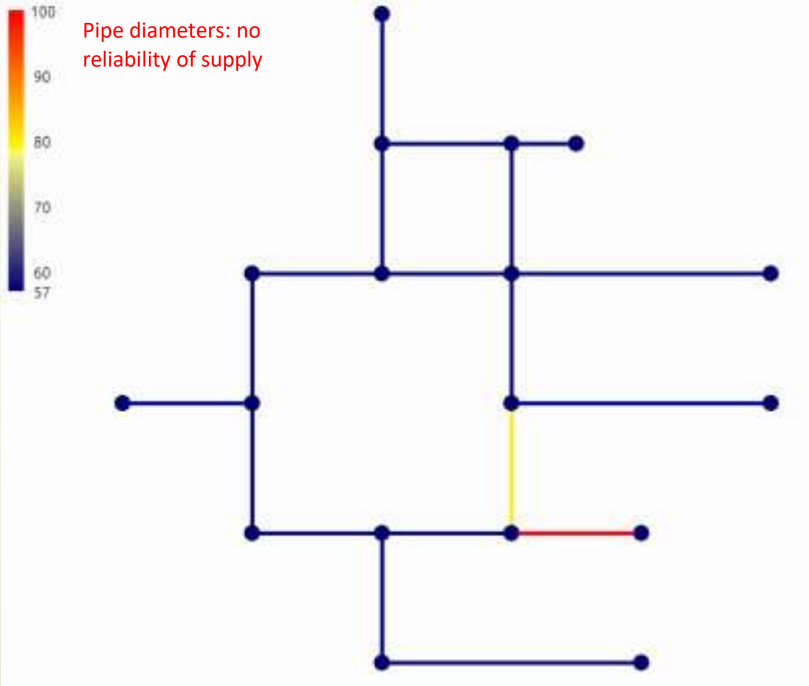


Reliability of supply







Conclusions

Advantages:

- Optimal solution vs feasible solution (manual);
- Possibility to include scenario’s;
- Possibility to compute updated solutions based on new information;
- Insight into the trade-off between objectives.

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Challenges:

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- Definition of operational decisions;
- Size of real networks;
- Model conversion to EPANET (from Synergi, Infoworks, etc).

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Future developments:

- Consideration of reliability of supply including a description of operational decisions during section failures;
- Inclusion of future demand scenario's;
- Timeline for pipe replacement (transition from current network to blueprint).

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Questions?

Presentation 6

Marta F Cabral: Rehabilitation cost modelling of water supply infrastructures

REHABILITATION COST MODELLING OF GROUND AND ELEVATED TANKS

Marta Cabral, Alexandre Pinheiro, Valentina Marchionni, Dália Loureiro, Dídia Covas

21rd June 2017, Trondheim

CONTENTS

- Scope
- Methodology
- Case Study
- Results
- Conclusions
- On-going research

CONTENTS

- **Scope**
- Methodology
- Case Study
- Results
- Conclusions
- On-going research

Scope & Objective

- Two-fold objective |
  - To establish reference costs for rehabilitation alternatives
  - To compare rehabilitation costs with construction costs

- Rehabilitation costs |
  - In developing countries the water networks may be up to 150 years old
  - Budgets are usually limited, allowing only partial solutions

- Novel index |
  - Rehabilitation reference costs functions for ground and elevated tanks to estimate the capital cost of future works and to help in the priorization of rehabilitation alternatives

How to establish reference costs for rehabilitation alternatives?

REHABILITATION: any physical intervention that extends the life of an existing system or improves its structural, hydraulic or water quality performance.

CONTENTS

- Scope & Objective
- **Methodology**
- Case Study
- Results
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Methodology | Rehabilitation cost function estimation

1. Database construction and analysis
2. Present cost value calculation
3. Key parameters identification and cost function establishment
4. Rehabilitation cost functions estimation
5. Cost function testing and validation

Well-establish methodology for construction cost function estimation

Methodology | Rehabilitation cost function estimation

1. Database construction and analysis

- Infrastructure and equipment data were selected
- Rehabilitation cost data were processed and analysed per cost item for each asset
- Construction of a database for ground and elevated tanks

Asset	Asset Characterization	Cost items
Ground storage tank	Total volume, number of cells	• Building site • Exterior arrangements • Civil works • Electromechanical equipment • Electrical facilities
Elevated tank	Total volume, number of cells, tank height	

Methodology | Rehabilitation cost function estimation

2. Present cost value calculation

- Costs collected referred to different rehabilitation dates (2004-2014)

- Present Costs in 2016:

$$PC = IC \prod_{i=0}^{n} (1 + t_i) = IC \times IF_{0-n}$$

PC = present cost (2016)
IC = cost in the construction year
t_i = inflation rate in year i
n = number of years between construction and 2016
IF_{0-n} = the cumulated inflation factor

- The inflation rate for the capital costs of infrastructures in the public sector:
  - Varies every year
  - Calculated based on historical data

Methodology | Rehabilitation cost function estimation

3. Key parameters identification and cost function establishment

– Key parameters for rehabilitation cost functions are identified per each type of asset:
  - Storage tanks: total volume
  - Elevated tanks: total volume, tank height

– Two major costs were identified for tanks:
  - C_{cc}: Cost of civil works to build the tank's structure (associated to earthworks, architecture, civil works, building site and exterior arrangements)
  - C_e: cost of the electromechanical equipment and electrical facilities (associated to pipes, valves, electromechanical equipment, electrical facilities and automation)

Methodology | Rehabilitation cost function estimation

4. Rehabilitation cost functions estimation

Storage tank	$Y_i = \alpha + X_i^{\beta}$ $\ln Y_i = \ln\alpha + \beta \ln X_i$	Y_i : Civil works cost, C_{CW} (€/m^3) Y_i : Equipment cost, C_e (€/m^3) X_i: Volume, V (m^3)
Elevated tank	$Y_i = \alpha + X_{i1}^{\beta} + X_{i2}^{\gamma}$ $\ln Y_i = \ln\alpha + \beta \ln X_{i1} + \gamma \ln X_{i2}$	Y_i : Civil works cost, C_{CW} (€/m^3) Y_i : Equipment cost, C_e (€/m^3) X_{i1}: Volume, V (m^3) X_{i2}: Height, h (m)

– Power relationship: logarithm transformation to obtain a simple linear regression

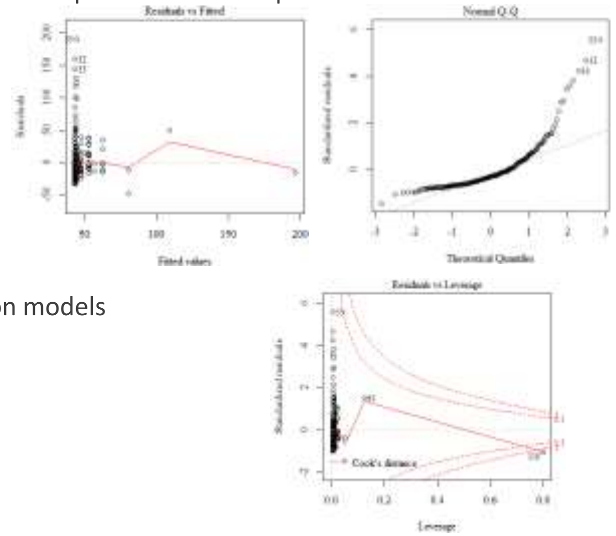
– Multiple power relationship: logarithm transformation to obtain a multiple linear regression

Methodology | Rehabilitation cost function estimation

5. Cost function testing and validation

– Assumptions tested:
  - Linearity and additivity of the relationship between dependent and independent variables
  - Statistical independence of the errors
  - Homoscedasticity of the errors
  - Normality of the error distribution

– Goodness-of-fit of the model:
  - R-squared for simple linear regression models
  - Adjusted R-squared for multiple linear regression models
  - p-value



CONTENTS

- Scope & Objective
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Case Study

19 rehabilitation projects managed by several Portuguese urban water utilities from AdP e iPerdas

ÁGUAS DE PORTUGAL

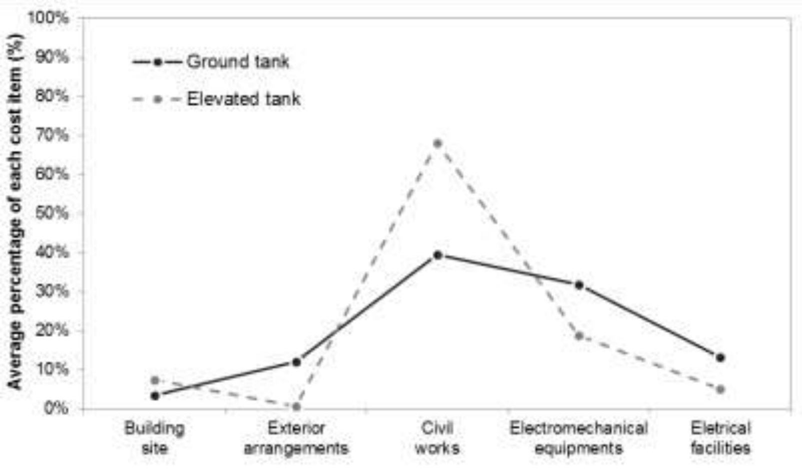
iPerdas

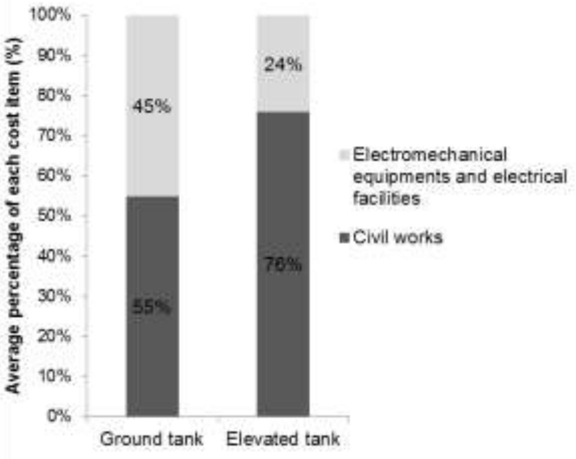
Asset	Number of contracts	Number of elements	Volume (m^3)	Number of cells	Height (m)
Ground storage tanks	10	17	[50 – 5000]	[1 – 4]	–
Elevated storage tanks	9	13	[200 – 750]	–	[15 – 30]

Case Study

– Rehabilitation alternatives study include:

- Exterior arrangements, such as paving, fence, gate, green spaces
- Civil works, such as protective coating, interior and exterior painting, demolitions, structural repairs and foundations, crack and holes repairs
- Electromechanical equipment and electrical facilities, such as pipe and equipment replacement and electrical facilities and automation replacement





CONTENTS

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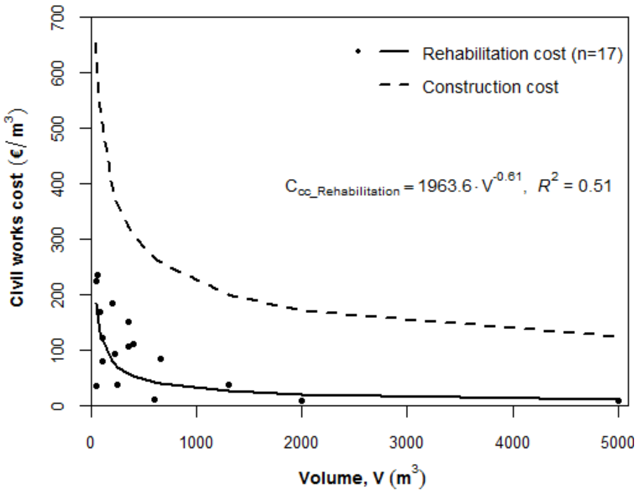
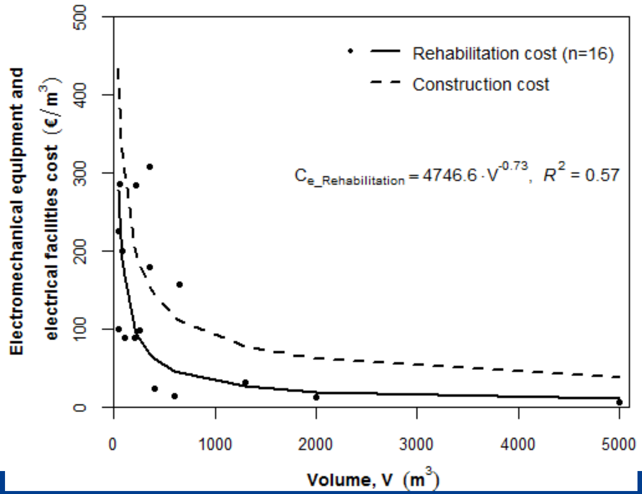
Results | Ground tanks

Civil works cost



Electromechanical equipment and

eletrical facilities cost

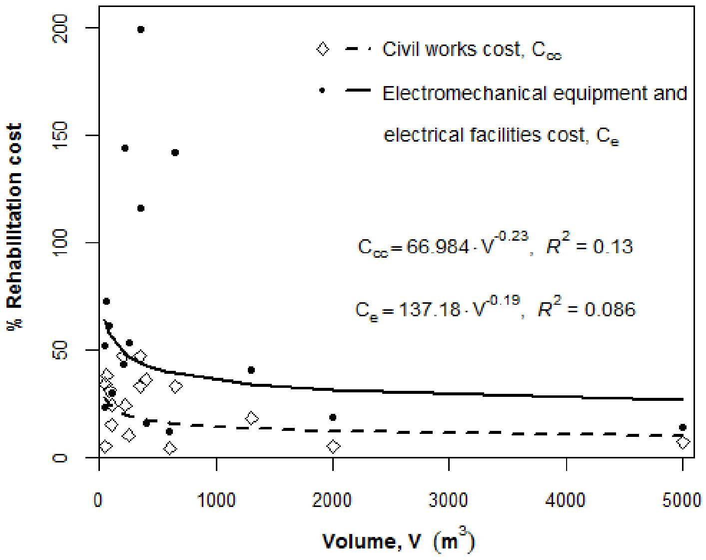


Results | Ground tanks

– Rehabilitation costs (C_{cc} and C_e) decrease with volume

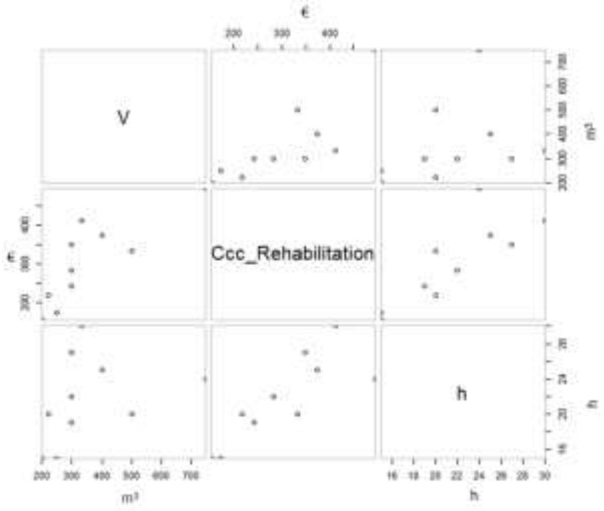
– C_{cc}: 5 and 50% of the construction cost

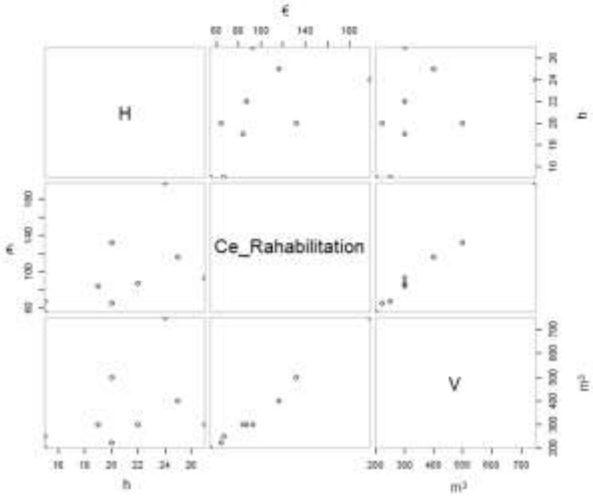
– C_e: 10 and 200% of the construction cost



Results | Elevated tanks

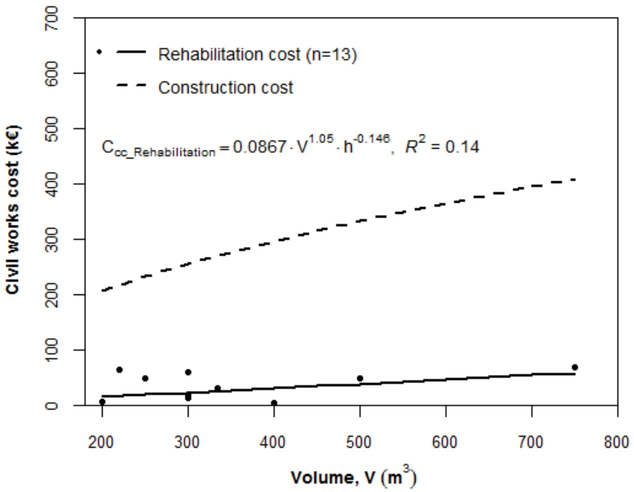
– Scatterplot matrix: evaluated how the variables are related to each other





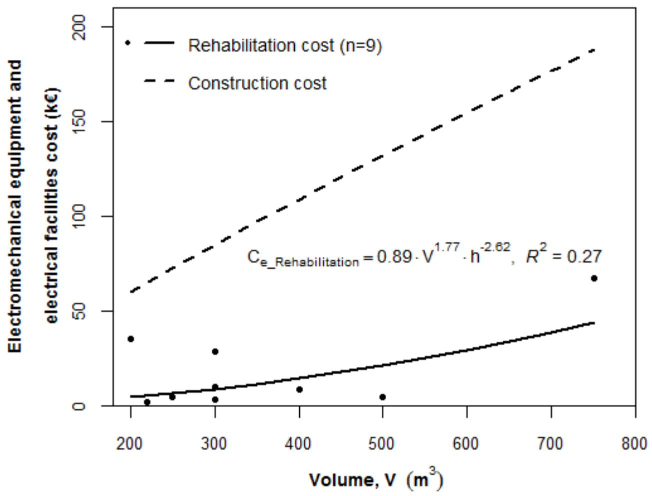
Results | Elevated tanks

Civil works cost



Note: Considering a constant height of 20 m

Electromechanical equipment and eletrical facilities cost



Results | Re-chlorination systems

– Installation of re-chlorination systems:

- Type I: Sodium hypochlorite (pre-oxidation/disinfection)
- Type II: Sodium carbonate or sodium hydroxide (hardness, aggressiveness and pH correction)

Type of treatment	Only Treatment system (€) n=6	Treatment system with shed (€) n=3	Treatment system with shed and photovoltaic panels (€) n=9	Treatment system with photovoltaic panels (€) n=6
Type I (7 l/h) or Type II (17 l/h)	[1 977; 4 712] **2 500**	[5 719; 8 269] **7 000**	[7 602; 10 672] **8 000**	[2 673; 3 583] **3 600**
Type I (3 l/h) and Type II (17 l/h)	–	**8 500**	[14 007; 16 957] **15 500**	–

CONTENTS

Conclusions

- **Methodology** | the rehabilitation cost functions have been estimated and validated for ground and elevated tanks
- **Rehabilitation cost** | divided in two different cost items (civil works and electromechanical equipment and electrical facilities) and compared with construction cost functions
- **Civil works cost** | varies between 5 and 50% of the construction cost for ground tanks
- **Electromechanical equipment and electrical facilities cost** | varies between 10 and 200% of the construction cost for ground tanks. These costs might be higher than the construction cost, when advanced technology equipment is installed

CONTENTS

- Scope & Objective
- Methodology
- Case Study
- Results
- Conclusions
- **On-going research**

On-going research

- Rehabilitation costs should be dividided in more cost items than civil works and electromechanical equipment and electrical facilities
- Rehabilitation costs should be estimated for the different assets of water and wastewater systems and compared with the construction costs
- Reference costs for rehabilitation are important in the priorization of rehabilitation alternatives

Thanks For The Attention

LESAM 2017
NTNU, Trondheim, Norway

Norwegian University of Science and Technology

Presentations

Session 6:

Short and long-term planning

Presentation 2

Angela Martinez: A pipe deterioration model based on dynamic explanatory variables

Canal de Isabel II

A pipe deterioration model based on dynamic explanatory variables

(Francisco Cubillo & Ángela Martínez-Codina)

Ángela Martínez Codina
PhD in civil engineering
Research, Development and Innovation Directorate
Canal de Isabel II (Spain)

LESAM 2017
NTNU, Trondheim, Norway

Study case

A public company responsible for the management of the whole water cycle within the Madrid Region (Spain)

6,238,000

supplied citiziens

17,500 km

distribution network

179

municipalities supplied

Introduction

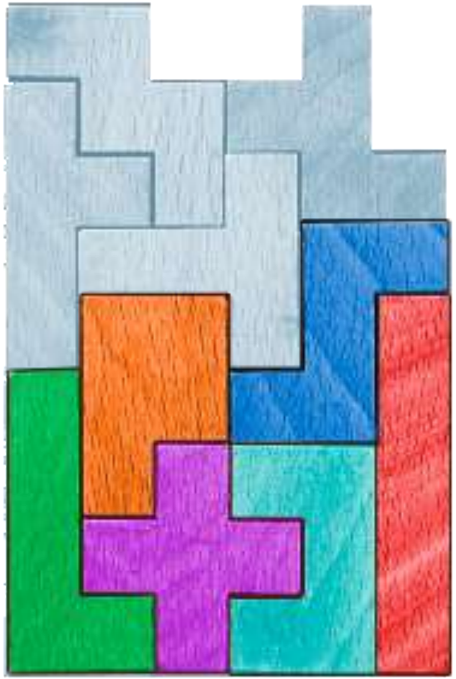
A MAIN OBJECTIVE

IS TO MAINTAIN

THE LEVEL OF SERVICE

ASSET MANAGEMENT POLICIES

INDEX



Model of types of breaks
Multivariate model
Useful life model
Transient model
Investment planner
Deterioration model

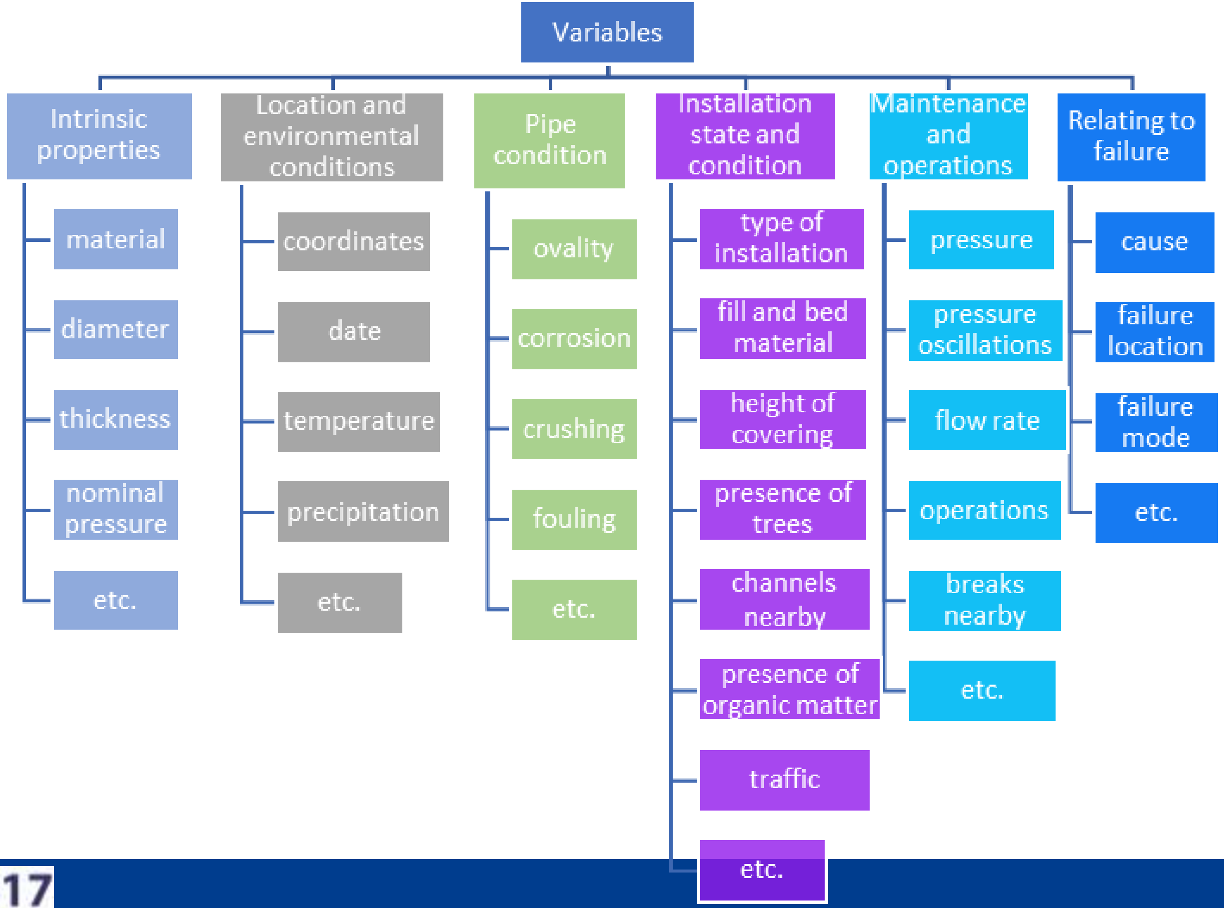
MODEL OF TYPES OF BREAKS

FIELD VISITS, LABORATORY ESSAYS and OFFICE WORK

- PIPES
- SERVICE CONNECTIONS
- WATER METER ASSEMBLIES

Influence breaks

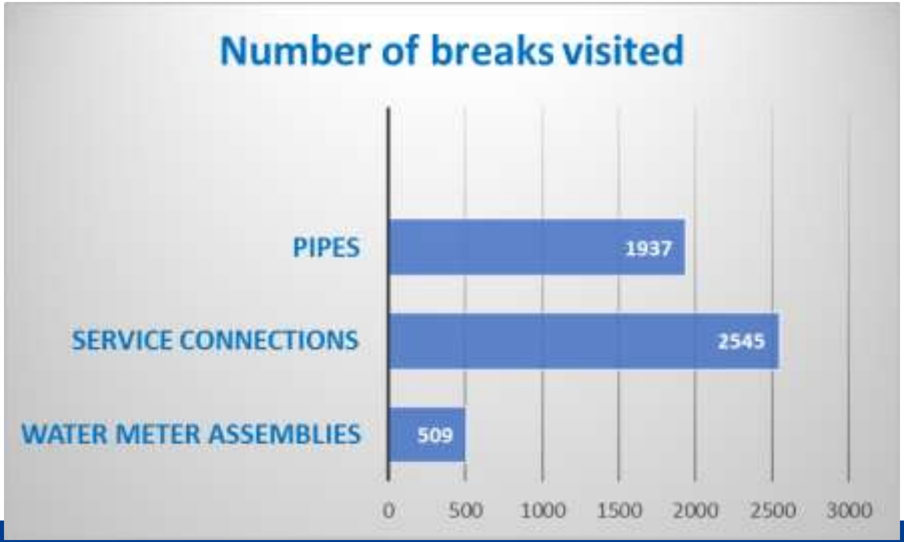
PROBABILITY OF BREAK OCCURRENCE



2016

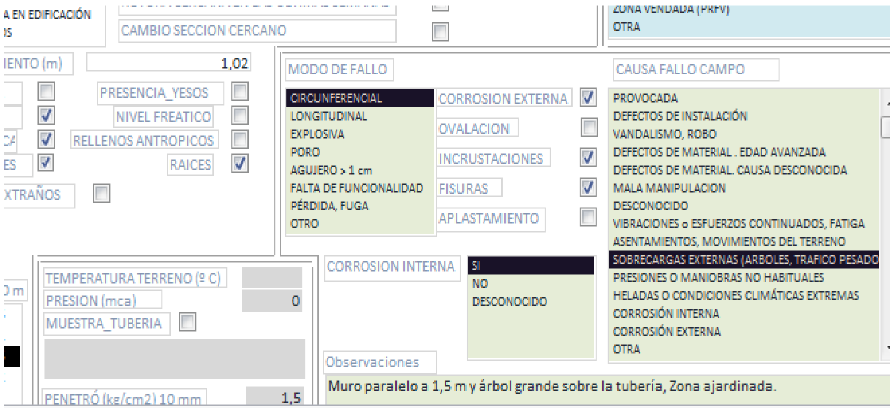
Field visits

2010-2013

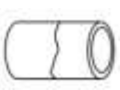


Field visits

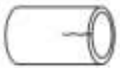
FOR EACH BREAK : A **data sheet** was filled



An estimated failure cause was identified



Circumferential



Longitudinal

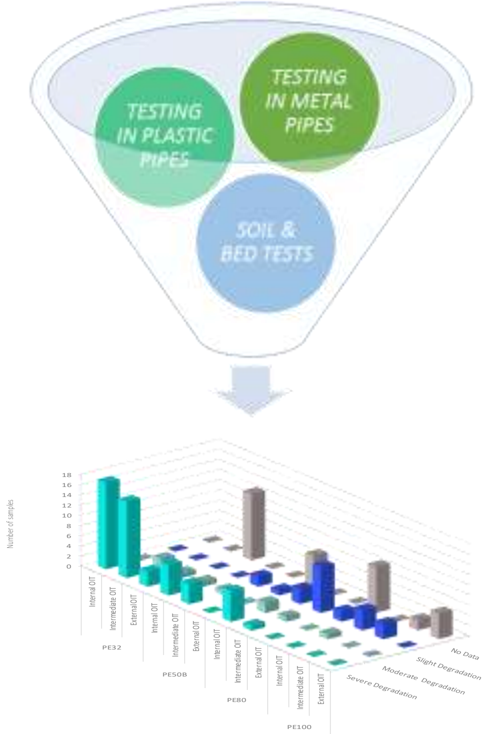
Explosive

Hole

The failure mode gives relevant information

Laboratory essays

A selected sample is sent to LABORATORIES



OFFICE WORK: a database was created

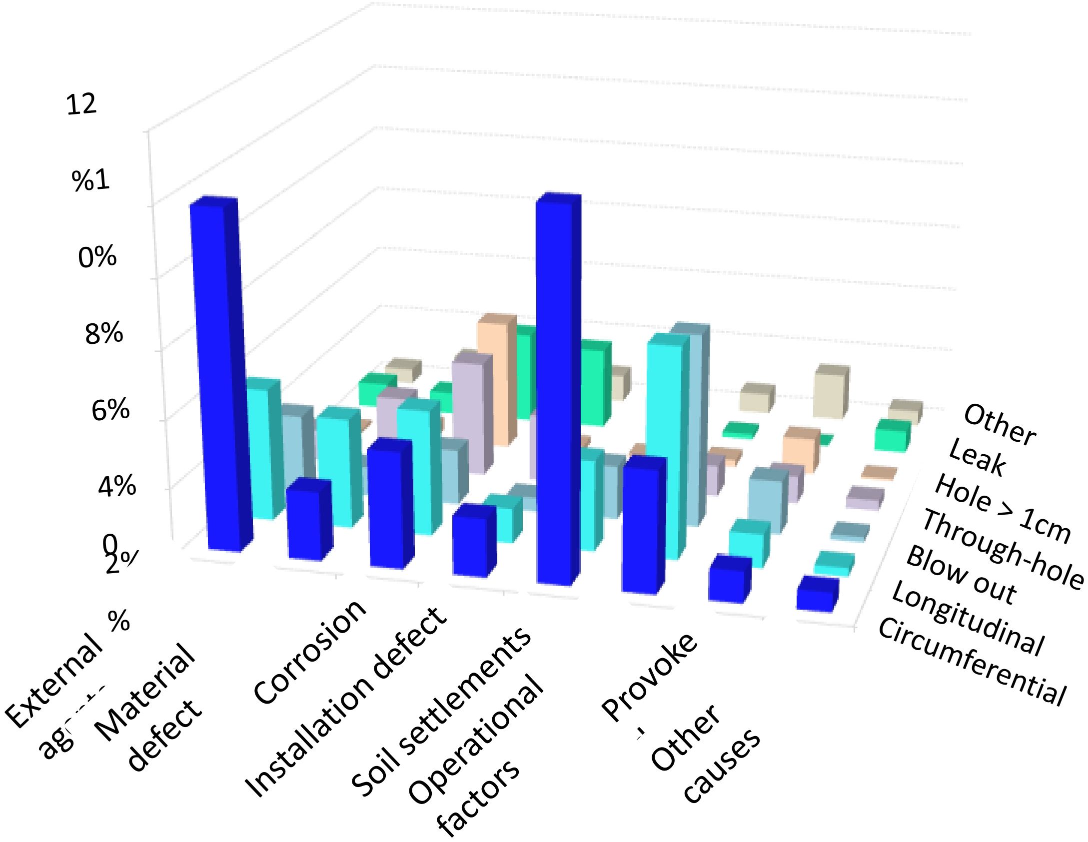
More than **7000 breaks** between 2009-2017

+other elements: valves, pipe bends, drains, etc.

+irrigation network and re-use water network

Typifying failures

Failure causes - Failure mode



Publications

2021

http://www.canaldeisabelsegunda.es/en/galeria_ficheros/comunicacion/documentacion/publicaciones/RDI_Booklet_24.pdf

MULTIVARIATE MODEL

USEFUL LIFE MODEL

Available data

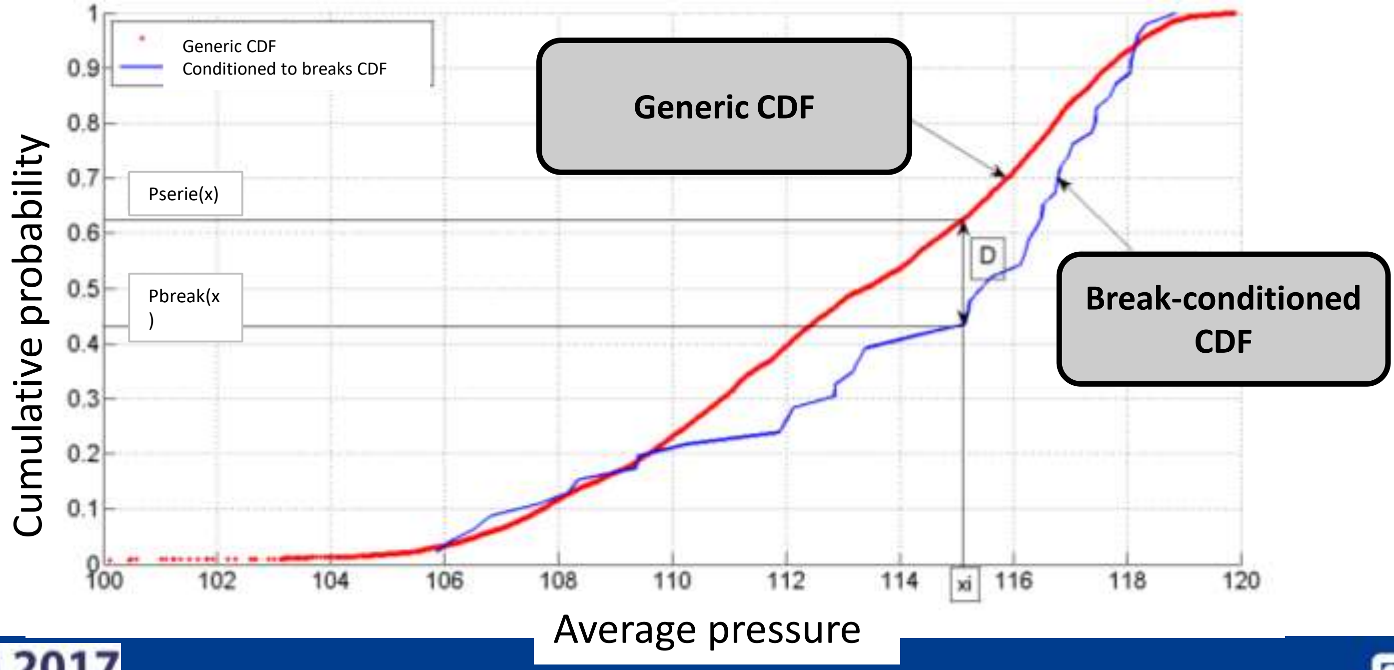
From 1 November 2010 to 30 September 2015

Type	No. Elements in database in 2014	No. Incidences	No. selected incidence
Breaks in service connections	607,360 service connections	33,227	25,916
Pipe breaks Distribution network	373,113 14,176 km pipes	11,905	9,438
Pipe breaks Strategic network	39,915 3,297 km pipes	410	410
Leaks in elements	210,095	1,701	901
	Total	47,243	36,665

Methodology

KOLMOGOROV-SMIRNOV TEST:
assesses weather the two samples come from the same parent population

Null hypothesis: Ho: Fserie(x) = Frot(x) → Rejected → **The variable influence the probability of breaks**

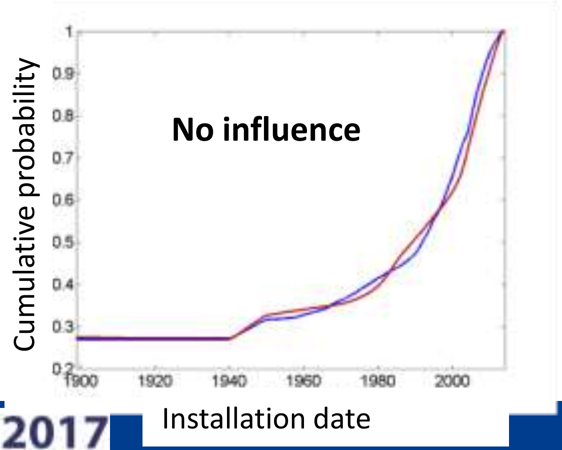


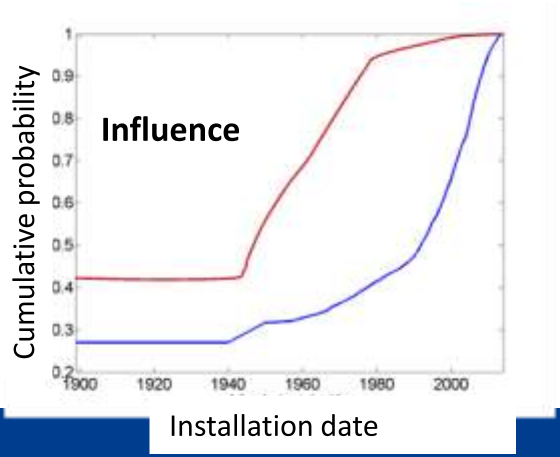
Explanatory variables

Explanatory variables

- Diameter
- Installation date
- Material
- Soil type
- Land use
- Manoeuvres

- Maximum pressure
- Average pressure
- Minimum pressure
- Maximum velocity
- Average velocity
- Minimum velocity





BUILDING THE MODELS…

PROBABILITY

%

PROBABILITY OF BREAK OCCURENCE

VARIABLES

(X)

DIFFERENT EXPLANATORY VARIABLES

BAYES THEOREM

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} = PR.P(A)$$

BAYES THEOREM

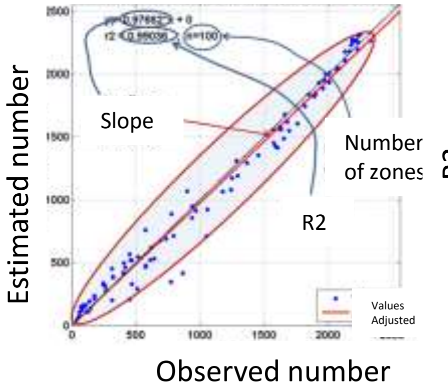
$$P(A) = \frac{N_f}{N_T}$$

N_f: No. failures
N_T: No. total of elements

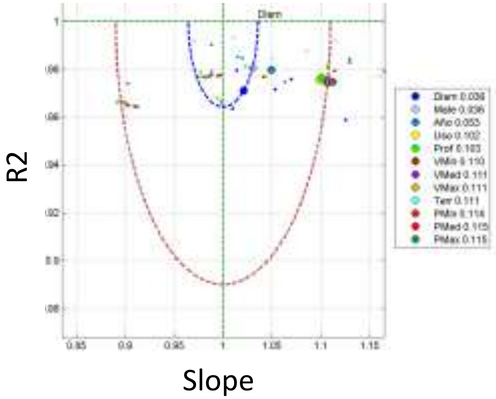
Model structure

ASSESSMENT OF THE MODELS

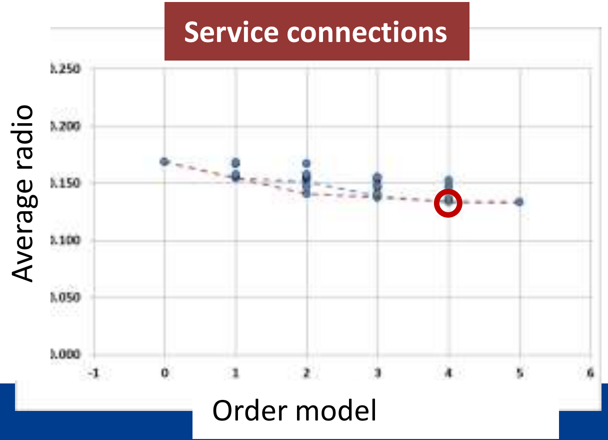
Distribution network – diameter year



Dispersion– one variable



NUMBER OF VARIABLES



Best models

Types	Dependent variables	Independent variables
Service connections		Diameter-depth-Soil-Age
Pipes in distribution network	Diamater-Age	Average pressure-Depth
Pipes in strategic network		Diameter-Material-Use land
Elements		Diameter-Age-Depth-Location

PROBABILITY

%

...ple

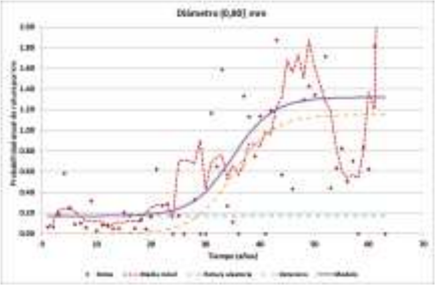
Pipes in distribution network

Model: $p = p_{1,2}(t) f_3 f_4$

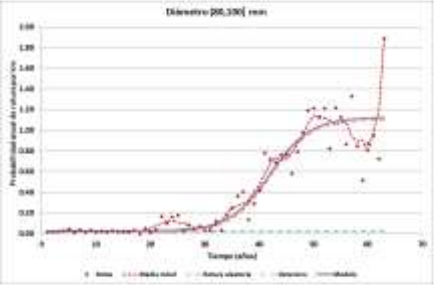
$$p_{1,2}(t) = A_i + \frac{B_i}{1 + e^{C_i(t-D_i)}}$$

Diamater-Age

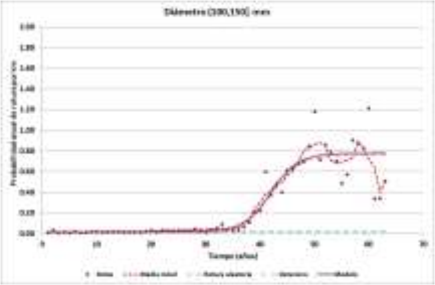
(0-80]



(80-100]

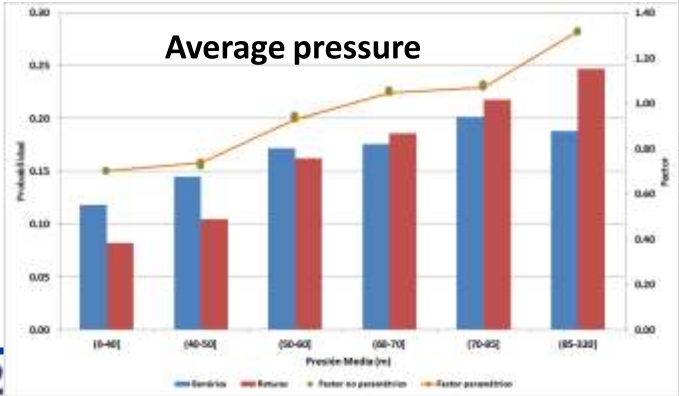


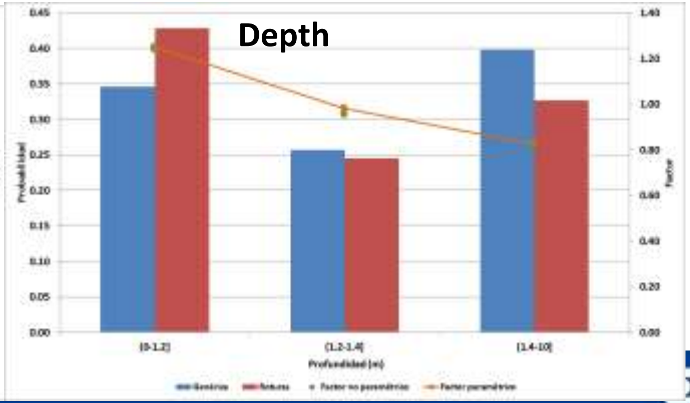
(100-150]



$$f_3 = 0{,}6565 + 0{,}0011p + \frac{0{,}3245}{1 + e^{0{,}29(t-58)}}$$

$$f_4 = 0{,}82300 + 172{,}656e^{-5f}$$





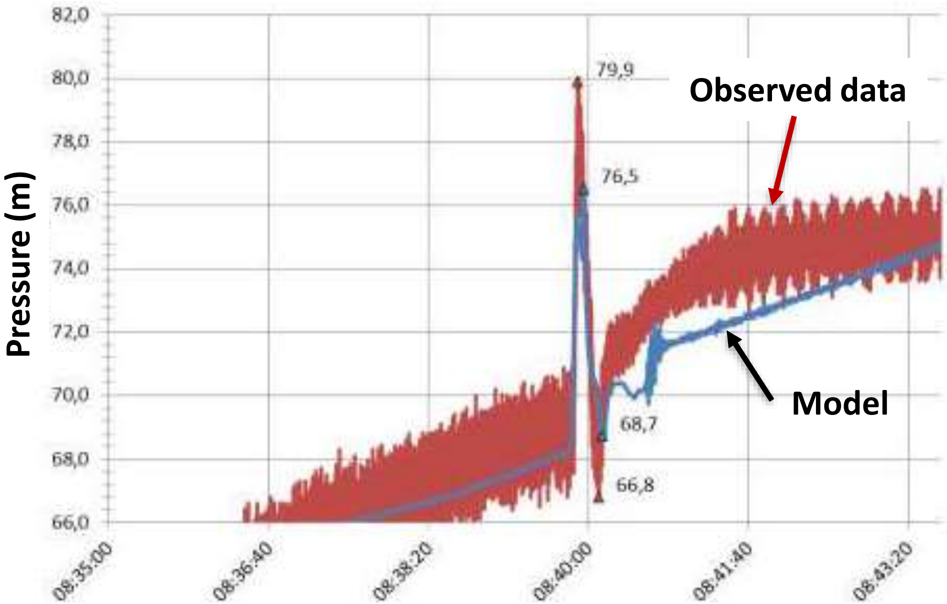
Publications

TRANSIENT MODEL

Transient model

100 records/min

1) Analysis of the possible **CAUSES**
2) Selection of the **ZONES**
3) Data **LOGGING** and **MODEL**
4) Analysis of the **RESULTS**



INVESTMENT PLANNER

Failure vs. consequences

What really matters?

The failure?

Its consequences?

Methodology

- MULTIVARIATE MODEL & FAILURE CONSEQUENCES

PROBABILITY OF FAILURE × IMPACT

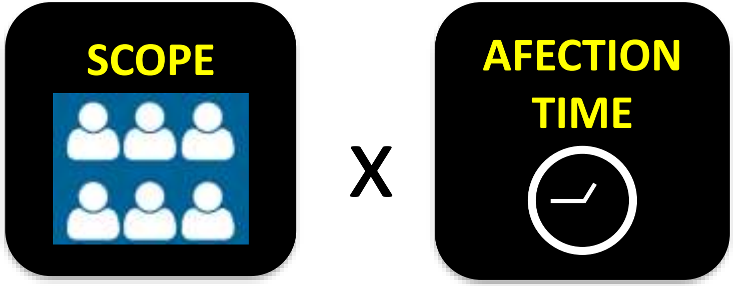
RISK

PROBABILITY

%

SCOPE x AFFECTION TIME

Impact



¿How many people…? *¿How much time…?*

Properties x hour

SCOPE

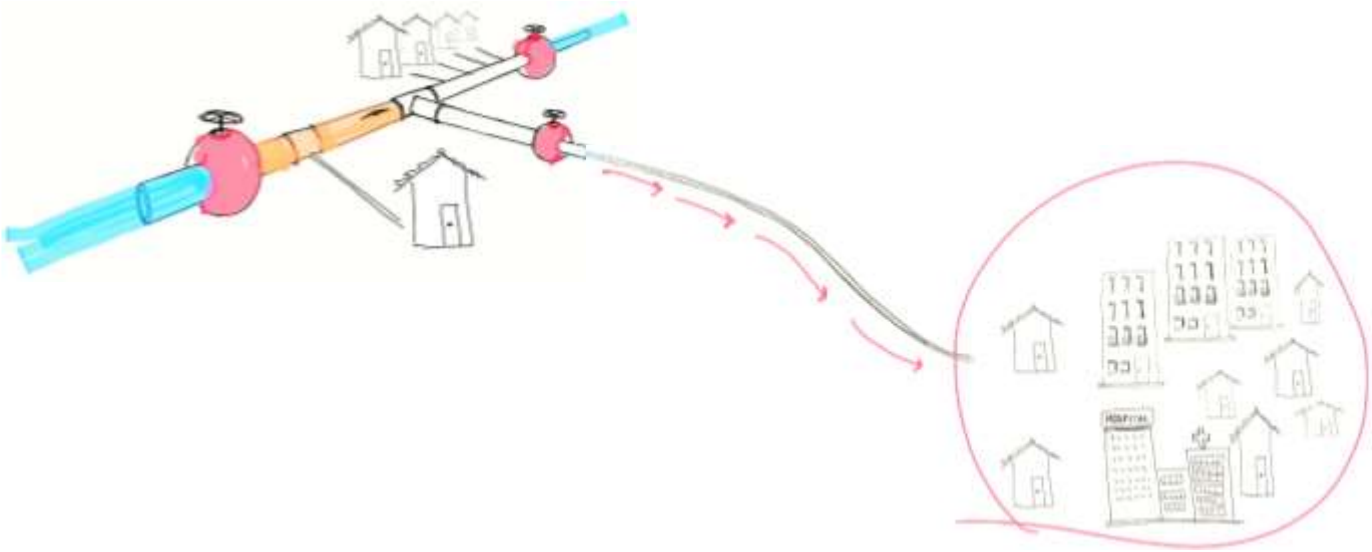
End-users

Sensitive end-users

Roads

Other services

AFFECTIO N TIME



SCOPE

AFFECTION TIME

- Warning
- Location of break
- Shut-off the valves **f (no. Valves)**
- Draining **f (vol. polygon, drainage capacity)**
- Repair **f (Detection, location, depth, diameter, material)**
- Restution **f (no. Valves)**

PROBABILITY

%

SCOPE

X

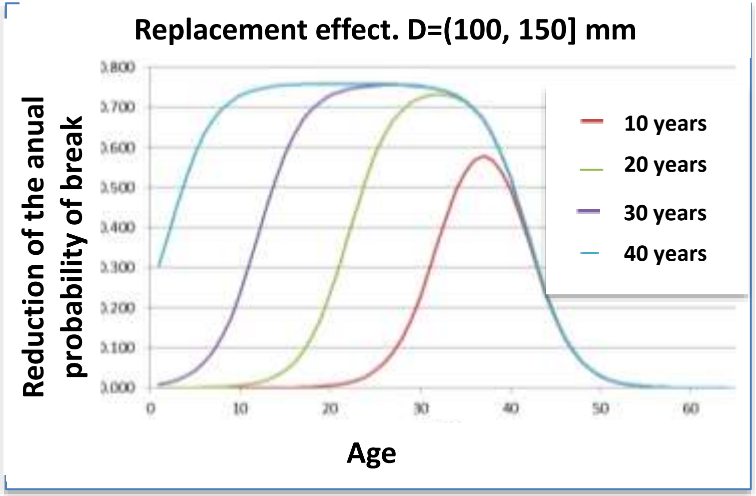
AFFECTION TIME

PROBABILITY OF FAILURE

IMPACT

PROFITABILITY

¿REPAIR
or
REPLACEMENT?



CAPITALIZATION FACTOR

$$CF = \sum_{1}^{N} \frac{p_{i+k}^{A} - p_{i}^{R}}{(1+u)^{i}}$$

p_{i+k}^{A} Probability of break of the actual element

p_{i}^{R} Probability of break of the replaced element

u Updated rate

N Years to capitalize the savings

k Age of the element to be replaced

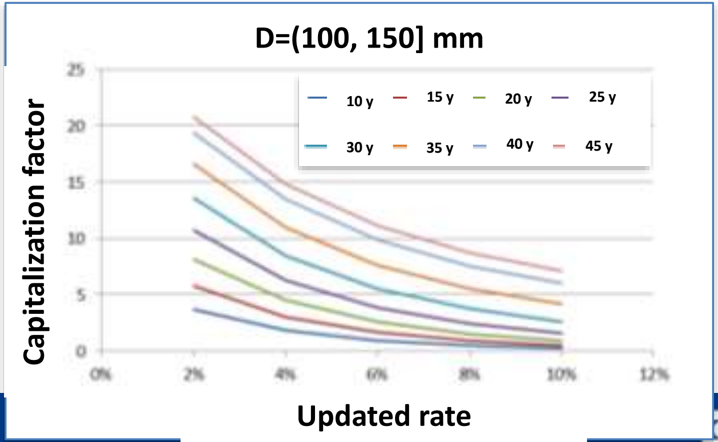
$$CF > \frac{c_R}{c_d f_c}$$ **REPLACEMENT**

c_R Replacement cost

c_d Damage cost

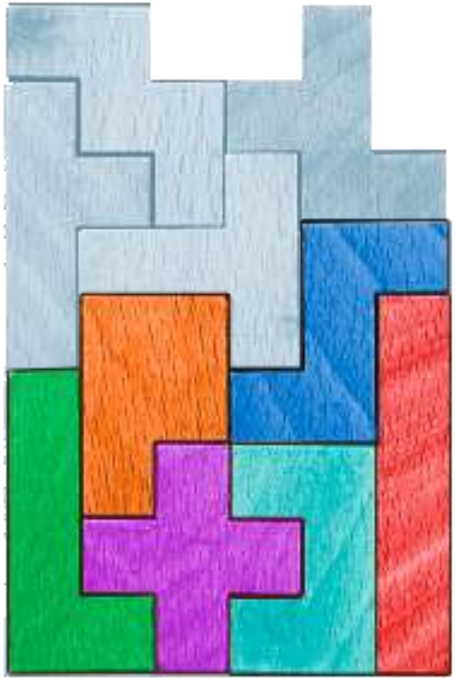
f_c Product of the f_i factors

Ex. $p = p_{1,2}(t) f_3 f_4 = p_{1,2}(t) f_c$



Strategic planner

Annual programs



Break prediction model

Model of types of breaks

Multivariate model

Transient model

Investment planner

Deterioration model

THANK YOU FOR YOUR ATTENTION

Canal de Isabel II

amcodina@canaldeisabelsegunda.es

www.canaldeisabelsegunda.es

Presentation 3

Mirjam Blokker: UKNOW - a framework to assess the need for pipe inspection and pipe replacement

UKNOW: A framework to assess the need for pipe inspection and pipe replacement

Mirjam Blokker

Rehabilitation of pipes, need for decision support

Aim: maintain network integrity, reduce or maintain risk level

Risk of pipe failure = function of probability and effect of pipe failure

Effect categories: cost (direct and indirect), interruption of supply (CML), negative impact on surroundings, health impact, image and customer trust, …

How to quantify these effects in a cost effective way, during the risk assessment phase?

How to include uncertainties in data and models?

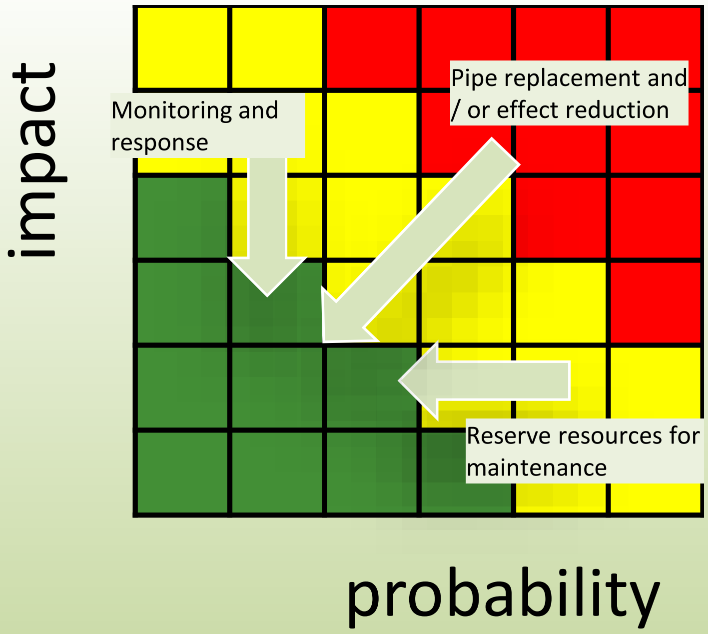
Risk Assessment

"**green**" (low) risk: no action required;

"**yellow**" (medium high) risk

- high probability and small impact: water company needs to reserve resources for maintenance,
- low probability and high impact: water company can take action when needed.

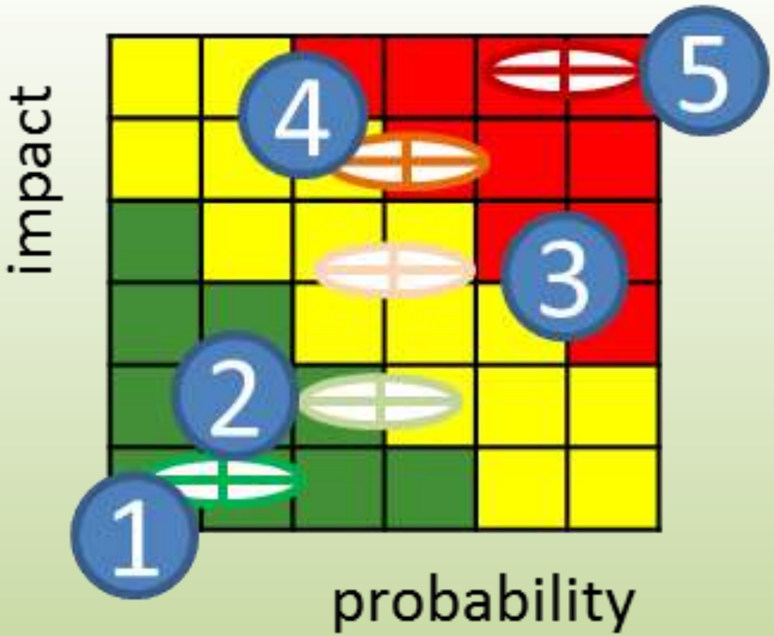
"**red**" (high) risk: risk mitigation actions to either reduce the probability or the impact (or both).



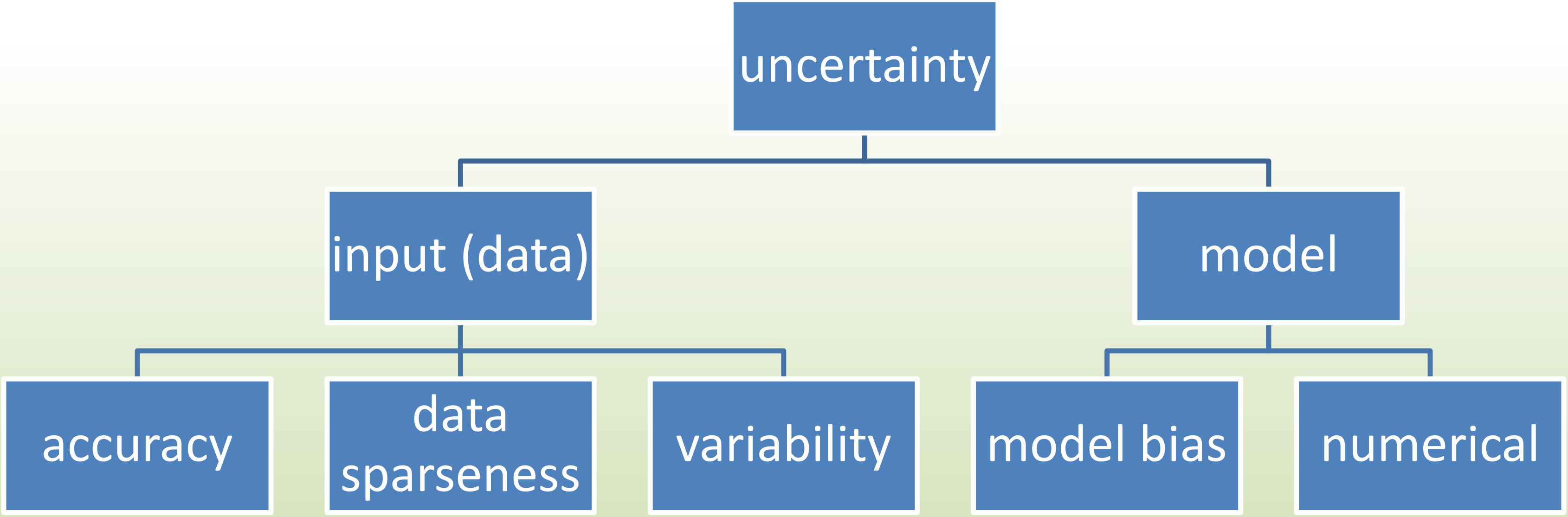
Risk assessment with uncertainties

Risk incl. variability spans over

1) Low risk: no action
2) Low - medium probability, low impact: condition assessment to determine if probability is medium (➔ reserve resources) or small (➔ no action)
3) Low - medium probability, medium impact: monitoring or reserve resources for maintenance
4) Medium - high probability, high impact: condition assessment to determine if probability is high (➔ pipe replacement) or medium high (➔ monitoring)
5) High probability, high impact: pipe replacement



Types of uncertainties



Results of inspection have limited resolution

Data available for limited number of (failed / inspected) pipes

Material degradation not equal over pipe length and circumference

Linear degradation over time is assumed

Truncation or aggregation errors

Example: pipe replacement w.r.t. CML

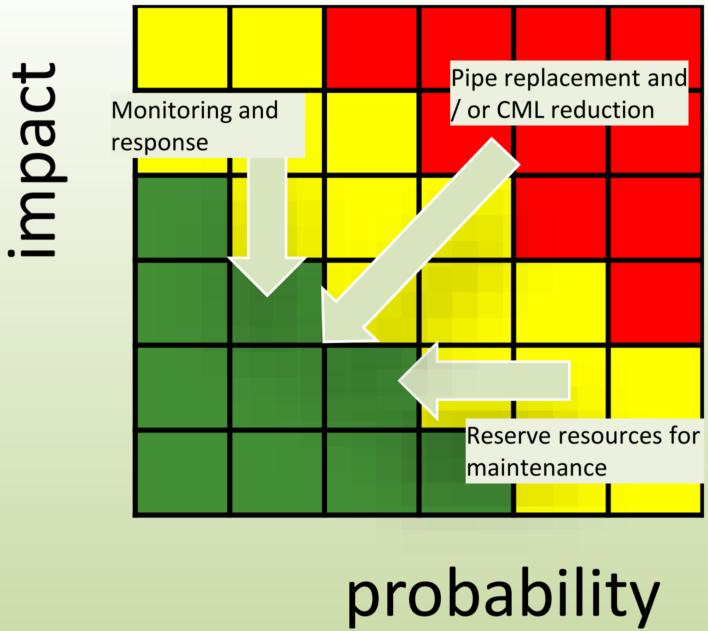
No uncertainties

CML (customer minutes lost) ~

Failure frequency per section
(= pipe failure (#/km.year) × section length)
× repair time (min)
× number of customers per section

Options to limit CML:

- Reduce pipe failure probability
- Reduce section size (length and number of customers)
- Reduce repair time
- Reduce number of failing valves (required for section isolation)



Example: pipe replacement w.r.t. CML

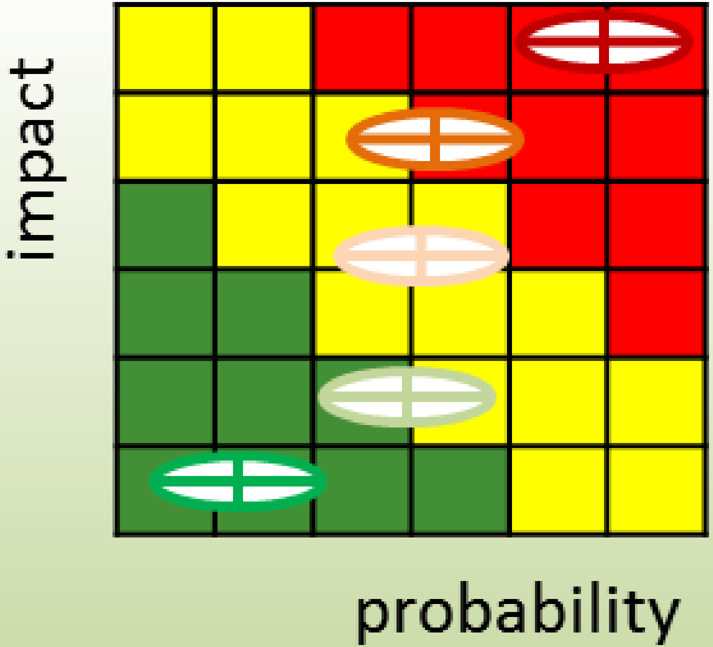
UKNOW

CML (customer minutes lost) ~

Failure frequency per section
(= pipe failure (#/km.year) × section length)
× repair time (min)
× number of customers per section

Uncertainties in CML: H/M/L

- pipe failure probability: depends on technology (USTORE, inspection cohort, inspection pipe)
- section size (length and number of customers)
- repair time
- Effect of failing valves (CAVLAR), valve reliability



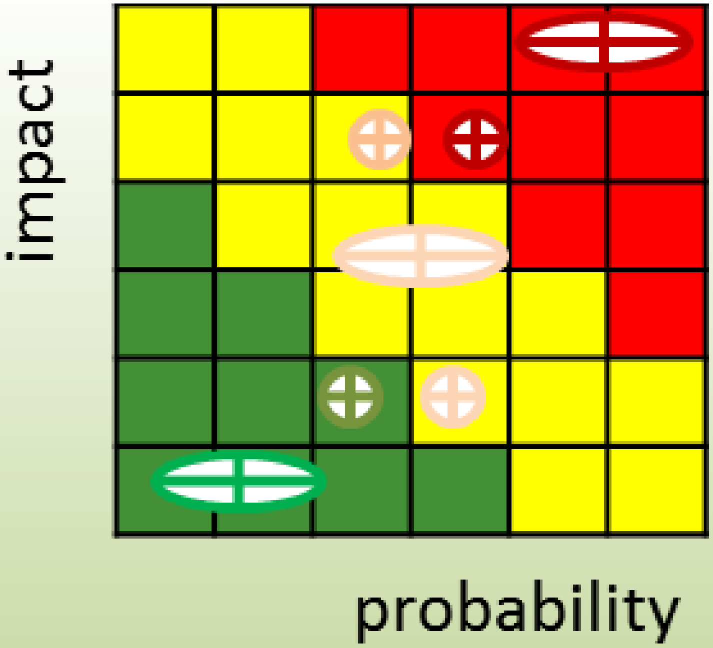
Example: pipe replacement w.r.t. CML

UKNOW – reduce uncertainties only if risk is affected

CML (customer minutes lost) ~
Failure frequency per section
(= pipe failure (#/km.year) × section length)
× repair time (min)
× number of customers per section

Uncertainties in CML: H/M/L

- pipe failure probability: depends on technology (USTORE, inspection cohort, inspection pipe)
- section size (length and number of customers)
- repair time
- Effect of failing valves (CAVLAR), valve reliability



Example: pipe replacement w.r.t. CML

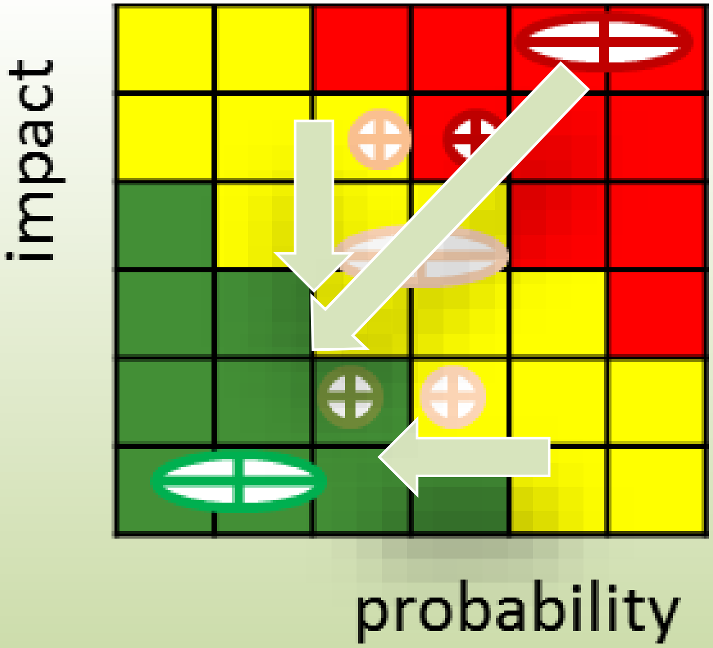
UKNOW – reduce risk as the next step

CML (customer minutes lost) ~

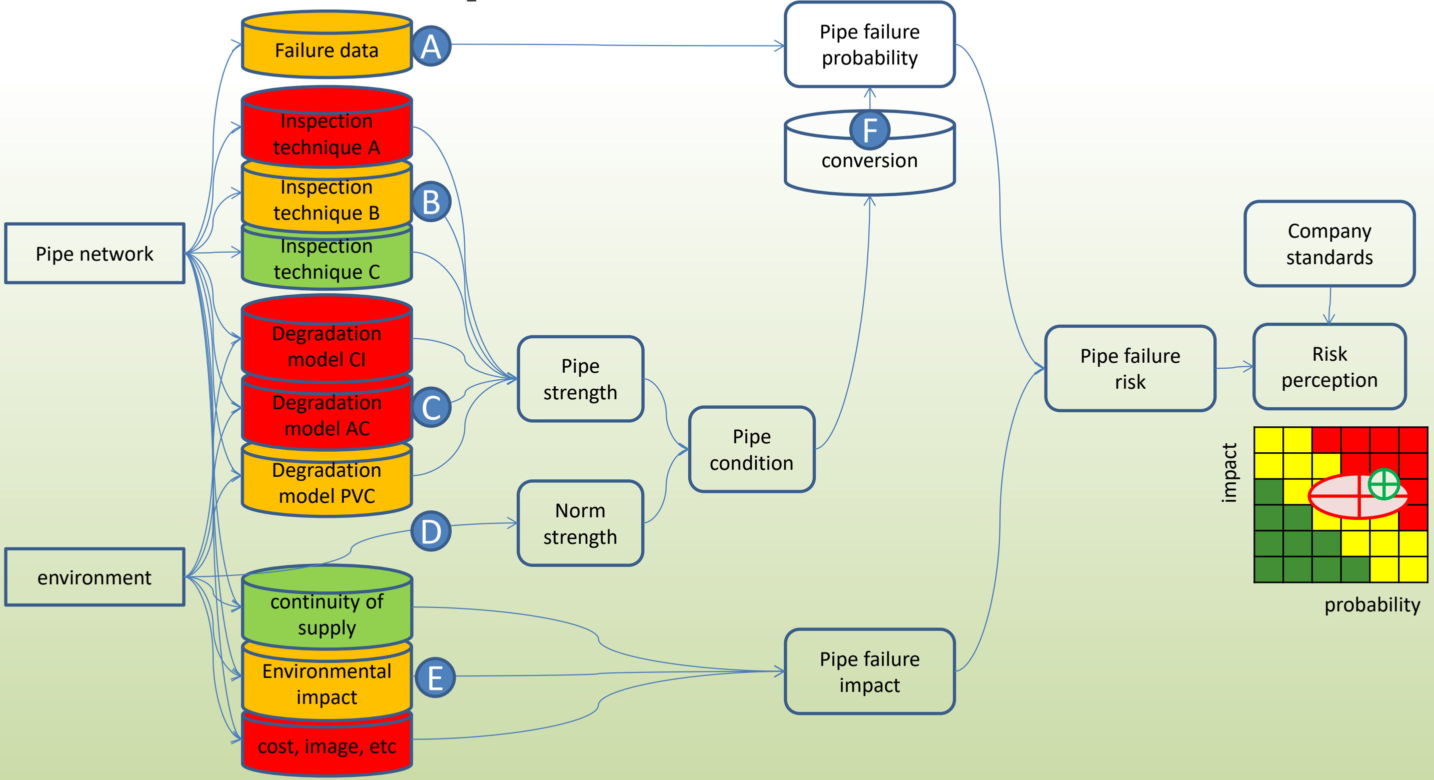
Failure frequency per section
(= pipe failure (#/km.year) × section length)
× repair time (min)
× number of customers per section

Options to limit CML:

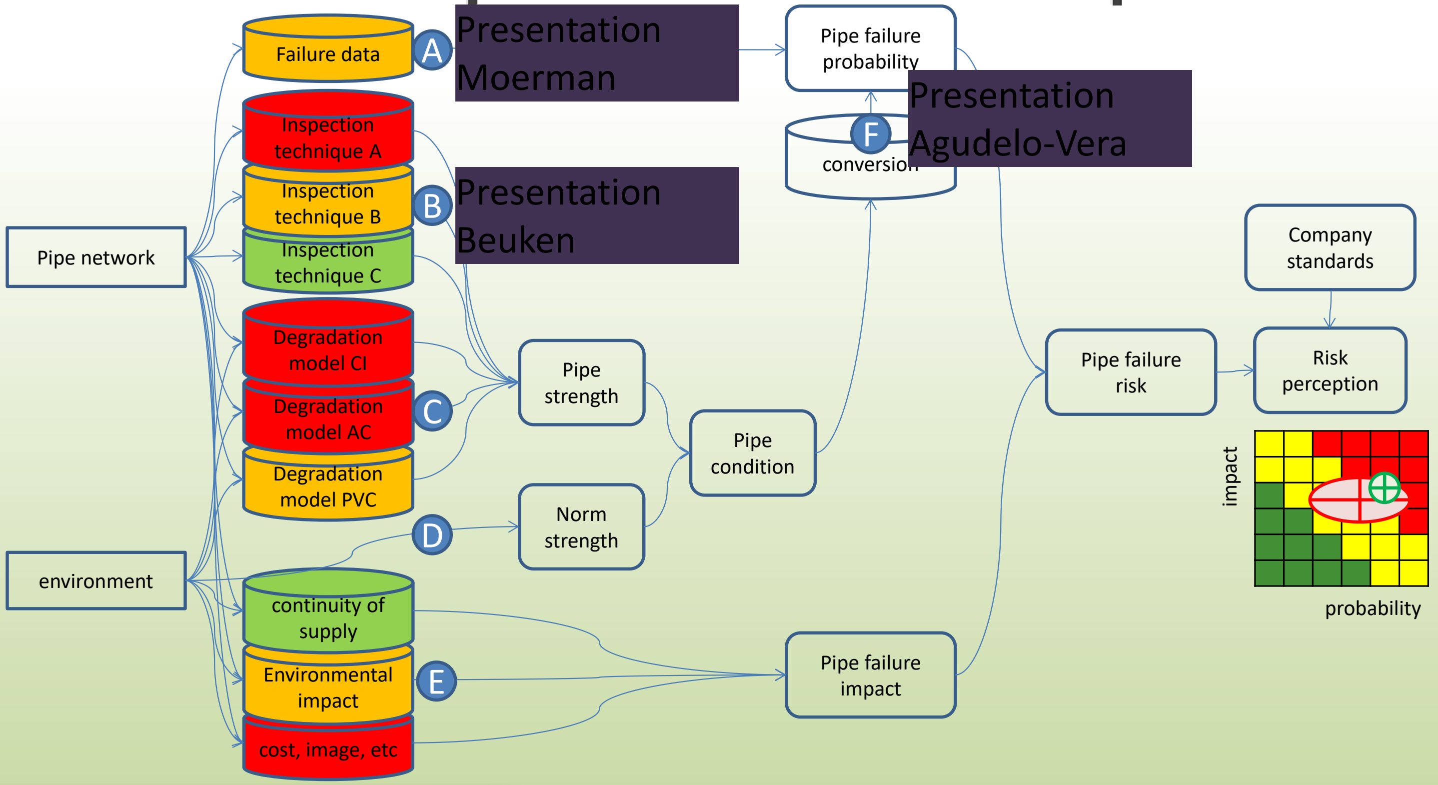
- Reduce pipe failure probability
- Reduce section size (length and number of customers)
- Reduce repair time
- Reduce number of failing valves (required for section isolation)

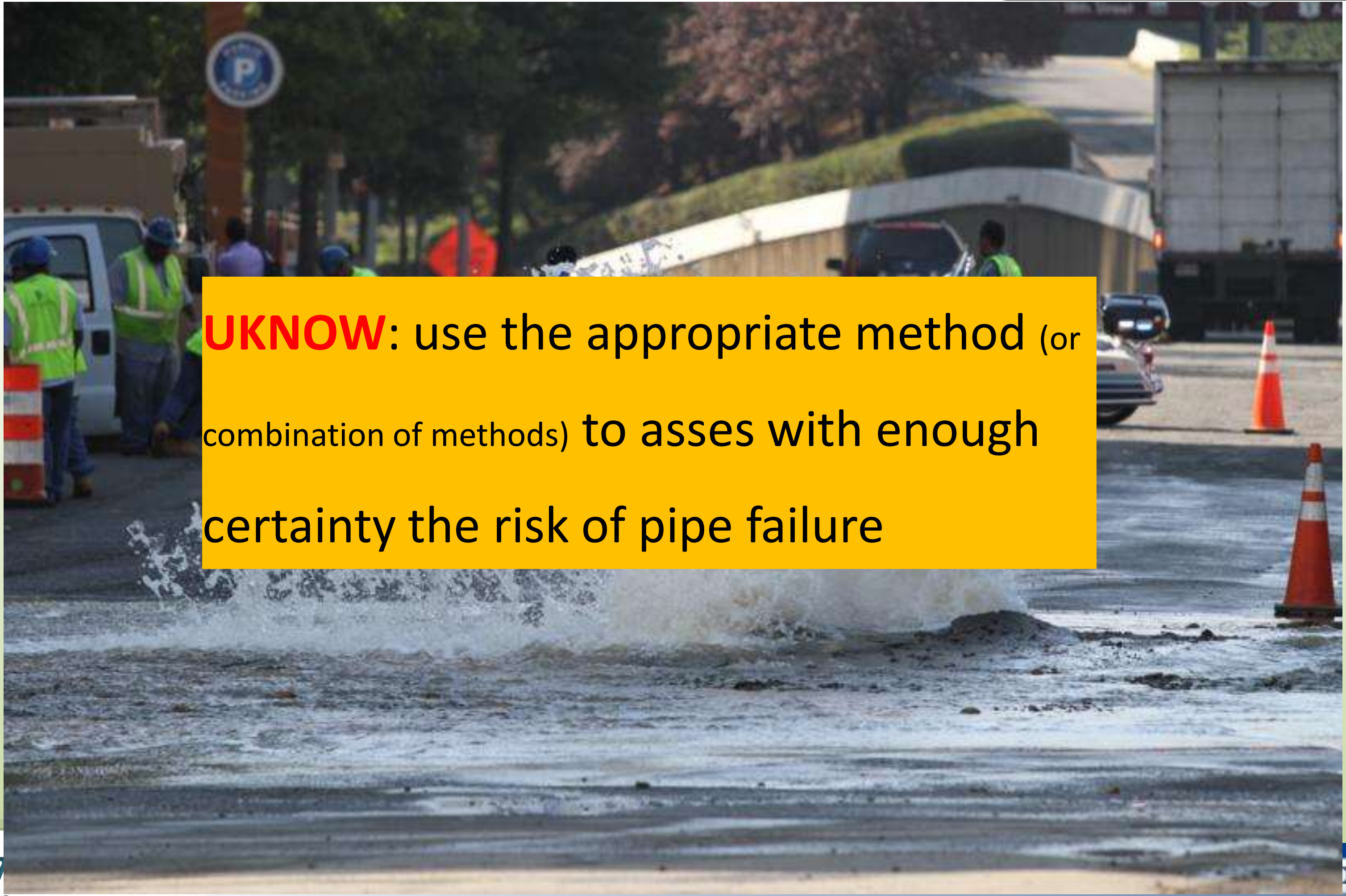


UKNOW concept



UKNOW concept – research developments





UKNOW: use the appropriate method (or combination of methods) to asses with enough certainty the risk of pipe failure

UKNOW: A framework to assess the need for pipe inspection and pipe replacement

Mirjam Blokker

Presentation 4

Andreas Moerman: Review on seven years of uniform failure registration (USTORE)

USTORE

The development of a unique database

Data quality

Andreas Moerman MSc
Ralph Beuken MSc

U.. what? ☺

USTORE (Uniforme Storingsregistratie)

- USTORE ('Uniform failure registration'): failure database of (almost all) DW companies in the Netherlands
- Supported by community of practice (members of DW companies and KWR)
- More than 20.000 uniformly registered failures collected by 8 DW companies
- Goal: collecting data for:
    1. Quantification of deterioration of pipe cohorts and
    2. Better understanding (knowledge) of pipe deterioration

Uniform failure registration; that's why

Benefits of sharing failure data

- Increases data quantity per pipe cohort → decrease statistical uncertainty
- Sharing knowledge about failure registration creates the opportunity to learn from each other
- Comparison of shared datasets

What is collected?

Focus on pipes for transport and distribution

Failure data

('when, where, what, how')

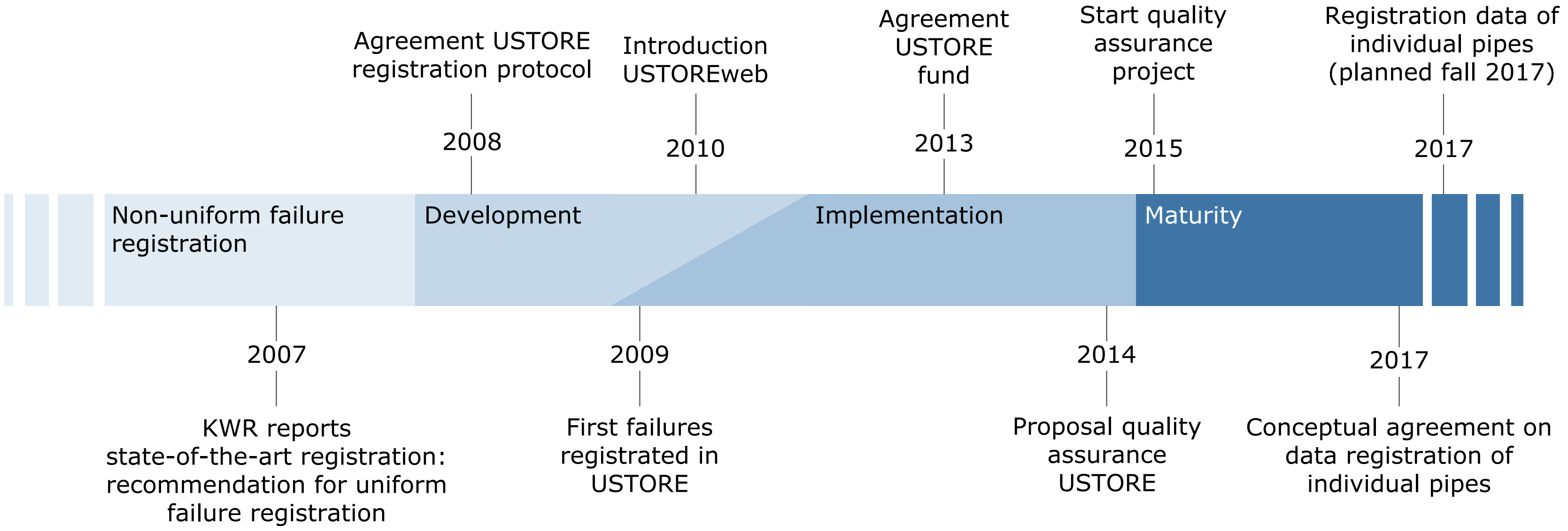
- Datum and location (coördinates)
- Component (pipe, joint, bend, etc.)
- Characteristics component (material, diameter, year of installation, etc.)
- Failure mechanism (longitudinal crack, radial crack, point leak, etc.)
- Cause (if known)
- Situation (trees, pipe depth, etc.)

Pipe data

- Material
- Diameter
- Year of installation

For pipe cohorts

Development timeline USTORE



Applications of uniform failure data

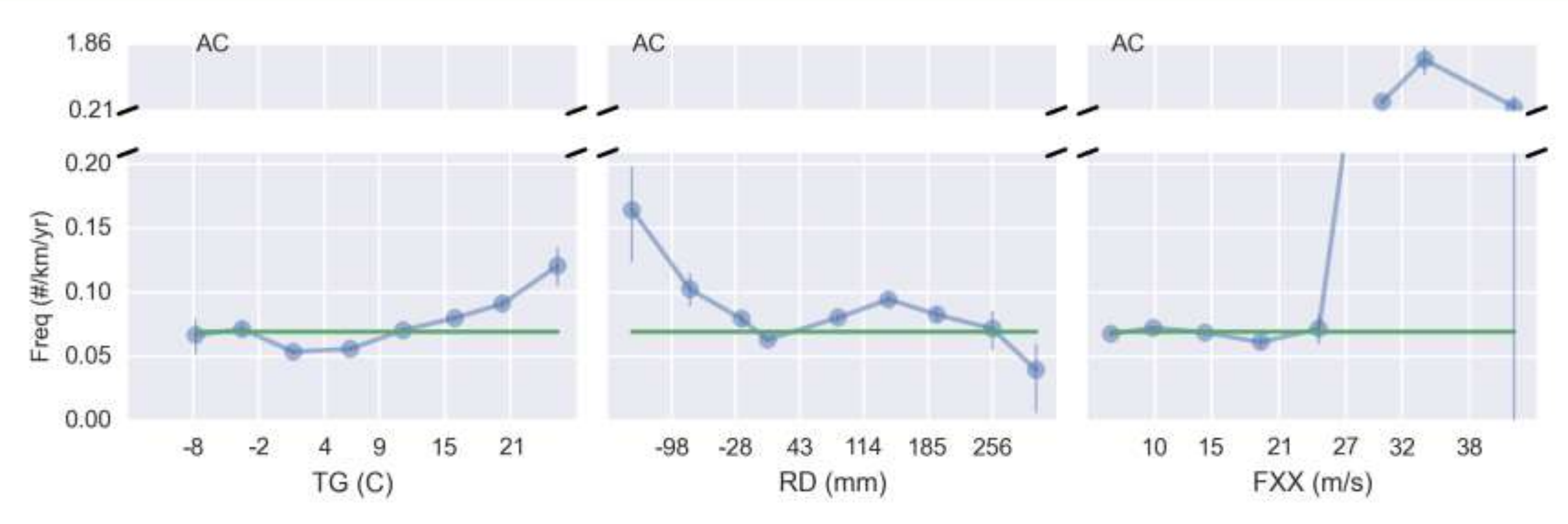
Examples (see paper)

- Prioritization of pipe cohorts for pipe replacement
- Correlation between pipe failure frequency and:
  - Weather parameters (temperature, rainfall/drought, windspeed)
  - Presence of roads (surrogate for traffic loads)
  - Pressure regimes
  - Soil conditions

- Impact of climate scenario's
- Input for QMRA (Quantitative Microbial Risk Assessment) model
- Potential for inspection techniques and trenchless techniques

Applications of uniform failure data

One example in detail



Wols *et al.* (under review), Effects of weather parameters on pipe failure frequencies in the Netherlands.

Data quality

- Boring
- Often not easy to quantify
- Could often not easily improved by technical measures
- However..

The quality of data defines the quality of decisions in AM

Data quality

Examples of quality issues in uniform failure registration

- Failure data registrations are not complete
  - Failures are missing
  - Failure parameters are missing (registered as ‘unknown’)

- Different interpretations for failure definition and different system boundaries.

- Impossible combinations of registered attributes
  (e.g. welded connection for PVC pipes).

Data quality assurance

Measures to improve data quality

- Agreement on uniform definition of:
  - Pipe failure
  - System boundary
  - Key activities in the process of failure data acquisition, enrichment and analysis

- Data model improvement
  - Questions which can be objectivily answered by fitter (to a reasonable extent)
  - Use of data sources to obtain environmental data

- Increase / maintain knowledge level of fitters to recognize failure situations
- Descriptions in workflows should match with practical situations

Quality control

- Quantification possible:
  Result oriented
  quality management

- Quantification hardly possible / impossible:
  Process oriented quality management

QUALITY ASSURANCE

QUALITY CONTROL (QC)

QC1: Data-integrity
- Completeness
- Uniqueness
- Meets data model

QC2: Measuring
- Repeatable / Reproducible
- Recognition of failure situation: knowledge level
- Appropriate IT support

QC3: Consistency
- Correctness
- Are there impossibilities?
- Preventing impossible combinations

QC4: Plausibility
- Correctness
- Based on expert judgement or statistical analysis

Lessons learned

- Uniform failure registration > ‘just a data model’
- (Uniform) failure registration is not only a matter of technical issues; there are also social challenges
- Sharing data of all individual pipes requires proven data security
- Some pragmatism is recommended... (not more, not less)

Future work

2018+

- Implementation of framework for quality assurance / quality control at DW companies and KWR
- Implementation of new failure data model (data collection of individual pipes)
- Feedback on data quality / data quality labeling

Acknowledgements

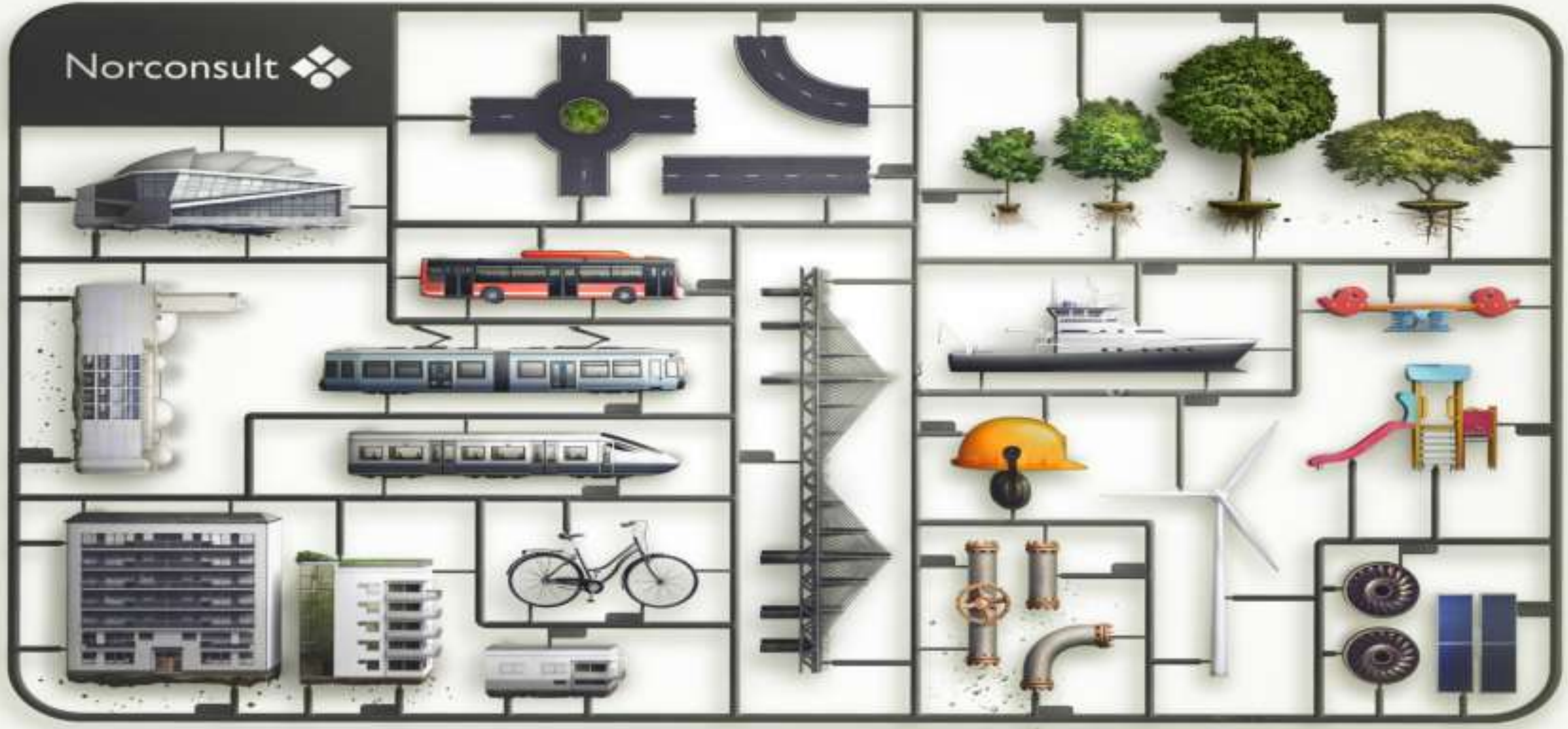
The authors want to thank the collaborating DW companies which for their effort and funding from 2009 until now.

Challenges

Related to the basis of our Asset Management

1. Collection of data (to start or to maintain)

2. Quantification and improvement of data quality



Thank you for your attention

LESAM 2017
NTNU, Trondheim, Norway

Presentation 5

Claudia Agudelo-vera: How to use pipe inspection data to validate pipe replacement decisions

Using pipe inspection data to validate pipe replacement decisions

Claudia Agudelo-Vera (KWR), Ralph Beuken (KWR),

Peter Horst (PWN), Kees Ruijg (DUNEA), Arne Bosch (Waternet), Mirjam Blokker(KWR)

Objectives

1. to validate pipe residual lifetime predictions using conditions assessment tests (CATs)
2. to use the Plan-Do-Check-Act (PDCA) concept to improve pipe replacement decisions

Overview of the replacements per company

Item	Dunea	PWN	Waternet
Drinking water network length (km)	4,700	10,000	3,400
Current annual replacement rate (%)	0.8	0.9	0.7
Decision about replacements due to third parties (%)	50	50	65
Decision support software tool (DSST)	WILCO	TRANSPARANT	RASMARIANT
Year of joining the national database USTORE	2009	2009	2010
Pipes for replacement to be determined by DSST (km)	21	45	11

Framework

1.Plan (per project):

For each project, identify and register:

Step 1: original wall thickness and year of construction

Step 2: environment data & required wall thickness

Step 3: expected technical lifetime

tion and degradatio

2. Do (per project):

Perform a condition assessment test (CAT)

Expected condition and degradation

Validation

Actual condition and degradation

(per project):

Step 1: Check pipe and environment data

Step 2: Compare expected vs. measured condition and calculate actual degradation

Step 3: Identify uncertainties and errors, and formulate recommendations

4. Act (After several projects):

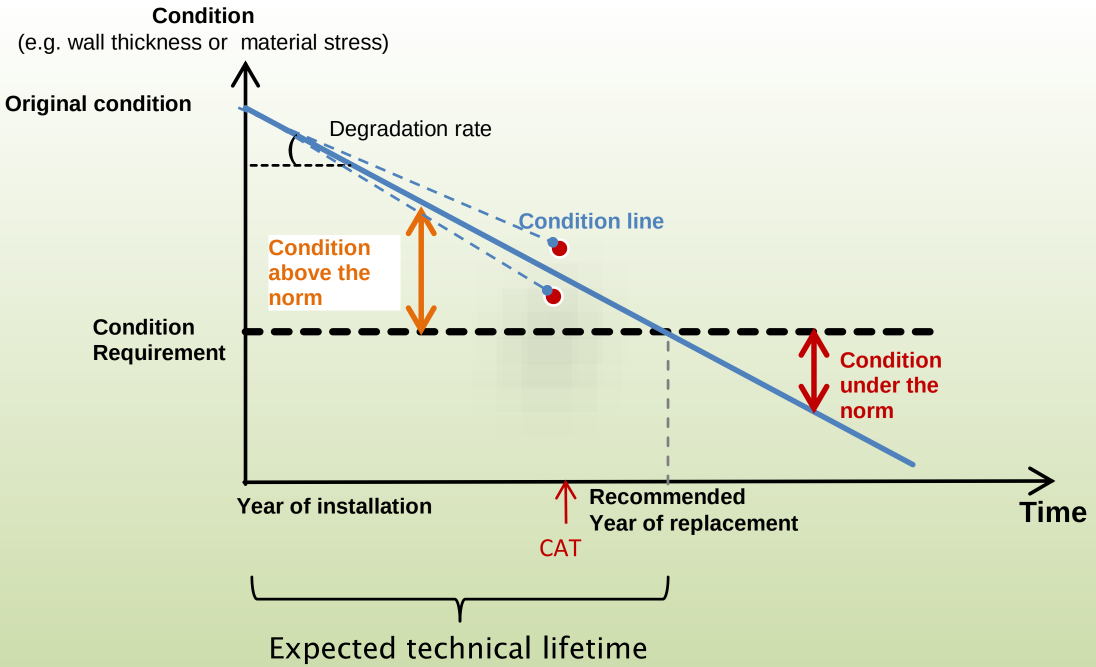
Adjust:

a) prediction technical life

or

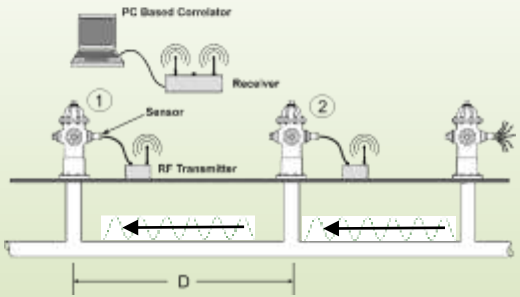
b) translation of the technical life to wall thickness

Assumptions



20 projects

E-PULSE (AC)

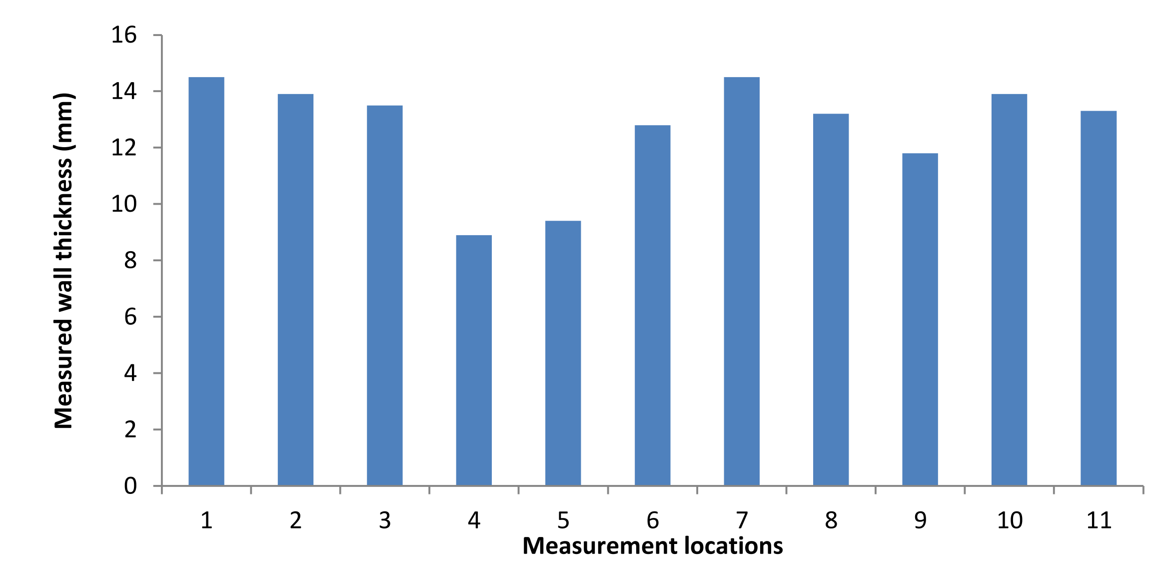


PHENOLPHTHALEIN (AC)

SAND BLASTING + TENSILE STRENGTH (CI)

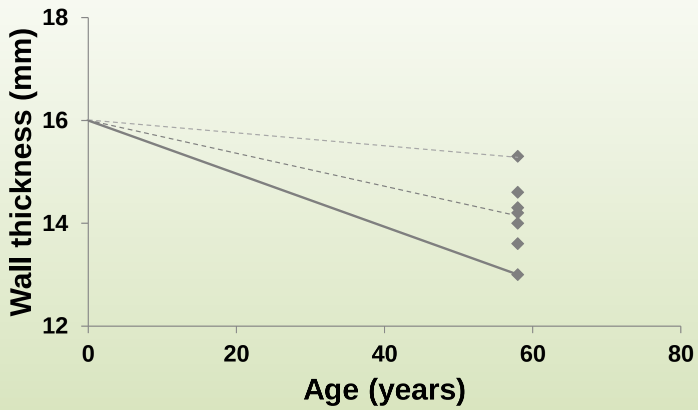
Variability of the condition in a pipe segment

Example of variation of e-Pulse measurements



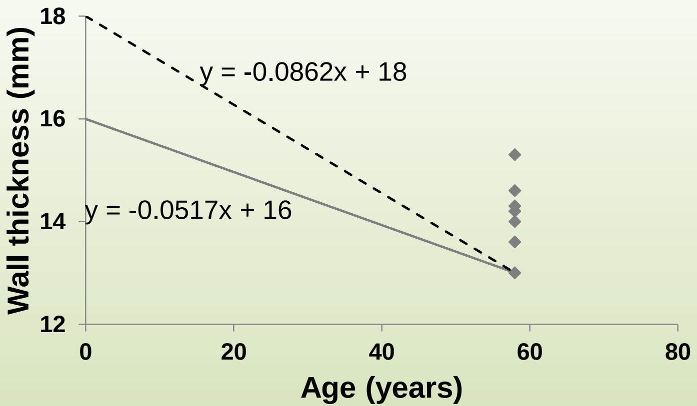
Variability and uncertainties

VARIABILITY MEASUREMENTS



Degradation varies along the pipe

UNCERTAINTY ORIGINAL WALL THICKNESS

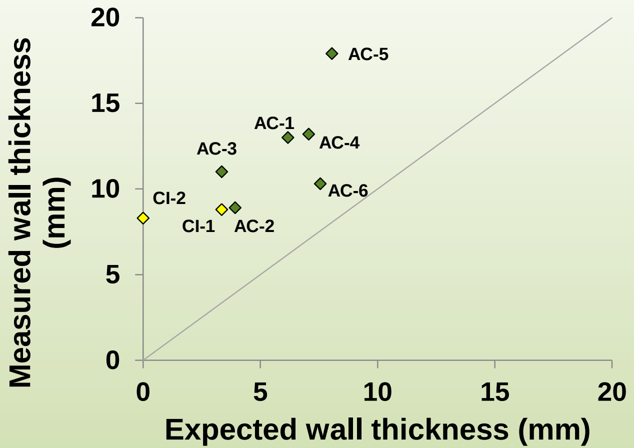


Original wall thickness can be uncertain

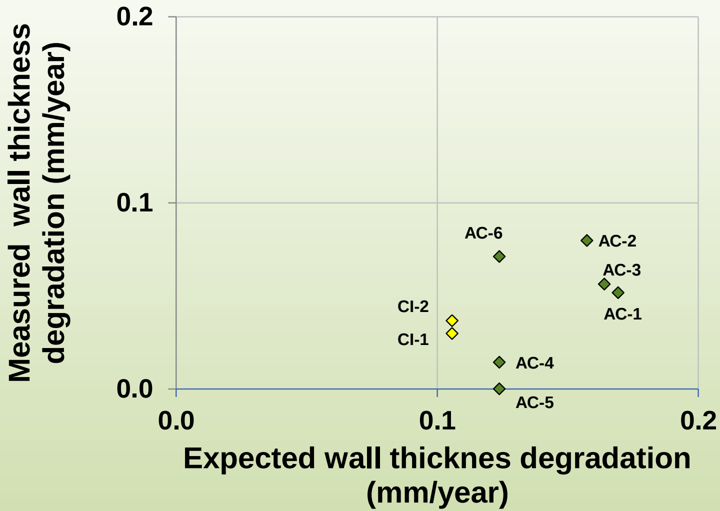
Results (1)

Expected vs measured wall thickness & degradation - AC 100 - 150mm en CI 100 mm

WALL THICKNESS



DEGRADATION



Limited number of tests

Results (2)

1.Plan (per project):

For each project, identify and register:

Step 1: original wall thickness and year of construction

Step 2: required wall thickness

Step 3: expected technical lifetime

…tion and degradatio…

4. Act (After several projects):

Adjust:

a) prediction technical life

or

b) translation of the technical life to wall thickness

2. Do (per project):

Perform a condition assessment test (CAT)

(per project):

Step 1: Check pipe and environment data

Step 2: Compare expected vs. measured condition and calculate actual degradation

Step 3: Identify uncertainties and errors, and formulate recommendations

Expected condition and degradation

Validation

Actual condition

Actual degradation

Conclusions & recommendations

Pipe inspection data offers the possibility to improve pipe replacement decisions.

Recommendations :

i) improve registration of CATs results (Data Quality) and

ii) use of comparable indicators - for measured data and life time assessment model

Implementation of the PDCA cycle can:

- improve the knowledge on the degradation of the pipes (related to the likelihood of failure).
- help to better prioritize replacements, which influence planned and unplanned CML.

A similar study is required within a few years to fully validate this hypothesis.

More articles and images
in our online annual report

annualreport.kwrwater.nl

@KWR_Water

Presentation 6

Ralph Beuken: Pipe-works: Sharing knowledge on condition assessment technologies for mains

PIPE-works: Sharing knowledge on condition assessment technologies for mains

Ralph Beuken, Stefan Urioc

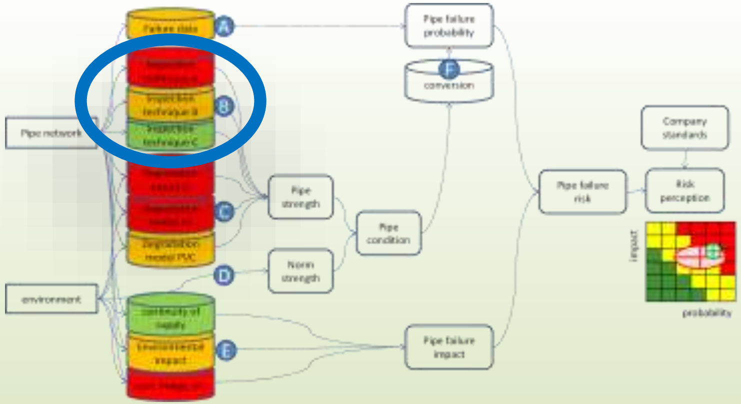
Condition assessment of mains

UKNOW framework:

- Quantify risk in a cost effective way
- Include uncertainties in data and models

From the risk matrix and back:

- Probability of pipe failure
    - Pipe’s condition
        - Pipe’s strength:
            - » state of pipe wall, absence of anomalies, joints



Main’s inspection technologies

The most important mains: how to know the condition?

- Little registered bursts
- Not allowed to fail
- Inspection is expensive and difficult
- Pipes not constructed for inspection
  - Issues: access, valves, bends, location, repair pipes, connections , water quality, …
- Technologies available from other sectors, but how to translate these to:

  AC, CI, PVC, lined steel, conditions of joints

Inspection technology versus market

Discussions

Utilities

I don’t trust the quality of this main

Is it reliable?

Positive business case?

We want innovations

- Bringing parties together
- Exchanging ideas
- Exchanging experiences
- Improving together
- Based on objective opinions
- No commercial bias

Tool providers

I have a great technology

We have some pilot results

Ve think so, but we are still developing

PIPE-works *Getting water utility pipelines to work better*

Required specifications for PIPE-works platform

Result of discussion with Dutch drinking water companies

1. Objective and as free as possible from commercial bias
2. Up-to-date
3. Open access and active community of utilities, tool providers and research institutes
4. Filtering technologies, tools and implementations for specific circumstances
5. International scope + pressured mains (drinking water, storm water and sewage)
6. Expandable to e.g. technology for rehabilitation, water quality sensors, etc.
7. The quality of the content must be assured and sustained

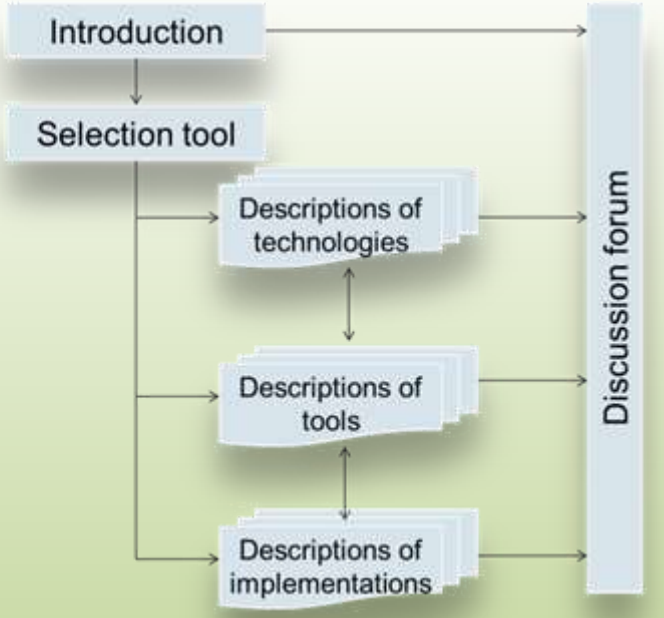
Configuration of PIPE-works

Inspection technology for mains

1. Selection tool

2. Descriptions of technologies
   – Content from researchers
3. Descriptions of tools
   – Content from tool providers
4. Descriptions of implementations
   – Content from utilities

5. Discussion forum



Typical topics, such as:

Technologies

- Research
- Objective descriptions of measurement
- Possibilities
- Drawbacks
- Degree of maturity
- References

Tools

- Specs by supplier
- Checked by administrator
- Accuracy
- Practical applications in the field
- Required efforts utility
- Indication of costs

Implementations

- Experiences of utilities
- Specs of site
- Experiences in the field
- Satisfaction
- usefulness of results
- Required preparations
- Costs of implementation

Common and huge challenges for the water sector

- Demographic changes
- Climate issues
- Ageing assets
- Scarce resources
- Need for more sustainable strategies

Watershare

www.watershare.eu

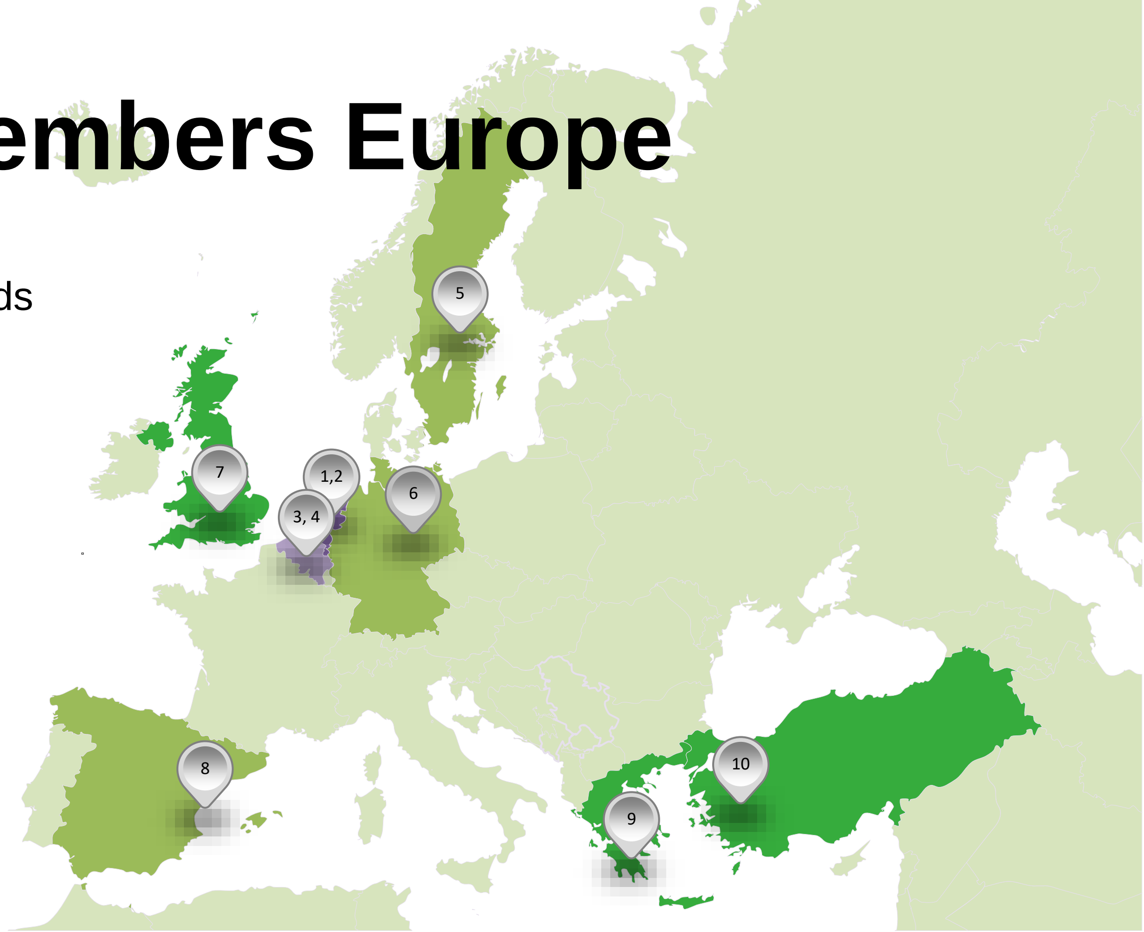
Research

Water utility practice

- Improving the impact of the distributed global water research community
- By easy access to benchmarked and up to date water cycle knowledge

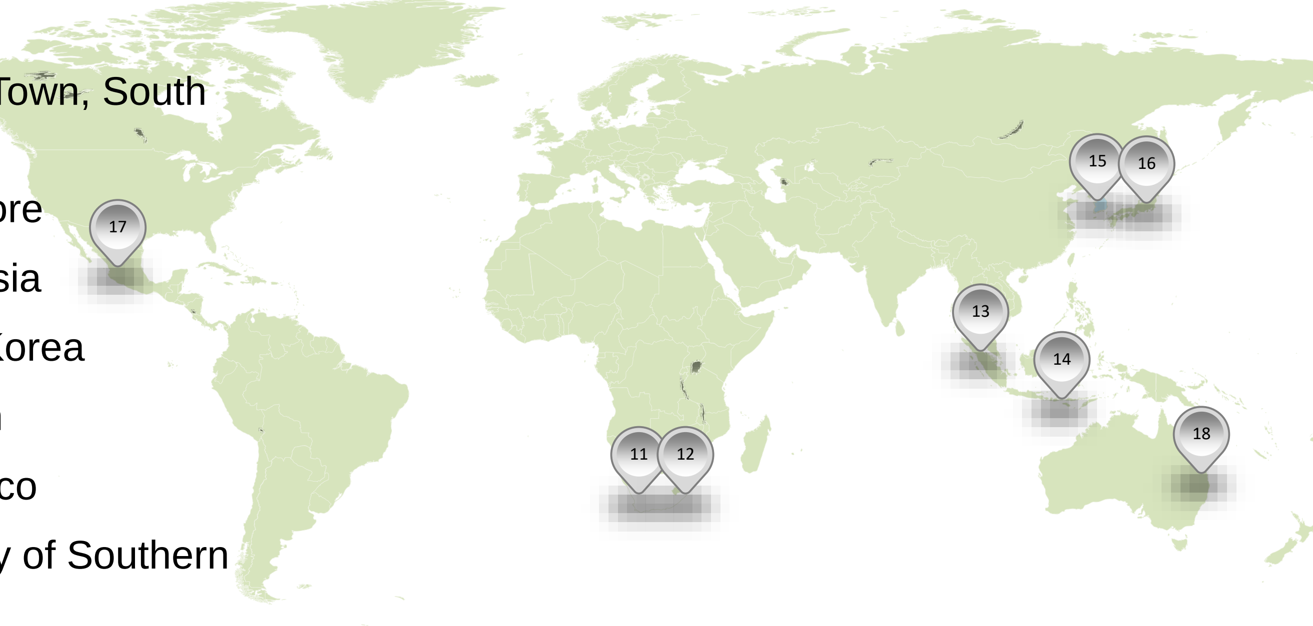
Watershare members Europe

- 1 KWR, the Netherlands
- 2 Naturalis, the Netherlands
- 3 VITO, Belgium
- 4 VLM -Belgium
- 5 SWWA, Sweden
- 6 KWB, Germany
- 7 WIRC, UK
- 8 CTM, Spain
- 9 NTUA , Greece
- 10 Io Cevre, Turkey



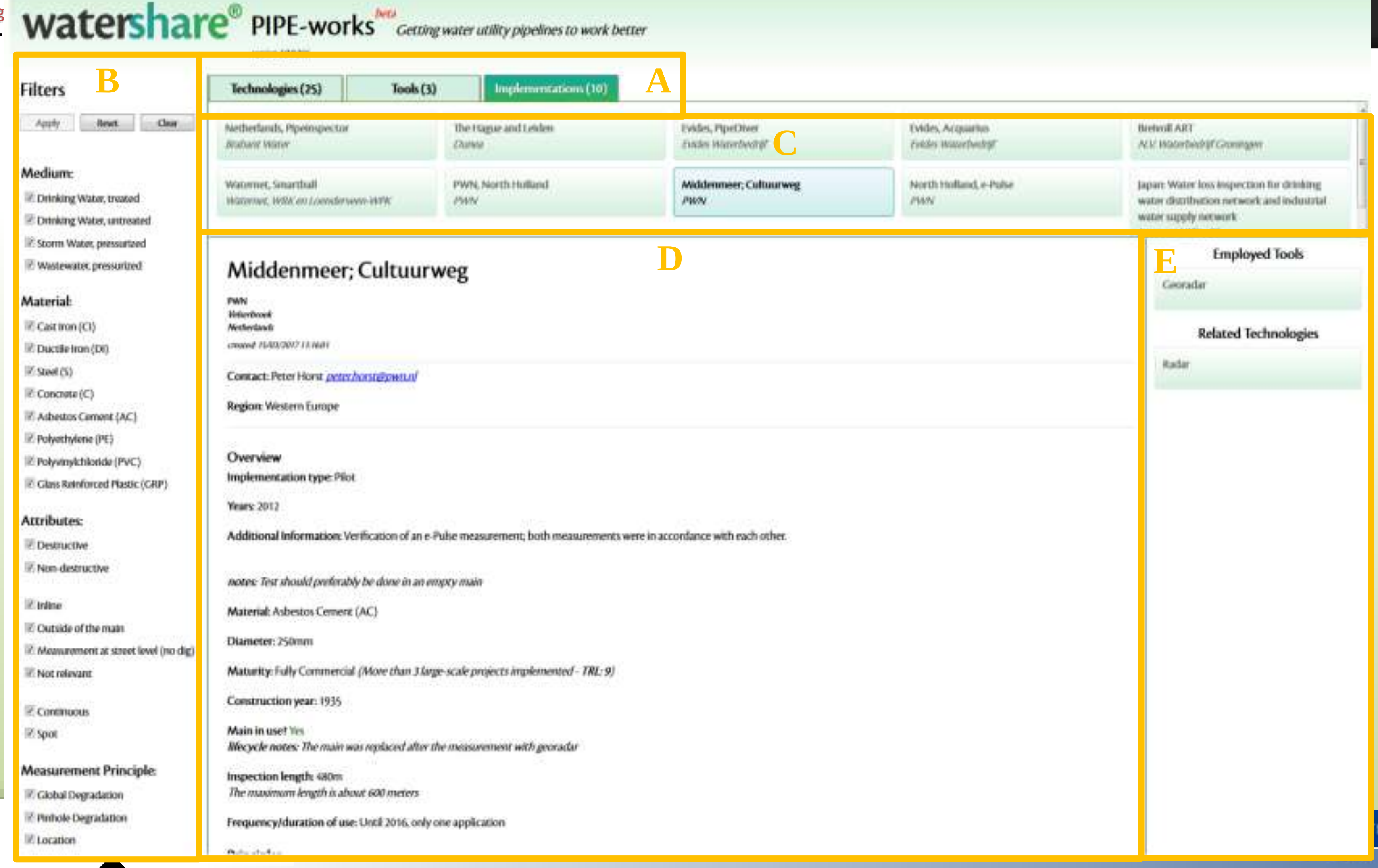
Watershare members outside Europe

- 11 Water Research Commission, South Africa
- 12 City of Cape Town, South Africa
- 13 PUB, Singapore
- 14 WLN, Indonesia
- 15 KIST, South Korea
- 16 JWRC, Japan
- 17 Victoria, Mexico
- 18 The University of Southern Queensland



Further developments

- Discussion forum
- Expanding and improving content (more visual)
- Database on rehabilitation techniques
- Establishing a Watershare Community of Practice acting as a quality board
- Dividing the database into a public and a private part
- Improved selection criteria
- Ask a limited contribution to improve and maintain PIPE-works


watershare® PIPE-works beta Getting water utility pipelines to work better
A
B
C
D
E
Filters
Apply
Reset
Clear
Technologies (25)
Tools (3)
Implementations (10)
Medium:
Drinking Water, treated
Drinking Water, untreated
Storm Water, pressurized
Wastewater, pressurized
Material:
Cast Iron (CI)
Ductile Iron (DI)
Steel (S)
Concrete (C)
Asbestos Cement (AC)
Polyethylene (PE)
Polyvinylchloride (PVC)
Glass Reinforced Plastic (GRP)
Attributes:
Destructive
Non-destructive
Inline
Outside of the main
Measurement at street level (no dig)
Not relevant
Continuous
Spot
Measurement Principle:
Global Degradation
Pinhole Degradation
Location
Netherlands, Pipeinspector
Brabant Water
The Hague and Leiden
Dunea
Evides, PipeDiver
Evides Waterbedrijf
Evides, Acquarius
Evides Waterbedrijf
Brettell ART
N.V. Waterbedrijf Groningen
Waternet, Smartball
PWN, North Holland
PWN
Middenmeer; Cultuurweg
PWN
North Holland, e-Pulse
PWN
Japan: Water loss inspection for drinking water distribution network and industrial water supply network
Middenmeer; Cultuurweg
PWN
Netherlands
Contact: Peter Horst peter.horst@pwn.nl
Region: Western Europe
Overview
Implementation type: Pilot
Years: 2012
Additional information: Verification of an e-Pulse measurement; both measurements were in accordance with each other.
notes: Test should preferably be done in an empty main
Material: Asbestos Cement (AC)
Diameter: 250mm
Maturity: Fully Commercial (More than 3 large-scale projects implemented - TRL: 9)
Construction year: 1935
Main in use? Yes
lifecycle notes: The main was replaced after the measurement with georadar
Inspection length: 480m
The maximum length is about 600 meters
Frequency/duration of use: Until 2016, only one application
Employed Tools
Georadar
Related Technologies
Radar

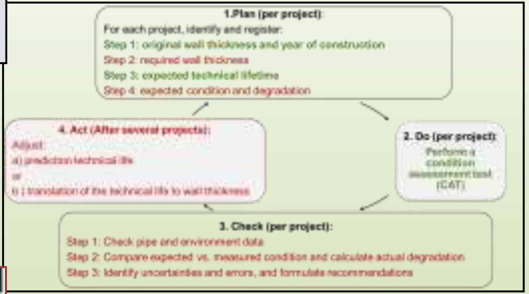
Four presentations into perspective

From a concept to tools and methods

USTORE

PIPE-works

UKNOW



PDCA-cycle

LESAM 2017
NTNU, Trondheim, Norway

Presentations

Session 7:
Short and long-term planning

Norwegian University of Science and Technology

Presentation 1

Mehdi Ahmadi: Sewer asset management: impact of the sample on inspection and rehabilitation program, and on budget allocation provisions

IMPACT OF THE CALIBRATION SAMPLE ON THE INSPECTION AND REHABILITATION PROGRAM

Mehdi Ahmadi – SINTEF, Norway

Authors: Mehdi Ahmadi[1], Frédéric Cherqui[2], Tim Maeckelberghe[3], Pascal Le Gauffre[3]

1 Stiftelsen SINTEF, Trondheim, Norway
2 INSA-Lyon, Université Claude Bernard Lyon 1, DEEP, F-69621, F-69622, Villeurbanne, France
3 INSA-Lyon, DEEP, F-69621, Villeurbanne, France

International Water Association
7th Leading Edge conference on Strategic Asset Management
June, 2017
Trondheim, Norway

IWA International Water Association | Leading-Edge Asset Management

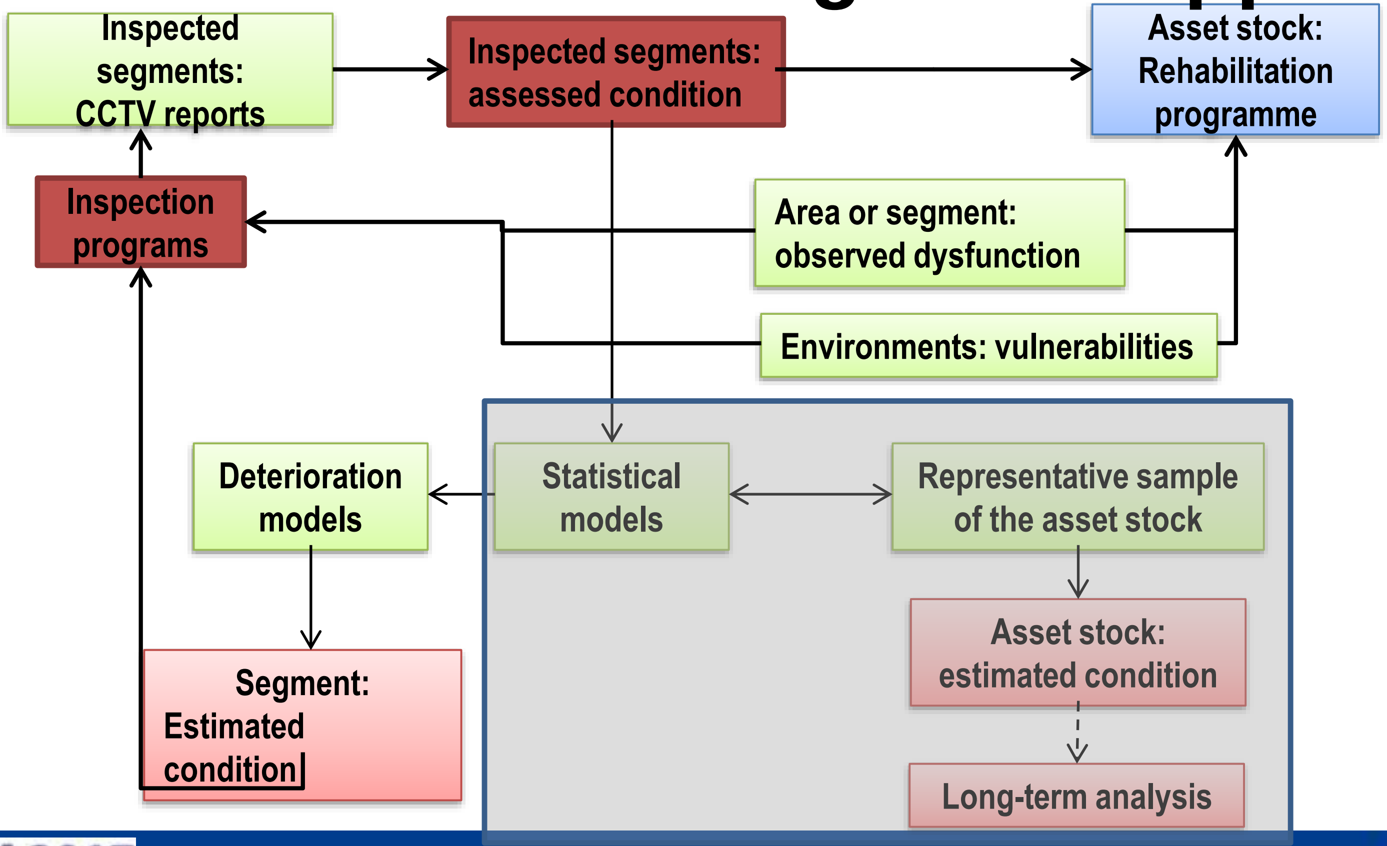
Content

1. French point of view on sustainable AM
2. **Impact of available sample on the calibration of a deterioration model**
3. Impact of available sample on the long-term

1. Context

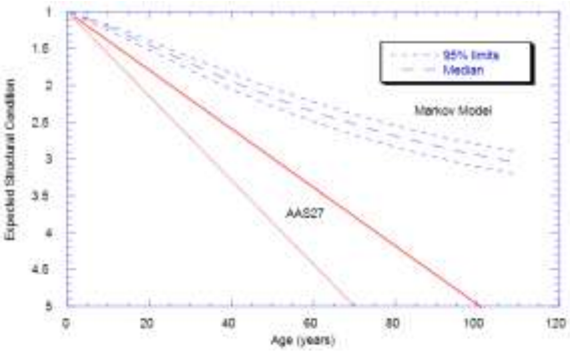
- French National Guide on sewer asset management
  - Technical section
  - Economic-financial section

Sustainable asset management approach

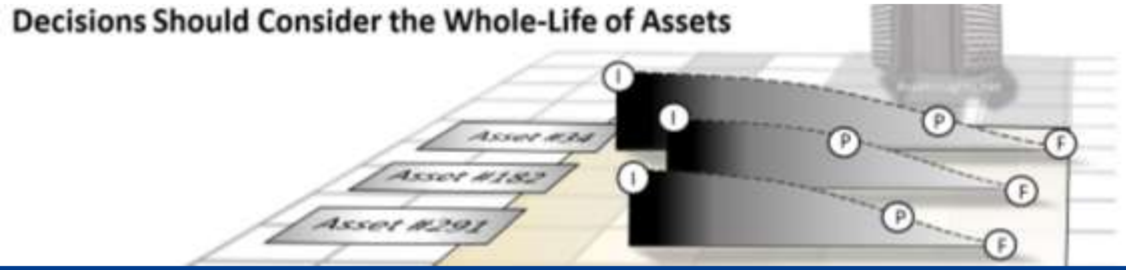


Why deterioration models?

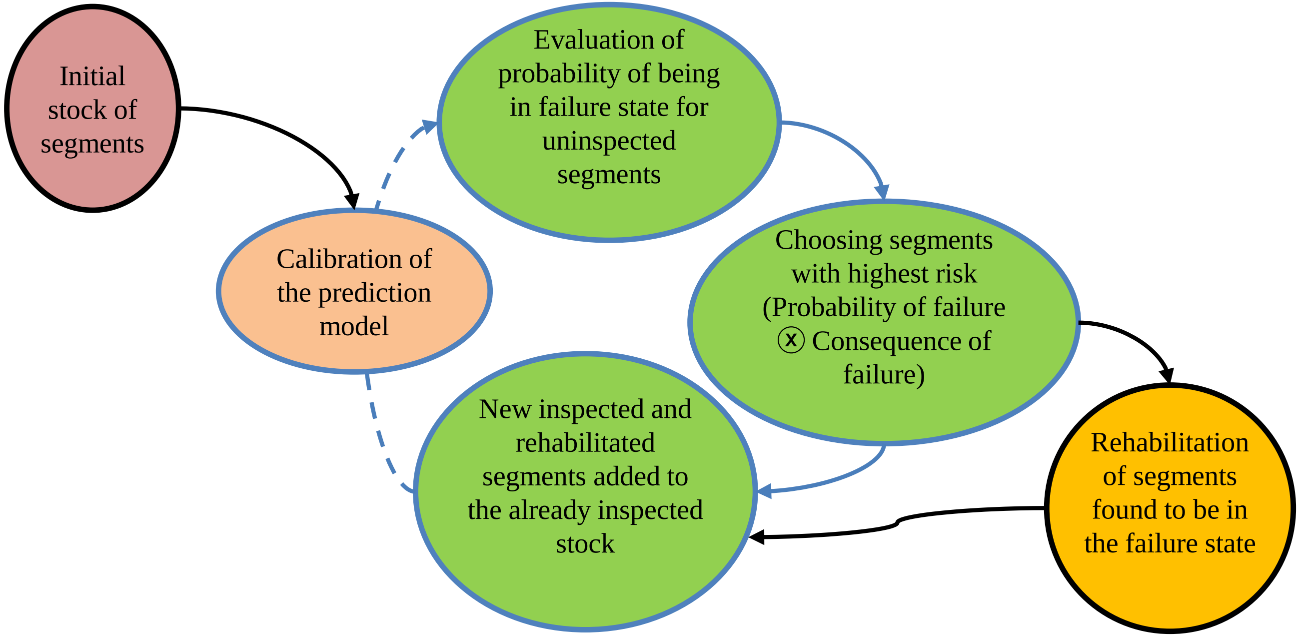
- Estimation of service life→ Depreciation
- Budget



Adapted from Coombes et al., (2002)



What might happen in reality?



Objectives

1. Impact of calibration sample
   - How to draw a representative sample of an asset stock?
   - What is the impact of used sample on the calibration outcomes of these multivariate models?

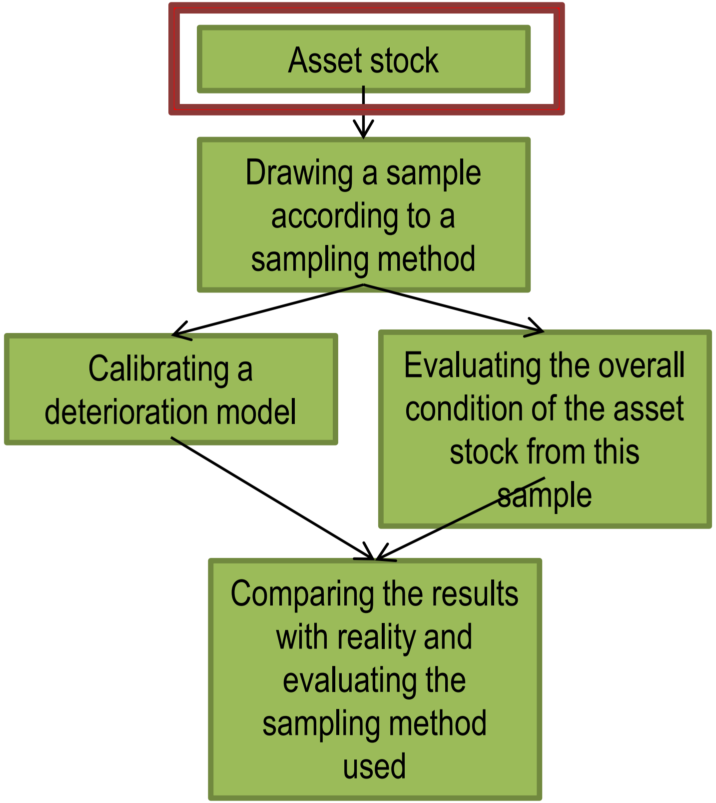
2. Impact of initial sample size in the long-term
   - What is the impact of initial sample size on the inspection programmes?

1. Impact of calibration sample

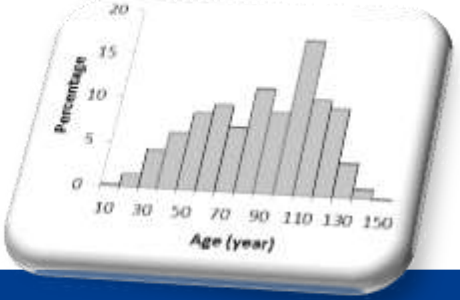
- **Context:**
  - **Small proportion of the asset stock inspected**
- **Objective:**
  - **To evaluate the overall condition of an asset stock**
  - **To calibrate deterioration model**

Impact?

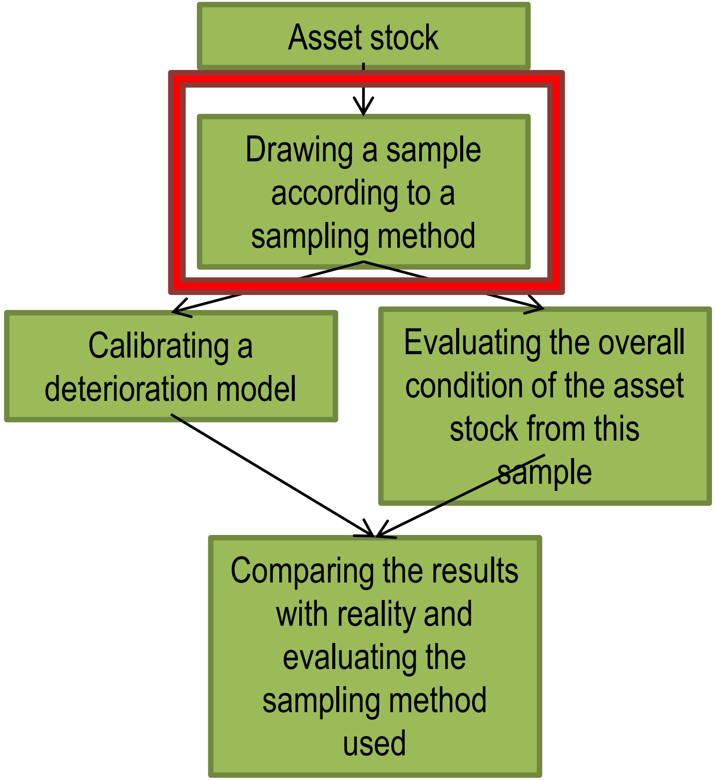
1.1. Research approach



- Inspired from the Greater Cincinnati asset stock
- 8 influential factors + binary condition grade
- Generated:
  - 9810 segments
  - 213 km
  - 22% in failure state



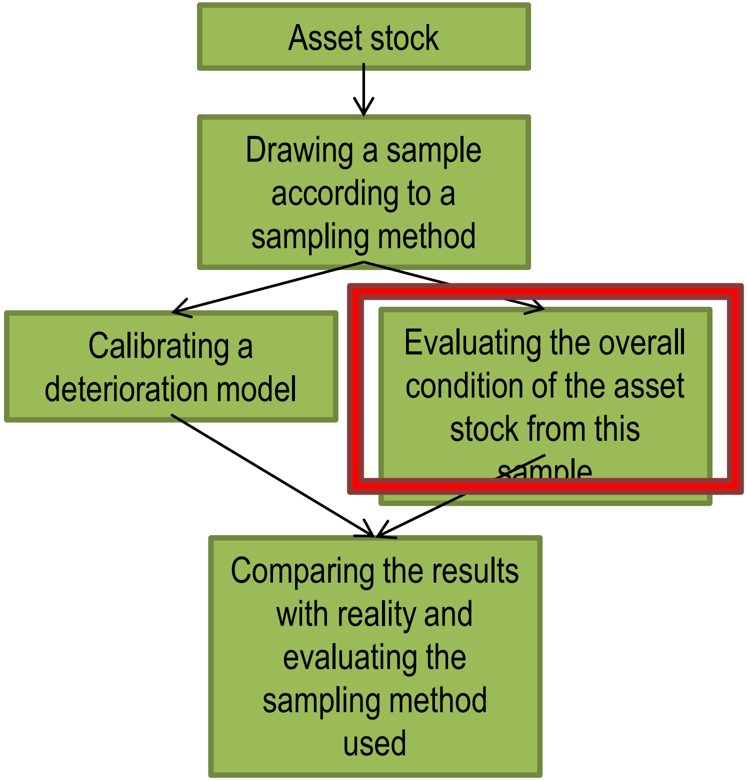
1.2. Sampling methods



- Simple random sampling (SRS)
- Proportional allocation in stratified random sampling (PSRS)
- Optimum allocation in stratified random sampling (OSRS)

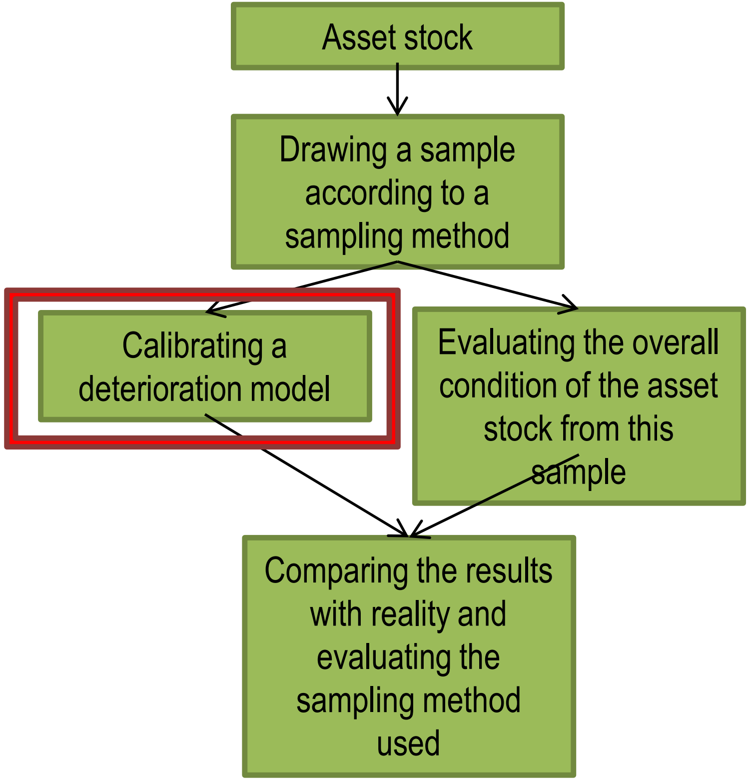
- Sample size: [600-5000] by a step of 400 segments

1.3. Overall condition



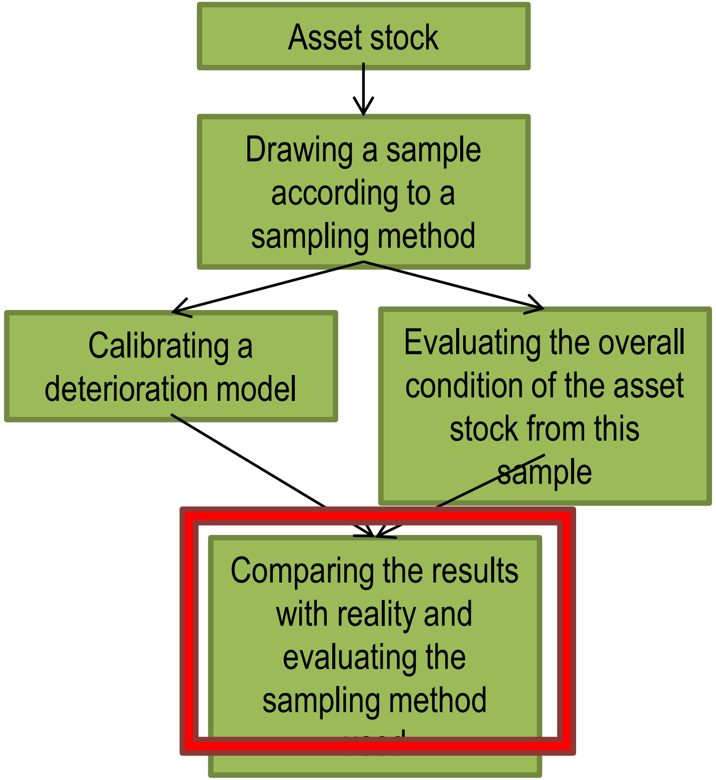
- **Estimating the proportion of segments in a given state according to a chosen indicator**

1.4. Calibration of the deterioration model



- **Binary logistic regression**
- **Estimating k coefficients associated to k variables**

1.5. Comparing the estimates for different samples



- **Monte Carlo 1000 tries**

1.6. Indicators for comparing the estimates

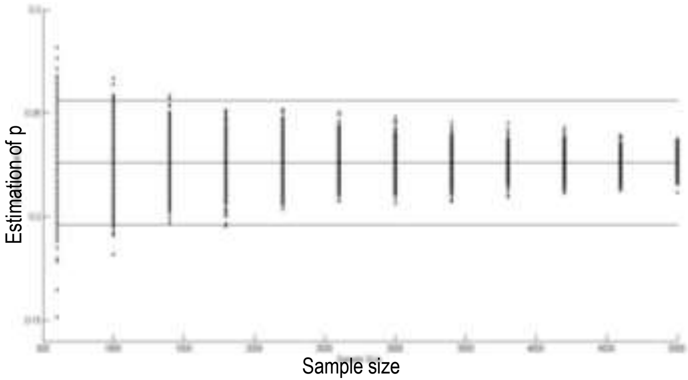
- **Estimating the overall condition:**
  - **% of simulations in which:**
    - $p - 0.03 \leq \hat{p} \leq p + 0.03$
- **Estimating the regression coefficients:**
  - **% of simulations converged**
  - **statistical significance of coefficients:**
    - **% of converged simulations in which the 90% confidence interval does not meet zero and contains the true value**
  - (Accuracy of coefficients)
  - (Precision of coefficients)

1.7. Theoretical representativeness threshold

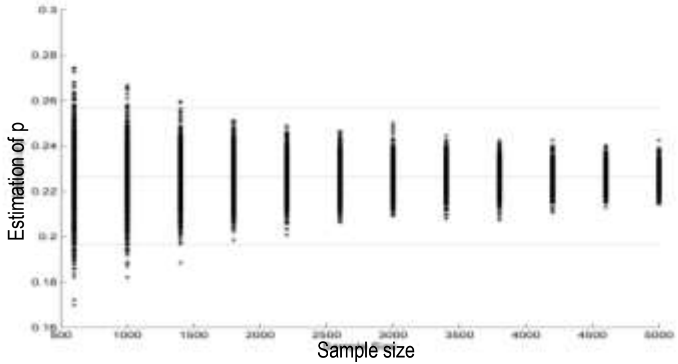
- Required size calculation for having an estimation of the overall condition (*p*) by ± 0.03
- *p* unknown: worst hypothesis (50% in failure state) → 1000 segments for all sampling methods

A randomly-drawn sample of 1000 segments according to properties of each method will be considered representative

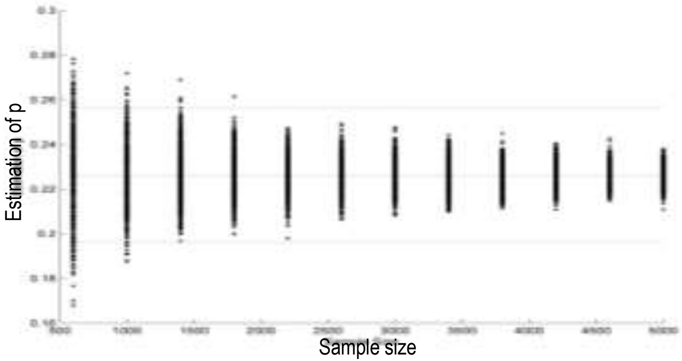
1.8. Result of simulations: estimating *p*



Simple random sampling (SRS)



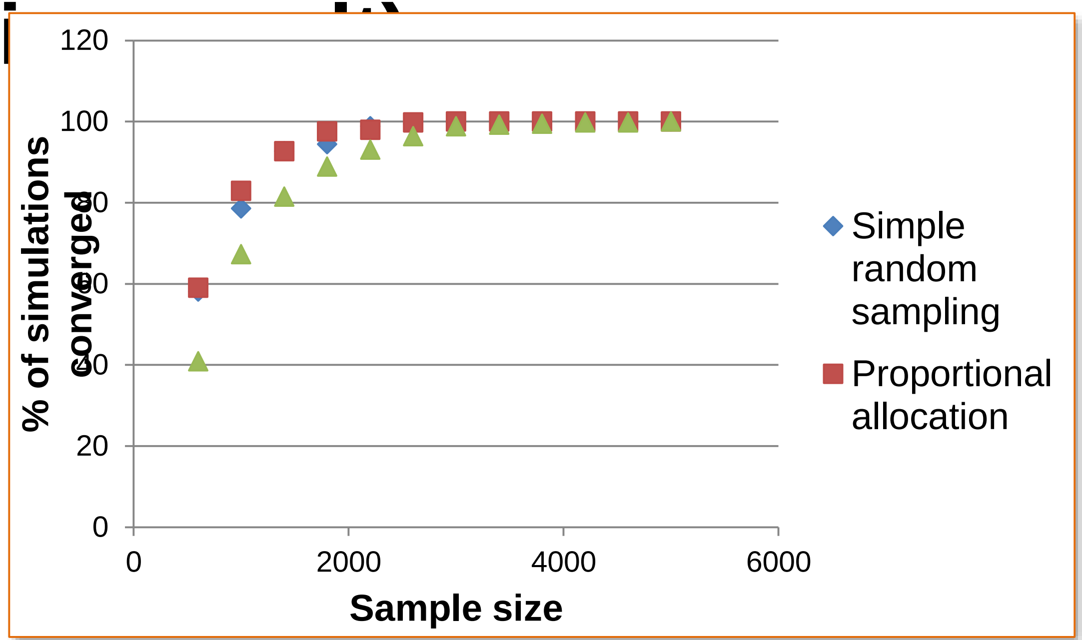
Optimum allocation (OSRS)



Proportional allocation (PSRS)

Results show that OSRS is slightly better than others to estimate *p*

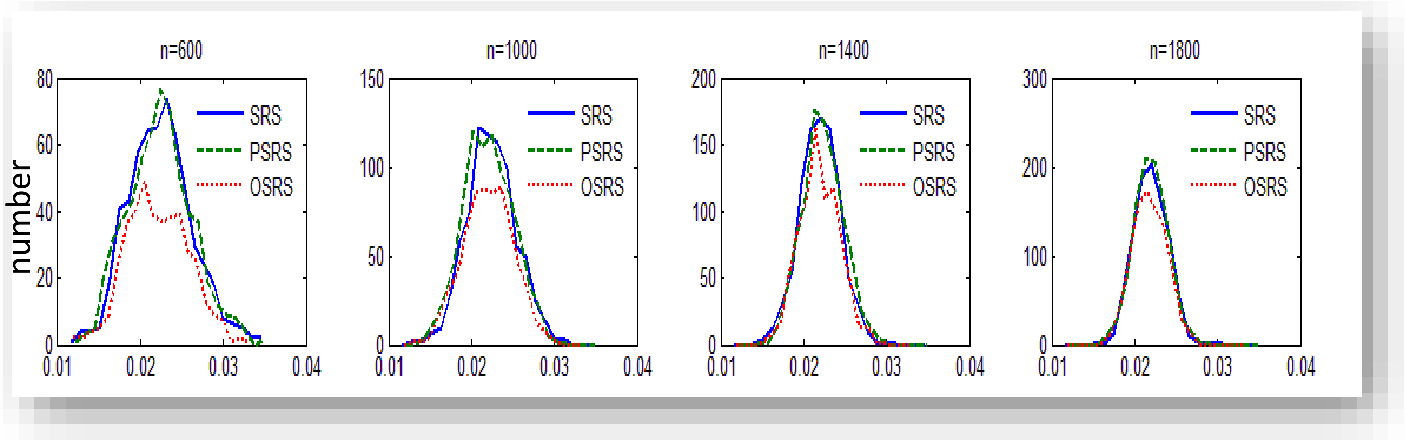
1.9. Estimating the regression coefficients: % of simulations converged (providi... lt)



PSRS> SRS> OSRS

For a sample of 1000 segments, between 65 to 82% of simulations have converged

1.10. Frequency distribution of estimates for age factor

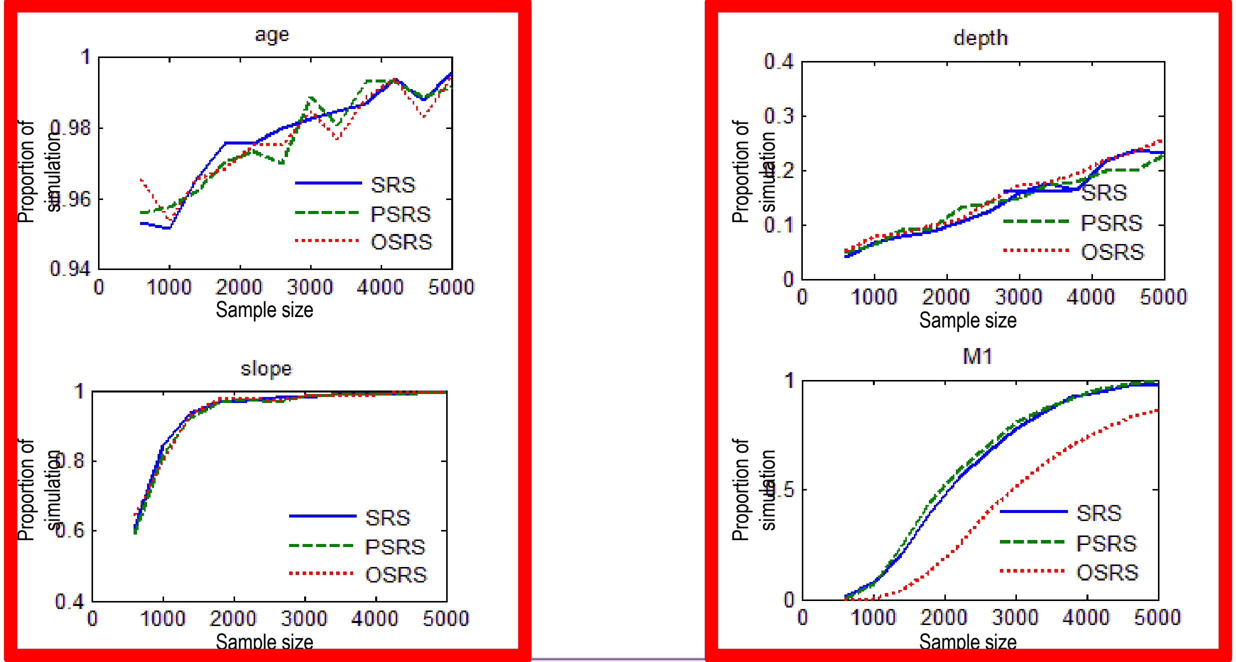


PSRS> SRS> OSRS
Larger domain of variation for smaller sample size

1/12/2017

1.11. Statistical significance (1)

proportion of converged simulations in which the 90% confidence interval about the estimated regression coefficient includes the true value and does not meet zero.



PSRS> SRS> OSRS

Results not satisfying at all for all coefficients except age

1.12. Conclusion (1/2)

- giving an estimation of the proportion of segments in failure state for the whole asset stock is very likely
- **Sample size is crucial for the calibration of a multivariate model**
- **Having a representative sample does not necessarily mean that the multivariate model's calibration is always successful**
- **Optimum allocation is slightly better than others for estimating p**
- **Proportional allocation is better than others for estimating regression coefficients**

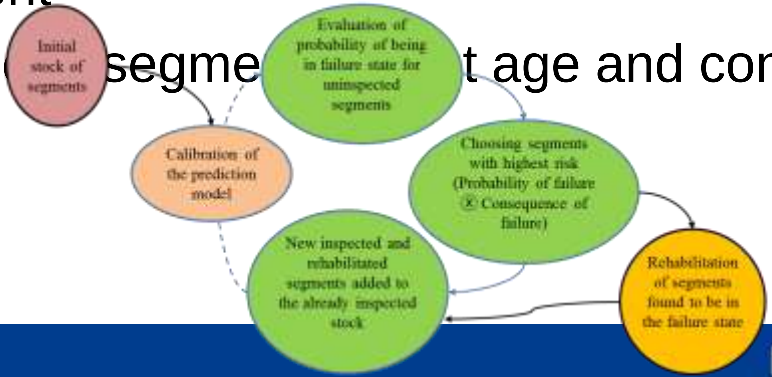
Sewer asset management: impact of sample size and its characteristics on the calibration outcomes of a decision-making multivariate model

Mehdi Ahmadi[a*], Frédéric Cherqui[c,d], Jean-Baptiste Aubin[b,c] and Pascal Le Gauffre[b,c]

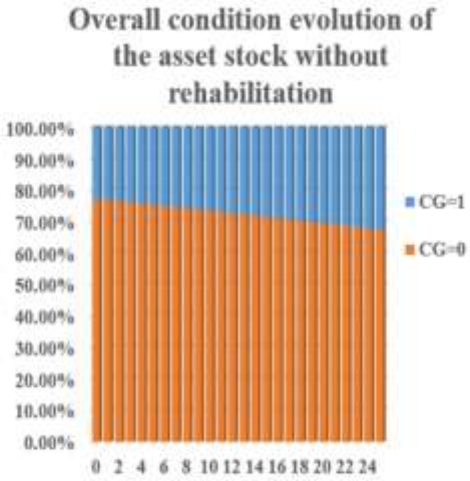
[a]*G2C Environnement, Venelles, France;* [b]*INSA-Lyon, LGCIE, Villeurbanne, France;* [c]*Université de Lyon, Lyon, France;* [d]*Université Lyon 1, LGCIE, Villeurbanne, France*

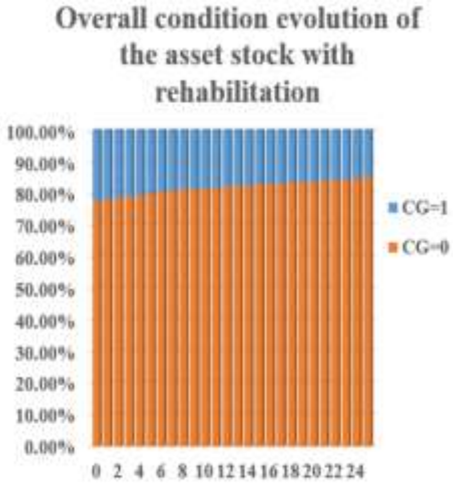
2. Impact of initial sample size in the long-term

- Initial sample sizes 400 and 1000 segments
- Simple random sampling
- Inspection rate 1%
- Rehabilitation rate 0.5% chosen randomly amongst segments in the failure state.
- One inspection per segment
- No change in characteristi segme t age and condition grade after rehabilitation
- Programme for 25 years.

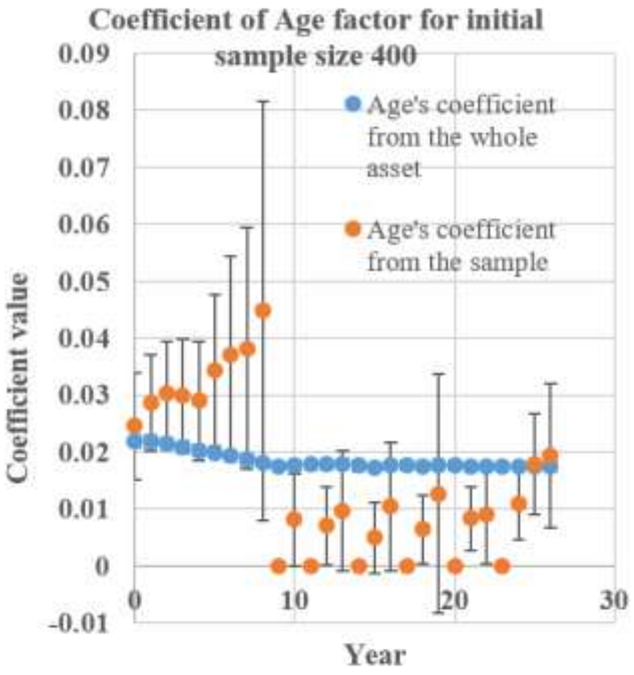


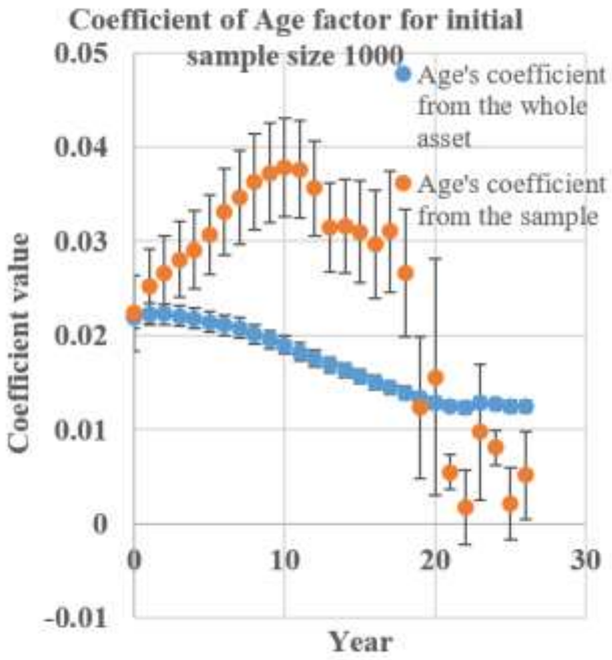
2.1. Evolution of the whole asset stock





2.2. What impact on the deterioration model?





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Conclusion (2/2)

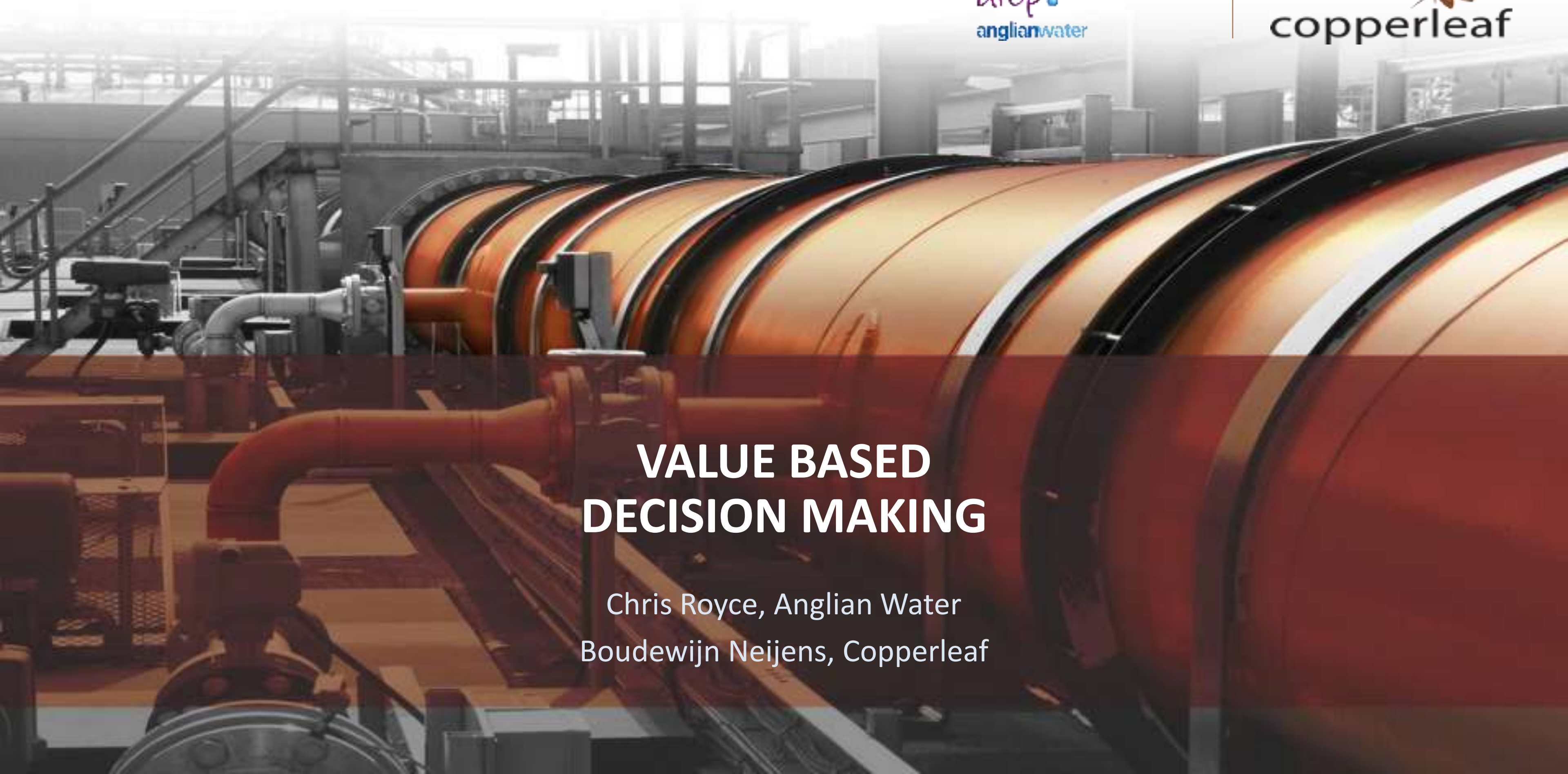
- No major impact of initial sample size
- Volatile regression coefficients considering rehabilitated segments
- Not reflecting the reality of the asset stock
- making the existing decision-support models somehow inaccurate

THANK YOU FOR YOUR ATTENTION!

LESAM 2017
NTNU, Trondheim, Norway

Presentation 2

Boudewijn Neijens: Value-Based Decision Making



VALUE BASED DECISION MAKING

Chris Royce, Anglian Water

Boudewijn Neijens, Copperleaf

ARE YOU A TOP LESAMER?

copperleaf

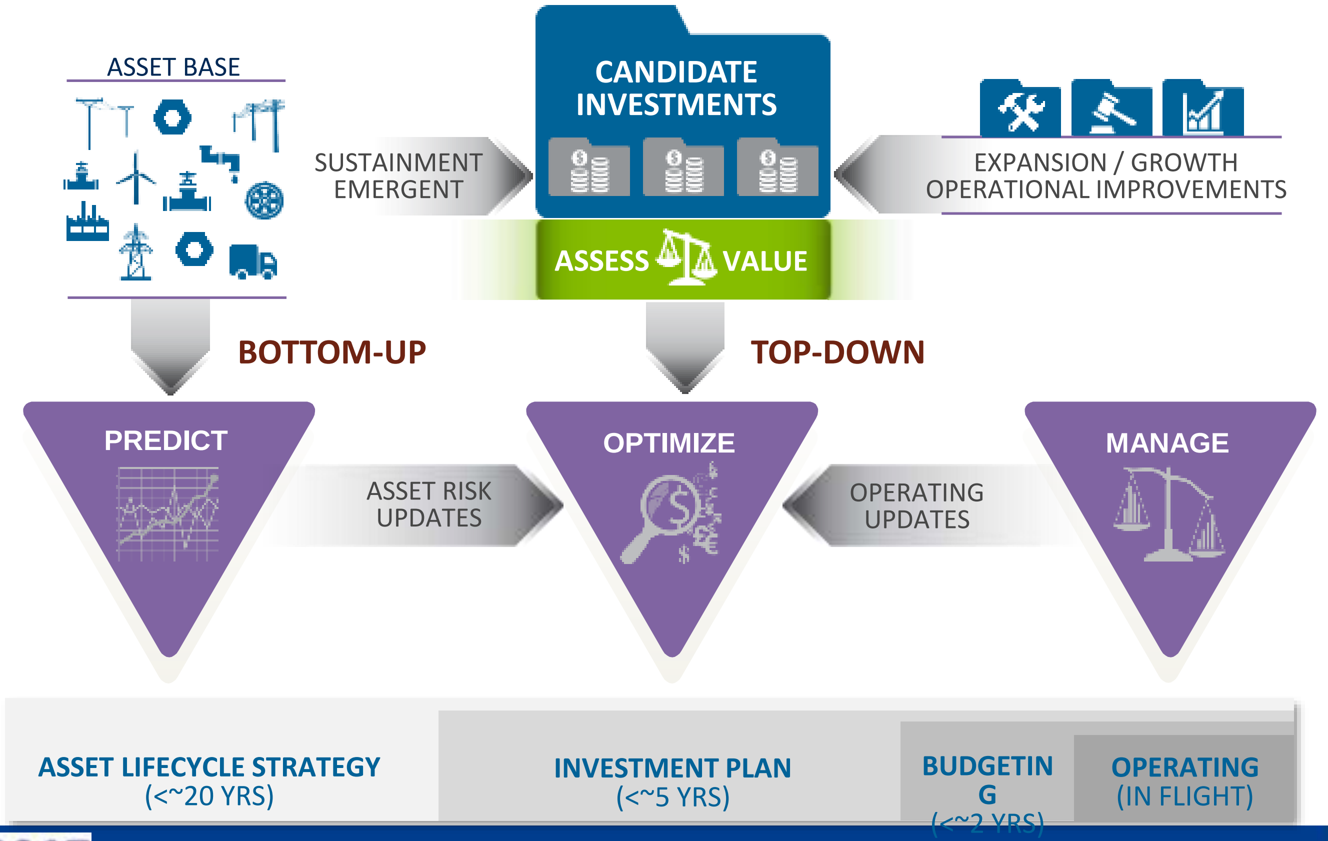
VANCOUVER, BC

copperleaf

ISO 55001 – A MANAGEMENT SYSTEM

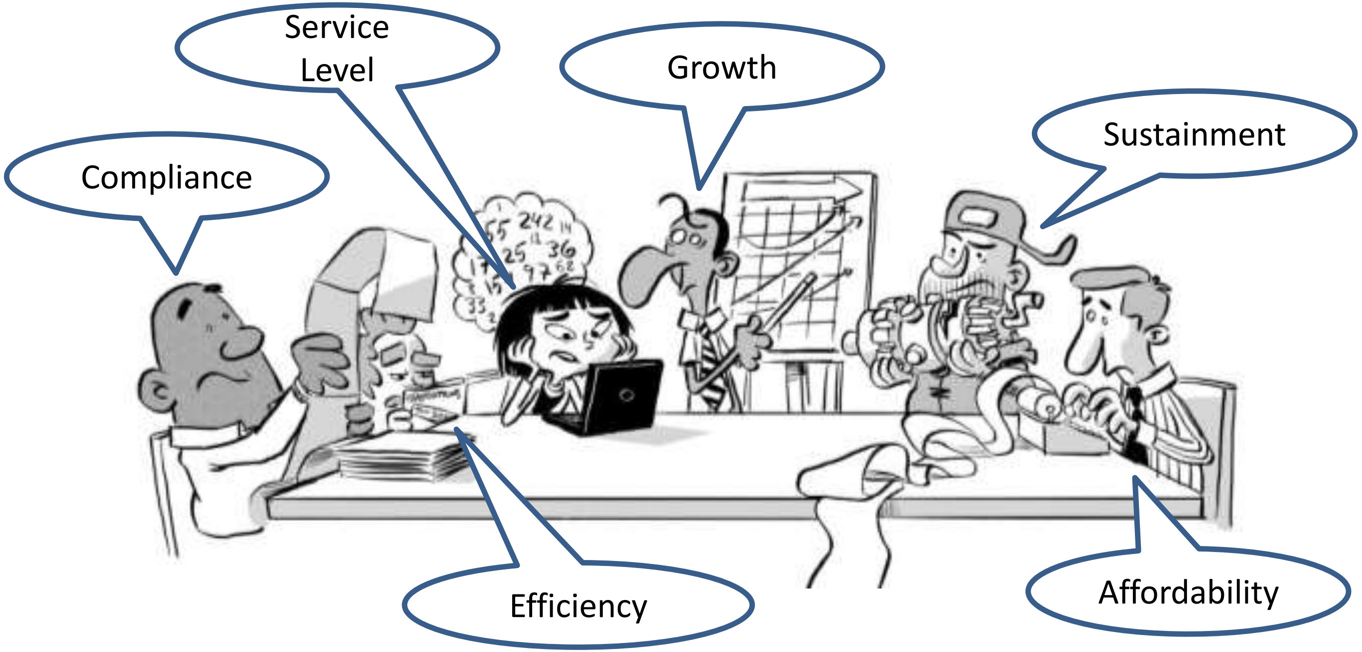
- Value
  - **Assets exist to provide value** to the organization and its stakeholders
  - Value can be tangible or intangible; positive or negative
  - Asset management enables realization of value
- Alignment ("Line of Sight")
  - **Asset management objectives align** with organizational objectives
  - Asset management decisions, plans and activities (technical, financial and operational) collectively enable the achievement of AM objectives
- Leadership
  - Leadership and culture are **determinants of realization** of value
  - Roles, responsibilities and authorities for AM are clearly established
  - Employees are aware, competent, and empowered
- Assurance
  - **AM gives assurance** that assets will fulfill their required purpose
  - Assurance is derived from effective governance, controlled processes and robust management of risks
  - Monitoring, evaluation, review and continual improvement

ASSET INVESTMENT PLANNING & MANAGEMENT



LET’S MAKE A PLAN!

copperleaf



STRATEGIC VALUATION

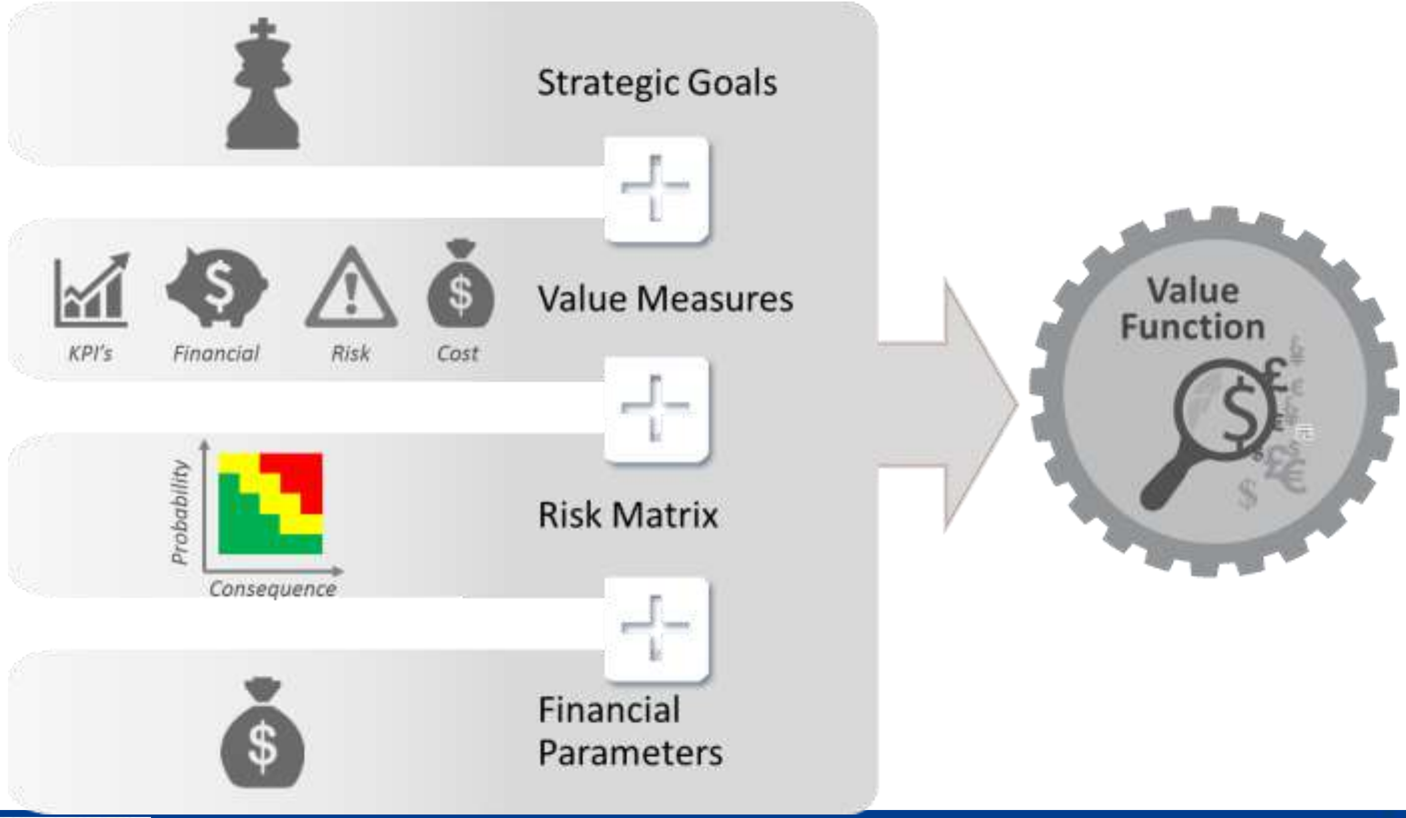
Stakeholder	***Values***
• You	→ Speed, looks, technology
• Spouse	→ Comfort, convenience, affordability
• Children	→ Entertainment, space
• Insurer	→ Safety, repair costs
• Banker	→ Resale value
• Colleagues	→ Image, pride

Different values need not be weighted equally

VALUE DRIVERS

- Strategic Objectives/Goals
  - What are we trying to achieve?
  - What do we value?
- Examples:
  - "Lower customer bills by 20%"
  - "Provide reliable, cost-effective distribution service"
  - "Maintain the environment for generations"
  - "Achieve industry top quartile in employee engagement"
  - "Grow the top line by 15%"
- Sources:
  - Corporate Objectives and Goals
  - Corporate Values
  - KPI's
  - Risk Management Framework
  - Annual Reports
  - Rate Filings
  - Sector/Official Guidelines
  - etc.

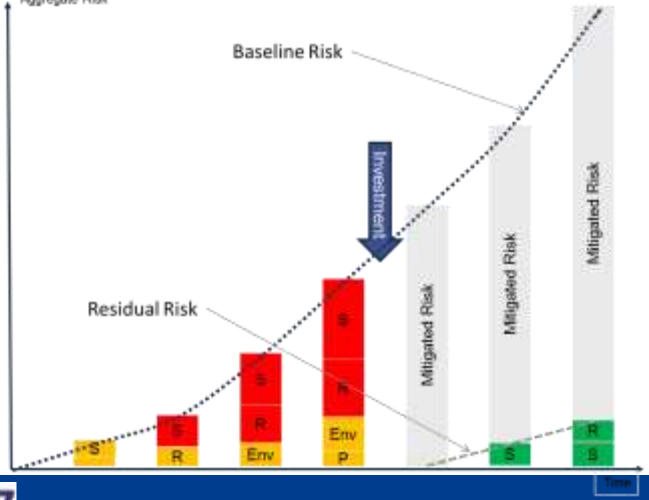
VALUE FRAMEWORK

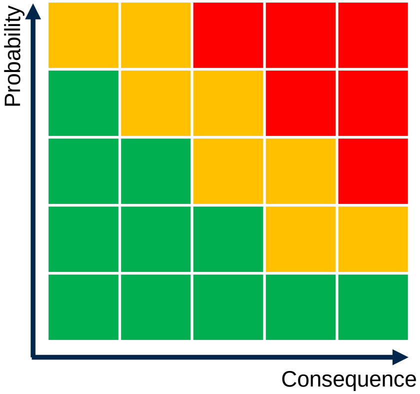


THE VALUE OF MITIGATING RISK

- The effect of uncertainty on objectives
- Probability x Consequences
- Investment benefit

  = Mitigated risk
  = Baseline – Residual





CALIBRATION

- Consequence levels aligned across different risk types
- Same logic can be applied to value

Event Type	Negligible	Small	Minor	Moderate	Major	Extreme
Safety	On-site first aid injury	Injury requiring medical attention / near miss	Injury requiring medical attention / lost time	Multiple injuries requiring medical attention / lost time	Permanent disability	Fatality / multiple fatalities
Environmental	Minor impact / no remediation required	Minor impact / contained on-site / simple remediation	Minor impact / contained / moderate remediation	Limited impact offsite / contained / moderate impact on site	Detrimental impact / on or offsite / long term remediation	Catastrophic offsite / impossible to mitigate / uncontained
Economic	< $100K	$100K → $300K	$300K → $1M	$1M → $3M	$3M → $10M	>$10M
Regulatory	Violation of regulatory requirement resulting in annual fines < $100K	Violation of regulatory requirement resulting in annual fines > $100K	Violation of regulatory requirement resulting in annual fines > $300K	Localized shutdown and/or violation of regulatory requirement resulting in annual fines > $1M	Prolonged localized shutdown and/or violation of regulatory requirement resulting in annual fines > $3M	Prolonged widespread shutdown and/or violation of regulatory requirement resulting in annual fines > $10M

VALUE FRAMEWORK DEVELOPMENT

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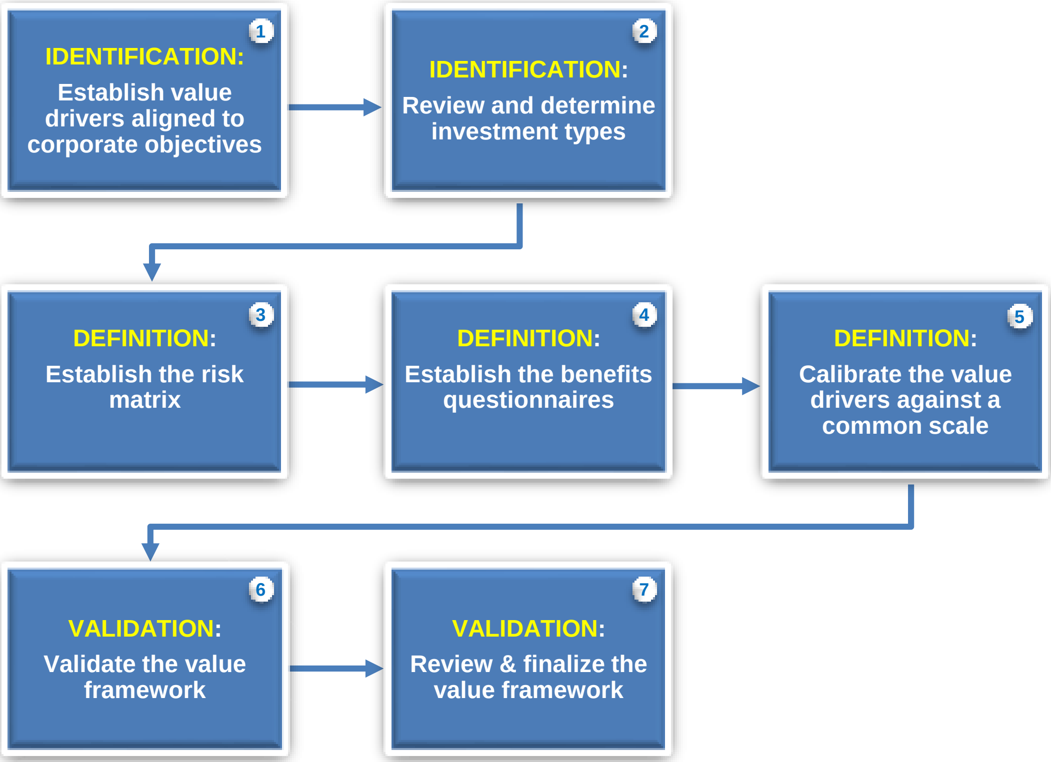


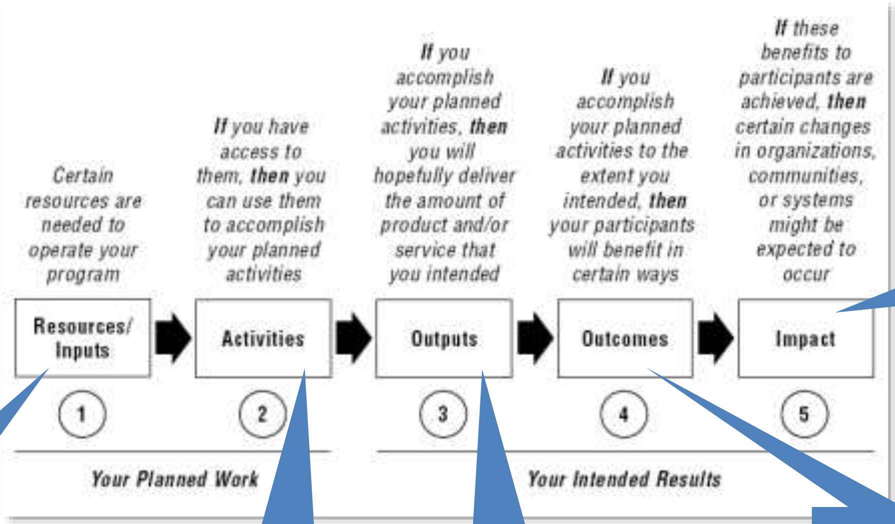
CONCLUSIONS

copperleaf

- Investment valuation must align with strategic objectives
  - Use a quantitative, rigorous and consistent method
  - Requires buy-in of multiple stakeholders and sign-off from leadership
  - Should be applied to all capital and to major opex decisions
- A constrained world requires specific metrics & techniques – or you'll leave money on the table
  - Respect risk tolerances
  - Honour financial, resource, and timing constraints
  - Consider different alternatives
  - Multi Criteria Decision Analysis works best
- Time is crucial
- Decision making maturity is a journey

SERVICE MEASURE FRAMEWORK

Our approach fits against the 'logic model'



Investment and Baseline service measures

Service Measures can include activities

Post investment service measures

Business Outcomes

Predictive service constraints

OUR OUTCOMES

We have a defined set of outcomes for our customers

- We are able to link every investment to an outcome
- Every investment and its alternative has been evaluated against our service measure framework
- Scale:
  - 240.000 Equipment items
  - 1.2m Pipes lengths
  - 1000 Standalone projects

OUR FRAMEWORK

High level measures

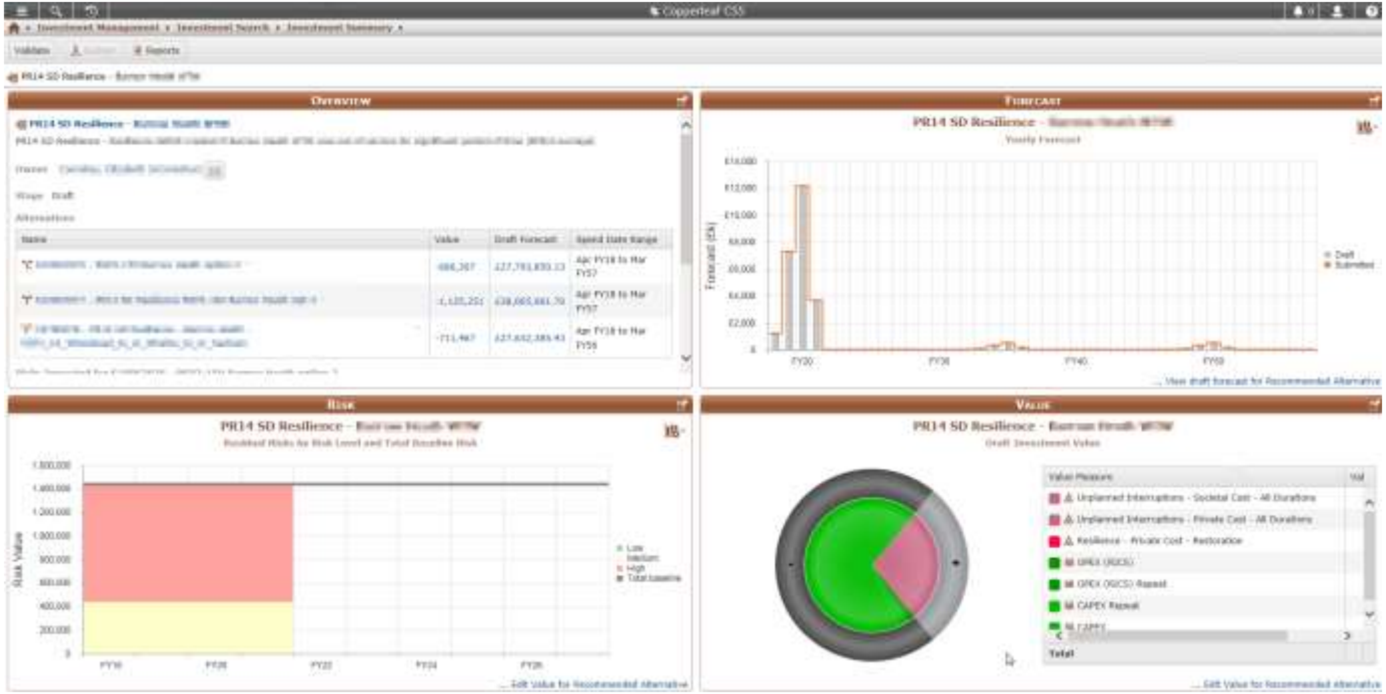
Element	Number of Sub Measures
Pollution	20
Complaints	10
Health and Safety	5
Water Quality	30
Interruptions	48
Low Pressure	2
Security	5
Compliance	39
Flooding	8

- 2 Valuation sets
- Over 160 sub measures
- Each sub measure:
  - 1 Business Values
  - 3 Societal Values

Societal values through customer engagement, published data and other studies

INVESTMENT SUMMARY EXAMPLE

Summary of an individual investment and its service measures



THANK YOU

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White Papers on Value Frameworks:
www.copperleaf.com

Resources on Asset Management
and Decision Making:
theIAM.org/knowledge

Resources on ISO55001:
committee.iso.org/tc251

LESAM 2017
NTNU, Trondheim, Norway

Presentation 3

Benedicte Rulleau: Assessing residents' preferences for sewer network asset management in France

LESAM 2017
NTNU, Trondheim, Norway

Assessing residents' preferences for sewer network AM in France

Bénédicte Rulleau, Anne Rozan
& Caty Werey

Context and research question

Sewerage system malfunctions diverse in nature but for the most part result in disturbance on customers, neighbouring residents, etc.

During heavy rainfall, street flooding (potentially leading to traffic disruption), damaged homes and public facilities, disruption for businesses…

During dry weather, water infiltration leading to the growth of mould in cellars, and odour issues

Malfunctions recorded and consequences assessed as part of AM procedures

Aim of this study: assess residents' preferences for different sewer network AM decisions aimed at reducing disruption or damage

Overflows occurring in or around residential properties more problematic than those occurring away from such buildings, and considerably more problematic than overflows occurring on roads (Hensher et al., 2005) → focus on the 1st category

All the more important in a context of climate change

Assessing and integrating people's preferences

Purpose: inform complex management decisions (objective decision-making)

Sewerage system malfunctions directly affect human welfare in myriad ways, but are often overlooked by:

- Operators who tend to focus on financial and planning strategies to management, control, system maintenance and asset renewal (disturbances = externalities)
- Policy makers who tend to focus on jobs and revenues

Problem: absence of market

Specific techniques developed, applied, constantly refined and improved by environmental economists

- So-called monetary or non-market valuation methods

Requirement = establish a link between changes in the environmental quality, etc. and changes in the stated or observed behaviour of people

The contingent ranking method

Multi-attribute valuation method

Based on a survey on those people concerned with the issue

- Relies on the construction of hypothetical scenarios, which vary with regard to the provision of a good or service
- Changes described in a hypothetical market

Main goal = estimate those people's willingness to pay for the features of a good and the trade-offs that they make among these features

- Theoretical framework = consumers derive satisfaction not from a good in itself but from its "attributes" which are defined as the objective features of the good considered relevant by the consumers

Literature review:

Valuation methods widely used in the field of water research but…

… handful of studies dealing with the impacts of sewer network disturbance on neighbouring residents which use a multi-attribute approach to assess residents' preferences for alternative management schemes

Study design: study area

Eurométropole of Strasbourg

28 municipalities and 468,700 inhabitants in 2008, of which 272,100 in Strasbourg proper

1,677 km of sewers and 4 sewage treatment plants

66,323,487 m^3 of wastewater treated in 2011 (more than 180,000 m^3/day)

Wastewater Utility

Operation, management, control and maintenance of the sewer network for 5 municipalities (in blue)

Survey conducted with inhabitants of these 5 municipalities

Focused on people living in streets where:

- The utility carried out clean-up operations following an overflow
- Complaints were made to the utility about odours or flooding situations

Study design: questionnaire design

Different steps:

1. Break up the good into its attributes and assign them levels
   - Relevant attributes: reduction in the frequency of flooding (in %), reduction in the frequency of flooding (in cm) and reduction in the frequency of flooding (in %)
   - Monetary attribute in order to estimate welfare changes: annual increase in property taxes over 3 years (in €)
2. Combine the attributes in hypothetical scenarios
3. Construct the valuation questions (called “choice sets”)
   - The reference situation: the Wastewater Service of the Eurométropole addresses blockages, odours and flooding problems on an *ad hoc* basis (current situation)
   - 3 alternative scenarios: implementation of more substantial measures intended to reduce disturbance due to sewer network dysfunctions
4. Present the choice sets to the respondents inquired in order to disclose their preferences
   - Fixed number of choice sets: 6 per respondent
5. Ask them to rank the alternatives from their most favourite to their least favourite
6. Conduct an econometric analysis of answers

Study design: example of a choice set

Attributes	Prog. A	Prog. B	Prog. C	Prog. D
Reduction in the frequency of flooding	80%	0%	50%	0%
Reduction in water levels	15 cm	10 cm	0 cm	0 cm
Reduction in odour occurrences	80%	50%	80 %	0%
Financial contribution	€50	€25	€10	€0
Order	__	__	__	__

Alternative scenarios (Prog. A–C)

Reference situation (Prog. D)

Characteristics of the options

Respondents' responses to valuation questions

Before the choice sets:

Reminder of the current situation

Description of measures that help to mitigate risks and illustration using concrete examples

Study design: outline of the questionnaire

Questionnaire made up of 4 parts:

1. Risk perception (not necessarily specific to water)
2. Residents' experience of sewer overflows during rainfall and dry weather and with odour issues
3. Preferences elicitation, *i.e.* choice sets and follow-up questions
4. Socio-economic information about respondents

186 questionnaires collected

Quotas in order to reflect the size of the municipalities

Face-to-face configuration at the respondents' home

May 2009

4,152 usable observations

After eliminating the small number of incomplete questionnaires

Results: sample description

Experience of a flood event: 79.5% during rainfall and 15.5% in dry weather

Water level: >20cm 39%, 15-20cm 12.5%, 5-15cm 27.5%, <5cm 21%

Damage and consequences: 72%

- Water in the cave 62%, mould growth 59.5%, bad smells 43%, loss of furniture or of household appliances 32%, loss of photographs 16.5% or loss of food stocks 14%
- Stress and anxiety 43%

Compensation: 19%

Retrofitted home or change in behaviour: 59%

Experience of odour-related problems: 51.5%

48% “unbearable”

Consequences: 53%

- Material damage 21%
- Stress and anxiety 35.5%, problems between neighbours 3% and diseases 2%

Results: contingent ranking analysis

Hausman and McFadden (1984) test of the IIA hypothesis → a rank-ordered logit can be used to model the ranked answers

Variables	Rank-ordered logit
RED_FREQ	0.0118*** (0.0007)
RED_HIGH	0.0312*** (0.0033)
RED_ODOUR	0.0085*** (0.0008)
PRICE	-0.0187*** (0.0025)
PR*EARN	7.25e-06*** (1.61e-06)
Log-likelihood	-2,330.34
Observations / Groups	3,272 / 818
Wald χ^2	$\chi^2(5)$ = 416.88***

Probability of a better

RED_HIGH ≻ RED_FREQ ≻ RED_ODOUR

alternatives

significantly positive which is consistent with theory

the PRICE

Dependent variable = ranking assigned to the options

Explanatory variables = attribute levels

Conclusion

Important insight and information which can be integrated into public decision-making

Call attention to otherwise underestimated impacts of network malfunctions + understand the economic consequences of mismanagement

Better understand residents' preferences for sewer network AM policies

- Priority to a reduction in flood risks over odour problems
- Better target residents' needs and expectations with leaflet campaigns aiming to increase public awareness to prevent risks and change behaviour

1st step towards the development of more efficient AM strategies

To the best of our knowledge, no other study which considers an intangible externality, namely odour-related disturbance, in a multi-attribute valuation

Further research:

- Estimate willingness to pay to avoid the overflows consequences on the environment
- Investigate the psychological dimension of malfunctions/disturbance

Tusen takk!

For more information:

Forthcoming in the International Journal of Environmental Technology and Management (IJETM)

benedicte.rulleau@irstea.fr

Presentation 4

Caty Werey: Cost benefit analysis for water network resilience assessment

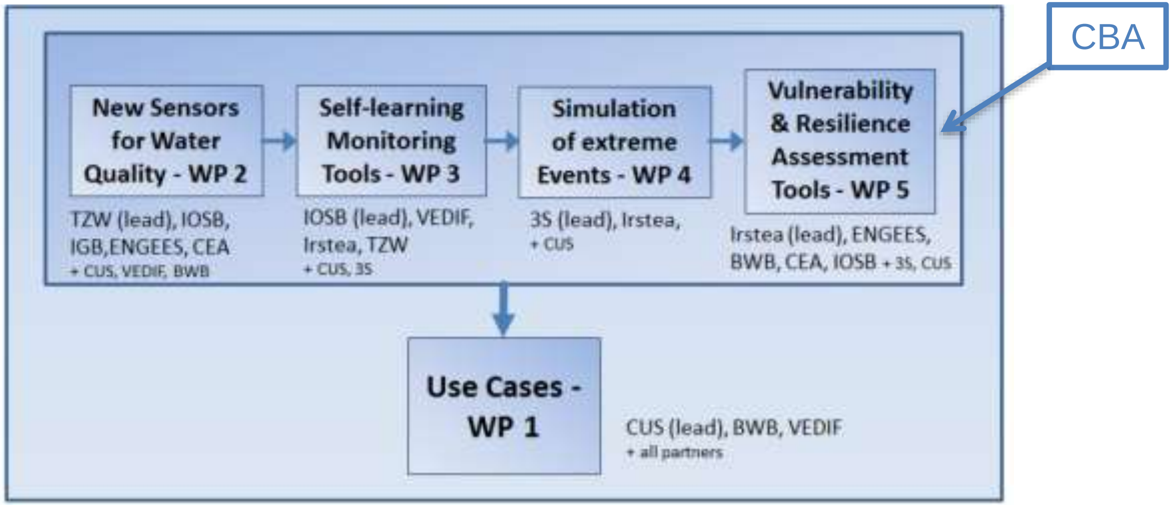
LESAM 2017
NTNU, Trondheim, Norway

Cost benefit analysis for water network resilience assessment

Caty Werey, Bénédicte Rulleau
& Jean-Marc Weber

RESIWATER

INNOVATIVE SECURE SENSOR NETWORKS AND MODEL-BASED ASSESSMENT TOOLS FOR INCREASED RESILIENCE OF WATER INFRASTRUCTURES



Overall project structure

PROJET FINANCÉ PAR L'ANR · PROJECT FUNDED BY THE ANR

SPONSORED BY THE

Federal Ministry of Education and Research

Context and research question

Water Utilities increasingly interested in the issue of the security of water supply, both in terms of quantity and of quality

Aim of this study = implementation of a cost-benefit analysis (CBA) of resilience scenarios in the face of a threat

First application of this kind

Cost Benefit Analysis (CBA)

Objective = economic appraisal tool that aims to measure the negative (*i.e.* costly) and the positive (*i.e.* beneficial) consequences of a policy or a program in monetary values

Helps design efficient and rational investment programs

Comparison of the pro and cons of different resilience programs compared to the reference one for a given event

Reference situation = current situation when a WDN failure due to an exceptional event occurs (business-as-usual)

- Based on current consequences of a WDN failure and current practices of the operator

Resilience programs = as a precaution in anticipation of future extreme events, the operator implements resilience measures

- Different scenarios varying according to the (level of) resilience of the system
- Impacts of a WDN failure due to an exceptional event assessed for each scenario and compared to that of the reference situation

Estimation of monetary values

Assessment of direct and indirect costs (social costs) or benefits due to WDN dysfunctions and of recovery solutions in case of an exceptional event

- Prevention, crisis management (emergency), recovery, post-crisis measures

Two approaches

Direct/internal costs or benefits valuation (cost for the water utility) estimated by using cost accounting methods (costs increase/costs reduction)

- Based on data from technical departments crossed with accounting data
- Reference costs, full costs, marginal costs, standard costs…

Monetary value of impacts estimated

Indirect costs (social costs) or benefits of the resilience scenarios estimated through an economic approach relying on a survey on consumers

study area

Eurométropole of Strasbourg

Water utility provides water service to 423,600 inhabitants within 12 municipalities

1,083 km of network, 4 water works, with a balancing tank

89,980 m^3 produced/day

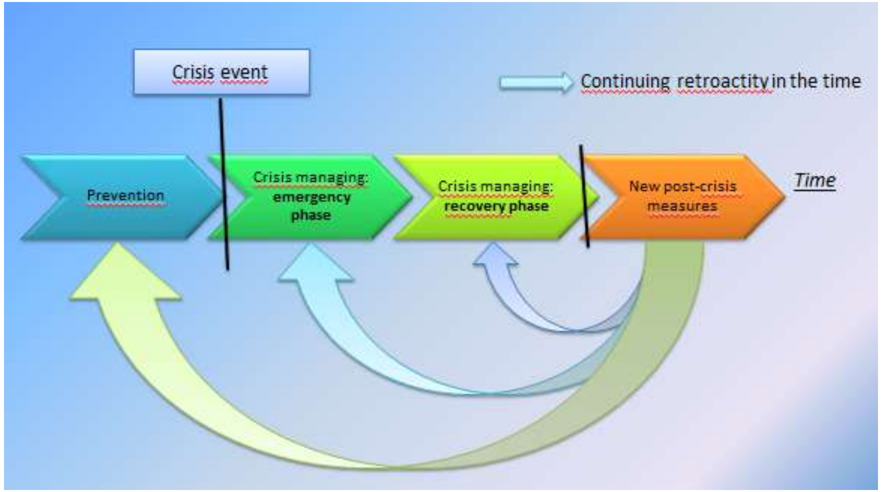
resilience scenario

Physical attack at a power plant supplying the balancing tank + cyber attack (replication of normal data series)

No compensation of the loss of pressure by the main plant

Detection of the problem when users call saying they experience water cuts = when the water distribution fails

Internal costs valuation: 4 resilience steps



Werey et al., LESAM 2017, Poster

Internal costs valuation: *Full costing* and *Job-order costing*

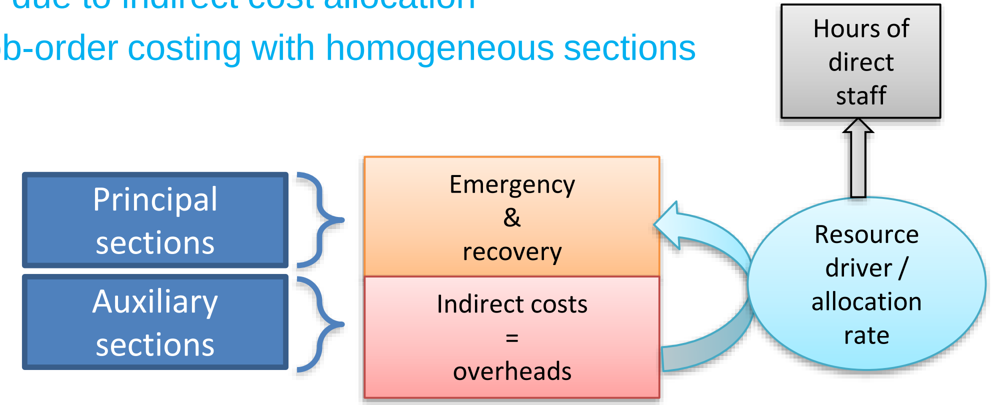
Full costing takes into account

Variable and fixed costs

Direct and indirect costs

Problem due to indirect cost allocation

Job-order costing with homogeneous sections



Werey et al., LESAM 2017, Poster

Full costing frame work (ex of a past big burst)

Fullcost recovery phase Pipe-burst EMS	Unité	Quantité	Coût unitaire €	Coût total €
Matériel utilisé	pièce	221		
Engins motorisés: camion et pelle mécanique	heures	1		
Frais de personnel	heures	148,5		
Frais de personnel (heures supp.)	heures	100		
Total				
Pertes d'eau (purges)	m3	7410		
Total charges directes				
Clé de répartition	Heures de MOD			
Frais de structure	€			
Total charges indirectes	€			
Coûts complets phase de recovery EMS	€			

Ordre de travail n°81563: réparation de la conduite	Temps en heures	Coût unitaire (taux horaire) €	Coût total €
Opération (Catégorie de métier C: techniciens)	65,5		
Pelle mécanique	4		
Camion	5		
Total	74,5		

Total time phase recovery
Total time service

Frais de fonctionnement sélectionnés	Total des coûts extraits du compte administratif
Entretien sur biens mobiliers(Autres)- mobilier ou matériel	
Entretien sur biens mobiliers (Matériel roulant)	
Entretien sur biens immobiliers (Réseaux)	
Entretien sur biens immobiliers (Fouilles de voirie)	
Dotations aux amortissements (Engins motorisés)	
Dotations aux amortissements (Mat et outillage industriel)	
Dotations aux amortissements (Mat de bureau et informatique)	
Dotations aux amortissements (Véhicules)	
Fournitures ENTR et petit équipement (Divers)	
Fournitures administratives	
Autres matières et fournitures (Matériel électrique)	
Autres matières et fournitures (Vêtements de travail)	
Autres matières et fournitures (Out et Pièces Détachées)	
Fournitures ENTR et petit équipement (Huiles ...)	
Fournitures non stockables (Combustibles)	
Autres matières et fournitures (Voirie)	
Autres matières et fournitures (Réparations)	
Autres matières et fournitures (Véhicules et engins)	
Autres matières et fournitures (Matériel de signalisation)	
Remboursement au budget principal de charges de personnel	
Carburants	
Total frais de fonctionnement crise	

Autres coûts	Temps en heures estimé	Dont heures supp.	Coût unitaire (taux horaire) €	Coût total €
Catégorie de métier A	65			
Catégorie de métier B	65			
Total	130			

Werey et al., LESAM 2017, Poster

Standard cost for hypothetical snénarios

Valuation of benefits: questionnaire design

Assessment of residents' preferences and estimation of their willingness to pay for the resilience measures using the Choice Experiment Method

Based on a survey on those people concerned with the issue

- Relies on the construction of hypothetical scenarios, which vary with regard to the providing of a good or service
- Changes described in a hypothetical market

Main goal = estimate those people's willingness to pay for the features of a good and the trade-offs that they make among these features

- Theoretical framework = consumers derive satisfaction not from a good in itself but from its "attributes" which are defined as the objective features of the good considered relevant by the consumers

Questionnaire design

Different steps:

1. Break up the good into its attributes and assign them levels
   - Relevant attributes: (1) the number of people affected; (2) the duration of the water cut as a result of the attack; (3) the duration of the water-use restrictions; (4) the information in the possession of the Water Utility about the location of sensitive consumers and its capacity to reach them in case of emergency
   - Monetary attribute in order to estimate welfare changes: the cost expressed as an increase in the water bill
2. Combine the attributes in hypothetical scenarios
3. Construct the valuation questions (called “choice sets”)
   - The reference situation: the utility addresses impacts of the cyber-attack on an *ad hoc* basis (current situation)
   - 2 alternative scenarios: implementation of measures intended to improve the system resilience
4. Present the choice sets to the respondents inquired in order to disclose their preferences
   - Fixed number of choice sets: 5 per respondent
5. Ask them to choose the alternative they prefer and the one they like least
6. Conduct an econometric analysis of answers

Example of a choice set

Alternative scenarios

Reference situation

Characteristics of the options

	Option A	Option B	Option C
Nombre de personnes touchées	200 000 personnes	10 000 personnes	400 000 personnes
Durée de la coupure d'eau	2 h	4 h	4 h
Durée de la restriction des usages	4 jours	5 jours	6 jours
Prise en charge des personnes sensibles	Exhaustive	Exhaustive et adaptée	Partielle
Coût par ménage (payé en une seule fois)	40 €	20 €	0 €

Quelle est l'option :

	Option A	Option B	Option C
Que vous aimez le plus ?	O	O	O
Que vous aimez le moins ?	O	O	O

Respondents' choices

Outline of the questionnaire

Questionnaire made up of 6 parts:

1. Environment generally speaking
2. Water consumption
3. Perception of the water quality in EMS and health risk associated;
4. Perception of the water Utility performance and risks
5. Valuation questions and follow-up questions which are designed to explore the reasons for responses
   - Before the choice sets, presentation of a scenario which reminds of the current situation, description the concrete resilience measures, reminds of the budget constraint, etc.
6. Socio-economic questions

Currently tested before final implementation

Conclusion

Scientific challenge

First CBA on water networks resilience

- Handful of studies dealing the valuation of benefits of infrastructure resilience
- Methodological improvements in the comprehension and appreciation of consumers' preferences

Mixing an accounting full-costing approach for the assessment of internal direct costs and an economic valuation of consumers' willingness to pay for the assessment of the benefits of the policies (resilience scenarios)

- Very informative

Operational issue

Add a very useful decision tool to the existing approaches

Thank you

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Presentations

Session 8:

Risk assessment and resilience

Norwegian University of Science and Technology

Presentation 1

Martin Gilje Jaatun: Cyber risk for water infrastructure

Cyber security for water network operators – no longer only for science fiction authors?

Martin Gilje Jaatun

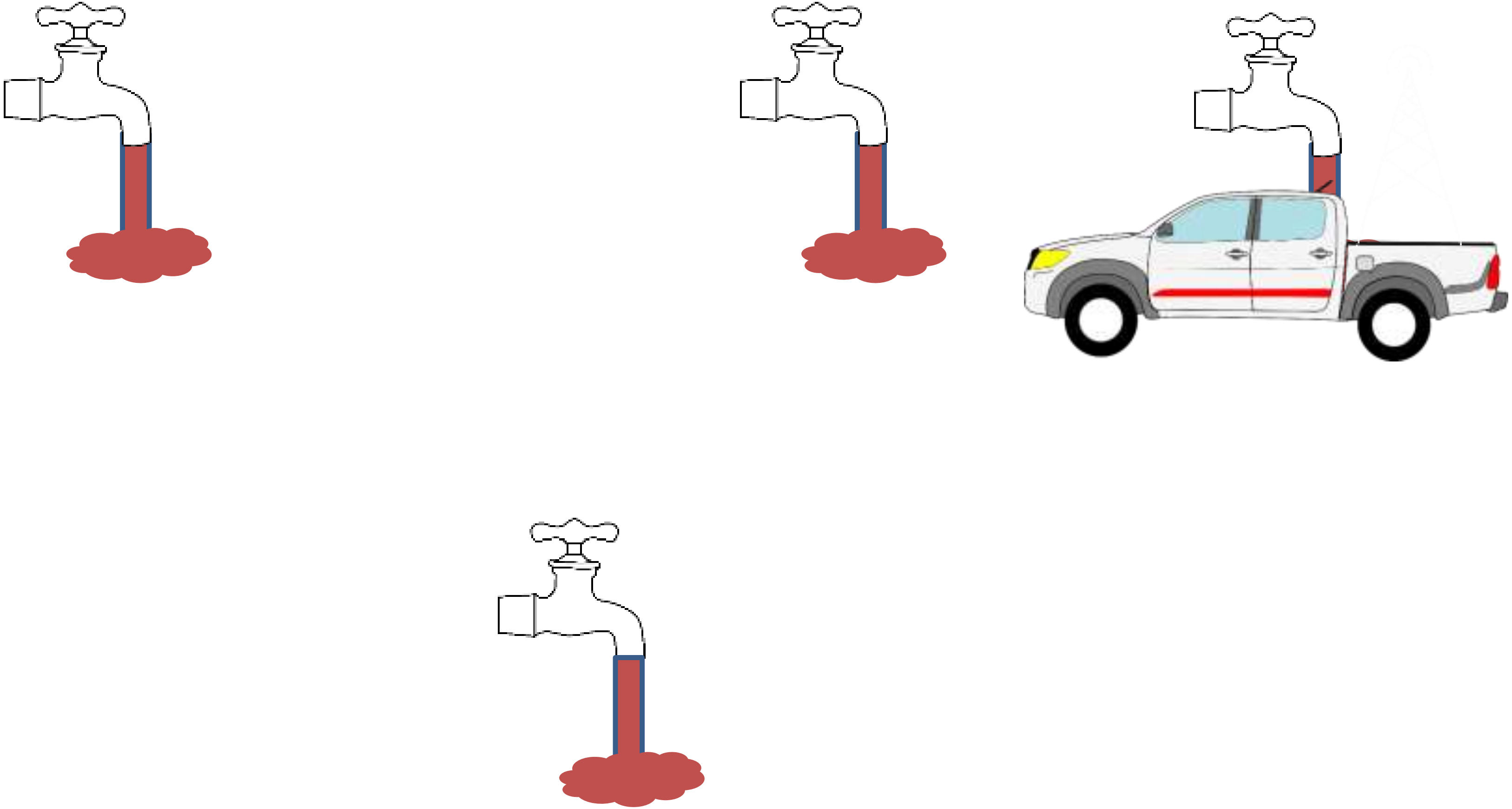
Martin.G.Jaatun@sintef.no

@seniorfrosk

Maroochy Shire, Australia

http://images.businessweek.com/ss/10/10/1014_cyber_attacks/8.htm

http://www.flickr.com/photos/26085795@N02/5379545920/sizes/l/in/photostream/

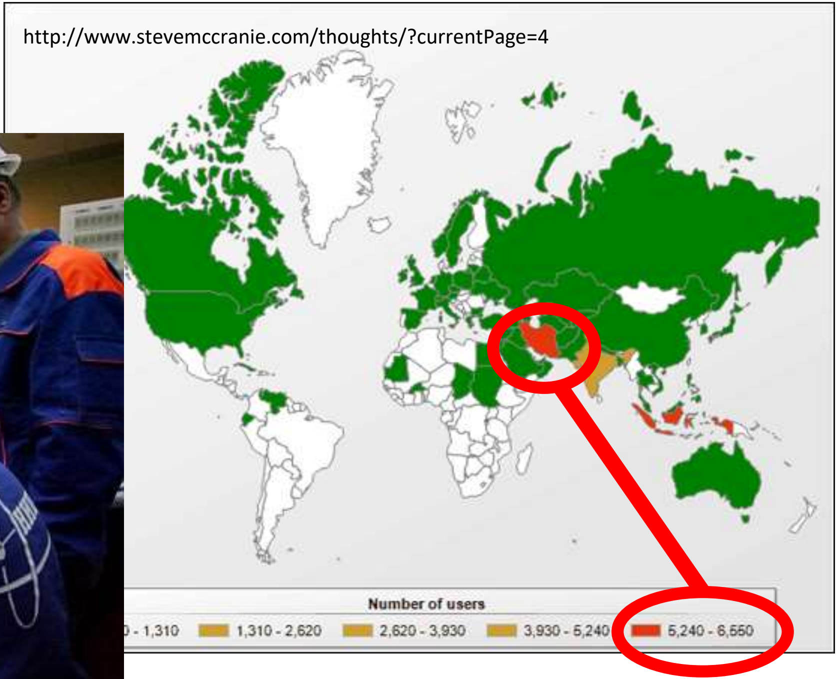


Now imagine all these on the internet…

Illustration by Jason Bolonski; https://www.flickr.com/photos/bolonski/5155412811 CC BY 2.0

Stuxnet

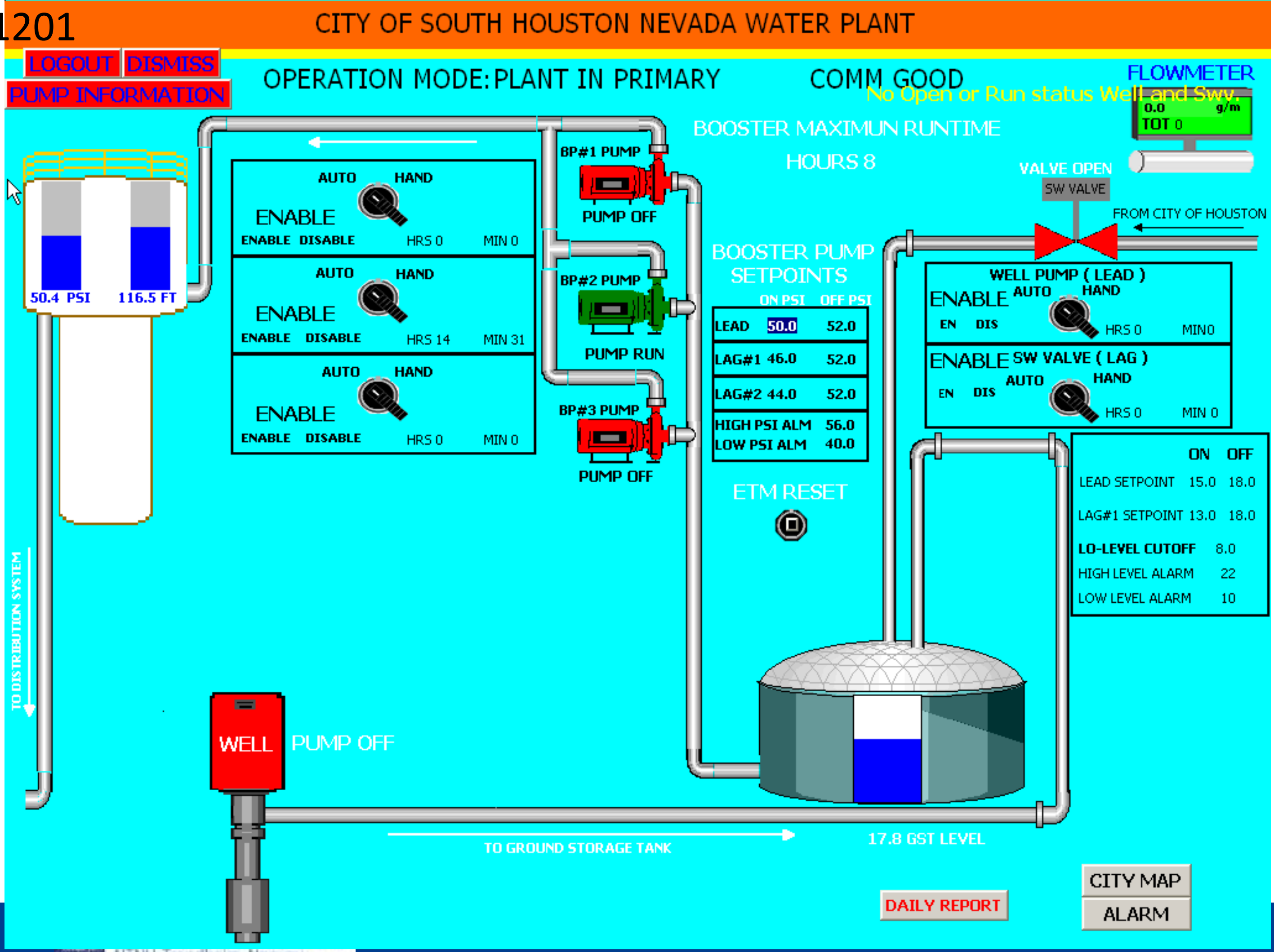
http://en.wikipedia.org/wiki/File:S7300.JPG



DUQU?

Flame?

1201



http://i41.tinypic.com/ip0aa0.png

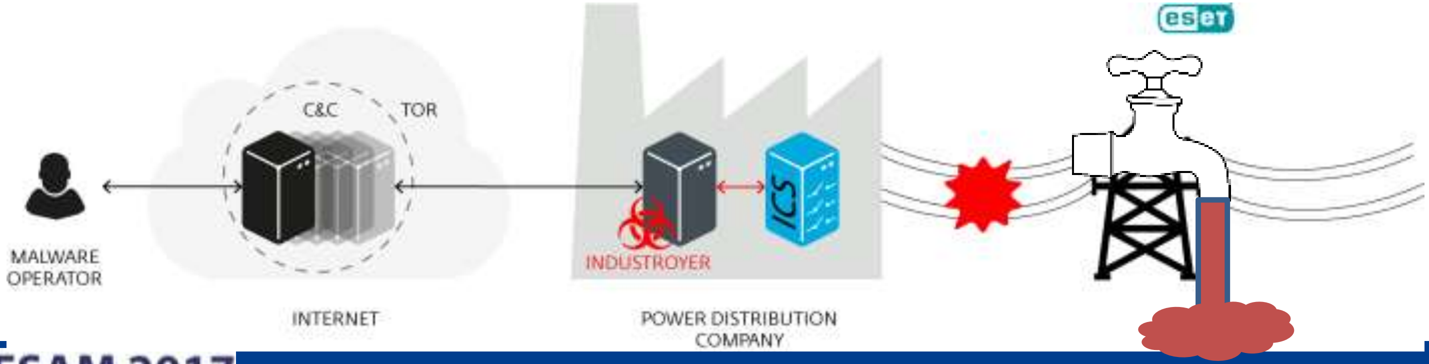
South Houston, Texas

- Siemens Simatic MMI accessible from internet
- 3-letter passwords are worse than four-letter words…

http://en.wikipedia.org/wiki/File:S7300.JPG

(…) the default password for Siemens SIMATIC is "100". There are three different services that are exposed when Siemens SIMATIC is installed; Web, VNC, and Telnet. The default creds for the Web interface is *"Administrator:100"* and the VNC service only requires the user enter the password of *"100" – B.K. Rios*

And the malware keeps on coming…



https://www.welivesecurity.com/2017/06/12/industroyer-biggest-threat-industrial-control-systems-since-stuxnet/

@seniorfrosk

Digitalization allows us to do more with less

- … but it also leaves us vulnerable to cyber attacks
- YOU need to worry about cyber security in your water infrastructure
- Build security in
- The air gap is probably just a mirage…

Can you go to manual…

…when you no longer have the (wo)manpower?

Illustration by Kitmondo PPM https://www.flickr.com/photos/kitmondo/15982943085/ CC BY 2.0

Questions?

STOP-IT

http://www.stop-it-project.eu

Martin.G.Jaatun@sintef.no

Presentation 2

Manuel Franco-Torres: Governance of urban water services. A new framework of analysis

Norwegian University of Science and Technology

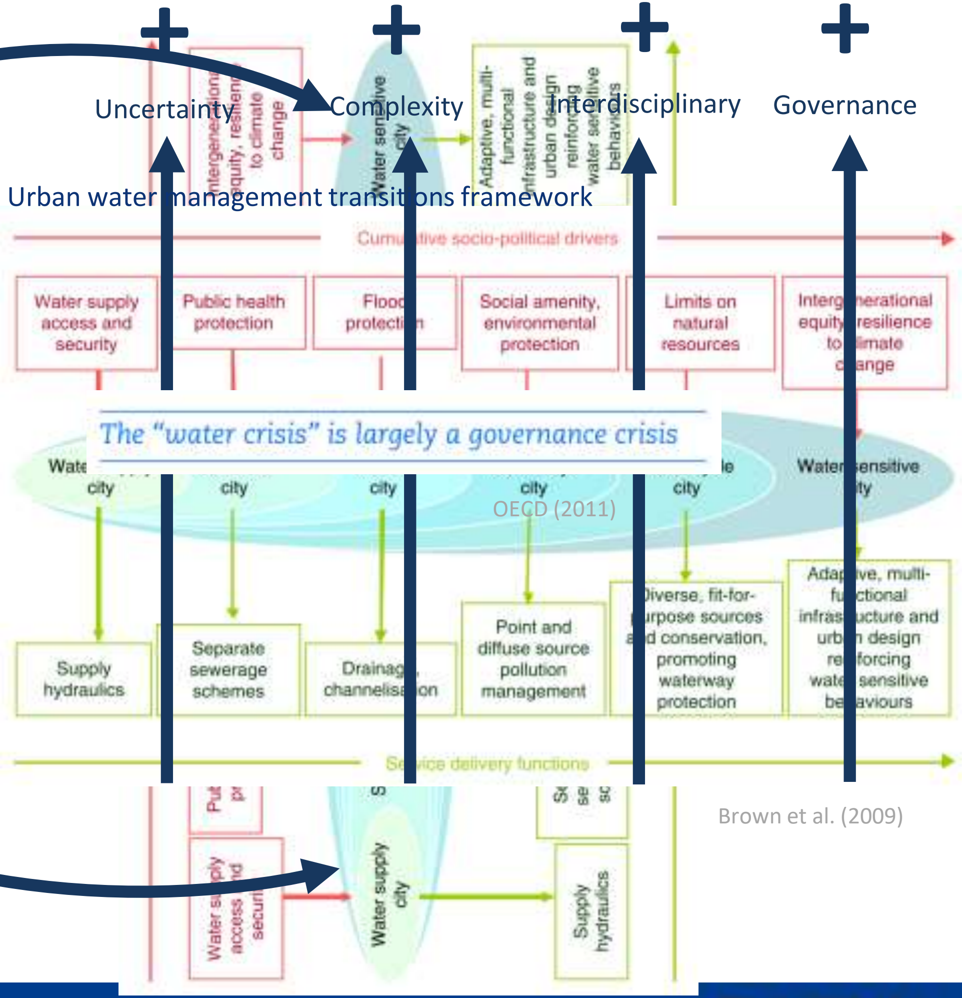
Governance of Urban Water Services

A new framework of analysis

Manuel Franco Torres
Rita Ugarelli

Background

UWS
Urban water services
(De Haan et al., 2014)
(Pahl-Wostl et al., 2011)

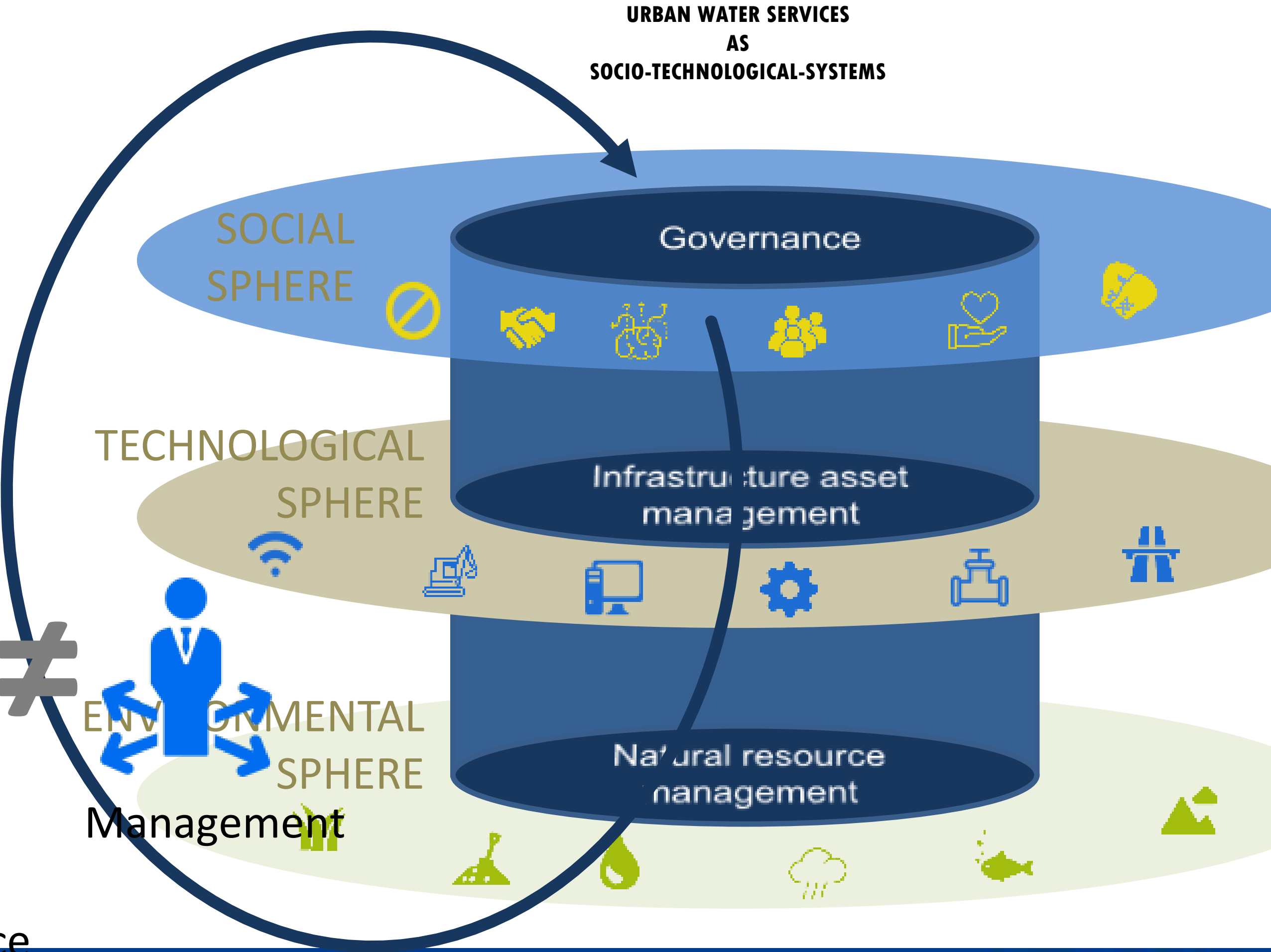


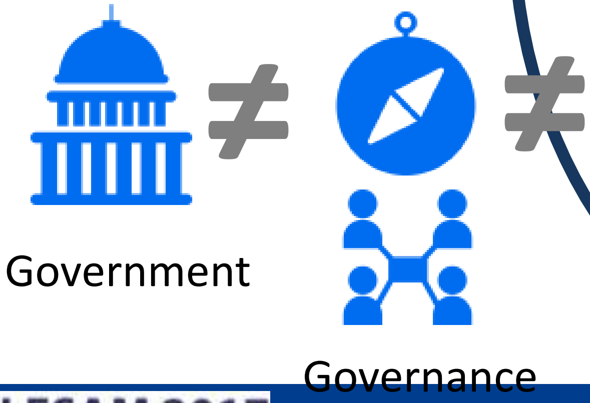
Uncertainty
Complexity
Interdisciplinary
Governance
Urban water management transitions framework
Cumulative socio-political drivers
Water supply access and security
Public health protection
Flood protection
Social amenity, environmental protection
Limits on natural resources
Intergenerational equity, resilience to climate change
The "water crisis" is largely a governance crisis
OECD (2011)
Water sensitive city
Supply hydraulics
Separate sewerage schemes
Drainage, channelisation
Point and diffuse source pollution management
Diverse, fit-for-purpose sources and conservation, promoting waterway protection
Adaptive, multi-functional infrastructure and urban design reinforcing water sensitive behaviours
Service delivery functions
Brown et al. (2009)

What is governance?

Our definition:

Governance is the collaborative social processes and their resulting social structures that allow individuals to organize for the achievement of common goals.





Method

Different approaches to governance

Sociology

Perspective: Institutionalism

New Institutionalism
(Meyer & Rowan, 1977)
(DiMaggio & Powell, 1991)

Economy

The meaning that guides action:

The institutional logics

(Friedland & Alford, 1991)
(Thornton & Ocasio, 2008)
(Thornton et al., 2012)

The institutional logics of UWS

(Fuenfschilling & Truffer, 2014)

Political sciences

Hydraulic logic
(Security of supply)

Water market logic
(Economic efficiency, rationalization)

Water sensitive logic
(Environmental sustainability, resilience)

Building blocks:

The Institutions

- Rules
- Norms
- Culture /Cognition

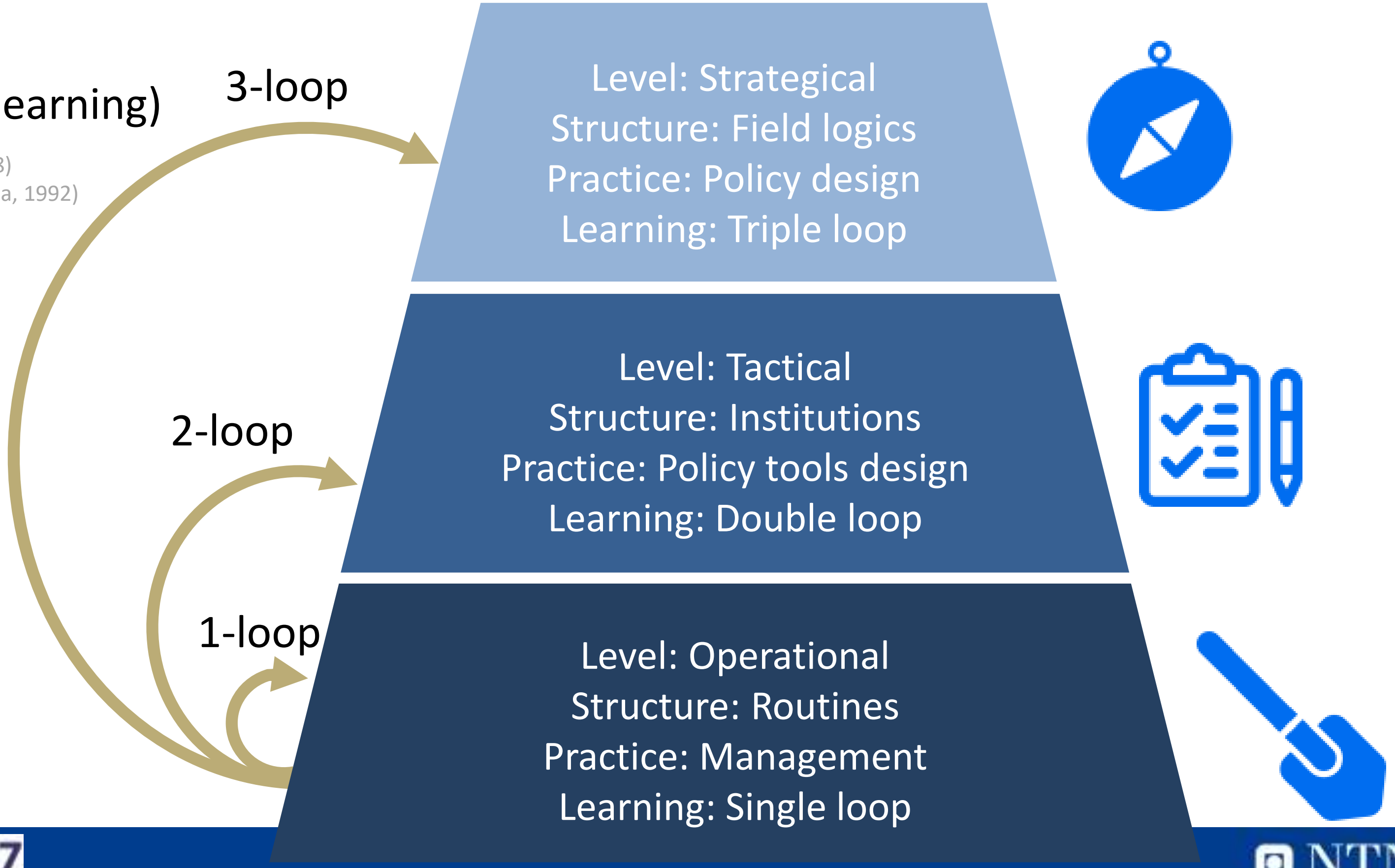
Scott (2014)

Conceptual framework

Governance framework

Practice:
Reflexive (learning)

(Argyris & Schön, 1978)
(Swieringa & Wierdsma, 1992)

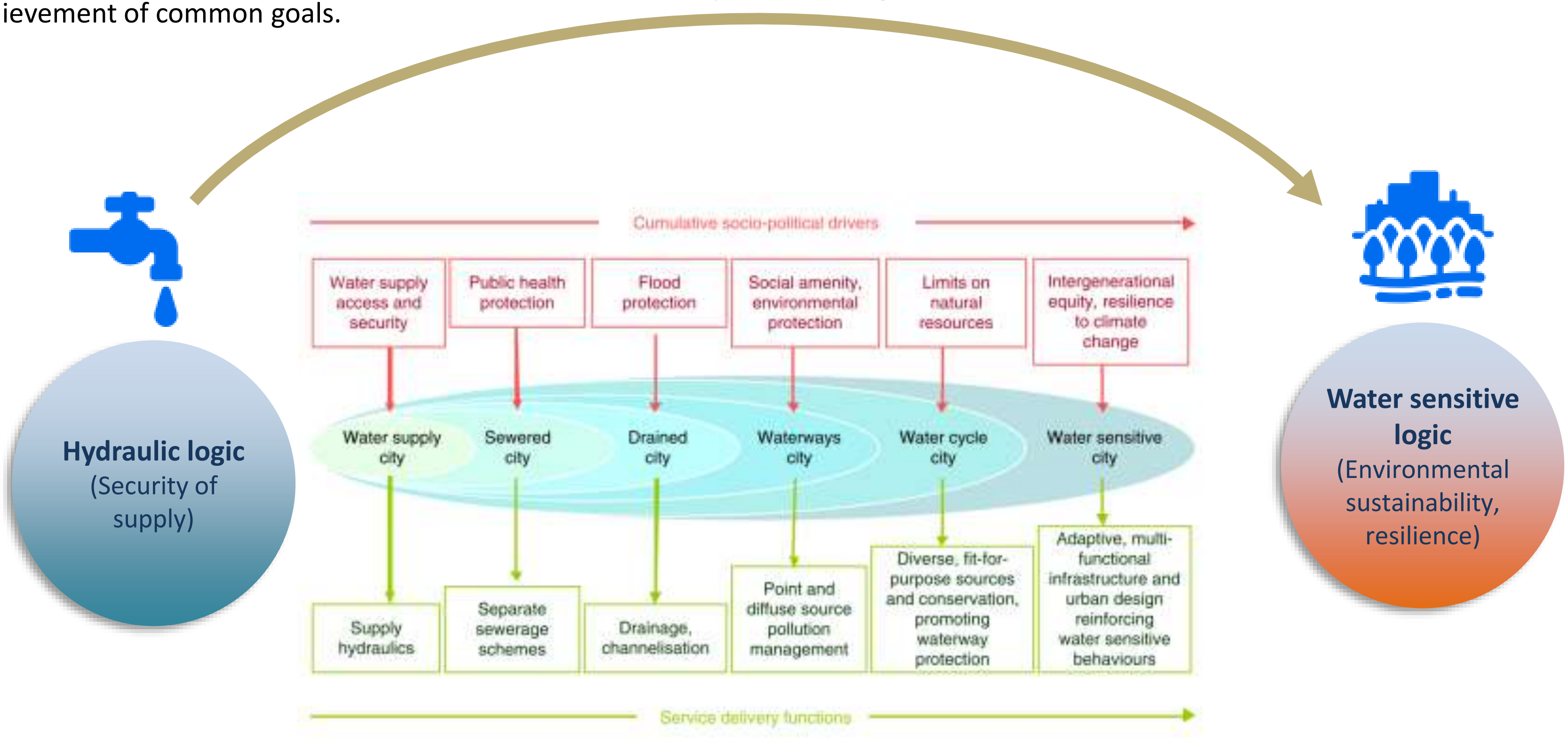


Governance is the collaborative social processes and their resulting social structures that allow individuals to organize for the achievement of common goals.

Where are we today?

How to advance towards the water sensitive city?

3-loop learning



Governance of Urban Water Services

A new framework of analysis

Manuel Franco Torres
Rita Ugarelli

Norwegian University of Science and Technology

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LESAM 2017
NTNU, Trondheim, Norway

Presentation 3

Paul Conroy: Resilience planning in the UK water sector and novel application of simulation tools for quantifying resilience needs

Resilience Planning in the UK Water Sector

Paul Conroy, Alec Yeowell, Elliot Gill, Peter von Lany - CH2M

Ana María Fernández – CH2M/EuroAquae intern

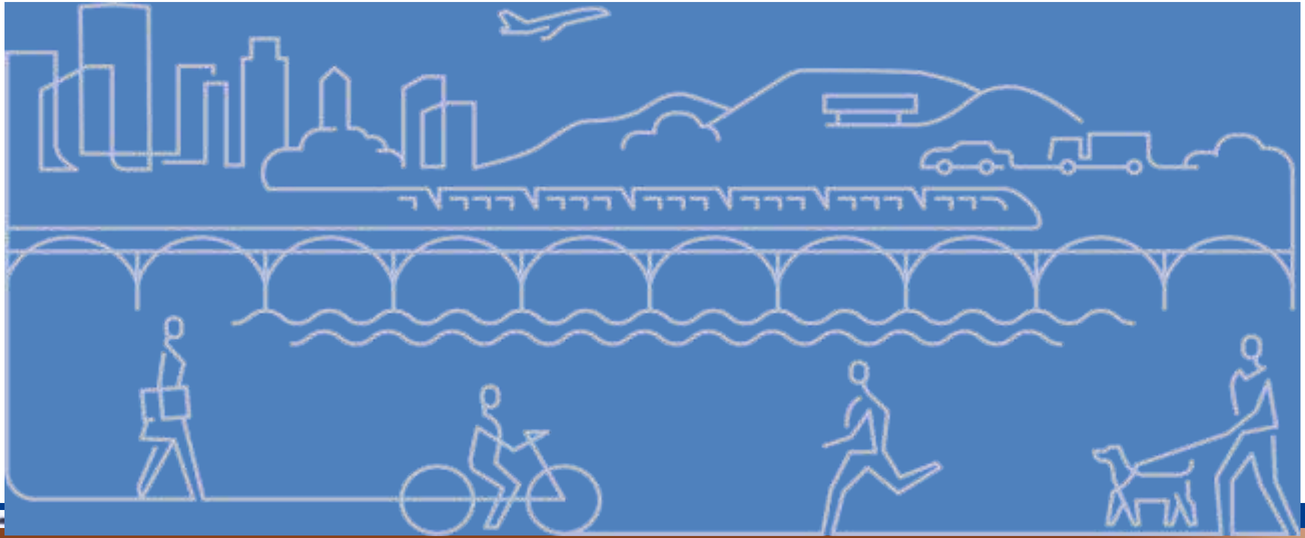
Contributions from: Keith Banner, Carli van Niekerk –
Thames Water

Contents

1. Introduction
2. Resilience definitions
3. Why does it matter?
4. Key developments UK water sector
5. System modelling
6. Thames Water case study
   - Water
   - Wastewater
7. Conclusions

About CH2M

- **20,000 employees** worldwide, **4,000** in Europe
- Full service engineering and environmental consultancy covering water, road, rail and air
- Client-centric operating model (state & local, national, private)
- Clients in more than 50 countries



CH2M – Swindon (some of the local sights)

What is resilience?

National view:

- *Resilience is the ability of assets, networks and systems to anticipate, absorb, adapt to and / or rapidly recover from a disruptive event (2011 UK Government, Cabinet Office Keeping the Country Running)*

Water sector interpretation:

- *Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future*

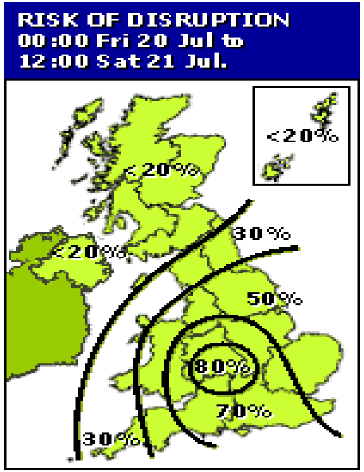
Why do we need to be resilient?

copperleaf

- Unexpected severity of natural hazards, coupled with vulnerable and critical assets has resulted in significant loss of service, environmental damage and recovery costs
- These are major risks and should be considered as part of the overall asset management planning process
- They should be addressed based on consideration of acceptability, affordability and cost-benefit

Key developments

- <u>Trigger</u>: Summer flooding 2007
- Service Risk Framework 2008
- Ofwat resilience planning principles 2011
- UKWIR resilience planning framework 2012
- Ofwat Task and Finish group 2016
- UKWIR Resilience: performance measures, costs and stakeholder communication 2017



Resilience planning principles

Principle	Requirement
Principle 1	An ‘all-risks’ approach to resilience planning
Principle 2	Third party engagement to identify risks and needs
Principle 3	Resilience planning should to be focused on risk to service, damage cost avoidance and risks to life (the same metrics used for asset management, master planning, quality planning etc..)
Principle 4	Monetization of risk metrics to support equitable decision making
Principle 5	Broad consideration of intervention options for resilience
Principle 6	Using cost benefit analysis to support significant decisions
Principle 7	Uncertainty analysis built into decision making
Principle 8	Continuous improvement cycle embedded into the planning process

Typical UK planning cycle (Cabinet Office)

Flood Risk Assessment ramework (use

1) Climate Analysis:

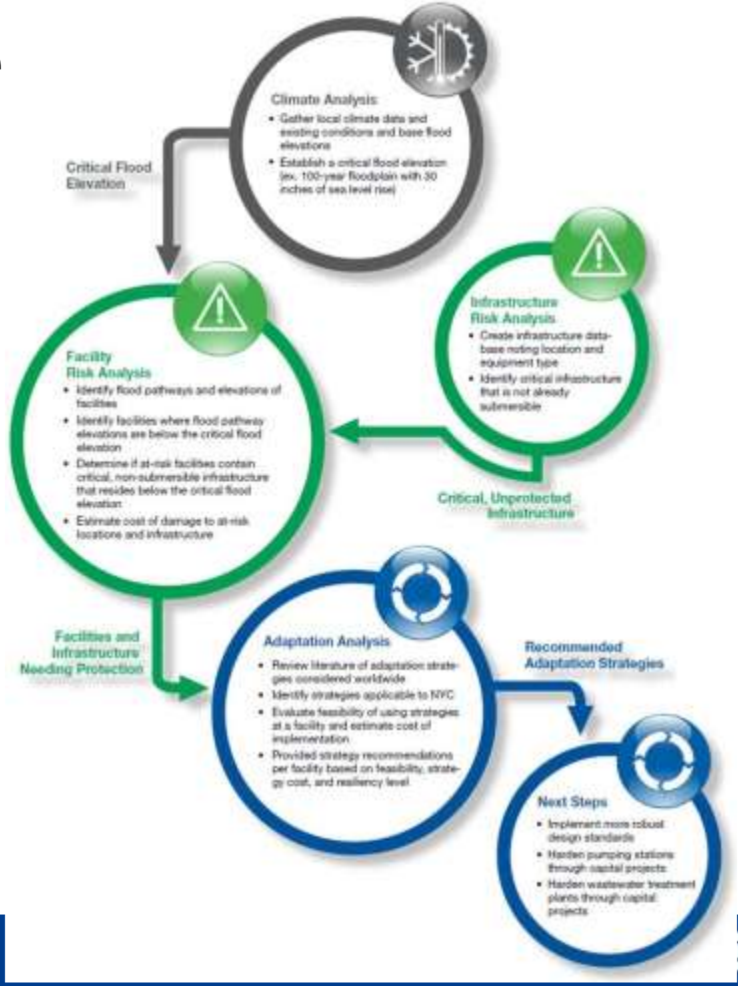
– What current & future climate and storm surge conditions should we prepare for?

2) Risk Analysis:

– What are the critical flood pathways ?
– What buildings and assets are at risk?
– What is the value of assets at risk?

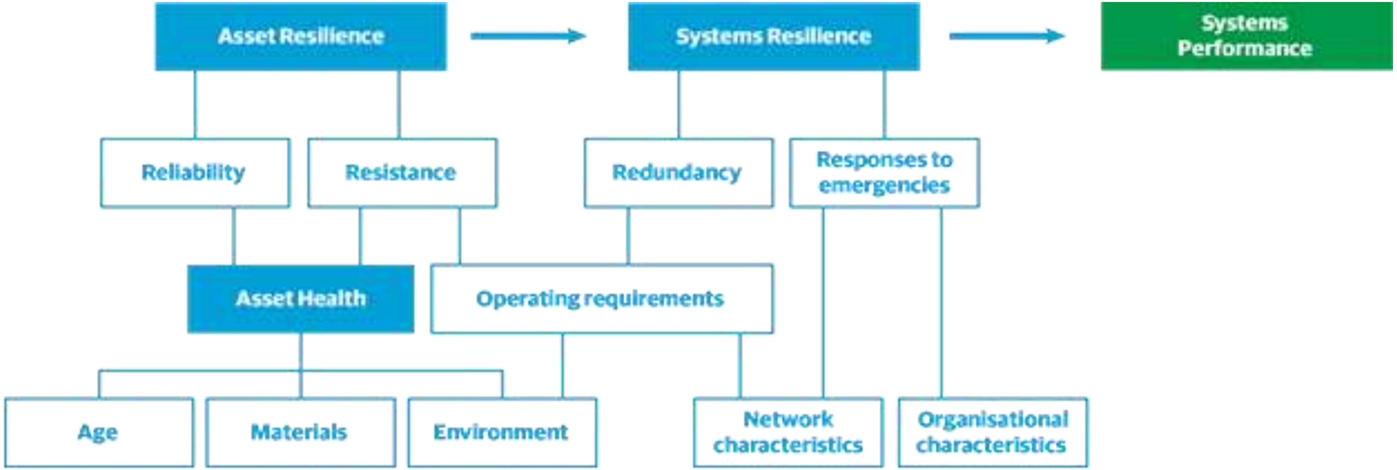
3) Adaptation Analysis:

– What protective measures should be implemented to reduce risk while balancing resilience and cost?



Solutions based on the 4Rs

- **Resistance** – ability of the asset to resist the stressor (this could be a flood wall)
- **Reliability** – how reliable the asset is (this could be the mean time to failure)
- **Redundancy** – availability of an alternative to take the load, convey the product
- **Response and recovery** – the ability to respond operationally to mitigate the impact



Solutions can be about attenuating flows


Blue Roofs


Staten Island Bluebelt


Porous Pavements


Green streets


Bioswales

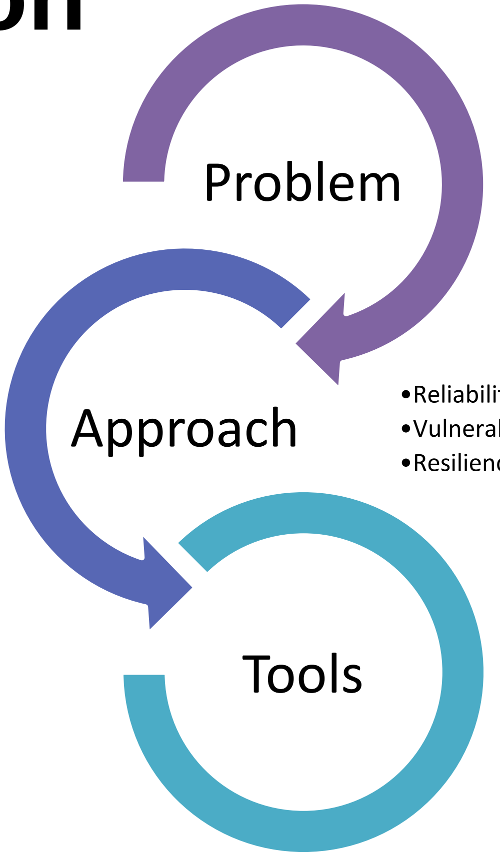
Thames Water case studies

About Thames Water

- **Thames Water is the UK's largest water and wastewater services company**
- Every day, they supply around 2,600 million litres of tap water to 9 million customers across London and the Thames Valley. They also remove and treat more than 4 billion litres of sewage for 15 million customers

Our area

Introduction



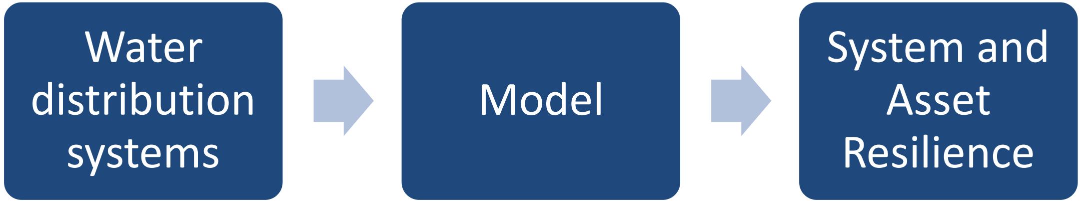
- Urban Water Demand/Wastewater load
- Aging assets
- Natural Hazards

- Reliability
- Vulnerability
- Resilience

- ExtendSim
- Voyage™
- Modelling

Project Definition

CH2M developed a bespoke configuration of the **ExtendSim** software called **Voyage™**, which has been used to look at system dynamics and assess loss-of-service risk in complex systems where interconnectivity, demand, deterioration and operational regime all influence the risk potential.



Voyage^{TM} System Resilience Modelling

ExtendSim

- Simulation tool that can be used to develop dynamic models
- Model real-life processes and simulate different conditions in order to study the performance of the system

Voyage^{TM}

- System simulation tool was created by **CH2M** using the simulation software **ExtendSim**
- Study the resilience of an overall system of network assets
- Blocks that allows analysis of the risk associated with the reliability of components and the system and the hazards that impact a system

Voyage™ Scenarios

What-if

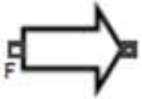
- Asset failure at a fixed time step during the simulation run
- Asset downtime fixed
- Observation of changes in system during asset downtime

Probabilistic

- Asset failure at random time step of simulation run based on failure probability
- Downtime based on sample from Weibull distribution with mean downtime
- Multiple simulation runs to determine probability of combined asset failures

Water system modelling

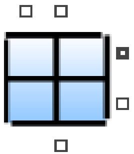
Voyage™ Blocks (water)



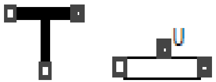
Source

Drivers

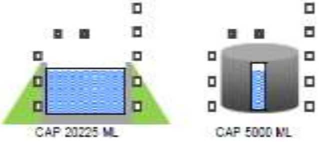
Pump Control



Water Treatment Works



Junctions



Reservoir

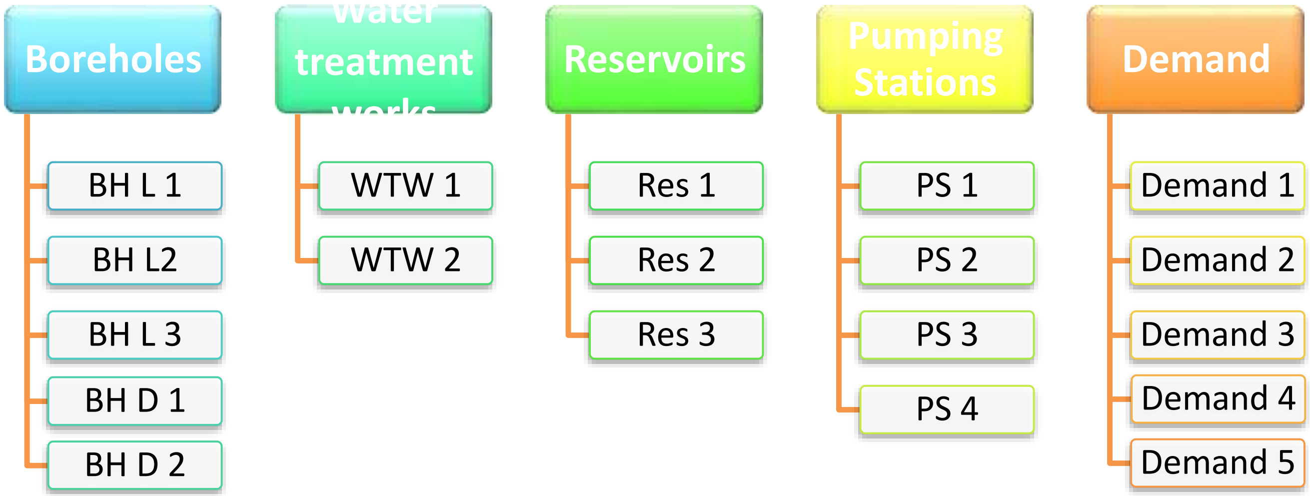
Demand

Hazard and reliability

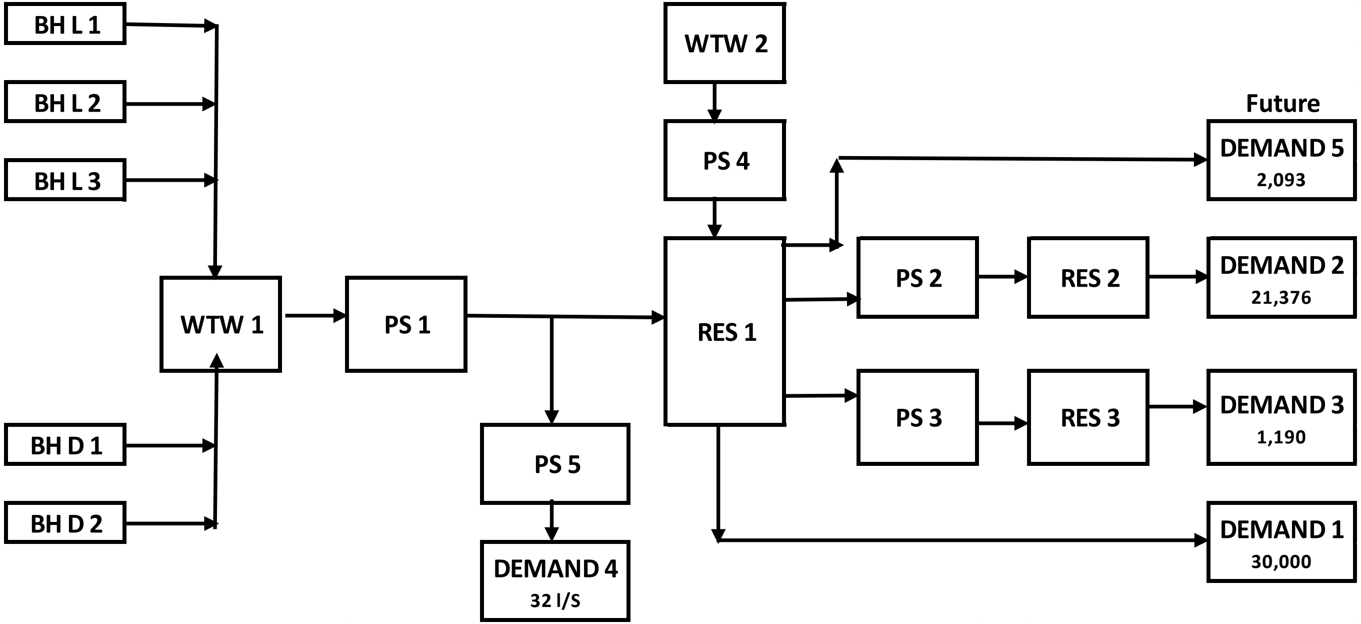
Data Requirements

Data Element	Data Source
1. System	1.1 Schematic
	1.2 Asset inventory (GIS)
2. Abstractions	2.1 SCADA telemetry data
	2.2 Licence details
3. Works	3.1 Location Plan
	3.2 Pipe and Valve Schematic
	3.3 Site Operating Manual (SOM)
4. Stations (Pumping)	4.1 Site Operating Manual (SOM)
	4.2 Hydraulic Analysis Reports
	4.3 Hydraulic Model
	4.4 SCADA telemetry data
5. Storage	5.1 Pipe and Valve Schematic
	5.2 Site Operating Manual (SOM)
	5.3 SCADA telemetry data
6. Zones	6.1 SCADA telemetry data
	6.2 Demand forecast model
7. Failure / Deterioration	7.1 Resilience Assessment (4Rs)
	7.2 Deterioration rates

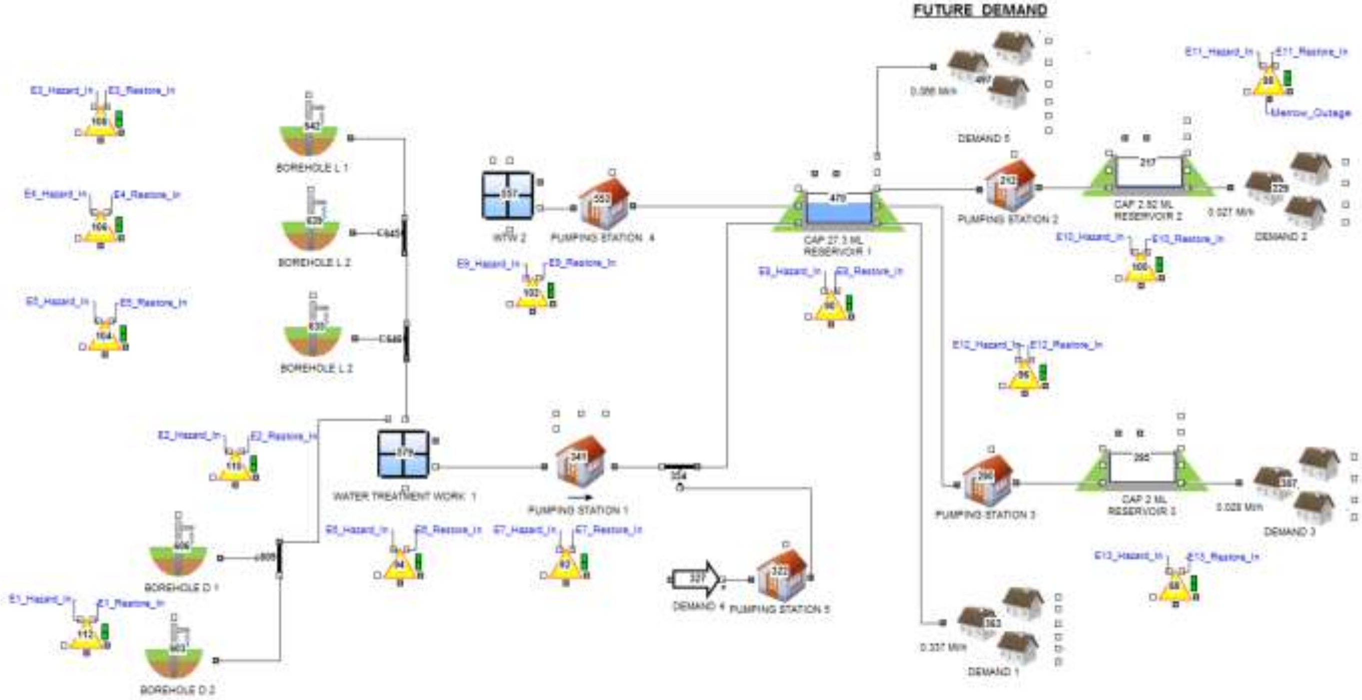
Voyage^{TM} Water Distribution Model Components



Model Schematic



Model Schematic



Data

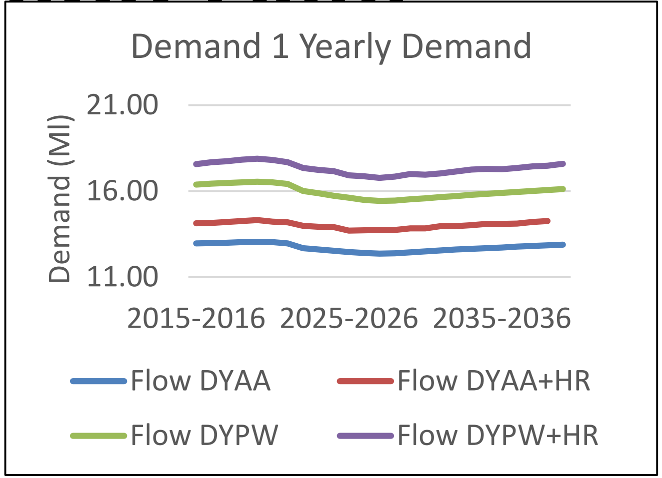
Borehole Name	Pump Rate (Ml/d)	Pump Rate (Ml/hr)	Pump when (*without exceeding the licence)	Daily Licence (Ml)	Annual Licence (Ml)
BH L 1	9	0.188*	Required Contact tank volume is >0.188	20.513	7487.262
BH L 2		0.188*	Required volume is >0.366		
BH L 3		0.188*	Required volume is >0.564		
BH D 1	10.3	0.33*	Always Pumping		
BH D 2		0.09583*	Always Pumping		

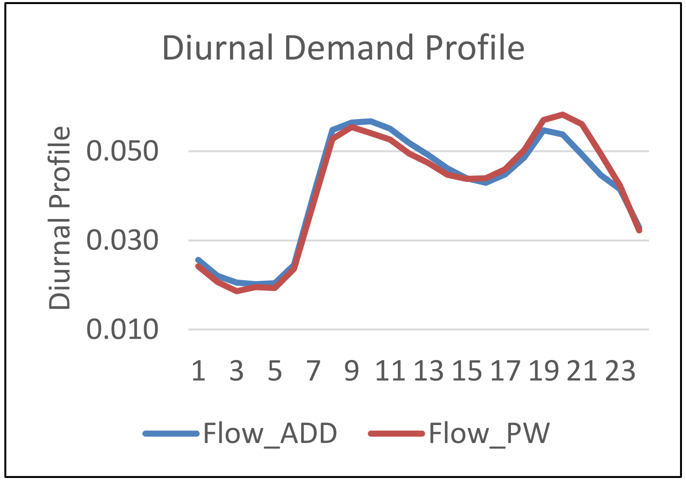
Boreholes Pump Rate

Reservoir Name	Capacity (Ml)	Initial Volume (Ml)	Target Volume (Ml)
WTW 1	24	20*	20*
Reservoir 1	27.26	25*	25*
Reservoir 2	2.92*	2*	2*
Reservoir 3	2.92	2*	2*

Reservoir Capacity

Demand Data





- Dry Year Annual Average (DYAA)
- Dry Year Peak Week (DYPW)
- Dry Year Annual Average plus Headroom (DYAA + HR)
- Dry Year Peak Week plus Headroom(DYPW + HR)

- Average Day Demand (ADD)
- Peak Week (PW)

DEMAND 1	30.000 customers
DEMAND 2	21.376 customers
DEMAND 3	1.190 customers
DEMAND 4	32 l/s
DEMAND 5	2.093 customers

Failure Data

Type of Asset	Rate of Failure (events/year)	Probability of failure	Restoration Time (hours)	Operational Comments
BH D2	2	0.00022831	12	Risk of contamination due to storm, this borehole is closest to the river
BH D 1 BH D 2	2	0.00022831	12	Risk of contamination due to microbiological contamination and old panels
BH L 1 BH L 2 BH L 3	1	0.00011415	12	Groundwater concern as to whether water level sufficient in drought to run the 3 BH simultaneously
	1	0.00011415	12	
	1	0.00011415	12	
WTW 1	2	0.00022831	12	- Chemical dosing equipment in poor condition - Flooding risk identified
Pump Station 1	1	0.00011415	12	Redundancy risk, three pumps to 19.4 Ml/d
Reservoir 1	1	0.00011415	12	- Water quality due to low Chlorine residuals - Accidental overfilling of reservoir because overflow not adequate to accept larger inflow rate could lead to damage to reservoir roof. Potential loss of the reservoir if roof damaged
WTW 2	1	0.00011415	12	Flooding risk
Pump Station 2	1	0.00011415	12	6 week outages seen
Reservoir 2	1	0.00011415	12	Inspect this tank on a 10 yearly basis it needs to be taken out of service for 3-4 days
Pump Station 3	2	0.00022831	12	19 week outages seen - pumping resilience assessment graded P3
Reservoir 3	1	0.00011415	12	Coliform failure 2011.

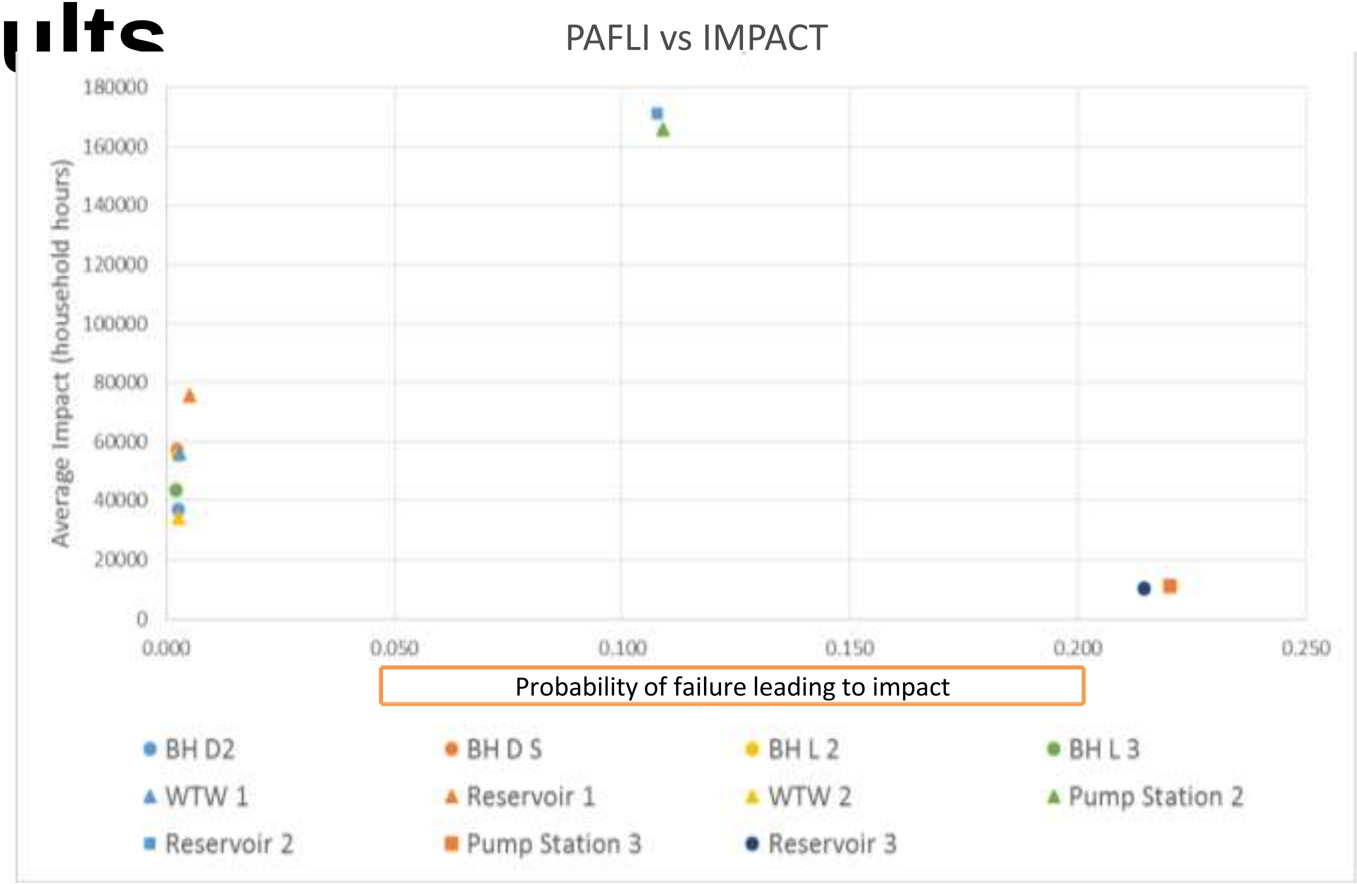
Results

Model Configuration	Model Setting
Length of simulation (in years)	1
Number of simulations	10,000
Demand Year	2015-16
Demand Configuration (yearly/monthly/hourly demand variations)	Hourly based on observed diurnal profile applied to yearly average demand
Drought Scenario (DYAA, DYAA+HR, DYCP, DYCP+HR)	DYAA (Dry Year Annual Average)
Failures to be modelled	See Data
Probability of failure of events	See Data
Restoration time of events	See Data
Outputs Required	PAFLI, Length of interruption to supply

Probability of a failure leading to an impact (PAFLI)

$$PAFLI = \frac{Events\ leading\ to\ loss\ in\ supply}{Number\ of\ events}$$

Results



PAFLI vs IMPACT
Average Impact (household hours)
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0.000
0.050
0.100
0.150
0.200
0.250
Probability of failure leading to impact
BH D2
BH D S
BH L 2
BH L 3
WTW 1
Reservoir 1
WTW 2
Pump Station 2
Reservoir 2
Pump Station 3
Reservoir 3

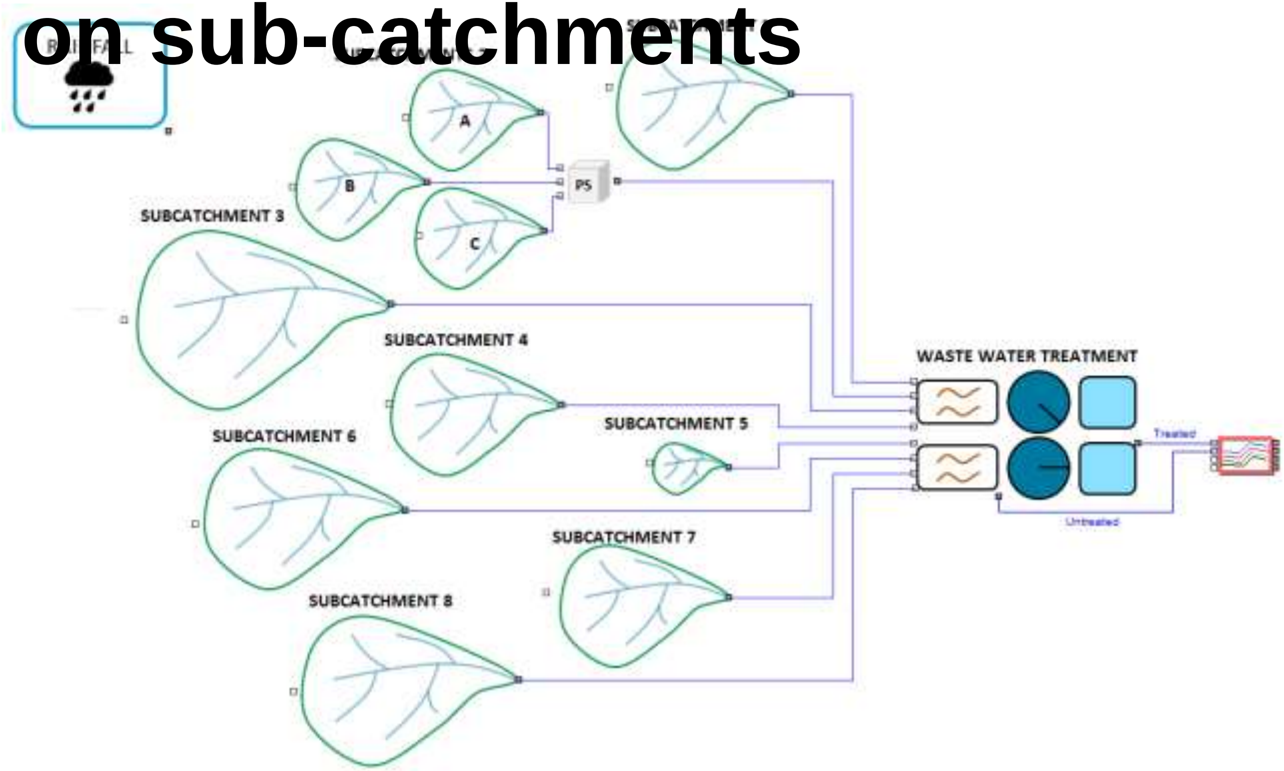
Results

PAFLI Matrix

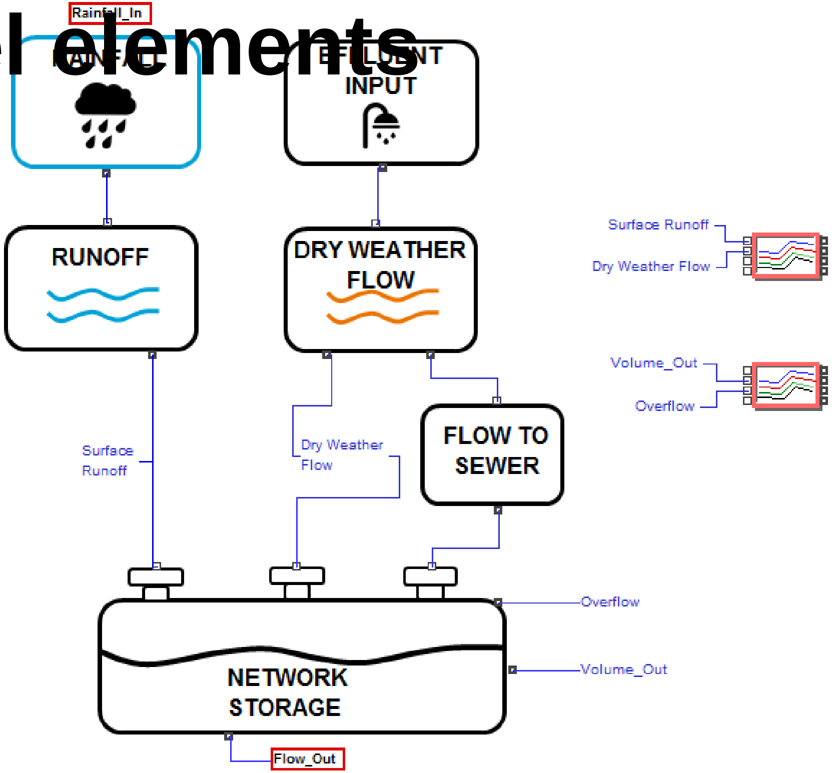
	BH D2	BH D S	BH L 1	BH L 2	BH L 3	WTW 1	Pump Station 1	Reservoir 1	WTW 2	Pump Station 2	Reservoir 2	Pump Station 3	Reservoir 3
BH D2	0.002	0.000	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.139	0.043	0.214	0.263
BH D S	0.000	0.002	0.000	0.000	0.000	0.010	0.000	0.019	0.000	0.106	0.091	0.227	0.263
BH L 1	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.048	0.000	0.059	0.038	0.200	0.290
BH L 2	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.200	0.107	0.154	0.308
BH L 3	0.000	0.000	0.000	0.000	0.002	0.019	0.000	0.000	0.000	0.074	0.000	0.269	0.250
WTW 1	0.018	0.010	0.000	0.000	0.019	0.003	0.000	0.000	0.000	0.163	0.163	0.227	0.294
Pump Station 1	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.075	0.280	0.297	0.143
Reservoir 1	0.000	0.019	0.048	0.000	0.000	0.000	0.000	0.005	0.000	0.067	0.121	0.275	0.367
WTW 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.048	0.100	0.228	0.333
Pump Station 2	0.139	0.106	0.059	0.200	0.074	0.163	0.075	0.067	0.048	0.109	0.273	**0.373**	0.226
Reservoir 2	0.043	0.091	0.038	0.107	0.000	0.163	0.280	0.121	0.100	0.273	0.108	0.250	0.179
Pump Station 3	0.214	0.227	0.200	0.154	0.269	0.227	0.297	0.275	0.228	**0.373**	0.250	0.214	0.188
Reservoir 3	0.263	0.263	0.290	0.308	0.250	0.294	0.143	0.367	0.333	0.226	0.179	0.188	0.220

Sewer system modelling

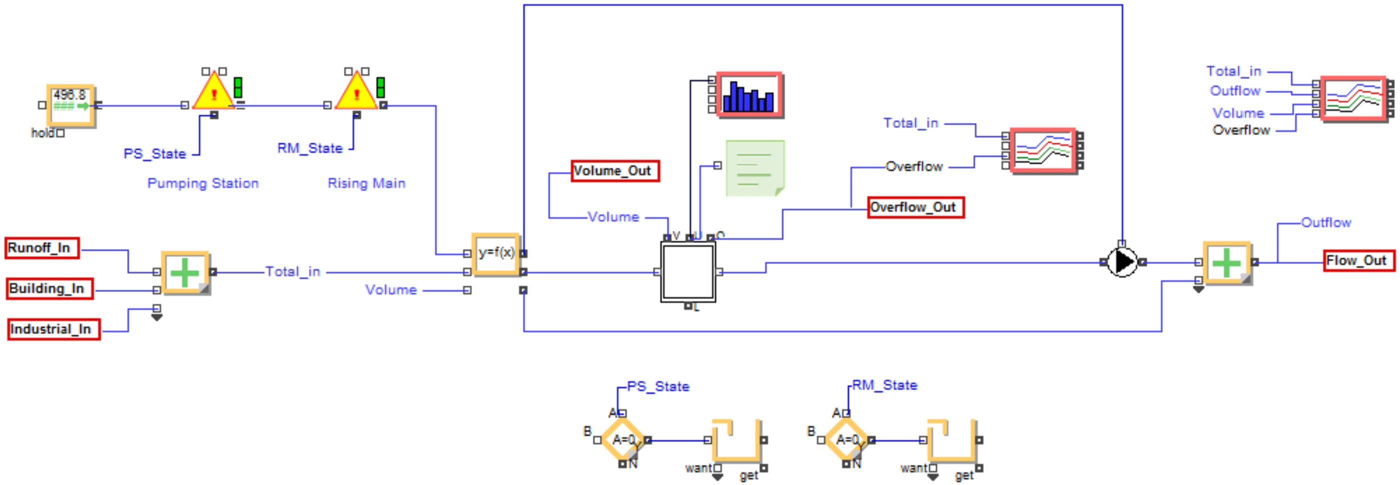
Strategic representation based on sub-catchments



Sub-catchment model elements

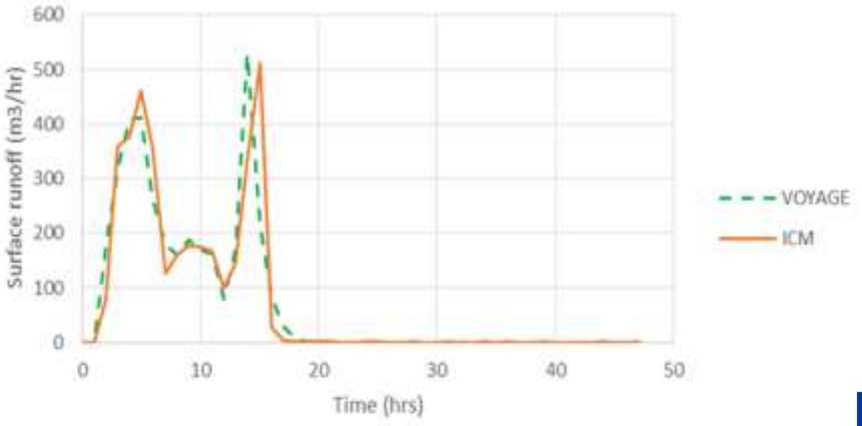


Network storage element



Outputs

- Have developed a metric based on % utilisation of network system storage
- Have validated Voyage^{TM} catchment models against hydraulic model outputs
- Need to calibrate against recorded failures (floods and CSO spills



Conclusions

- Voyage ^{TM} modelling is enabling:
  - Identification of the events that most frequently lead to interruptions to service, elevated risk or restricted capacity/headroom in the water and sewer system
  - Identification of the failures which have the greatest impact on the customer/environment (system capacity in the case of wastewater collection)
- With this understanding, a resilience mitigation assessment can be undertaken in order to reduce the risk and the impact of failures

Thank You

Questions?

Presentation 4

Raja-Louisa Mitchell: A holistic application methodology to increase the resilience of urban wastewater structures

Technische Universität Berlin

A Holisitic Adaptation Methodology to increase the Resilience of Urban Wastewater Infrastructures

Raja-Louisa Mitchell | TU Berlin | LESAM 2017

Technische Universität Berlin

kuras

Konzepte für urbane Regenwasserbewirtschaftung und Abwassersysteme

Technische Universität Berlin

Berliner Wasserbetriebe

KOMPETENZZENTRUM Wasser Berlin

Technische Universität Kaiserslautern

ifak

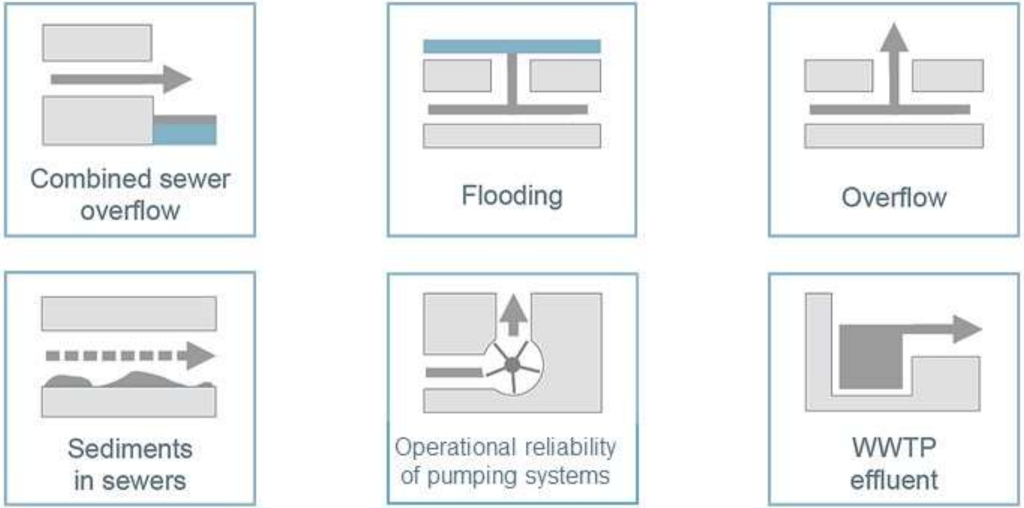
Methodology for adapting urban wastewater systems (UWWS)

Study site in Berlin

- 260.000 population
- 40.000 m³/day DWF
- Combined and separate system
- 90% to WWTP Ruhleben

Step 1: Definition of present and future challenges

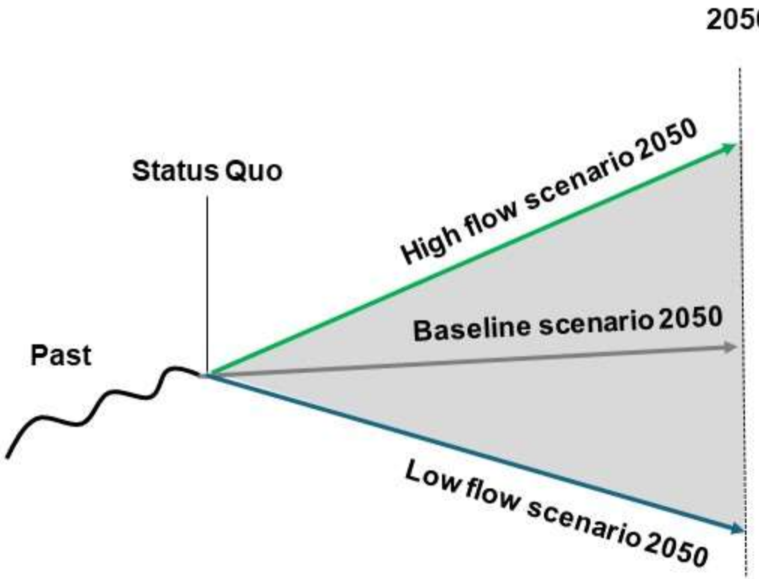
Step 1: Definition of present and future challenges



Timeframe: 2050

Step 2: Definition of goals

Goal: Adapt UWWS in a time frame upto and including 2050

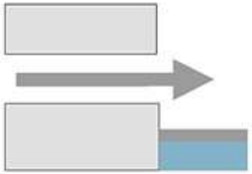


Drivers for scenarios:

- Population
- Contributing area
- Spec. Water consumption
- Precipitation

Step 3: Definition of performance indicators

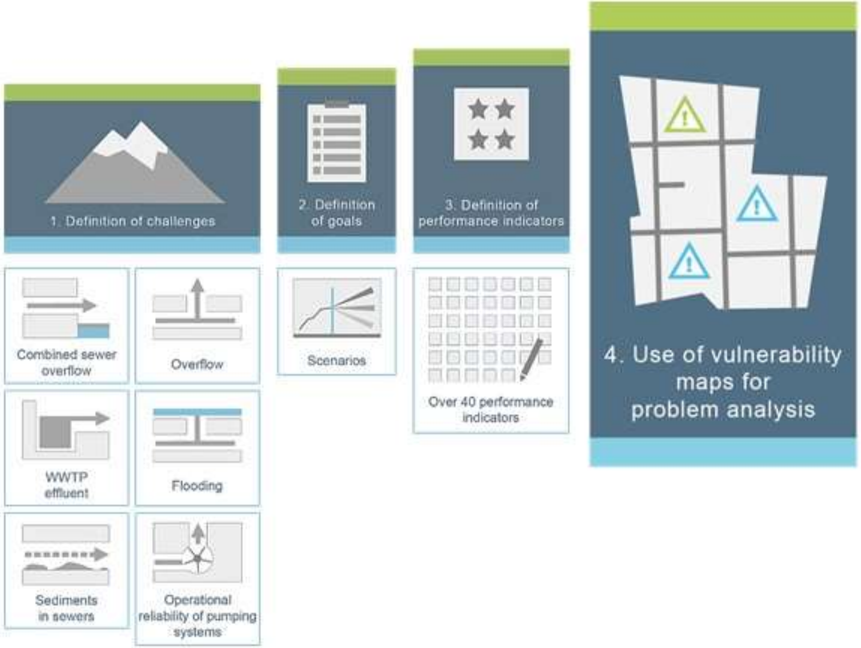
Performance indicators: Example CSO



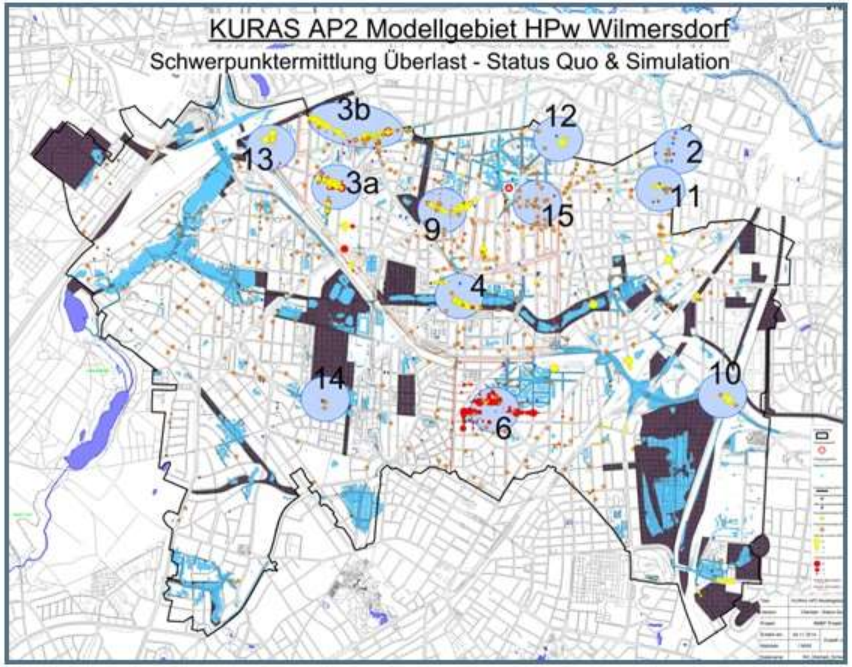
Combined sewer overflow

- CSO volume [m³]
- CSO duration [h]
- CSO frequency [-]
- Pollutant load [kg]

Step 4: Problem analysis

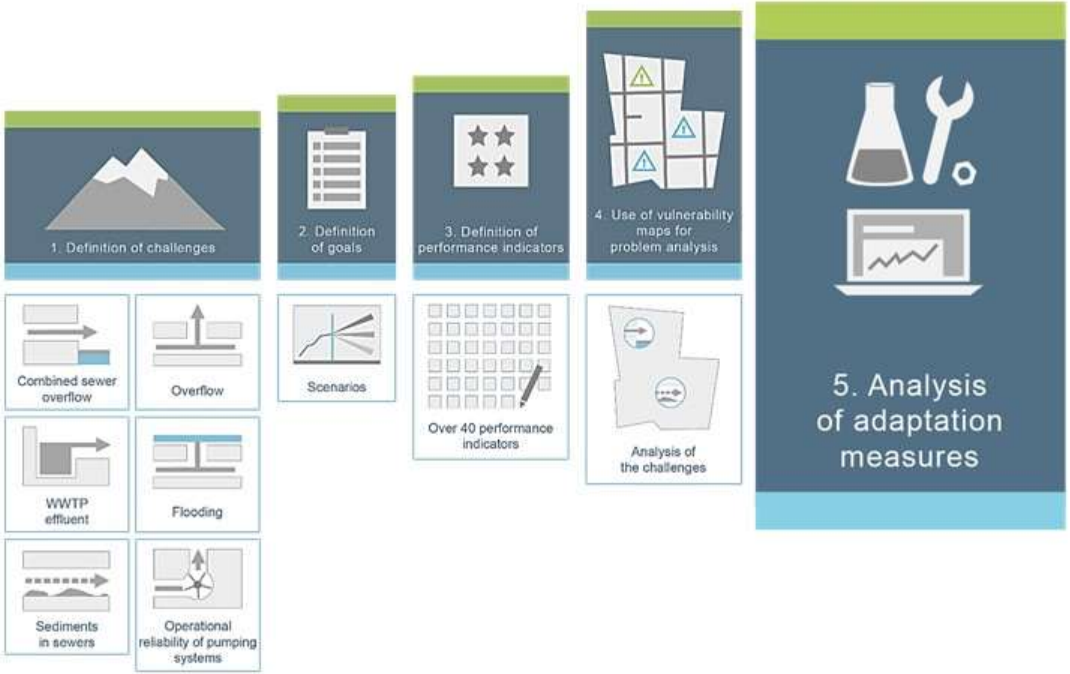


Problem analysis: Vulnerability maps



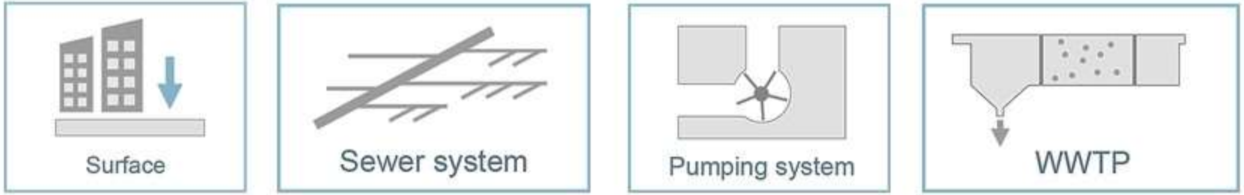
Simulated and reported overload hotspots in the study area

Step 5: Analysis of individual adaptation measures

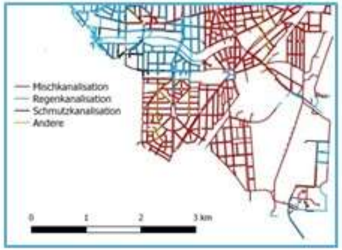


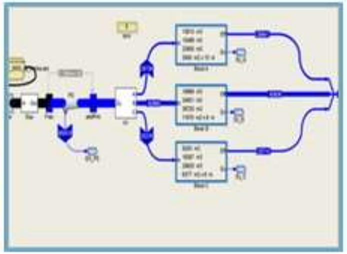
Analysis of individual adaptation measures

Subsystems

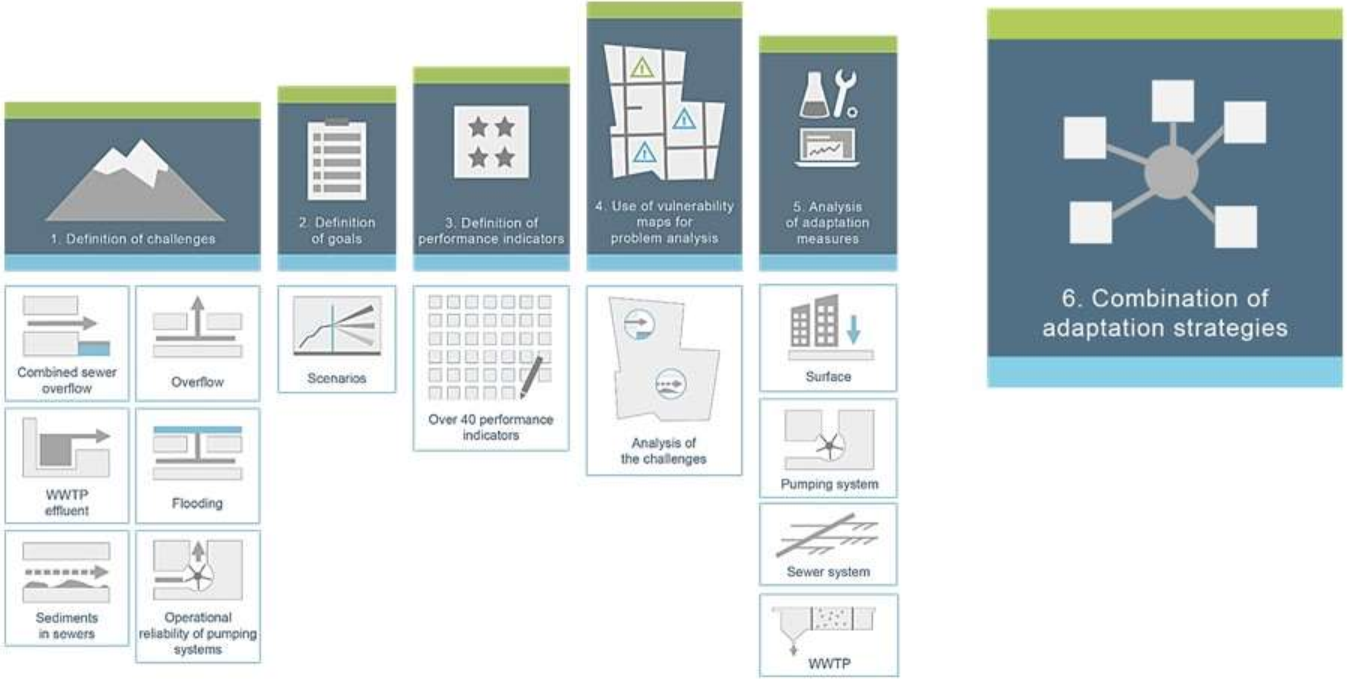


Research tools

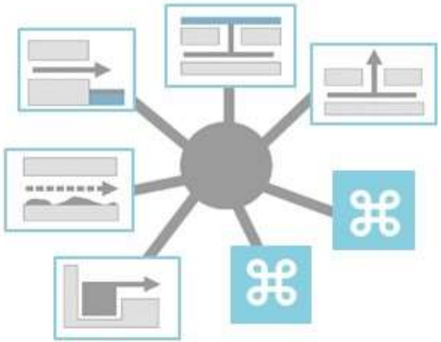




Step 6: Combination of adaptation strategies



Adaptation strategies

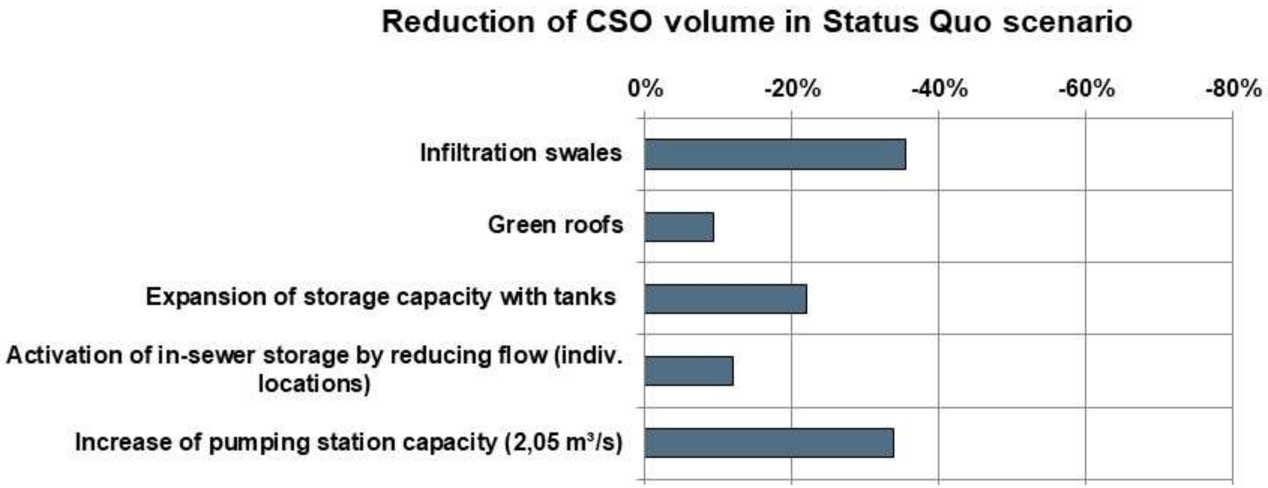


Adaptation strategies for specific goals and the total system

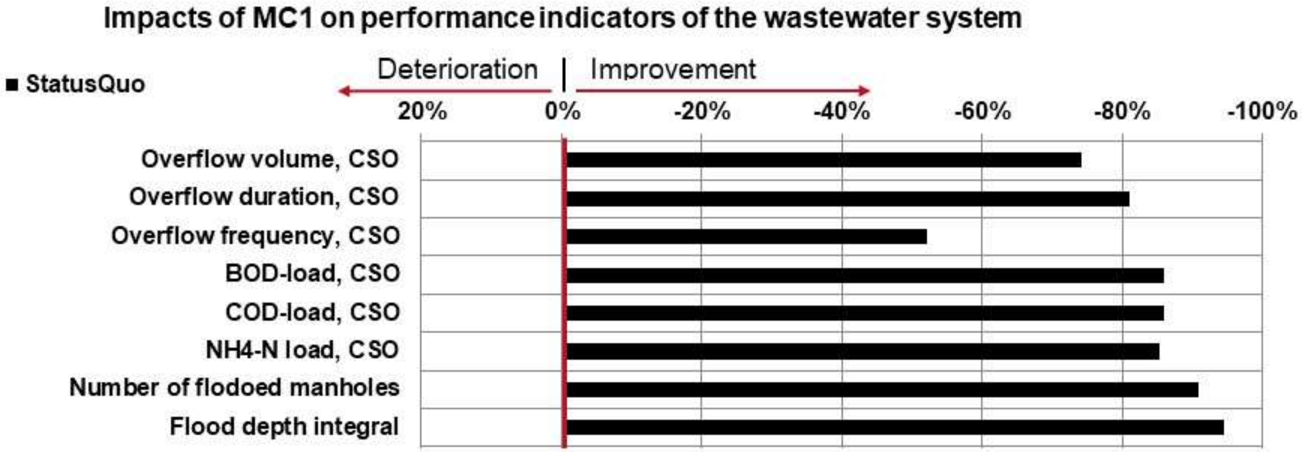
Strategy: Reduction of CSOs
Infiltration swales
Green Roofs
Extension of storage capacity
In-sewer storage activation
Increase of pump capacity
Operational measures on the WWTP

Step 7: Evaluation of adaptation strategies

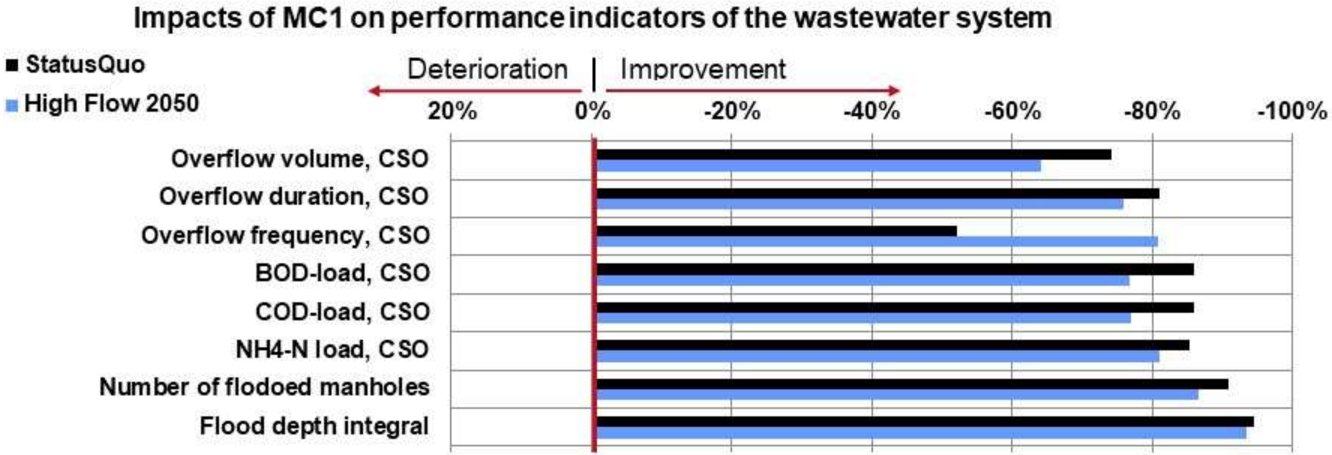
Example: Reduction of CSOs



Effectiveness of measure combination „Reduction CSOs“

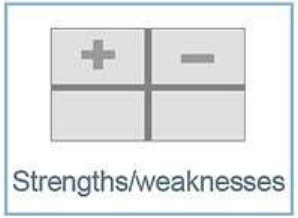


Effectiveness of measure combination „Reduction CSOs“



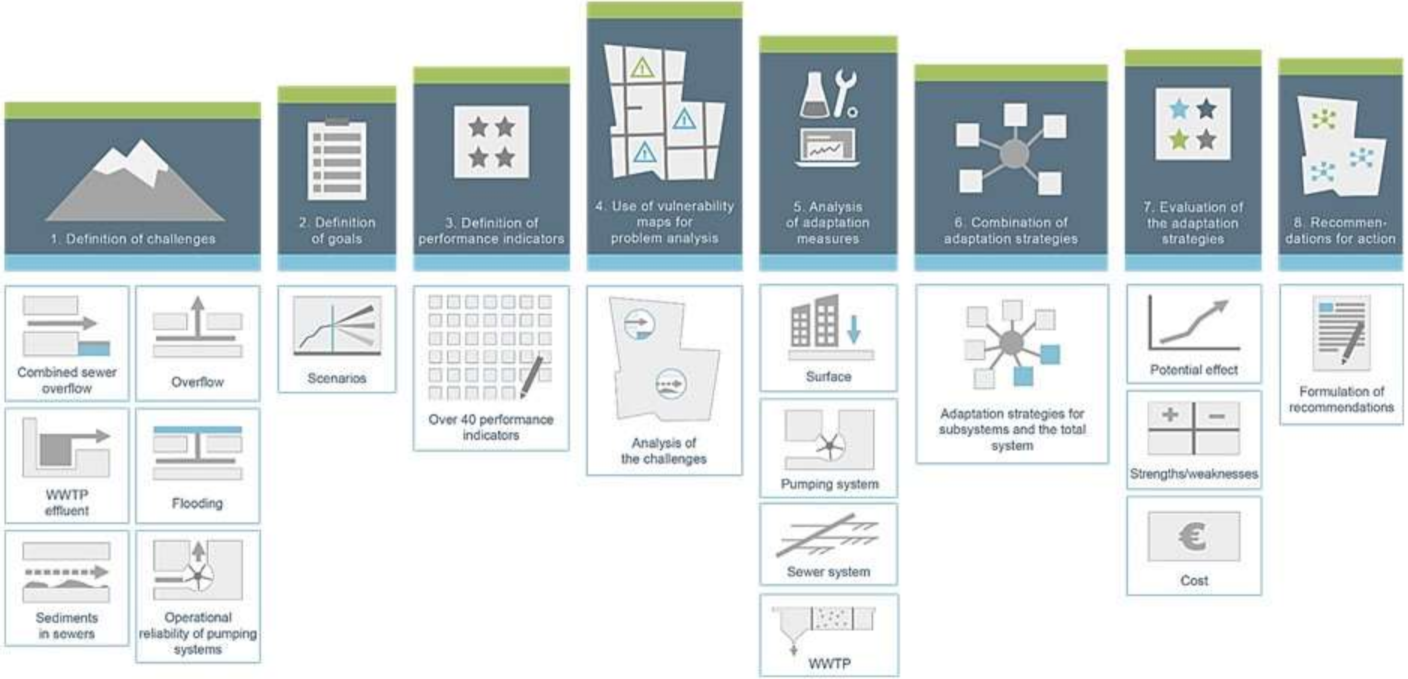
Further evaluation of adaptation strategies

Cost evaluation



Strengths, weaknesses, risks

Step 8: Recommendations for action

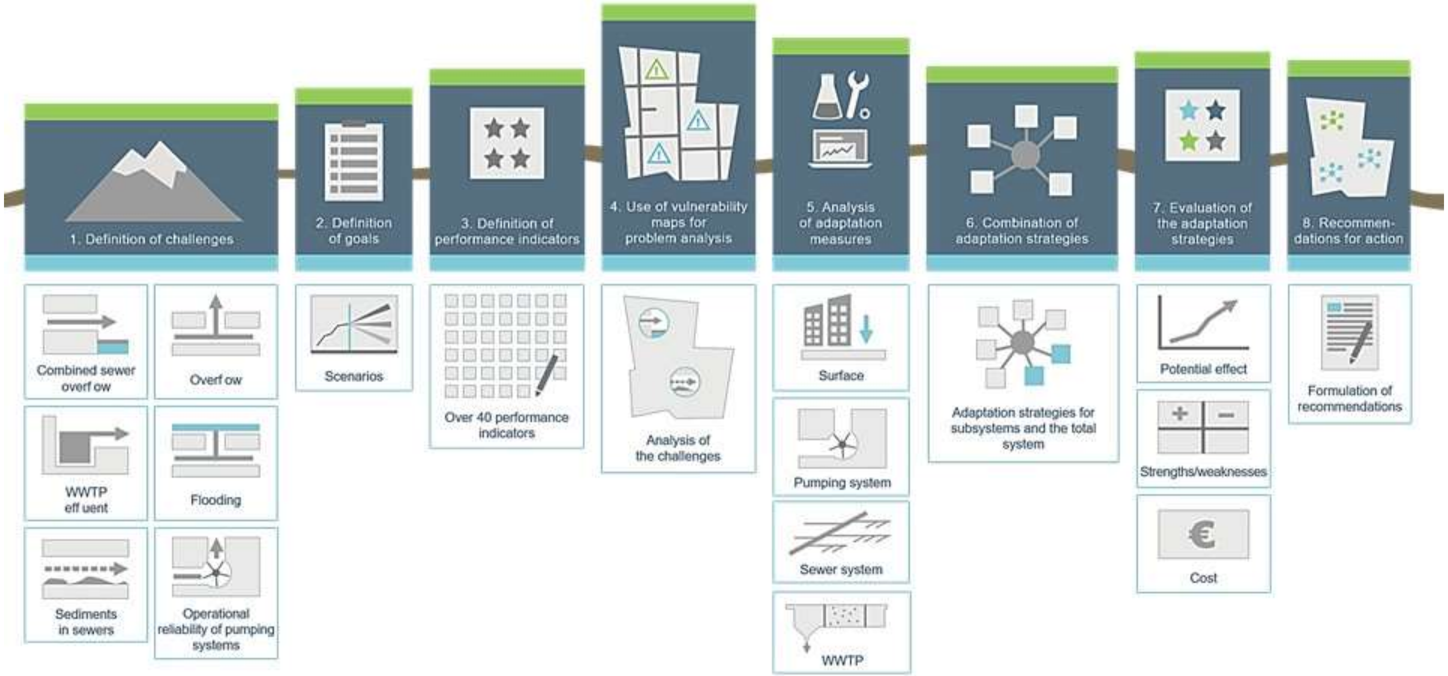


Findings and Conclusions

- **The developed method that was tested for Berlin makes sense and works!**
- **Method to find local adaptation strategies!**
- Large potential for adapting UWWS using **measure combinations → synergies!**
- Measure combinations and adaptation strategies have to be **evaluated for the whole UWWS**
- **Results described in Measure catalogue and practical Guidelines**

Thank you for your attention

Raja-Louisa Mitchell
raja-louisa.mitchell@tu-berlin.de


1. Definition of challenges
2. Definition of goals
3. Definition of performance indicators
4. Use of vulnerability maps for problem analysis
5. Analysis of adaptation measures
6. Combination of adaptation strategies
7. Evaluation of the adaptation strategies
8. Recommendations for action
Combined sewer overf ow
Overf ow
WWTP eff uent
Flooding
Sediments in sewers
Operational reliability of pumping systems
Scenarios
Over 40 performance indicators
Analysis of the challenges
Surface
Pumping system
Sewer system
WWTP
Adaptation strategies for subsystems and the total system
Potential effect
Strengths/weaknesses
Cost
Formulation of recommendations

LESAM 2017
NTNU, Trondheim, Norway

Presentation 5

Antonio Fortunato: Assessment of risks that can affect a regional water supply system

Assessment of the risks that can affect a regional water supply system: a case study

A. Fortunato, *C. Arena, M. Cannarozzo, A. Lombardo, I. Scolaro, M.R. Mazzola*

Dipartimento di Ingegneria Civile, Ambientale, Aeronautica, dei Materiali - DICAM
Università degli Studi di Palermo

UNIVERSITÀ DEGLI STUDI DI PALERMO

Introduction

Regional water supply systems provide millions of inhabitants with drinking water in areas of several thousands square kilometres and include a variety of supply sources, as well as water treatment plants and pumping stations.

The main issues in the management of such systems lie in finding appropriate, least-cost, operation rules in their current configuration, and understanding the best structural alternatives to improve service performances.

It is crucial the satisfaction of towns and villages' water demands with continuity and an adequate level of reliability.

A preliminary risk assessment analysis is essential in order to prioritize and select the possible alternatives to improve or preserve system's performances and reliability.

The paper describes a study, currently in progress, focused on the evaluation of the risks that can affect the regional water supply network managed by an Italian water utility, resorting to a detailed simulation/optimization model.

Methodology (1/2)

1. In a first phase, the more relevant, possible risk events have been identified and described, together with the company technical staff.

2. The probability of occurrence of each risk event has then been assessed based on historical data available to the utility.

3. Subsequently, based on the results of a detailed and reliable model of the system, the effects of the risk events have been evaluated in terms of water supply deficit, that can be ultimately expressed as the cost of an alternative supply.

If the system can face a specific risk event without any supply shortfall, the effects can be evaluated in in terms of operational costs increase.

4. Finally, the risks can be evaluated in terms of expected annual supply shortfall or expected annual costs increase.

Alternatively, the risks can be expressed as the probability level of occurrence multiplied by the consequent effects:

Methodology (1/2)

Probability of Failure		Consequence of Failure: Very Low 1	Low 2	Medium 3	High 4	Very High 5
Very Low	1	1	2	3	4	5
Low	2	2	4	6	8	10
Moderate	3	3	6	9	12	15
Quite Likely	4	4	8	12	16	20
High	5	5	10	15	20	25
Very High	6	6	12	18	24	30
Almost Certain	7	7	14	21	28	35

From: Asian Development Bank, 2013.

System description

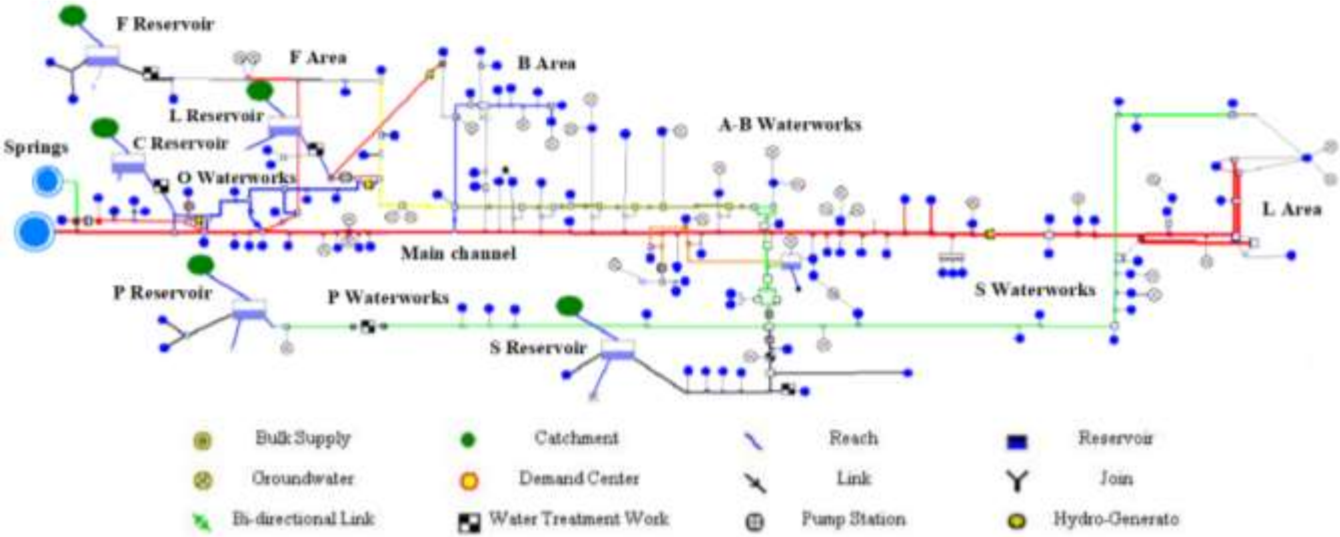
- The regional water network under study consists of a large and complex system supplying more than 4.000.000 inhabitants, over an area of about 20.000 km^2.
- It is a multi-purpose system with conflicting uses, mainly municipal and irrigation.
- It consists of 5 main aqueduct schemes, with over 1.300 km total length, and features 5 multipurpose reservoirs, with a total active capacity of around 900 Mm^3.
- Other important water sources are the springs, that supplied 4.900 l/s on average in the last 18 years, and about 200 wells located throughout the region, capable of 3.850 l/s.
- The system is capable of conveying about 790 Mm^3 per year.

Model of the system (1/2)

The system was modelled using *Aquator*, a state-of-the-art application for complex water network simulation and operational optimization by *Oxford scientific software*.

The model, that best represents the water system’s topology and operation under ordinary conditions, featuring around 100 demand centres and 350 links, was tested and validated together with the technical staff of the water utility.

It is a refinement and up-date of a model developed during a previous study and runs on an annual basis with a daily time step.



Model of the system (2/2)

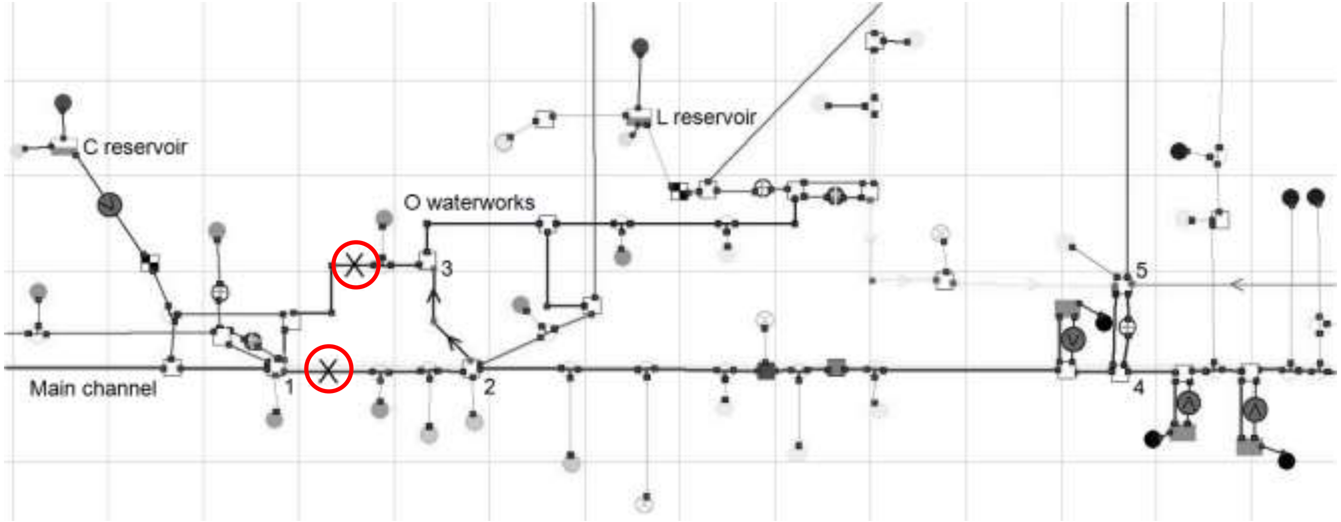
The derived-models describing the occurrence of each risk event have been calibrated and their results have been validated based on events already happened in the past.

If the model simulating the occurrence of a specific risk event is well calibrated and conditioned, so as to reproduce all the viable operational options to minimize performance shortfall, the risk evaluated is the residual risk after the adoption of the optimal operational rules.

These risks can be further reduced with the implementation of structural measures.

Risk events considered (1/3)

Water main breaks: the collapse of the Main channel and the failure of O waterworks, both passing through an area prone to landslides, are the most relevant for the utility.



The former occurs on average once every ten years and entails the unavailability of the broken channel segment for four months, due to the repair works. The latter occurs on average once every five years and the repair works last one month.

Risk events considered (2/3)

Water quality issues: The more relevant resources quality risk for the utility is the algal bloom in some reservoirs. The reservoir more subject to this phenomenon is F reservoir, where *planktothrix rubescens* is endemic and a significant bloom occurred in recently.

It is a complex event that involves many factors (water temperature, nutrients concentration, turbidity, water level, water column stratification, etc.) and whose study would require the construction of a detailed quality model.

In this project its probability of occurrence has been deducted looking at the environmental condition that in the past led to an algal bloom in F reservoir.

The main triggering factor turned out to be the low reservoir level during the autumn, and the consequent high concentration of nutrients, which happens on average every 4 years.

The phenomenon, which implies a reduction of the flow rate provided by the water treatment plant downstream the reservoir to about 15% of its maximum capacity (2.400 l/s), lasts about 3 months, starting from the beginning of the following year.

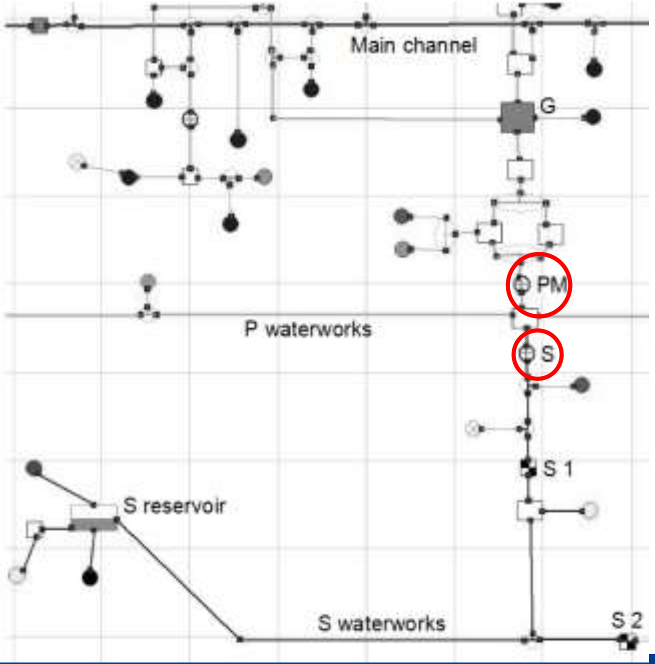
Risk events considered (3/3)

Drought: Based on historical data, it will be identified a high severe scenario entailing a significant reduction of the inflows to several reservoirs at the same time. Initial reservoirs levels and springs flow rates will be also considered.

Unavailability of pumping stations and water treatment plants: It is not due to their layout and functionality, but it mainly stems from the interruption of the electricity supply.

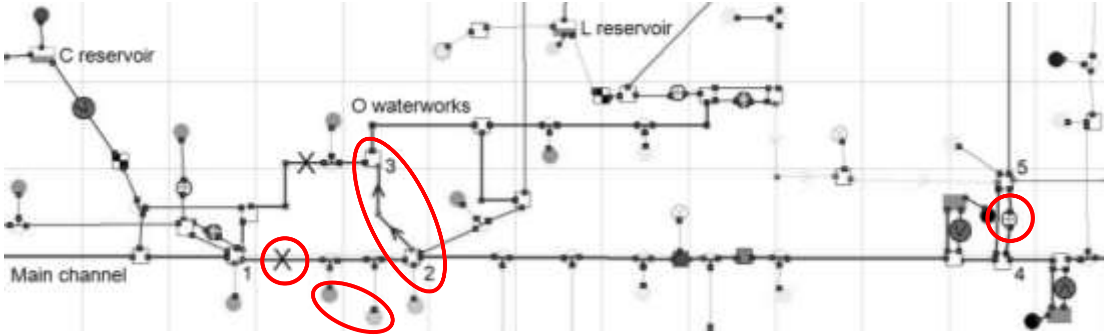
The event considered consists in the simultaneous unavailability of S and PM pumping stations.

The most severe power interruptions last up to 16 hours and occur about four times a year, during spring, summer and autumn, when rainfall events are more intense and are associated with strong winds.



Intermediate results (1/7)

Collapse of the Main channel:



Considering that pipeline 2-3 can operate in reverse flow, the failure will entail the unavailability of the channel segment between nodes 1 and 2 for four months.

In similar conditions, the flow direction, which is usually from node 4 to node 5, is also reversed by closing the pipeline 4-5 and activating the pumping station.

The months considered are the four warmest during the year: June, July, August and September.

Intermediate results (2/7)

A water supply shortage for the municipal sector of about 2 Mm^3 on an annual basis, corresponding to 0,4% of the total volume supplied under ordinary operation conditions (470,79 Mm^3), was determined, due to the impossibility to supply the service connections between node 1 and node 2.

Since the annual probability of occurrence is 10%, the supply shortage has a negligible expected annual value of $0,10 \times 2 = 0,2$ Mm^3.

It must be however underlined that this good performance cannot be expressed at present because the hydraulic conveyance capacity of pipeline 3-2 in reverse flow mode cannot be fully exploited due to its bad physical condition, which force to limit the pressure head at node 3.

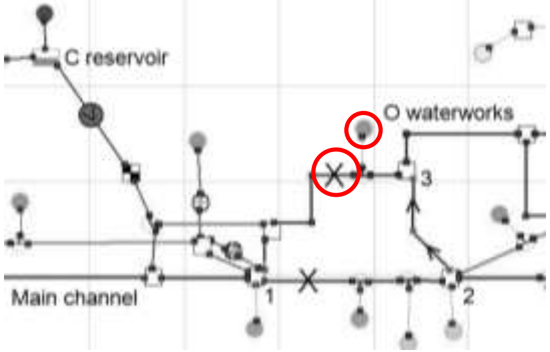
This latter consideration prompts the need to schedule the replacement/rehabilitation of the pipeline in order to preserve the system's performance and increase its reliability.

Intermediate results (3/7)

Failure of O waterworks:

The month considered for the interruption is August.

A water supply shortage of about 0,1 Mm^3 on an annual basis, corresponding to 0,02% of the total volume supplied under ordinary operation conditions, was determined, due to the impossibility to supply the service connection between node 1 and node 3.



Since the annual probability of occurrence is 20%, the supply shortage has a negligible expected annual value of $0{,}2 \times 0{,}1 = 0{,}02$ Mm^3.

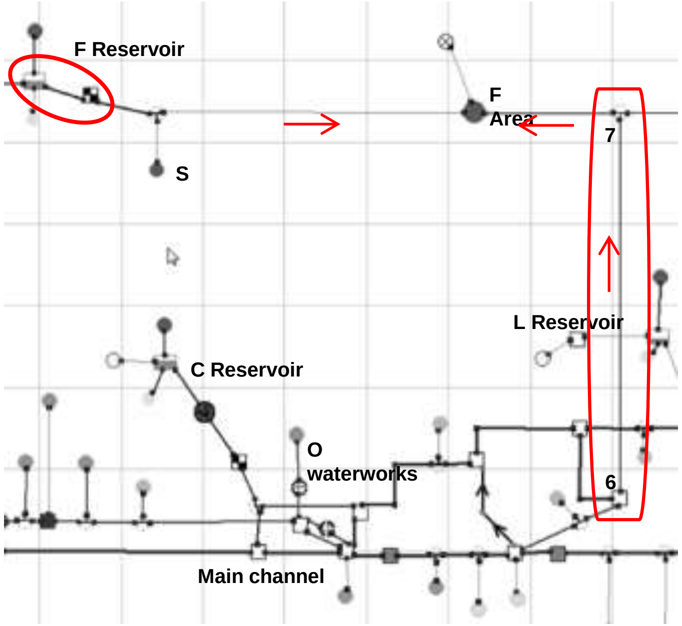
Intermediate results (4/7)

Algal bloom in F reservoir:

The reduction of flow rate provided by the water treatment plant lasts three months: January, February and March.

A water supply shortage of about 5,54 Mm^3 on an annual basis, corresponding to 1,18% of the total volume supplied under ordinary operation conditions, was determined.

Since the annual probability of occurrence is 25%, the supply shortage has an expected annual value of $0,25 \times 5,54 = 1,385$ Mm^3.



The supply shortage is concentrated at demand centres S and F area, that can be only supplied by F reservoir and pipeline 6-7, whose maximum capacity is completely exploited.

This latter consideration prompts the need to schedule the development of the pipeline in order to preserve the system's performance and increase its reliability.

Intermediate results (5/7)

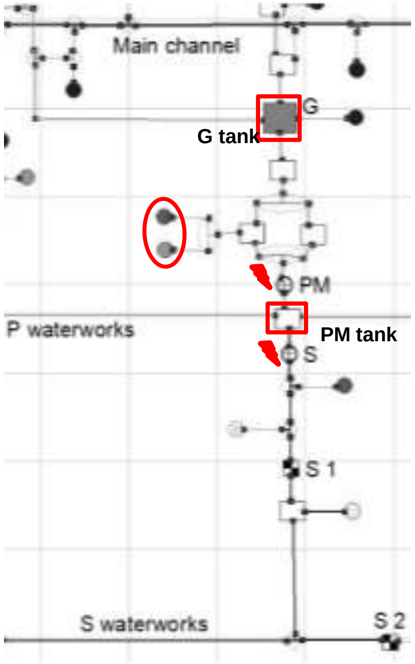
Blackout: On an annual basis this is actually not a risk event but almost a sure event, since it happens more than once every year.

Furthermore, the system features many tanks throughout the network, which can guarantee a normal supply for at least a couple of days.

G tank is a strategic reserve that alone can guarantee supply continuity for several hours.

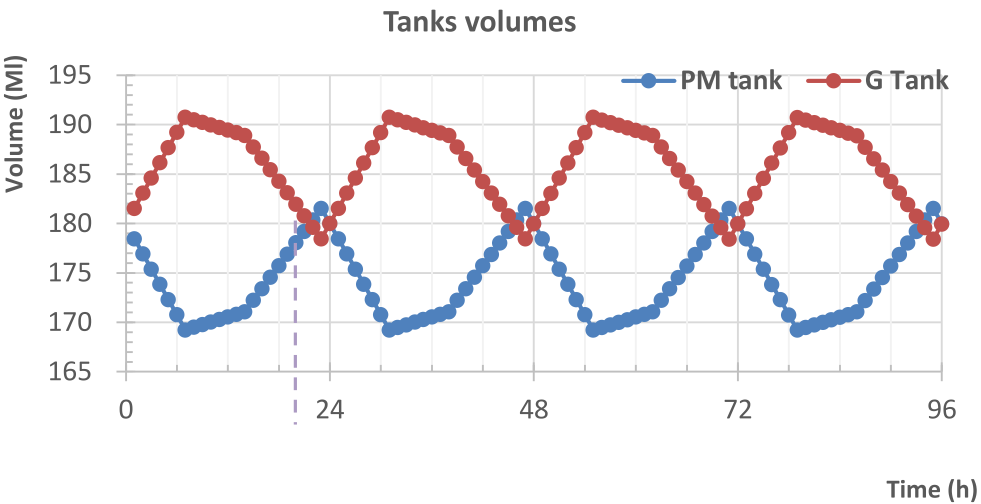
It is however important to quantify how long it takes for the water level to reach 2 m (76 Ml), when changes in flowrates from the tank occur.

This analysis required the implementation of a daily optimization model with hourly time step (a day of August was reproduced).



Intermediate results (6/7)

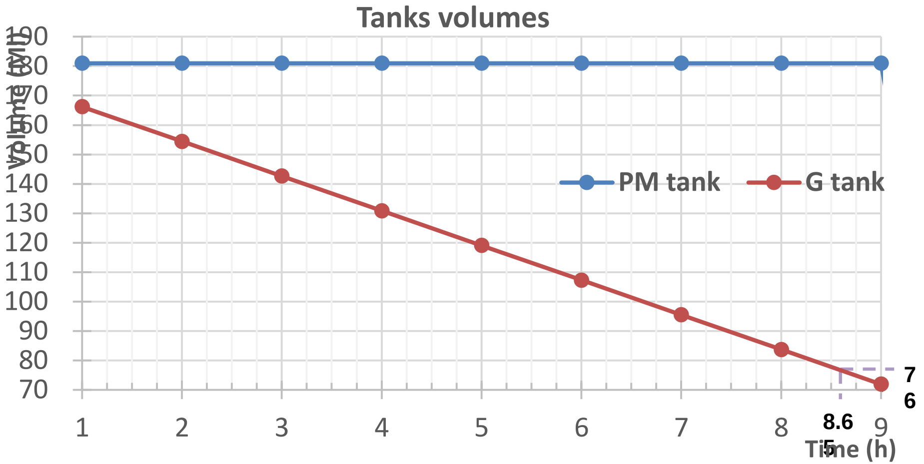
Subsequently, an optimized operation of PM pumping station, with respect to electricity cost during the day, was impemented in order to identify the minimum level at G tank:



Volumes (Ml)		
Hours	**23:00**	7:00
PM tank	181,5	169,2
G tank	**178,4**	190,7

Intermediate results (7/7)

Blackout simulation starts at 23:00:



There are 8h 39' to act before del level in G tank reaches 2 m.

Hours		Time step	G tank (Ml)	PM tank(Ml)
23:00	0:00	1	166,21	181,00
0:00	1:00	2	154,42	181,00
1:00	2:00	3	142,63	181,00
2:00	3:00	4	130,84	181,00
3:00	4:00	5	119,06	181,00
4:00	5:00	6	107,27	181,00
5:00	6:00	7	95,48	181,00
6:00	7:00	8	83,69	181,00
7:00	8:00	9	71,90	181,00

During the simulation a reduction of supply of 2.3% was obsserved, compared with the volumes supplied under ordinary conditions, due to the impossibility to supply the demand centres between PM pumping station and G tank.

Conclusions

It has been described a study, that is being conducted for an Italian water utility, aimed at evaluating the risks that can affect the regional water supply network managed by the utility, by means of a detailed simulation/optimization model of the system.

The supply network has been modelled in Aquator environment and the model simulating its ordinary operation conditions has been tuned and validated together with the technical staff of the utility.

The results of the this analyses demonstrate the advantages of resorting to such simulation/optimizations models for the evaluation of possible risk events' effects and the identification of the best operational measures, as well as structural investments, aimed at their minimization.

Thank you for your attention.

Presentation 6

Rita Ugarelli : Flood risk management in small catchments and urban areas with a Klima 2050 perspective

SINTEF

LESAM 2017
NTNU, Trondheim, Norway

URBAN AREAS WITH A KLIMA 2050 PERSPECTIVE

G. Raspati, R.M. Ugarelli, M. Ahmadi, E. Siversten
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Rita.ugarelli@ntnu.no

Outlines

- KLIMA 2050
- WP 2 STORMWATER MANAGEMENT IN SMALL CATCHMENTS
- PRELIMINARY STEPS FOR THE DEVELOPMENT OF A RISK ASSESSMENT FRAMEWORK IN KLIMA 2050
- FURTHER STEPS


KLIMA
2050
RISK REDUCTION THROUGH CLIMATE ADAPTATION
OF BUILDINGS AND INFRASTRUCTURE

Centre for Research-based Innovation (SFI)

- To strengthen innovation through long-term research in close cooperation between companies and research environments (5 + 3 years).
- To develop competence at a high international level in areas that are important for innovation and value creation.
- To strengthen technology transfer, internationalization and research education.
- To be co-financed between companies, host institutions and the Research Council.

Goals

- *Klima 2050* will reduce the societal risks associated with climate changes and enhanced precipitation and flood water exposure within the built environment.
- Emphasis will be placed on development of
  - moisture-resilient buildings,
  - stormwater management,
  - blue-green solutions,
  - measures for prevention of water-triggered landslides,
  - socio-economic incentives and decision-making processes.
- Both extreme weather and gradual changes in the climate are addressed.

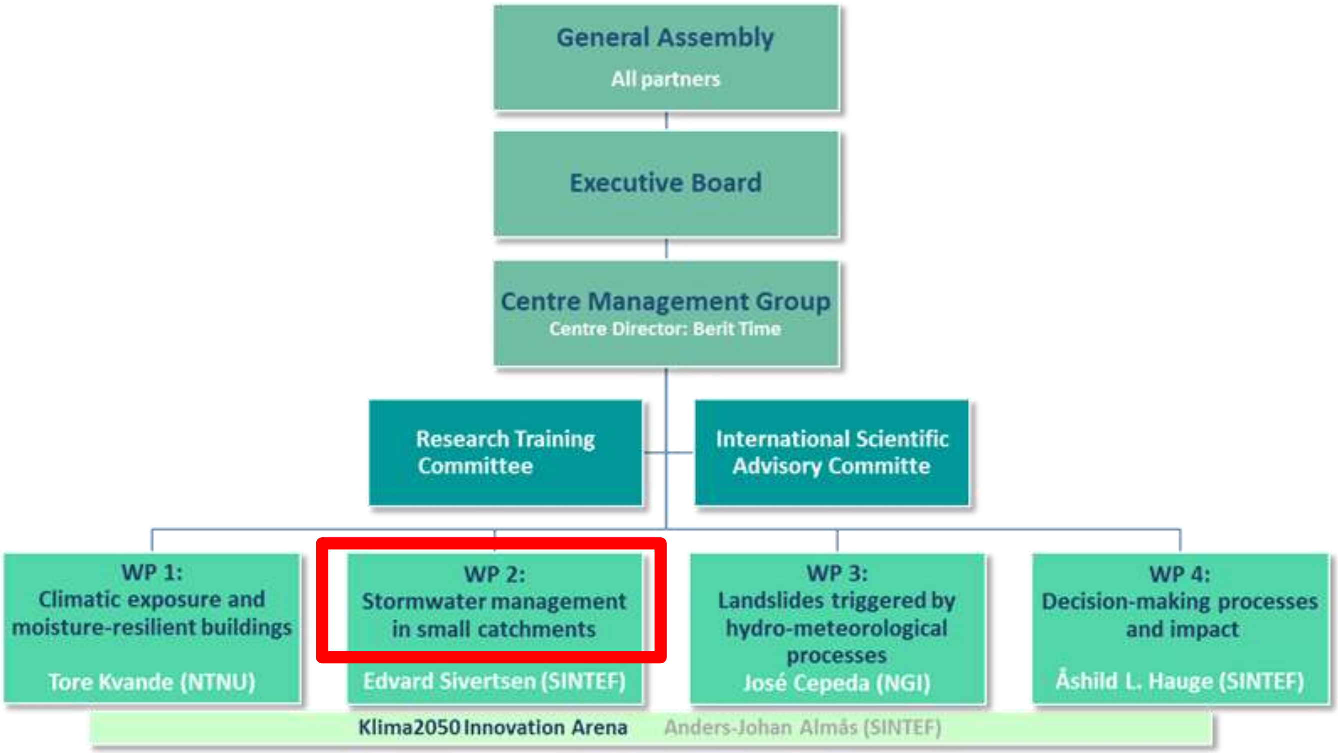



Photos: Internett

International collaborators

- KU Leuven, Belgium
- Chalmers University of Technology, Sweden
- Luleå Technical University, Sweden
- University of Minnesota, U.S
- University of Vienna, Austria
- Lomonosov Moscow State University, Russia
- IFSTTAR (French institute of science and technology for transport, spatial planning, development and networks), France

Organisation of Klima 2050



WP 2 STORMWATER MANAGEMENT IN SMALL CATCHMENTS

Research tasks

WP 2.1 Analysis of inventory databases including flooding damage data (Resp. Nathalie Labonnote, SINTEF)

WP 2.2 Flood risk management modelling (Resp. Mehdi Ahmadi, SINTEF)

WP 2.3 Blue-green solutions in urban environment (Resp. Gema Raspati, SINTEF)

WP 2.4 Innovative technical solutions for stormwater management (Resp. Kamal Azrague, SINTEF)

Flood risk management modelling (Klima 2050 WP2.2)

- Review of existing flood risk frameworks/guidelines for small catchments and urban areas, including robust open floodways.

- Recommendations and possible improvements for flood risk evaluation, including both technical and non-technical aspects.

-

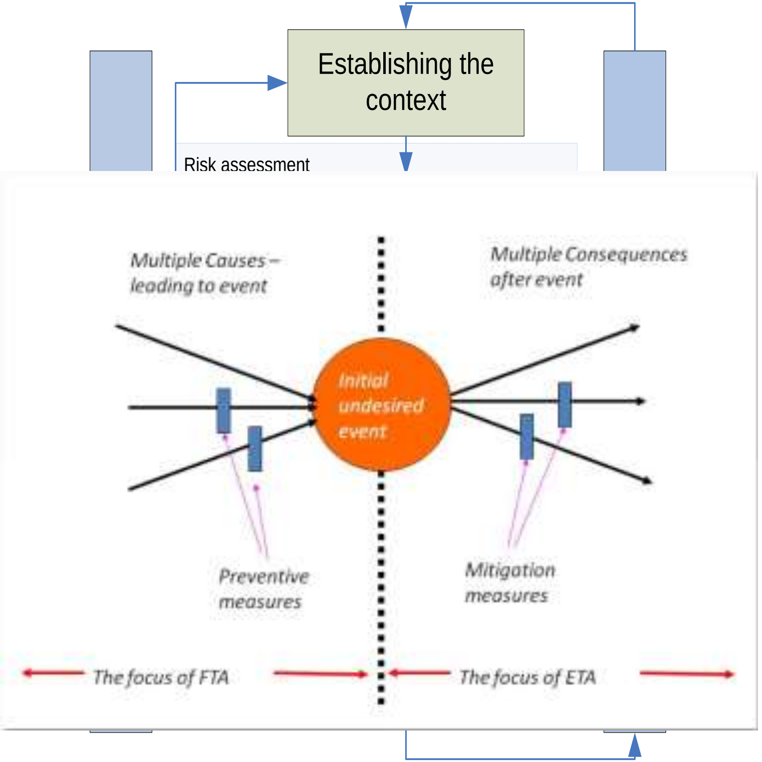
- Development of a risk framework model for flooding in small catchments and urban areas

→ The ultimate objective of the work is to develop a risk management framework enabling risk reduction by considering natural hazards at the planning stage for new infrastructure or for the maintenance and adaptation of existing infrastructure.

Preliminary steps for a risk assessment framework in Klima 2050

The proposed methodology follows the standard steps of a risk management process (ISO 31 000:2009)
The design of a risk assessment framework in WP2.2 follows three phases:

1. the creation of fault trees (FT) (as method to support the risk identification);
2. the creation of event trees (ET) (as method for consequences identification) and
3. the elaboration of risk assessment criteria (for risk evaluation)
4. the Bowtie method is planned to be used as assessment method, for the risk events identified.



Establishing the context

"Establishing the context" is not fully developed - But, to set the context of meaningful risk identification activity, a list of definitions was adopted (to be updated along the project and specific cases)

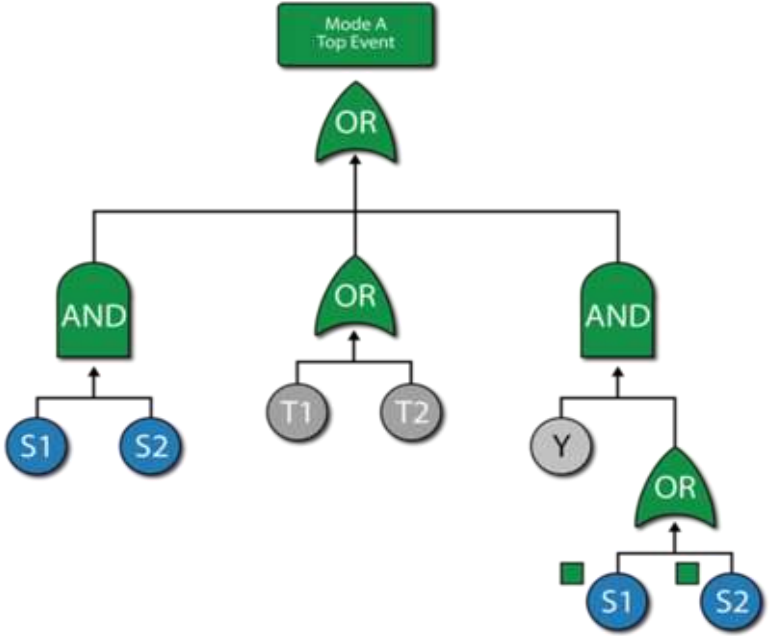
Term	Definition
Small catchment	A "Small catchment" is a catchment whose surface is below 50 km^2.
Reference rainfall	A rainfall with the return period of 200 years is considered as the reference rainfall
Hazard	Hazard generally defined as "a potential source of danger" is defined as the rainfall in WP2.2.
Risk assessment framework	This term is defined within WP2.2 as a methodological approach to identify, quantify and assess risks related to a given hazard in a holistic approach.
Infrastructures	The considered infrastructures within this task are roads and railways.

Risk identification

- The RI phase is supported by the creation of qualitative (at this stage) Fault Trees, to identify the failure modes, from hazard to event as expected to happen in the established context.

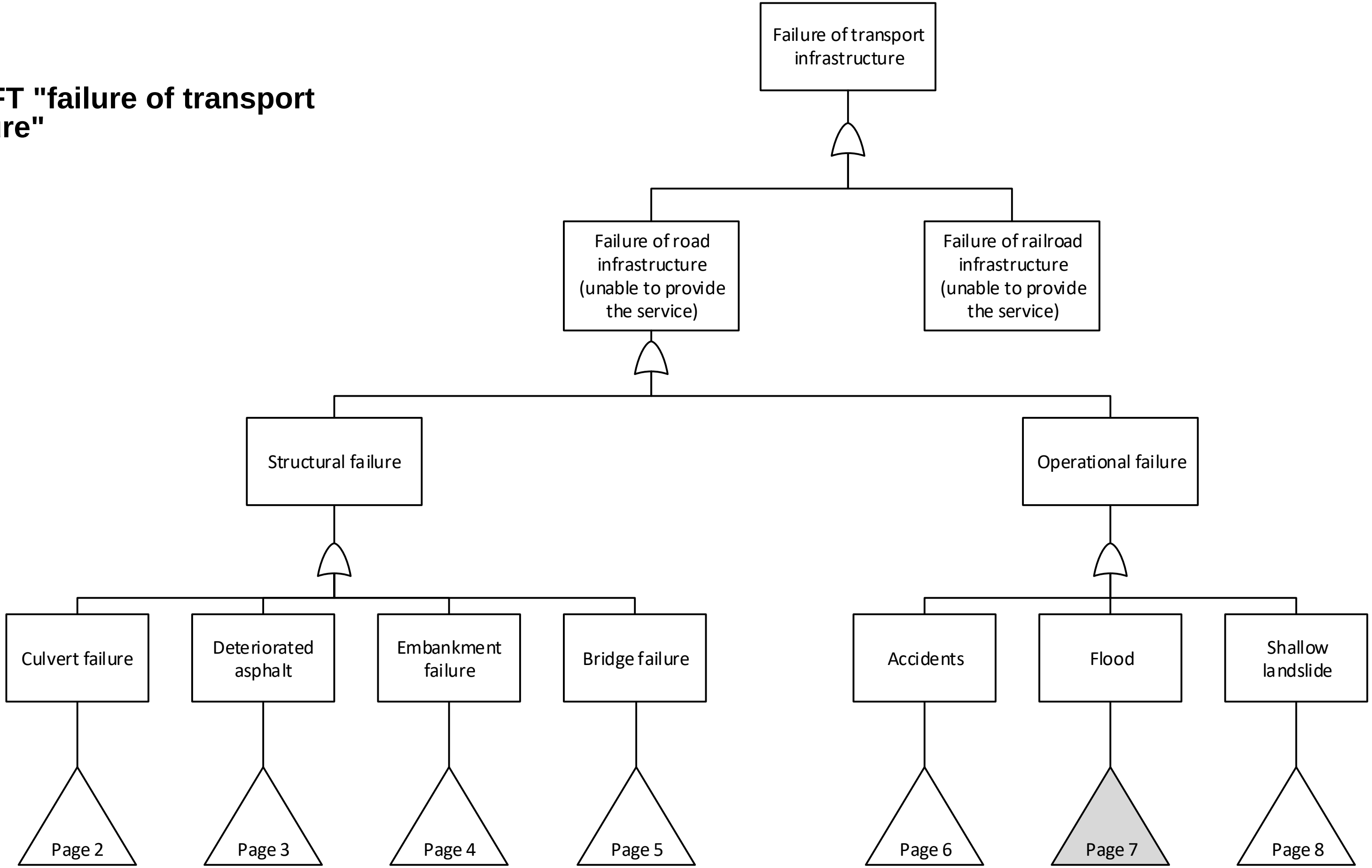
- The exercise will provide us with a list of fully described significant events, to be then analysed.

- Additional scope of the qualitative FT is to plan the activities to model the basic events and estimate, when possible, the corresponding probabilities in selected case studies.



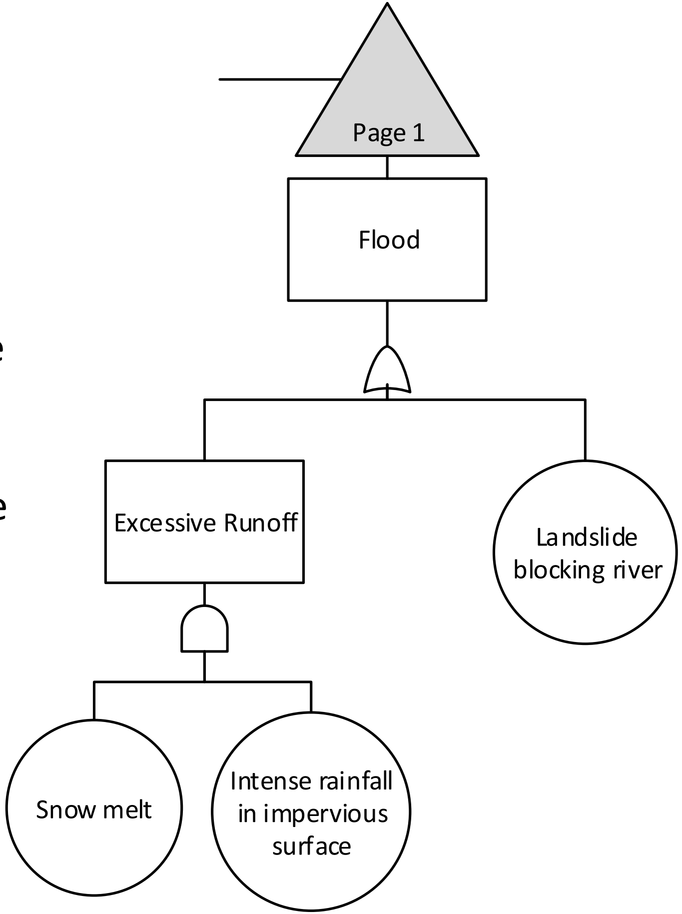
→ The trees, in addition to provide the list of relevant risk events, will also help mapping the research needs within the project and show the interactions between work packages.

Simplified FT "failure of transport infrastructure"



Simplified Sub-FT "failure of transport infrastructure"

- When FT are labelled with actual numbers for failure probability, computer programs can calculate the probability of the top event.
- When data are not available, minimal cut sets can be used to understand the vulnerability of a top event.
    - The longer a minimal cut set is, the less vulnerable the top event is to that combination of events.
    - Numerous cut sets indicate higher vulnerability.
    - Cut sets can be used to discover single point failures



FURTHER STEPS

After the concept and underlying methodologies for the three steps in the risk assessment framework has been established, next steps will be to

1. involve relevant partners in Klima 2050 and present the methodology,
2. eventually update the concept and methodology based upon input from the partners,
3. together with the partners identify one or two relevant case studies that can be used for testing of the framework,
4. make a risk assessment for a selected case.

Conclusions

- The preliminary steps to design an improved risk framework for flooding in small catchments and urban areas as part of WP2.2. of KLIMA2050 are presented.
- The framework follows the risk management process defined by ISO 31000:2009 and it is planned to adopt the bowtie method for risk analysis and evaluation.
- The framework development is at early stage and currently focusing on the risk identification phase with qualitative fault tree.
- The creation of the fault trees is twofold:
  - provide the list of all possible hazards affecting in a direct or indirect way the top events,
  - help mapping the research needs of the project, promoting Master, PhD and Post-doctoral studies target to the project requirements.

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SINTEF

Thank you for your attention!

Questions?

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