NYC Advanced Analytical Sewer and Water Main Replacement Planning

Annie Vanrenterghem Raven, PhD
infraPLAN

INFRA 2014
CONGRÈS | 20E ÉDITION
Vers une nouvelle dynamique municipale pour une urbanité durable
1ER AU 3 DÉCEMBRE | PALAIS DES CONGRÈS DE MONTRÉAL

- infraPLAN
- NYC Project

infraPLAN

- Solutions to manage buried (non inspected or inspected) linear assets
- Main questions:
  - How much money is needed for the next 20 years?
  - What projects should be addressed in priority?
- Consulting; tools development; training; “infraPLAN Service”
- Answers using utility data and advanced approaches
- Based in NYC

Utilities served

- Anchorage
- Apple Valley Rancho
- Aquarion Water of Ct (2008-2014)
- Boston
- Columbus
- Dallas
- Denver
- Las Vegas
- Los Angeles (Park Water)
- Montreal
- New York
- Philadelphia
- San Diego
- San Francisco

NYC Project 2012-2014

- Team
- Objective
- System
- Tasks – Results

Team

- Malcom Pirnie/Arcadis
- D&B
- infraPLAN

Objective

"The primary goal of this project is the development of a standardized methodology to evaluate linear asset condition and criticality and to assign R&R costs resulting in a 50-year cost model."

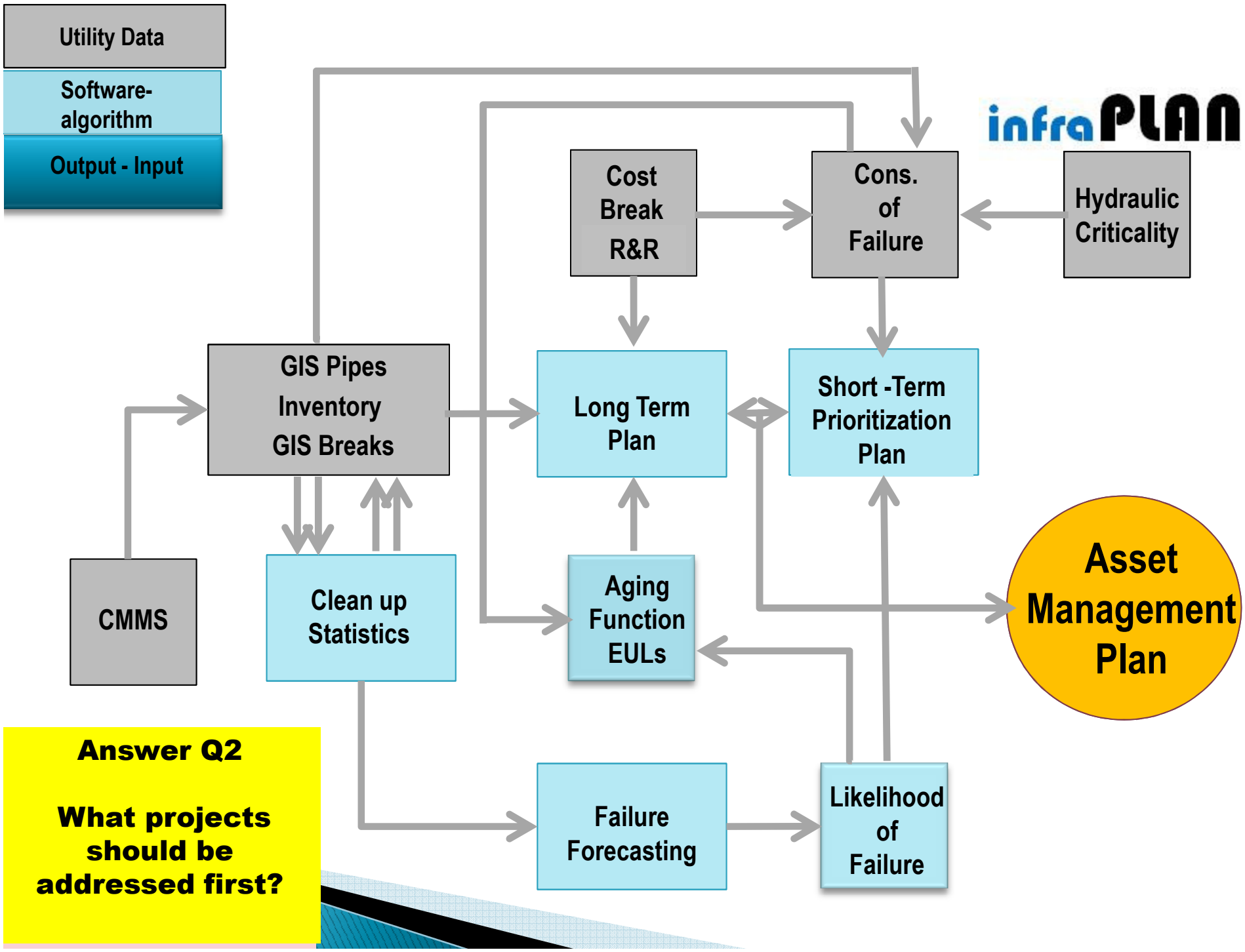
NYCDEP – System

- 9 million customers – 1.2 billion gallon /day
- 5 boroughs (Manhattan, Bronx, Brooklyn, Queens, Staten Island)
- Water
  - 239,714 pipe segments – 6,789 miles
  - Mostly CIP, LCP, DIP, STL
  - Oldest 1840
  - Current Break Rate: Low
  - Average Age: 80-100 yrs old (50-140)
- Sewers
  - Work Order Rate
  - 234,042 pipe segments – 4,565 miles
  - Mostly CP, RCP, VCP, BKR, CIP, ESVP
  - Oldest 1819
  - Average Age: 75 yrs

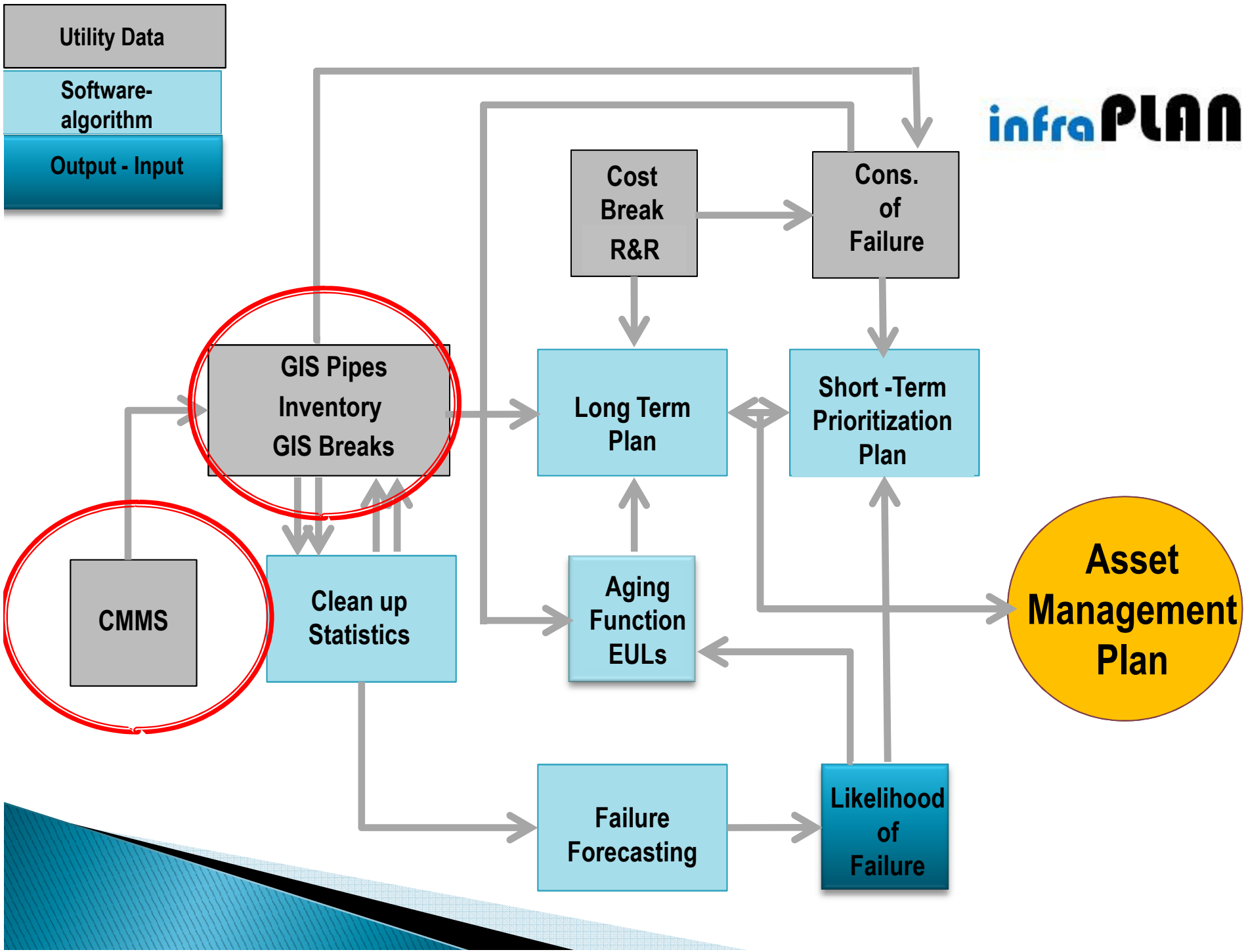
NYC Project 2012-2014

infraPLAN

- Flowchart
- Data availability, analysis and formatting
- Tools used
- GIS-based Consequences of Failure (COF)
- Costs (repair and rehabilitation)
- Statistical failure analysis:
  - Regrouping of mains and sewers
  - Determination of LOF
  - Determination of EULs for each previously-defined group of mains and sewers
- Rehabilitation Needs meeting service levels set by the Bureau
- Risk-based priority score (LOF x COF)
- Development of in-house capacity - Training


Utility Data
Software-algorithm
Output - Input
infraPLAN
Cost Break R&R
Cons. of Failure
Hydraulic Criticality
GIS Pipes Inventory GIS Breaks
Long Term Plan
Short -Term Prioritization Plan
CMMS
Clean up Statistics
Aging Function EULs
Asset Management Plan
Failure Forecasting
Likelihood of Failure
Answer Q2
What projects should be addressed first?

Data availability, analysis and formatting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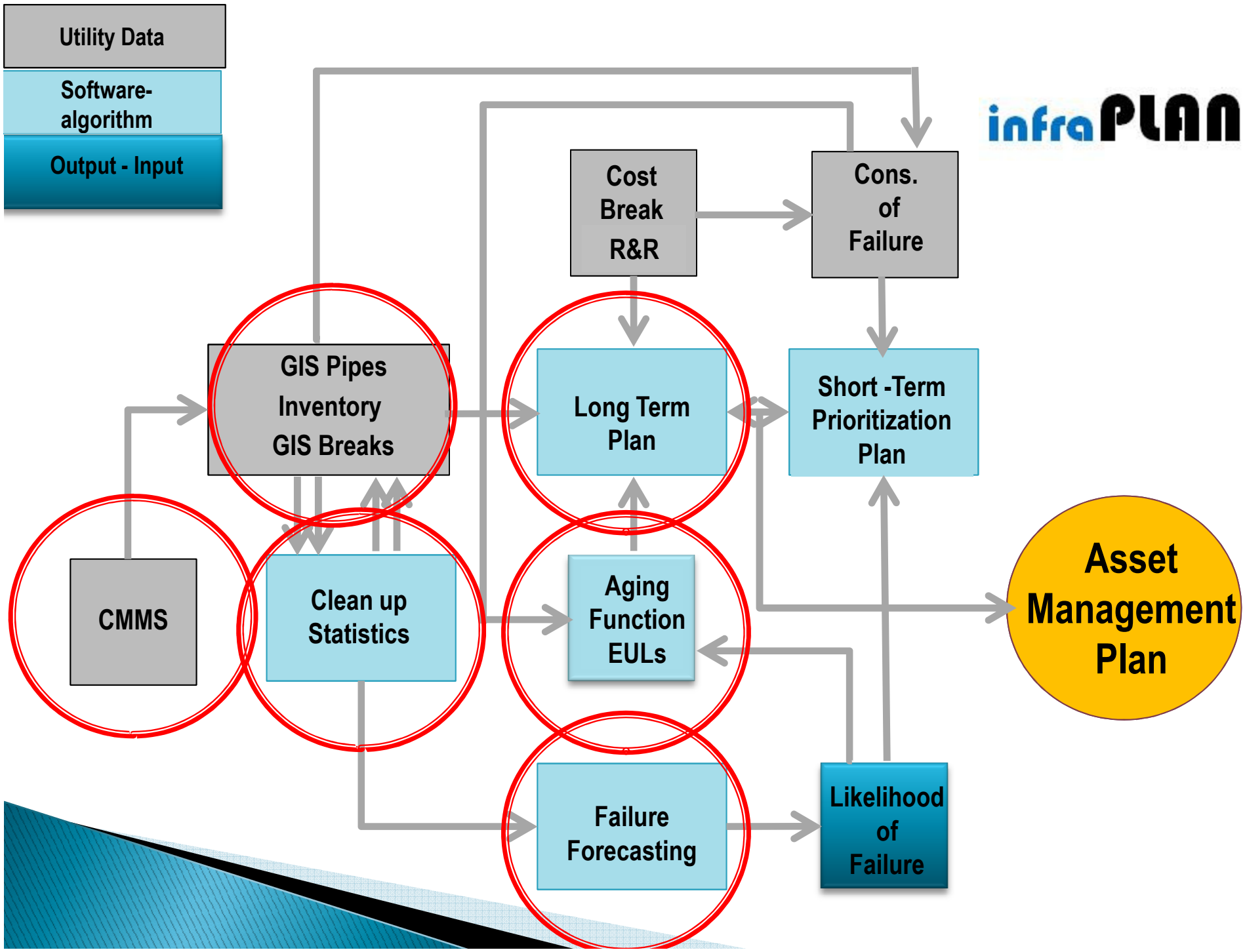
Data availability, analysis and formatting

- Hansen CMMS
- ESRI GIS
- Water main breaks 2000-2011
- Sewer work orders 2005-2011

Tools – Algorithms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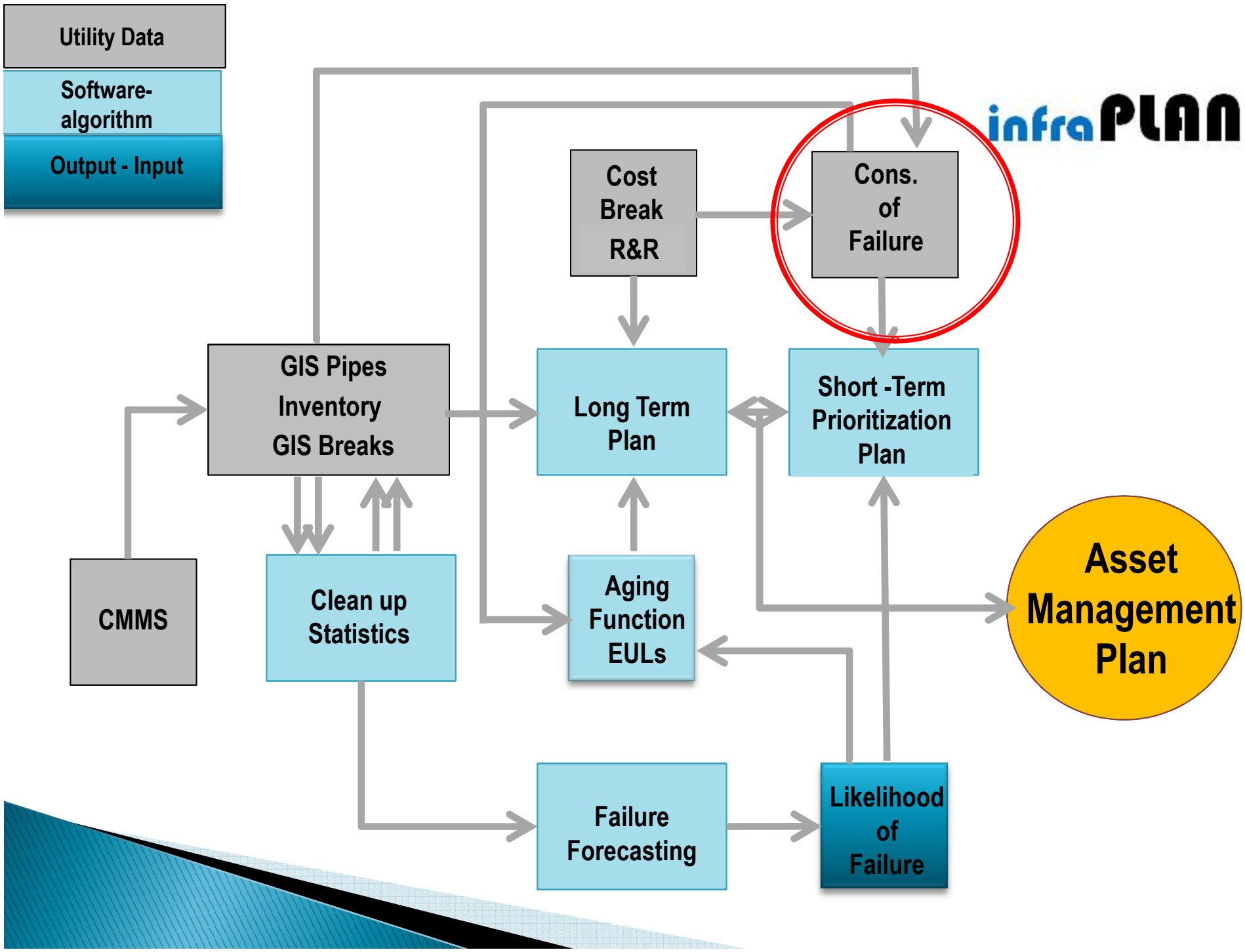
Tools – Algorithms

- GIS
- Clean up algorithm (proprietary)
- Failure forecasting model (free)
- EUL algorithm (proprietary)
- Long Term Planning tool ($8,000 – free)

Consequence of Failure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GIS-based Consequences of Failure (COF)

- Physical Criteria – Cost Impact to Repair
  - Size, Depth
- Performance Criteria – Impact to Customers
  - Number of customers served
  - “Critical Customers” (for super critical water trunk mains)
- Adjacency Criteria – Social/Economic/Environmental Impacts
  - Type of road (arterial, secondary, bridge/tunnel access roads)
  - Under buildings, subways and buffer zones, highways and access roads, railways, airports, canals, rivers, etc.
  - Intercepting wetlands and buffer zones

COF Process

- Water Research Centre (WRc)'s criticality guidelines

- The criteria are "automatic", not weighted; the higher score governs. For example, a water main that meets any of the criteria for Class A and some of the Class B criteria would receive an overall COF score of 3.

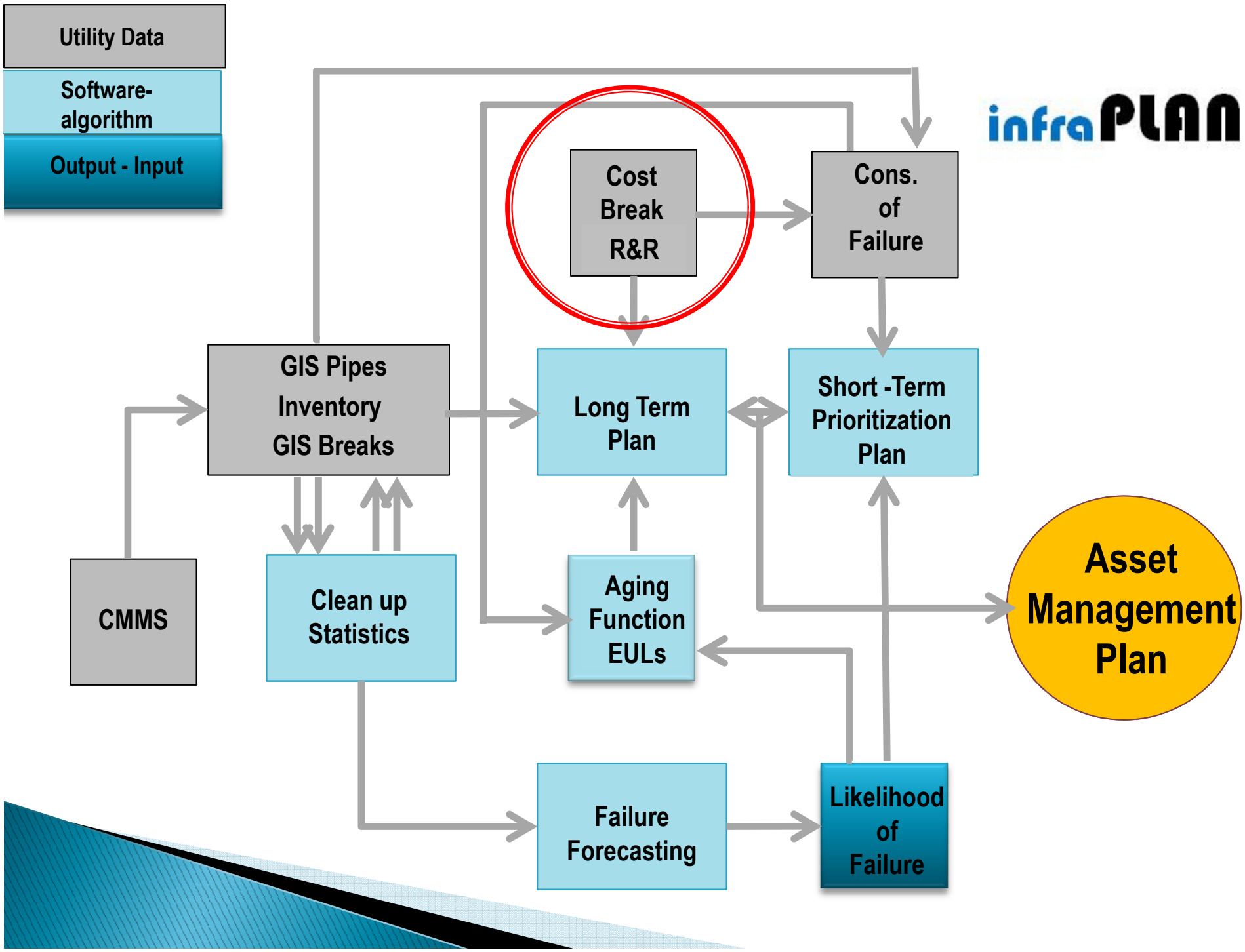
Criticality Criteria and Scoring – Water Mains	Automatic Score*
Class A • Pipes identified as super critical trunk mains that have a single point of connection (no redundancy) or serving critical customers.	Assets meeting any Class A criteria: Score =3
Class B • Pipes above 16-inch that are not included in Class A above. • Pipes intersecting buildings, subways and buffer zones, railways, airports, and water bodies. • Pipes intersecting arterial roads or bridge/tunnel access roads, or secondary roads.	Assets meeting any Class B criteria: Score =2
* High score governs. Pipes not meeting any of the Class A or B criteria are automatically Class C with a criticality score of 1.	

COF and Service Level

- Water:
  - Current Break Rate: x breaks/100 mi/yr. Low.
  - COF 1 Water Break Rate: 6x breaks/100 miles/year
  - COF 2 Water Break Rate: 3x breaks/100 miles/year
  - COF 3 Water Break Rate: x breaks/100 miles/year

- Sewers
  - Current Work Order Rate: y

Cost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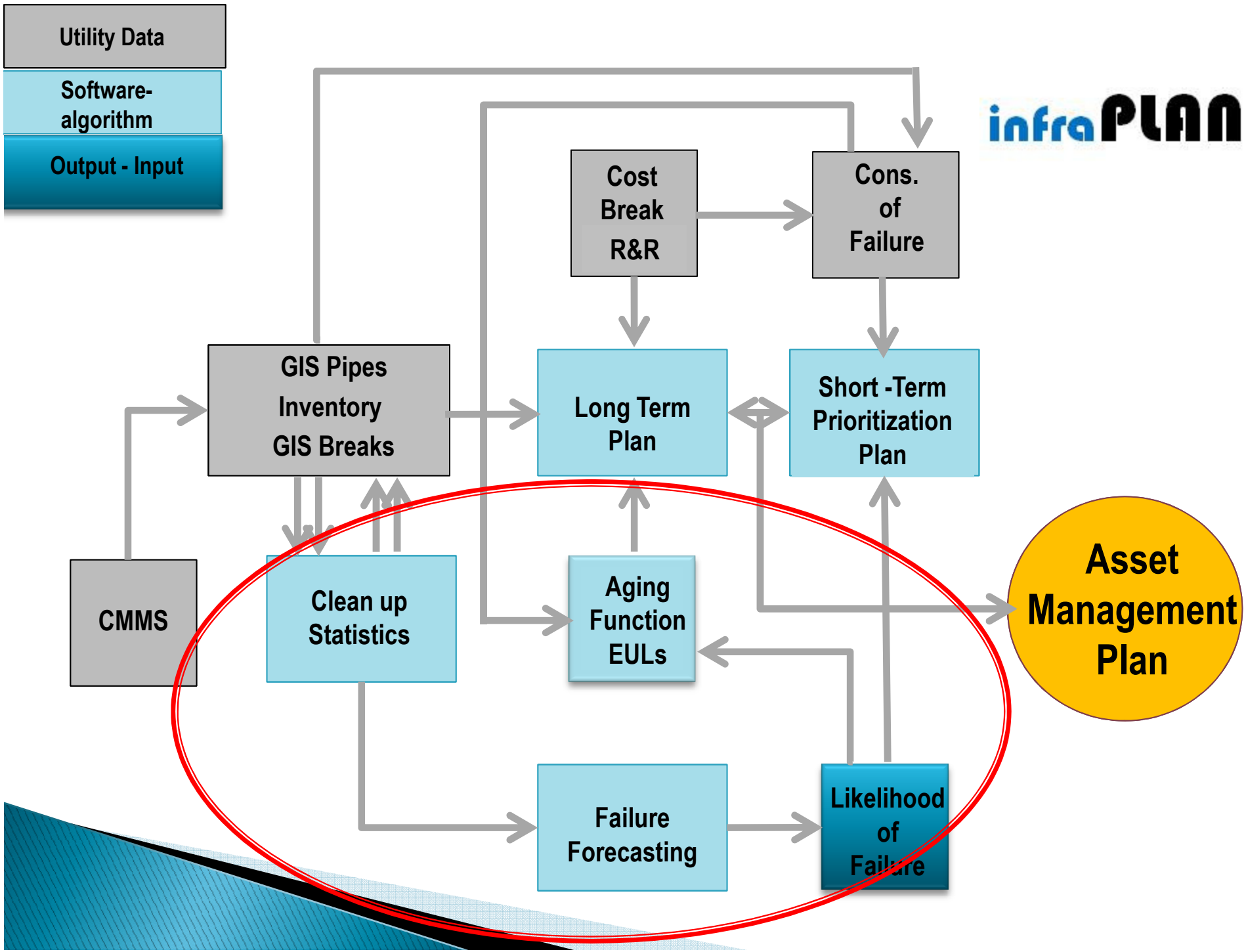
Costs (repair and rehabilitation)

- Water mains:
  - 100% open cut; cost depends on:
  - $800/ft – $4,600/ft based on size and borough

- Sewers:
  - DIAM<=36": 70% relining/30% replacement
  - DIAM>36": 100% relining
  - Replacement: $1,100/ft-$1,500/ft depending on size and borough
  - Relining (all boroughs): $300/ft (<=12") -$3,600/ft (372")

Data clean up and Failure Statistics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Statistical failure analysis Water

- Preliminary statistical study – definition of the cohorts based on :
  - borough
  - date of installation
  - diameter
  - material
  - Impact Level/location (IL)

  ➔Over 50 cohorts ➔ 150 risk-based sub-cohorts

- The failure forecasting model LEYP (free software) was used to generate the Predicted Break Number (PBN) and Predicted Break Rate (PBR) per year for each pipe.

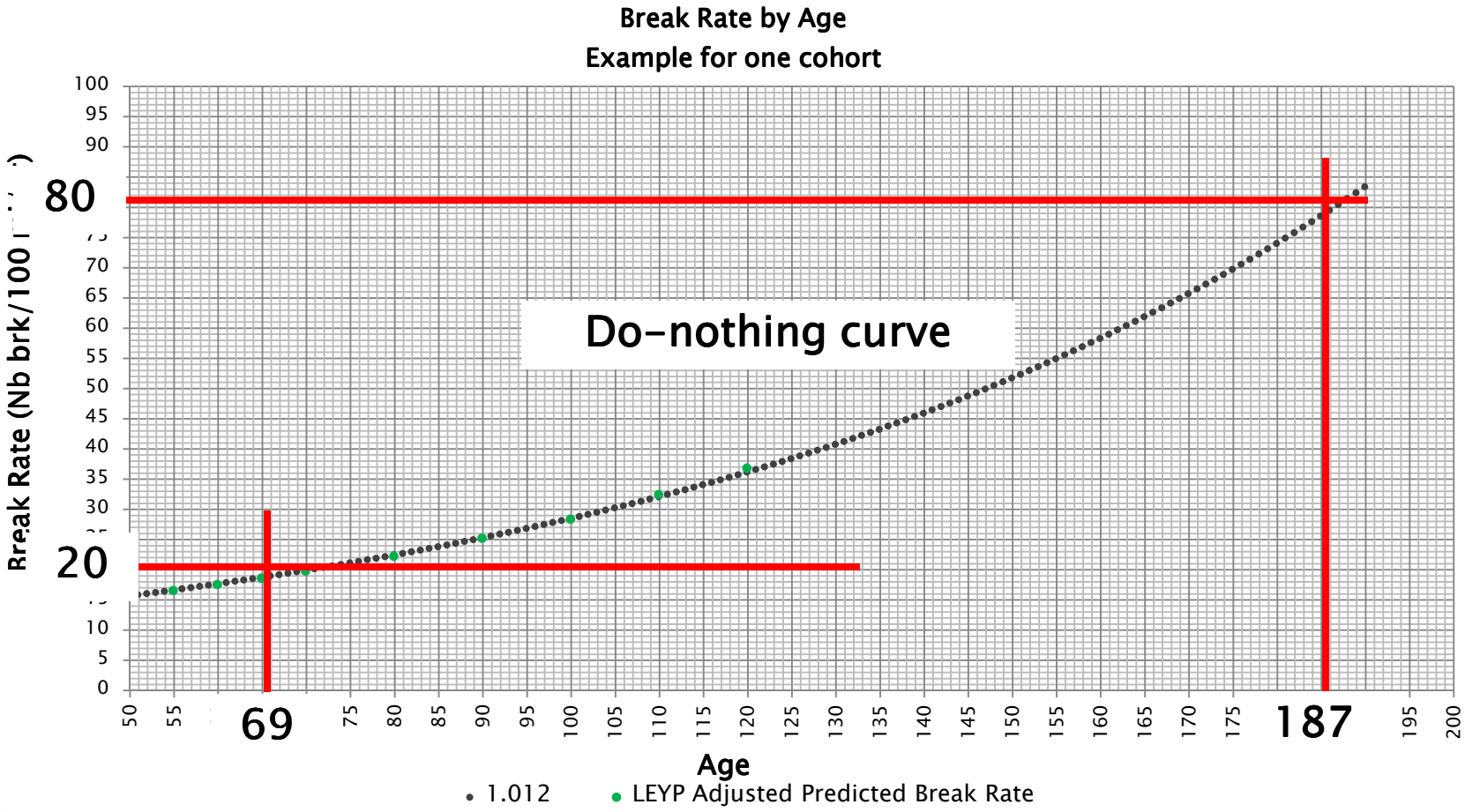
Failure Forecasting Tool

infraPLAN

- Input Data
  - Physical characteristics of mains:
  - Environmental factors
  - Needs breaks assigned to active and (if possible) abandoned mains – at least 5 years

- The following is generated:
  - Pipe: Nb breaks per pipe per year
  - Cohort:
    - Aging function (break rate per year)
    - Effective Useful Life
    - Likelihood of Failure – probabilistic approach

Aging Curve – example



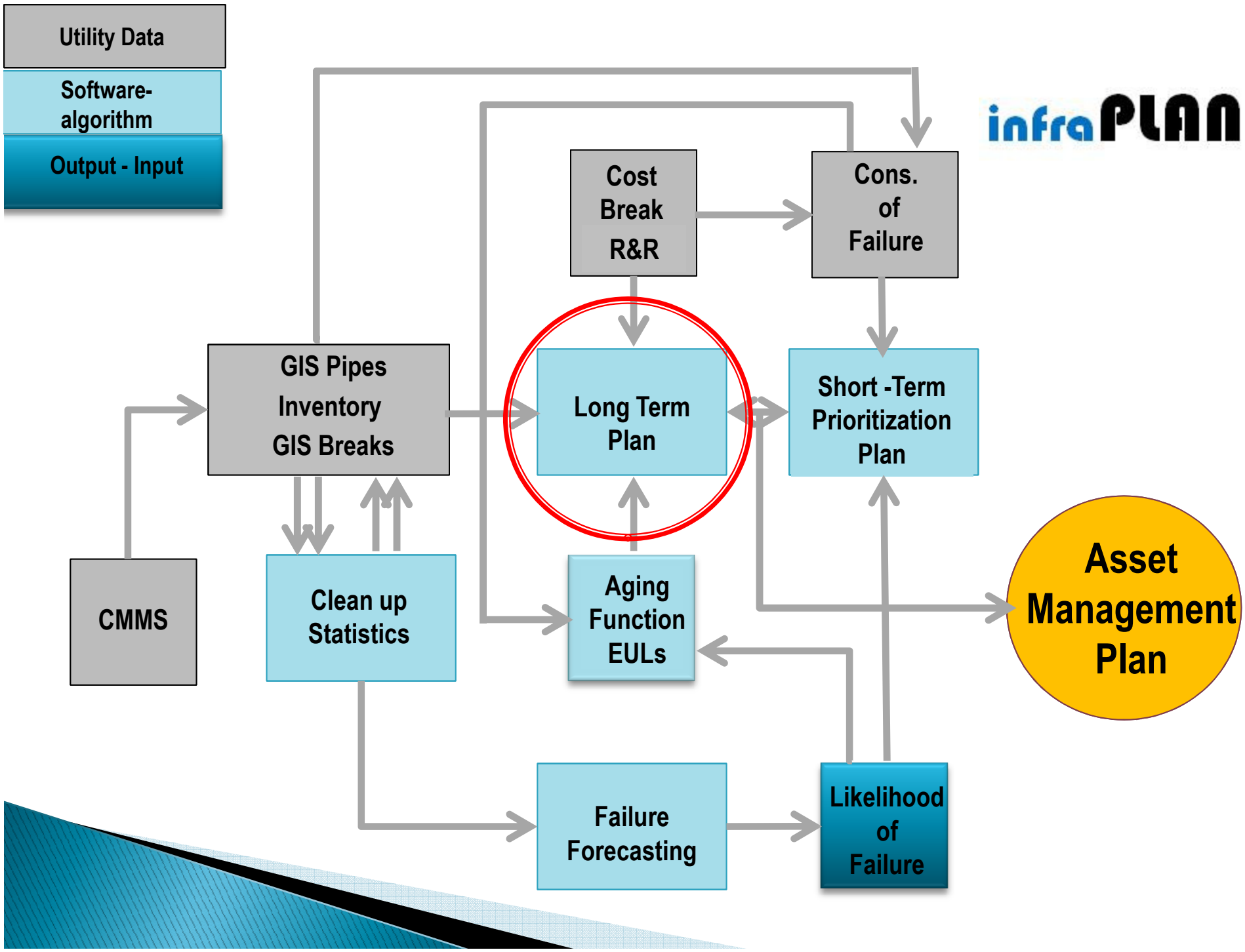
Statistical failure analysis Sewers

- Preliminary statistical study – definition of the cohorts based on :
  - diameter
  - material
  - COF

  ➔ 200+ sub-cohorts

- The failure forecasting model LEYP (free software) was not used to determine EULs. EULs were determined based on relative values of average age and work order rate.

Rehabilitation Needs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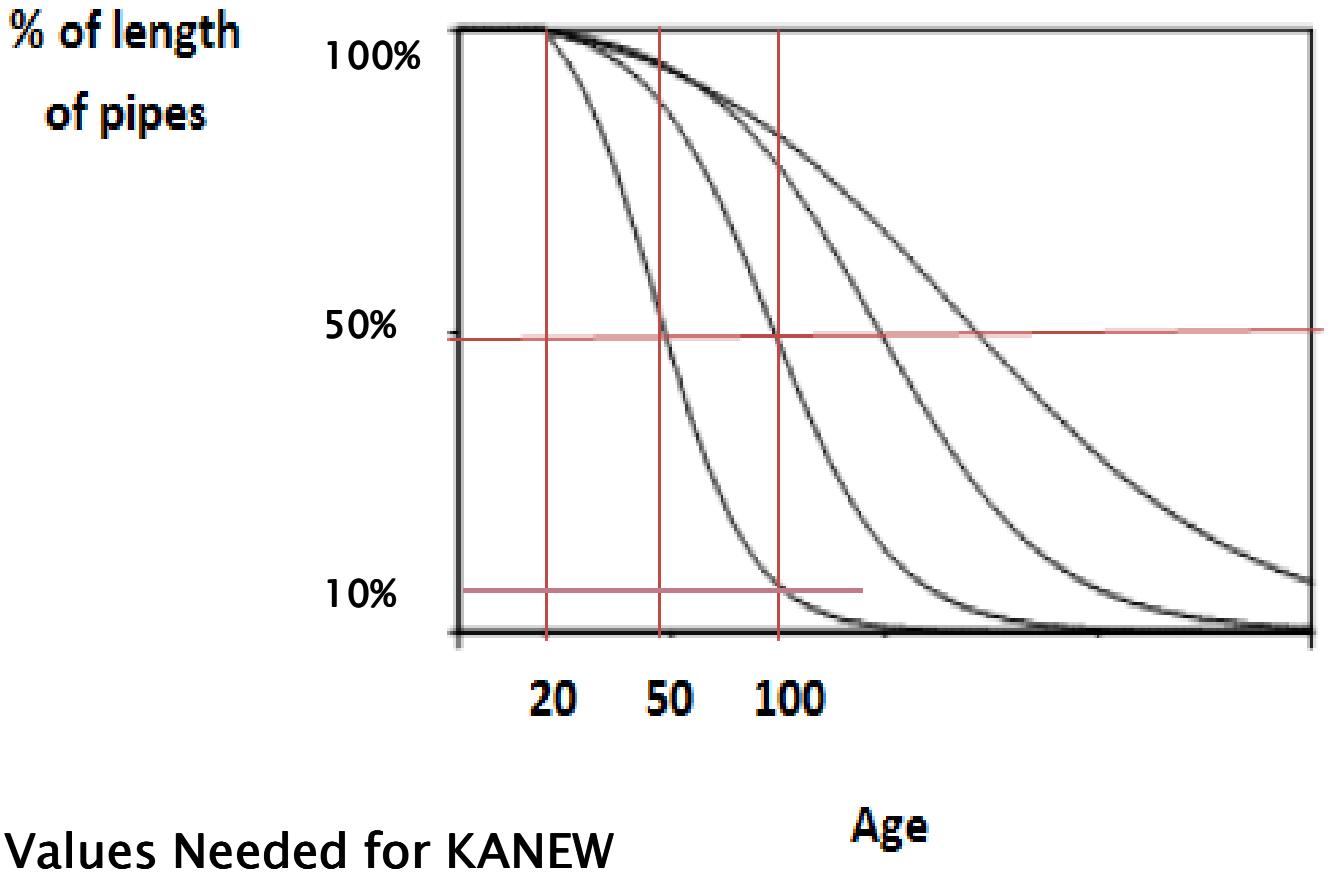
Probabilistic Aging Model and EULs



3 Values Needed for KANEW
100% – 50% – 10%

“Needs” with Utility Data

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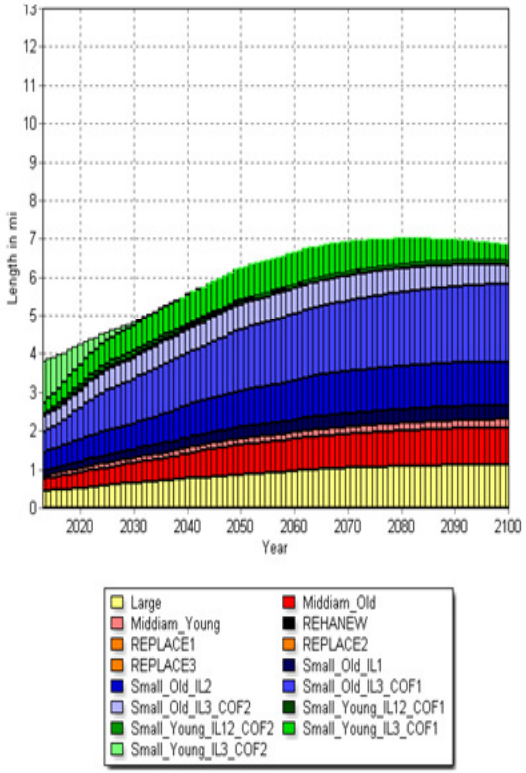
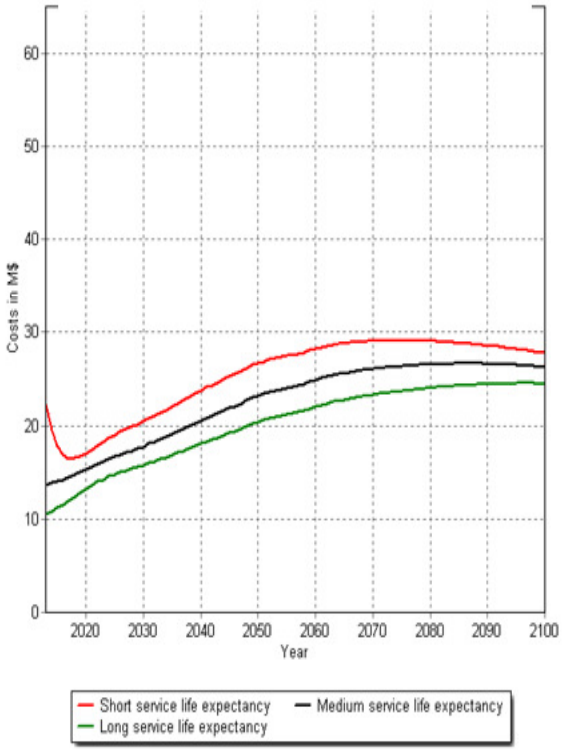
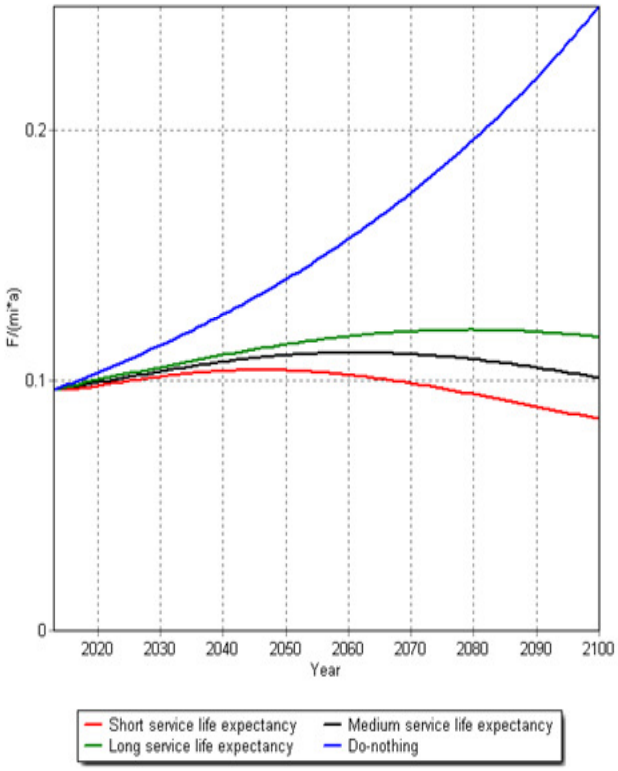
R&R Needs



R&R Cost

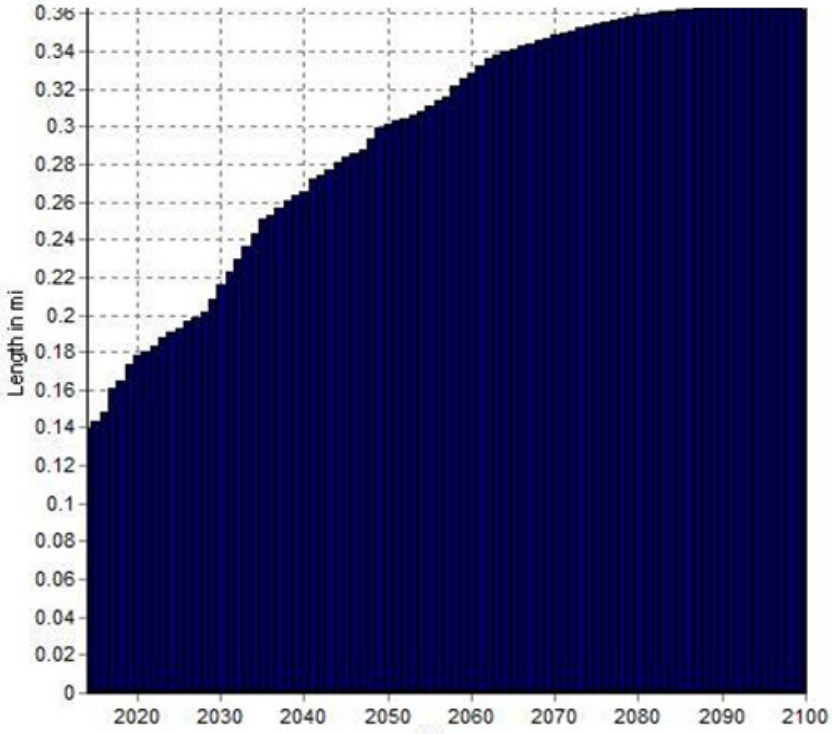


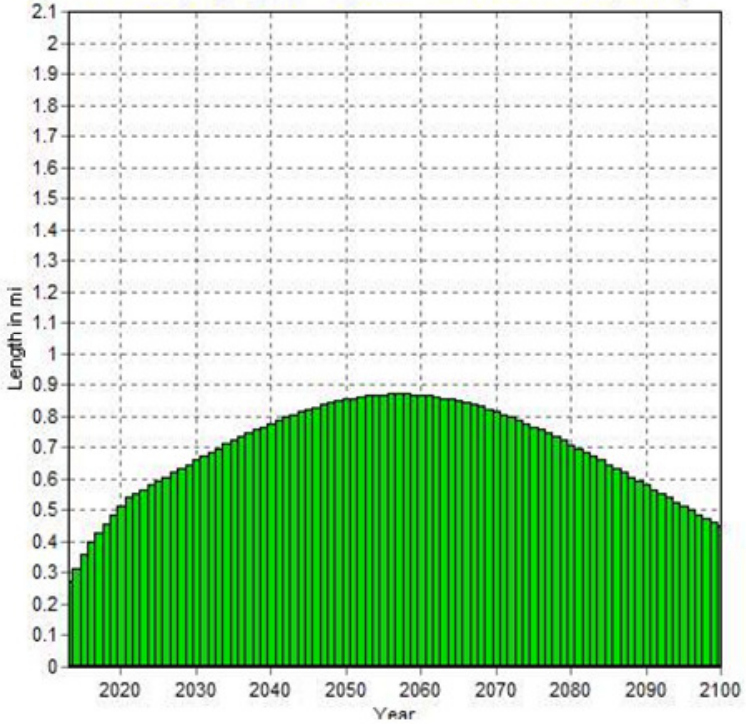
Resulting Failure Rate



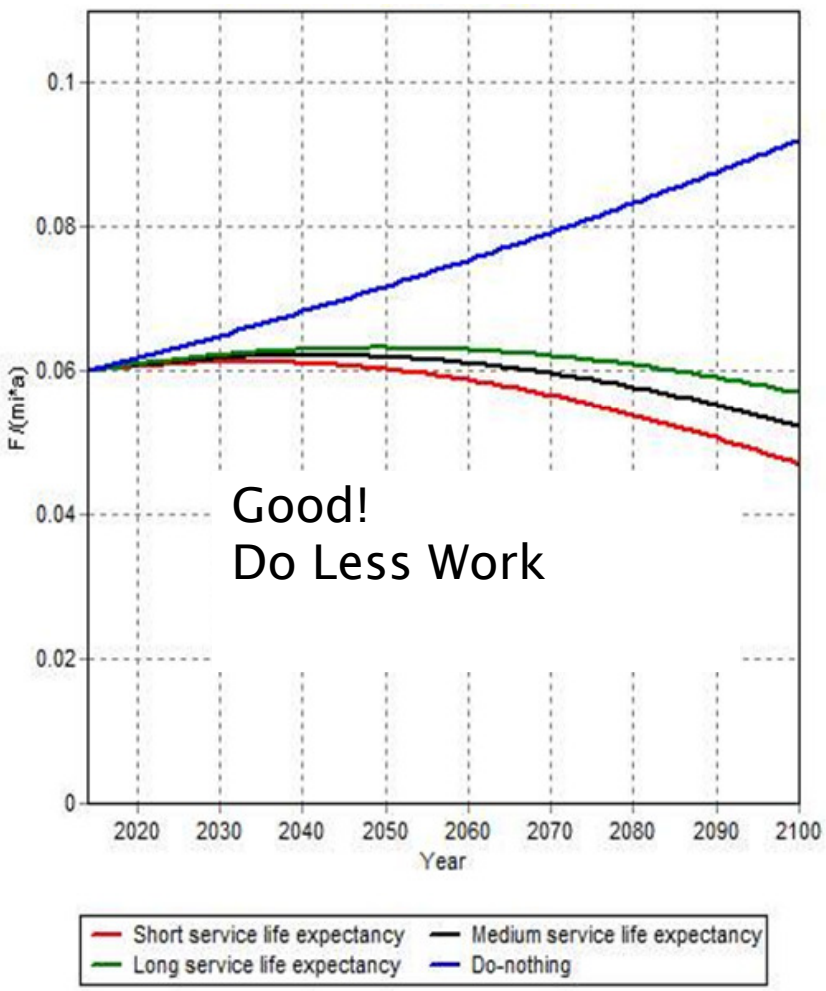
Needs at Cohort Level

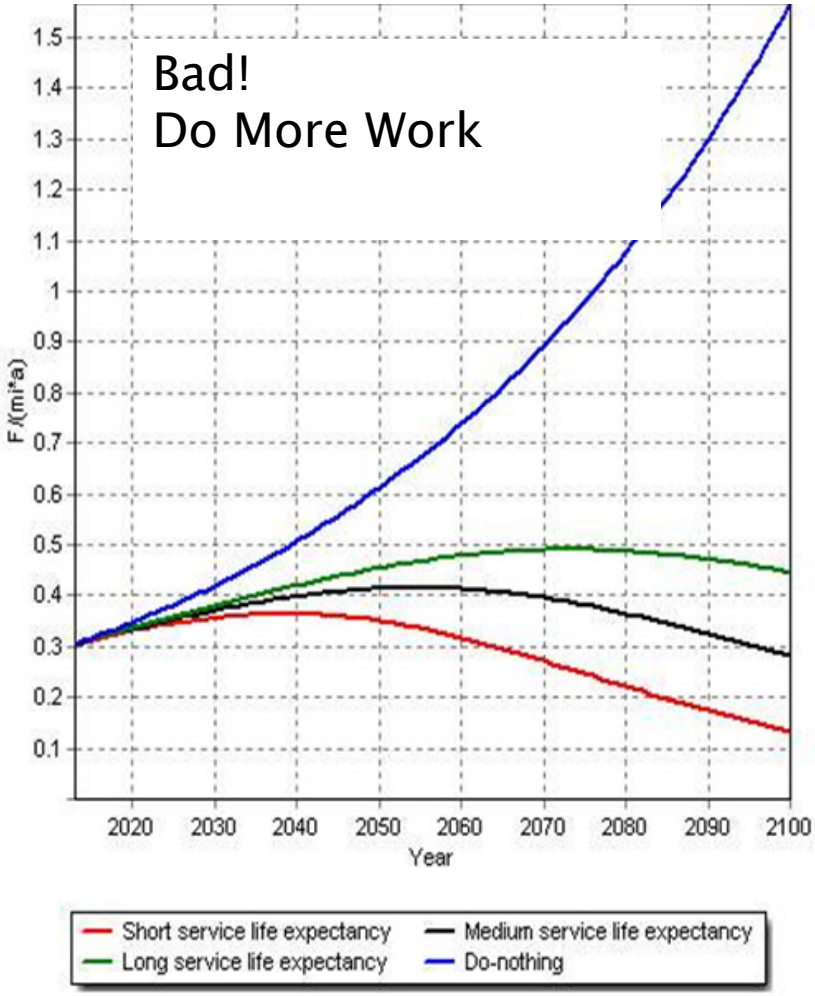
R&R Needs





More in bad areas – Less in good areas


0.1
0.08
0.06
0.04
0.02
0
F /(mi*a)
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year
Good!
Do Less Work
Short service life expectancy
Medium service life expectancy
Long service life expectancy
Do-nothing


1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
F /(mi*a)
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year
Bad!
Do More Work
Short service life expectancy
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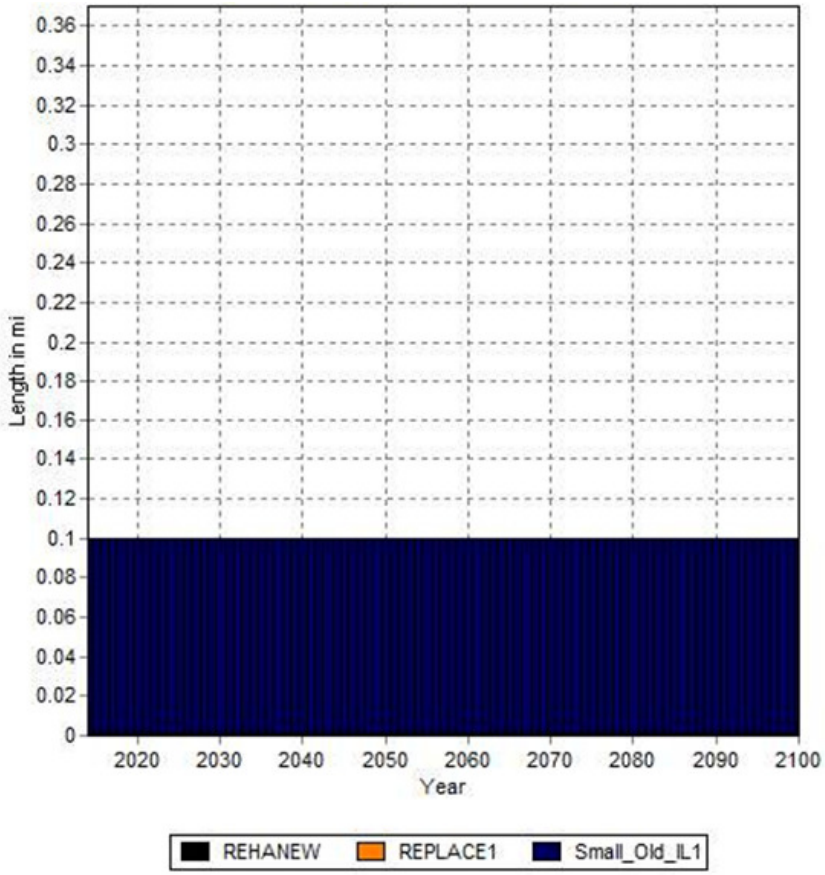
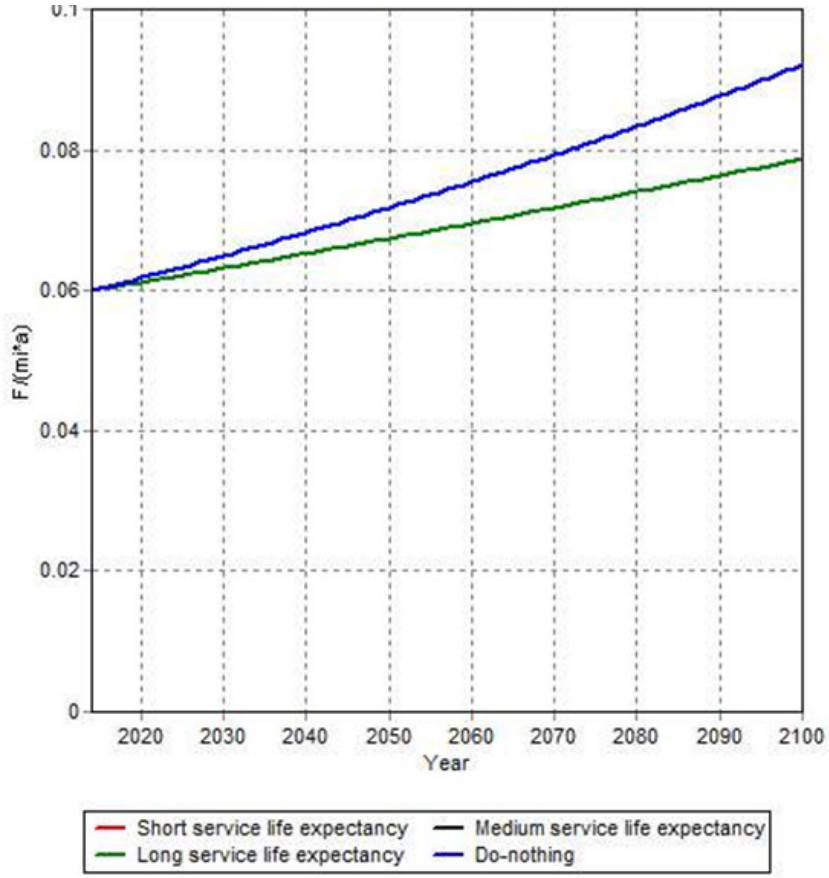
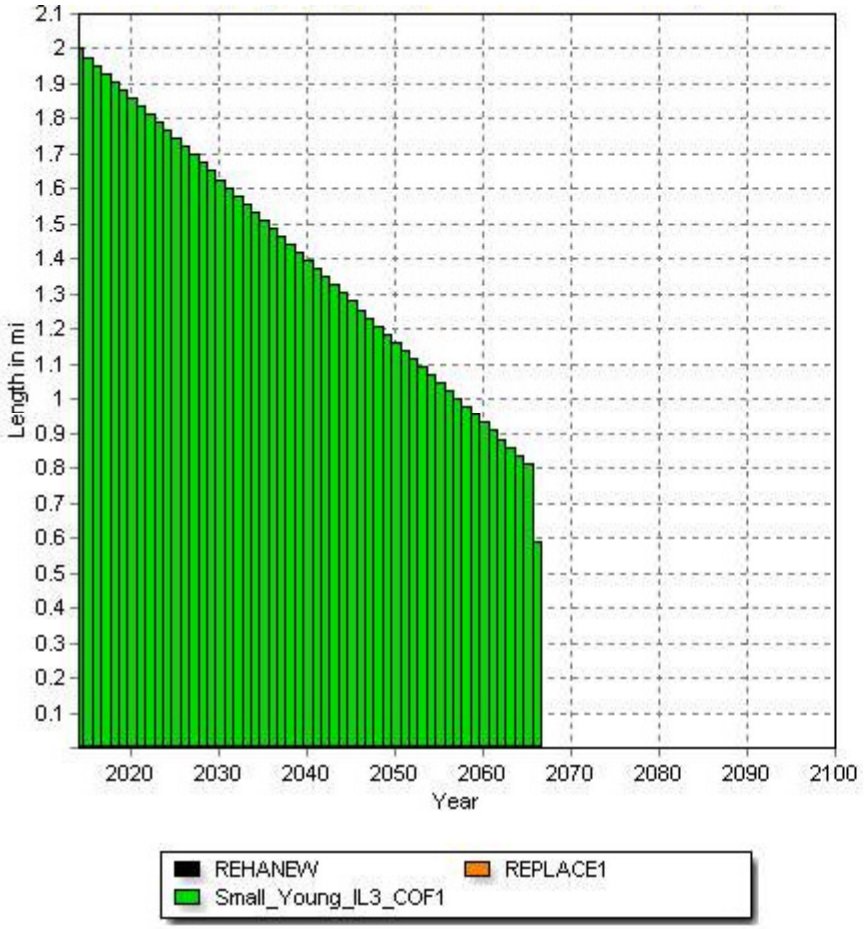
Do-nothing

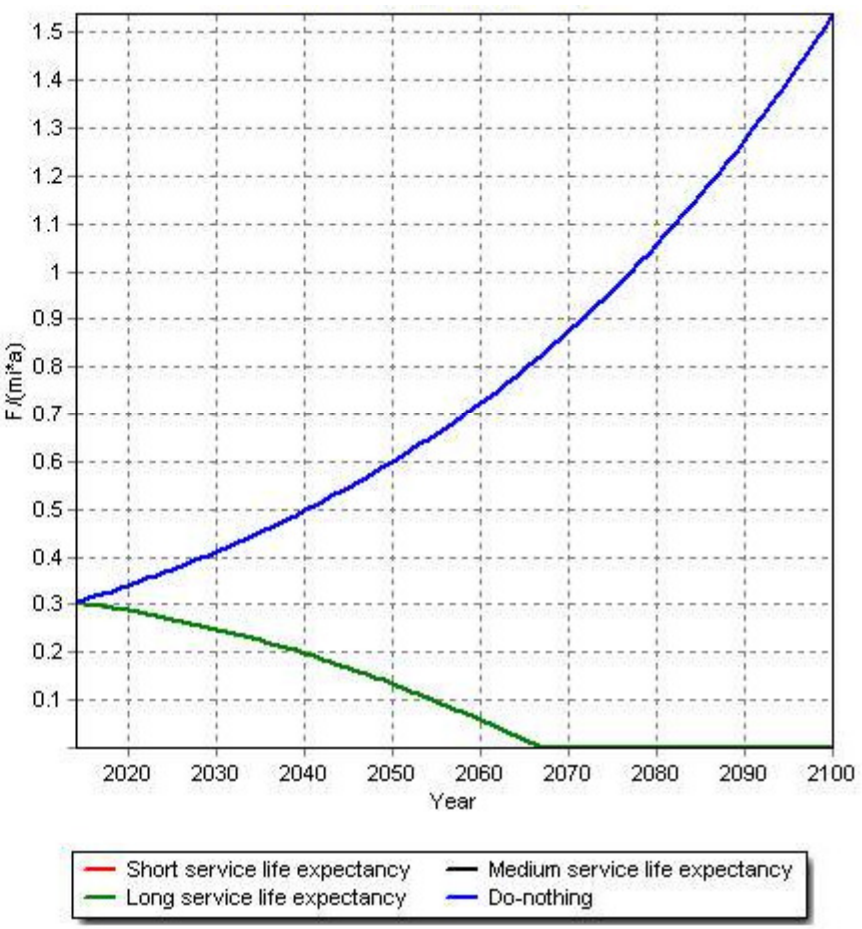
Optimization – Less Work





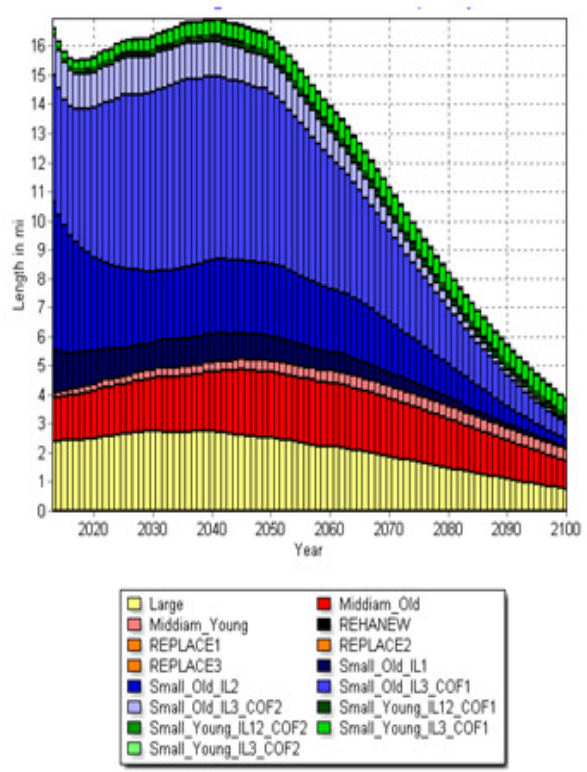
Optimization – More Work



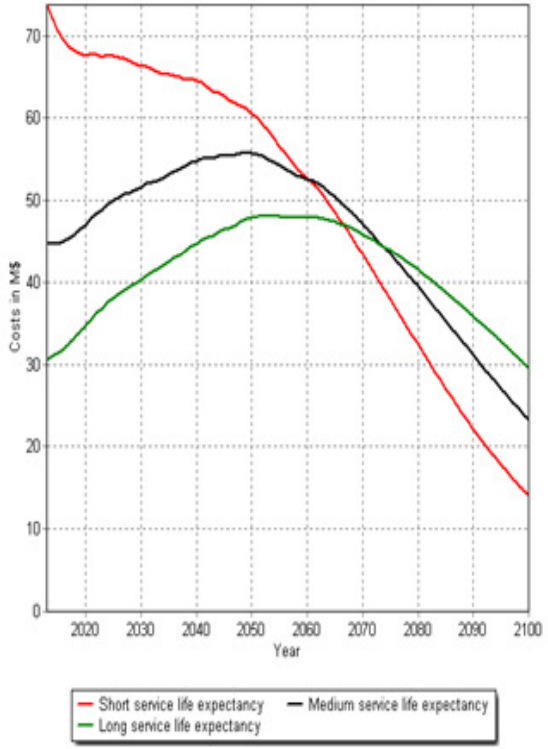


Industry-Assumed EULs

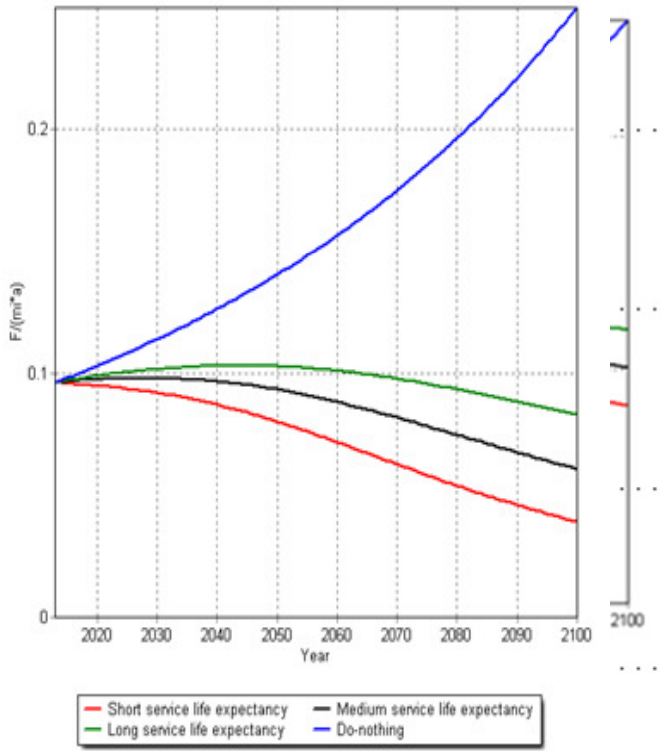
R&R Needs



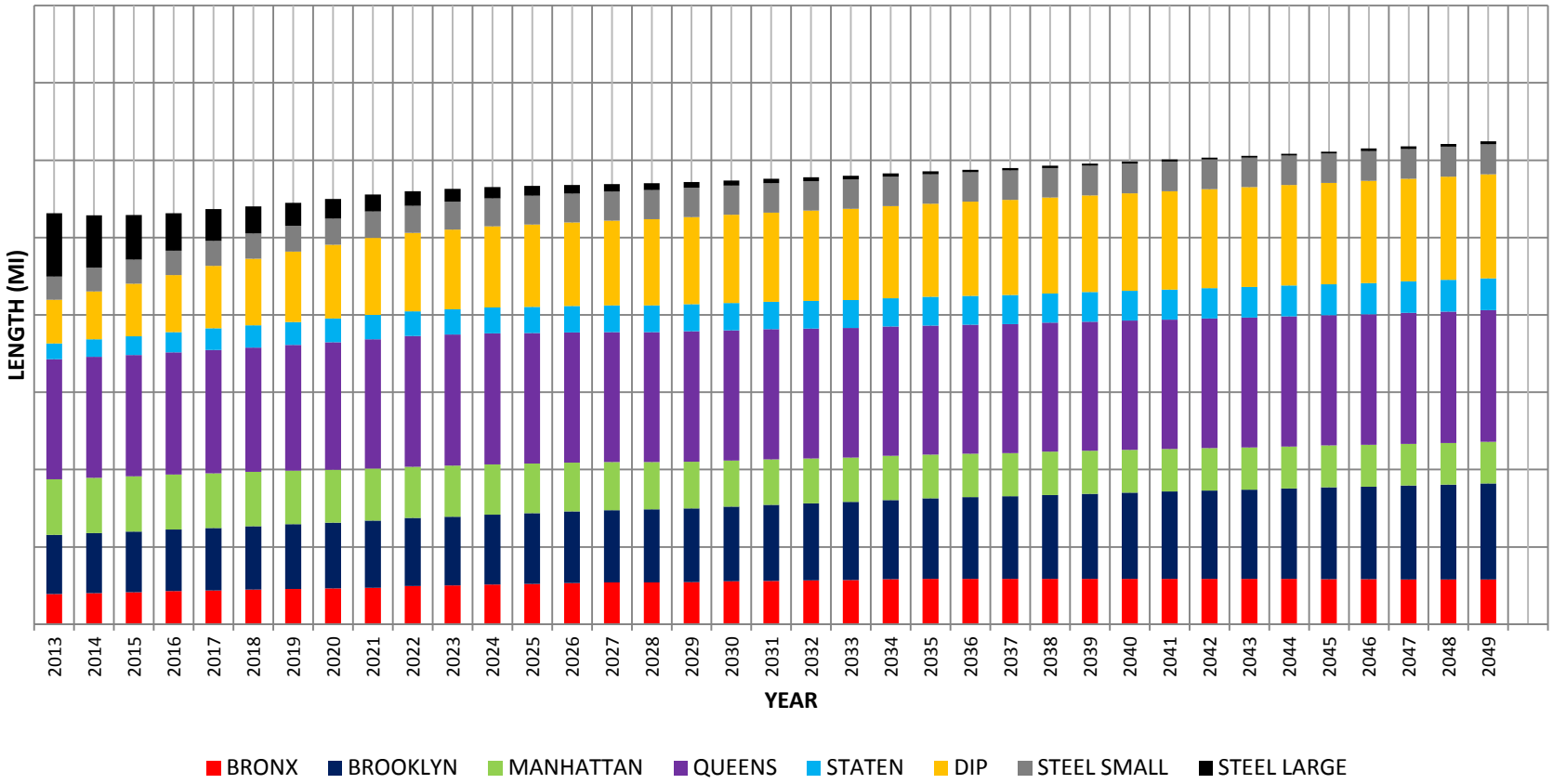
R&R Cost



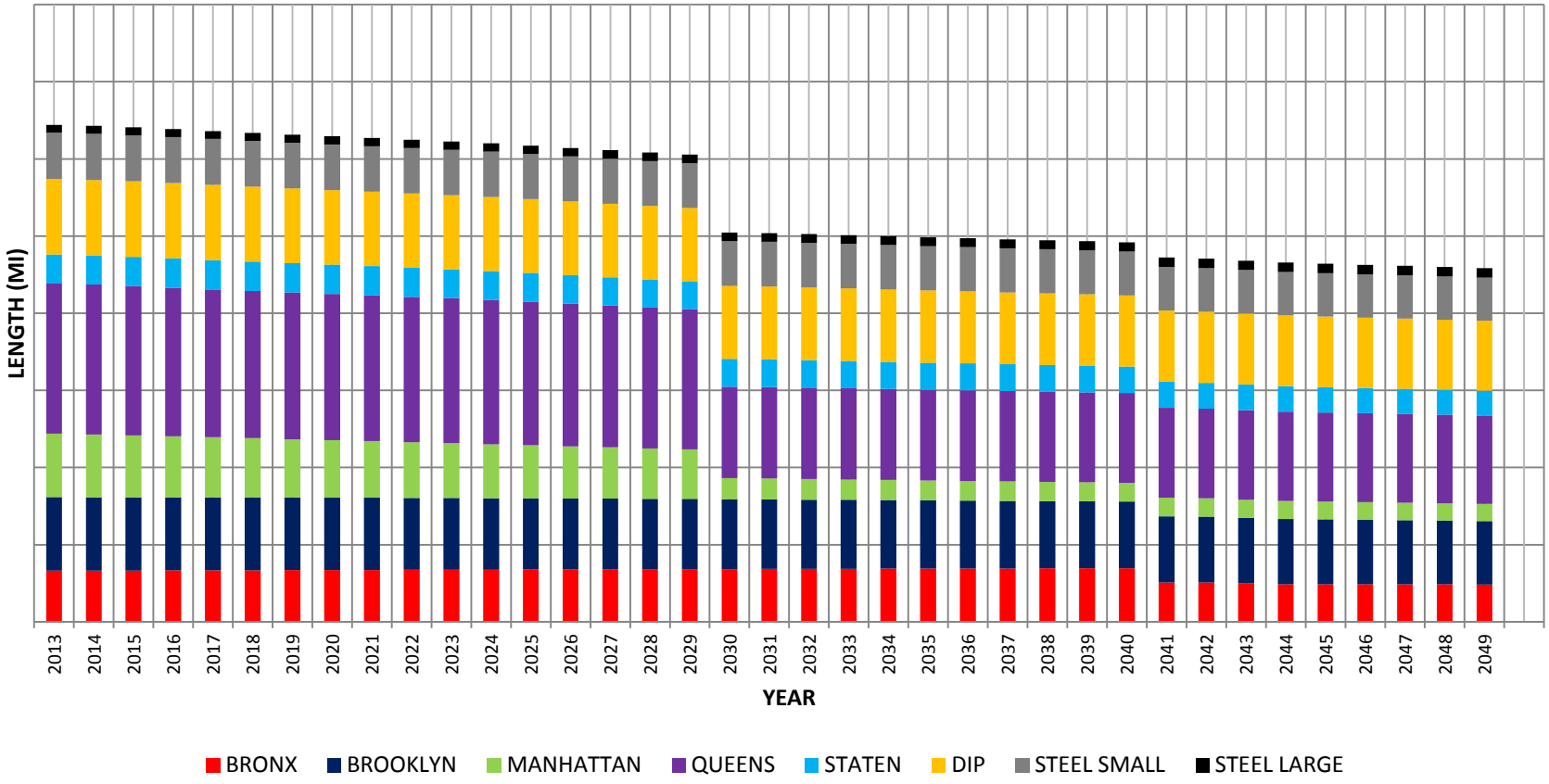
Resulting Failure Rate

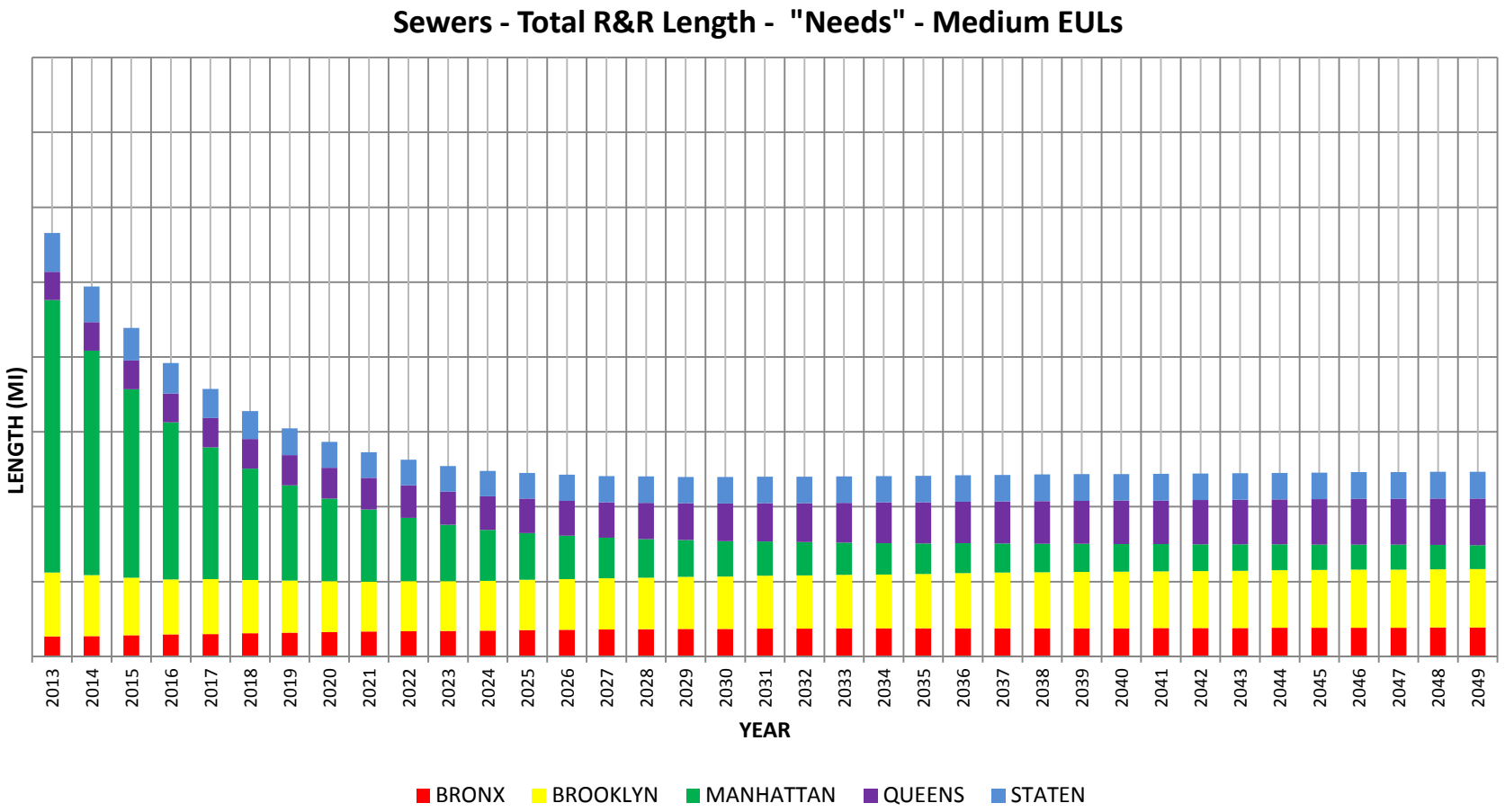


Water - Total R&R Length - "Needs" - Medium EULS



Water - Total R&R Length - Scenario - Medium EULS




Sewers - Total R&R Length - "Needs" - Medium EULs
LENGTH (MI)
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
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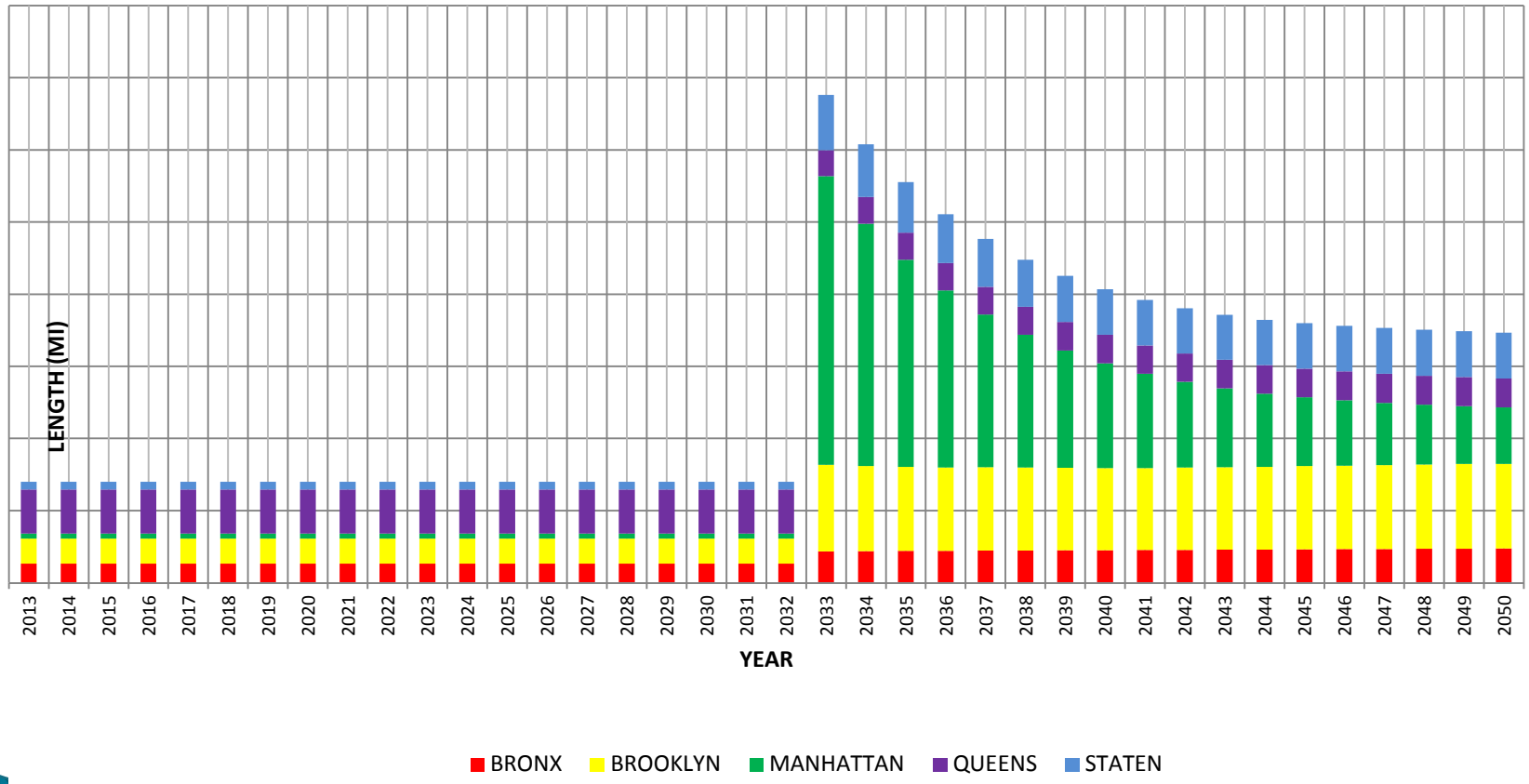
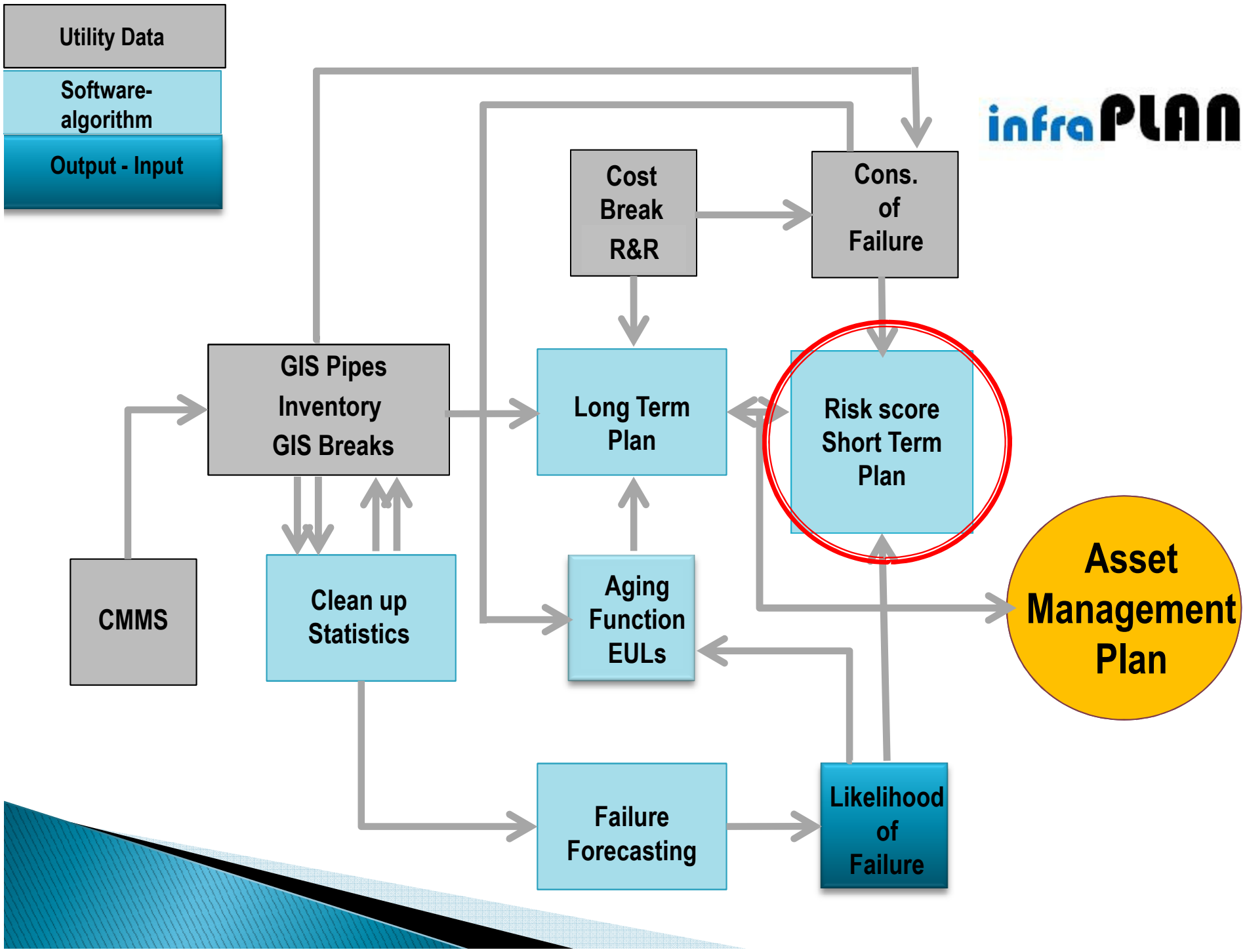
2041
2042
2043
2044
2045
2046
2047
2048
2049
YEAR
BRONX
BROOKLYN
MANHATTAN
QUEENS
STATEN

Sewers - Total R&R Length - "NYCDEP-Requested Scenario"
Medium EULS



Risk-based priority score (LOF x COF)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Risk-based priority score (LOF x COF)

- Each main is given a risk score
- Other considerations (other than break and physical condition control) taken into account in choice of project
- Coordination between sewers and water is done on case by case basis

In-house capacity

- 2 people trained to use Long Term Planning tool
- 2-day training + 2 webcasts
- Tool calibrated by JV – good for a few years (depends on break and replacement rates; over time cohorts and EULs evolve)
- NYCDEP able to create new scenarios

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