UIC Railway Asset Management
Global Conference 2019

17 - 19 April 2019
UIC Headquarters, Paris

# Bridging the gap between operations and long term asset investment

## a simulation case study applied to Network Rail's asset portfolio

COSMOTECH

*Witold Krasny, Product Owner, Cosmo Tech*

# CONTEXT > ASSET MANAGEMENT

- From managing assets, to asset management & asset optimization [1,2]
  - operating assets in a way that **maximizes their performance**,
  - investing in and maintaining assets in order to **minimize the cost** of those assets **over their life cycle**
  - optimizing **revenue streams** from existing assets
  - Grasping the untapped opportunity

- **Break the silos**

- Key enablers : ISO55k
  - governance
  - program monitoring
  - **Multiyear Planning & Optimization**

[1] ISO 55002:2018
[2] The Hidden Value in Government Assets, A. Audier, S Bard L. Robieux, The Boston Consulting Group, 2019

# CONTEXT > TECHNOLOGY

- Digitization initiatives are being adopted across industries
  - In-house solutions [1]
  - BI & data warehousing
  - EAMs, APMs [3], AIPs [2]

- Existing technology **struggles to integrate all silos influencing asset management strategies** in order to accurately test “what-if” scenarios

- Technology should contribute in bridging the gap between operations and strategy : how to achieve **integrated planning**?

- Simulation has proven benefits for short mid and long term investment planning : promising, and is being adopted!


[1] Structures modelling, Network Rail, M. Hamer, 2017
[2] TAMCL Market study Asset Investment Planning Solutions, 2018
[3] Gartner Hype Cycle for Utility Industry IT, 2018

# ABOUT NetworkRail

## Asset Portfolio

- Tracks: 32,000km
- Electrification, Telecoms, Signalling and 6,700 level crossings
- Bridges: 29,000
- Stations and buildings: 2,500
- Tunnels: 800
- Earthworks and drainage

## Annual expenditure

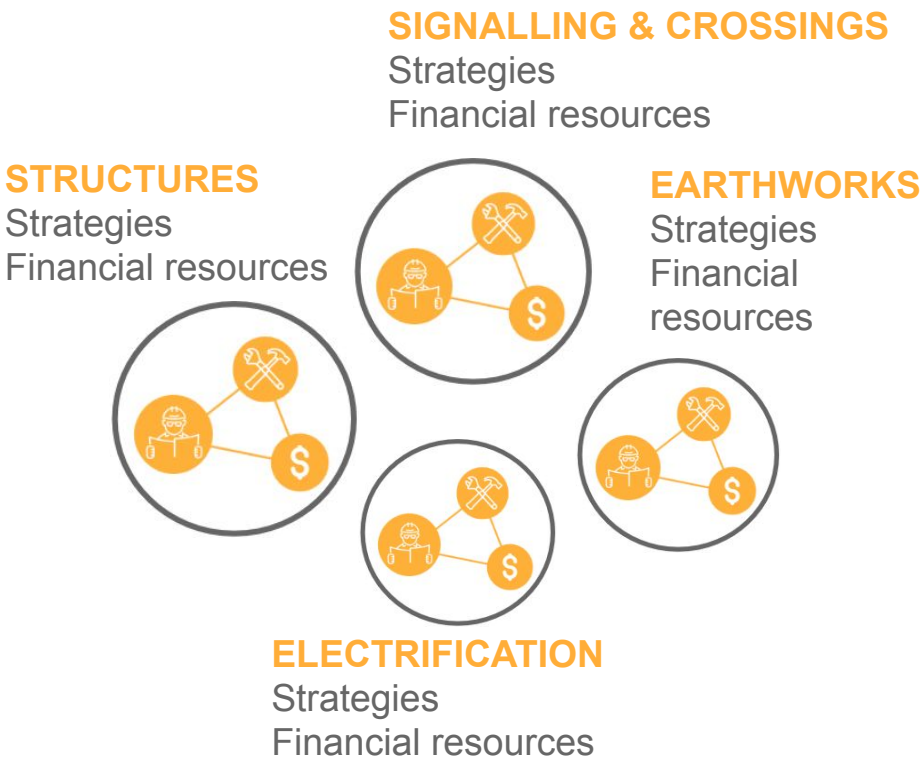
- £3bn Renewal
- £1bn Maintenance
- £3bn Enhancement

**WHAT NR DOES:**

Network Rail is the **owner and infrastructure manager** of most **of the railway network in Great Britain.**

The present work is part of a Make or Buy appraisal that Network Rail is carrying out to assess the viability, costs and benefits associated with moving to a commercial platform

# CHALLENGES TO BE ADDRESSED




**Strong baseline:**

- Existing models developed internally
- Sophisticated, calibrated & mature
- Simulation is SOP

**Challenge 1: the model**

- how to reach **integrated planning** bridging the gap between strategy and operations?

**Challenge 2: the architecture**

- Asset-specific approaches, no common methodology
- 1 referee per model
- No single auditable platform
- Cost of models' maintenance and evolutivity

# There are several ways to modelling and simulation in asset management…

**Physics-based**
Structural integrity assessments [6]
Leakage rate assessments [7]

**Statistical methods**
Survival analysis & degradation based reliability [1,3]
Petri net models [2]
Markov Chains Monte Carlo [4]
Bayesian networks [8]

**Digital twins**

**Complex systems [10]**
- Heterogeneous entities,
- vertical hierarchies,
- horizontal interactions,
- system of subsystems

**Agent-based [9]**
Agents and interactions
Multilevel simulation: maintenance & operation

**Predictive analytics**

**Machine Learning [5]**
Correlation between historical events and observations
Predictive maintenance
Vegetation maintenance

*"For such a system of systems, [...] the **emergent behavior** at the scale of the whole system cannot be inferred from the behavior of its **subsystems taken separately**"*
Brodsky, Y. I., & Tokarev, V. V. (2009).


[1] Grama et al. 2013
[2] Le et al 2017
[3] Boudreau et Poirier
[4] Wellalage et al 2015
[5] Redesign tout cost, SNCF, Héloîse Nonne, 2019
[6] Sharma et al 2018
[7] Asali et al, 2016
[8] Capra et a 2006
[9] A. Magnien, RailTopoModel, UIC, 2019
[10] Brodsky et al 2009

# ABOUT COSMOTECH

Founded in **2010** in Lyon, France

**81** employees

Series A: **$5.2M** (2014)

Series B: **$21M** (2018)

**WHAT WE DO:**

We **build software solutions** that draw on a proprietary **complex systems modeling and simulation** expertise

**OUR MISSION:**

We aim at **transforming the way that decision makers** in the energy, utilities, and transport sectors **increase the productivity of their assets**

# Our proprietary modelling tool : Cosmo Tech's Platform

INTERNATIONAL UNION OF RAILWAYS

Project Conceptual model Window Help

Conceptual model files

- ETNAging
- ETNOutage
- KPI
- MOA
- Planning
- ResourcesManagement
- MONA

Operations

Add
Add
Remove
Description
Add

Operation Edition

Operation Editor | Conceptual Model Tree View

Search...

| Name | Type |
|---|---|
| Data Types | |
| AgeAttributes | Composi |
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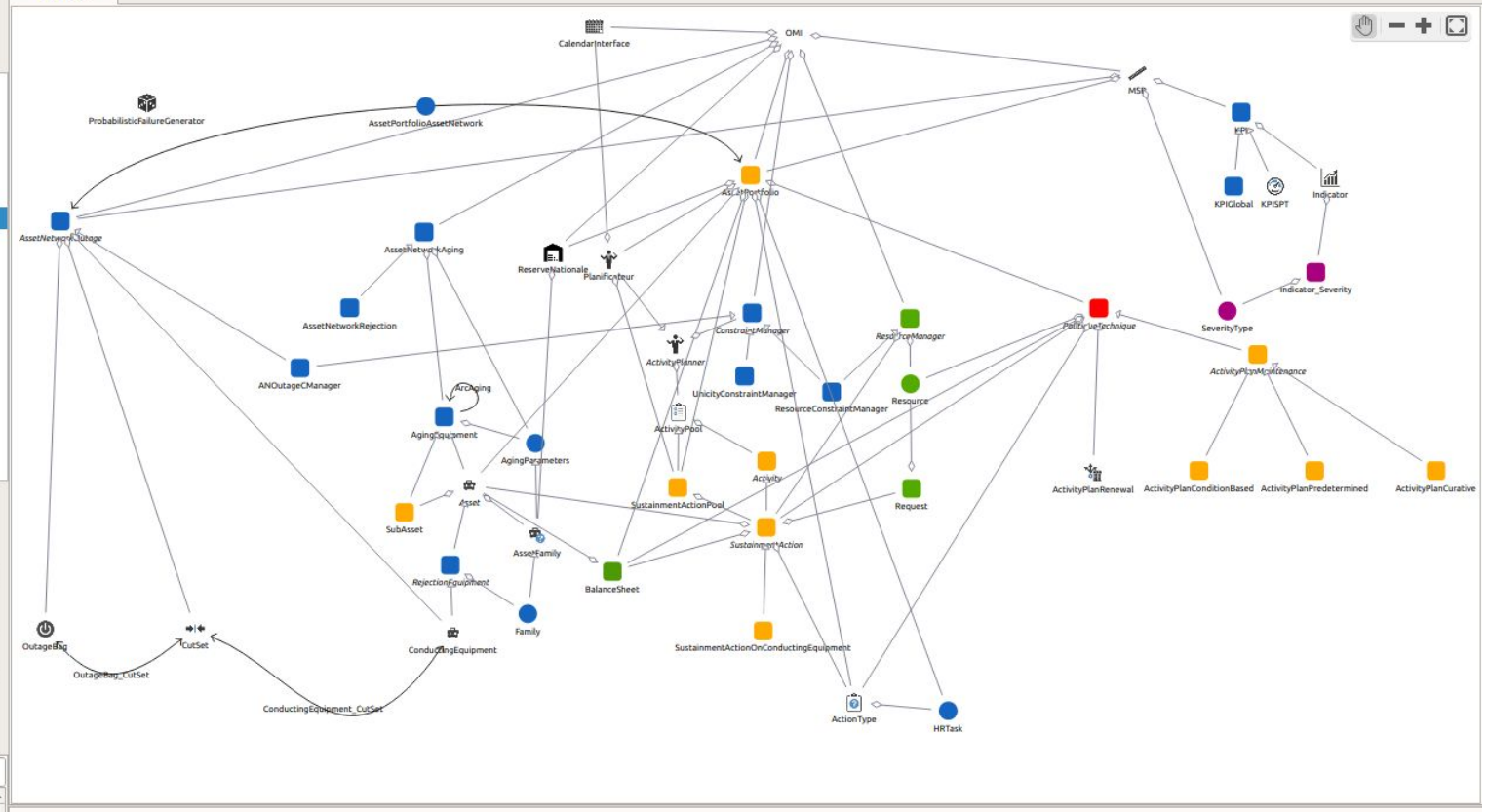
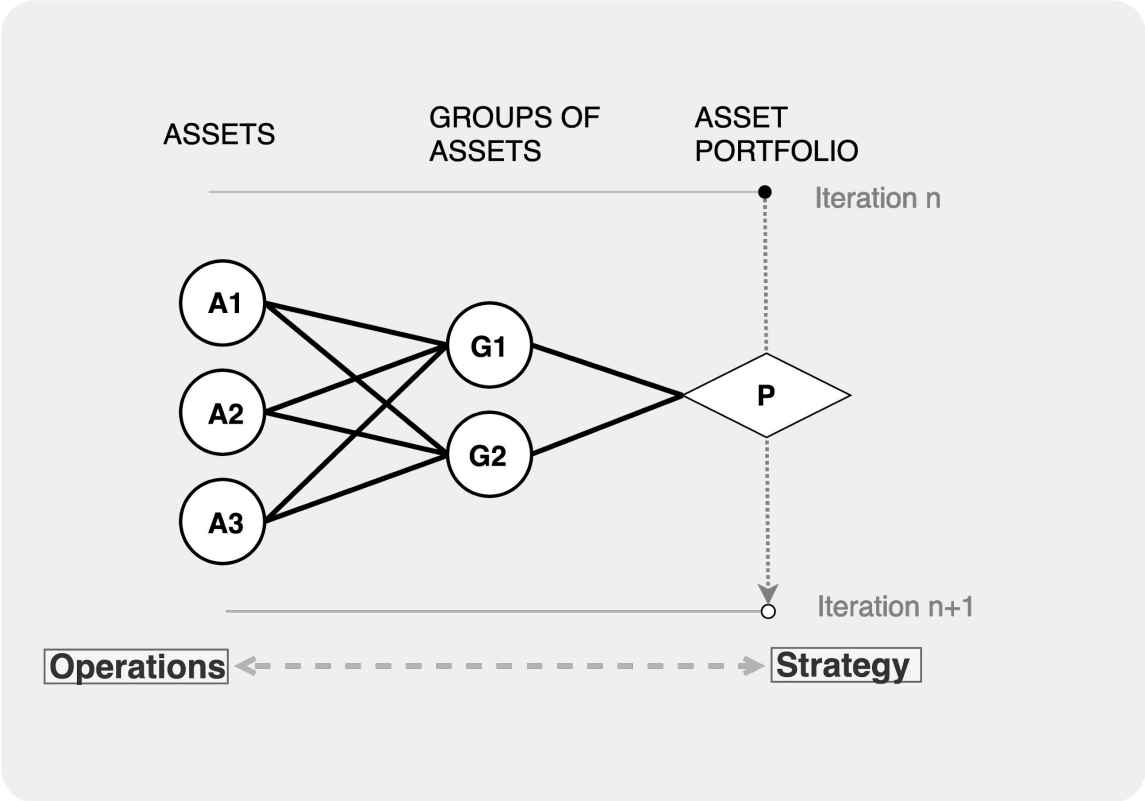



Conceptual model issues | Operation issues | Studio output

# Cosmo Tech's ASSET solution

Developed with asset managers throughout a **Rte + Cosmo Tech partnership** since 2017

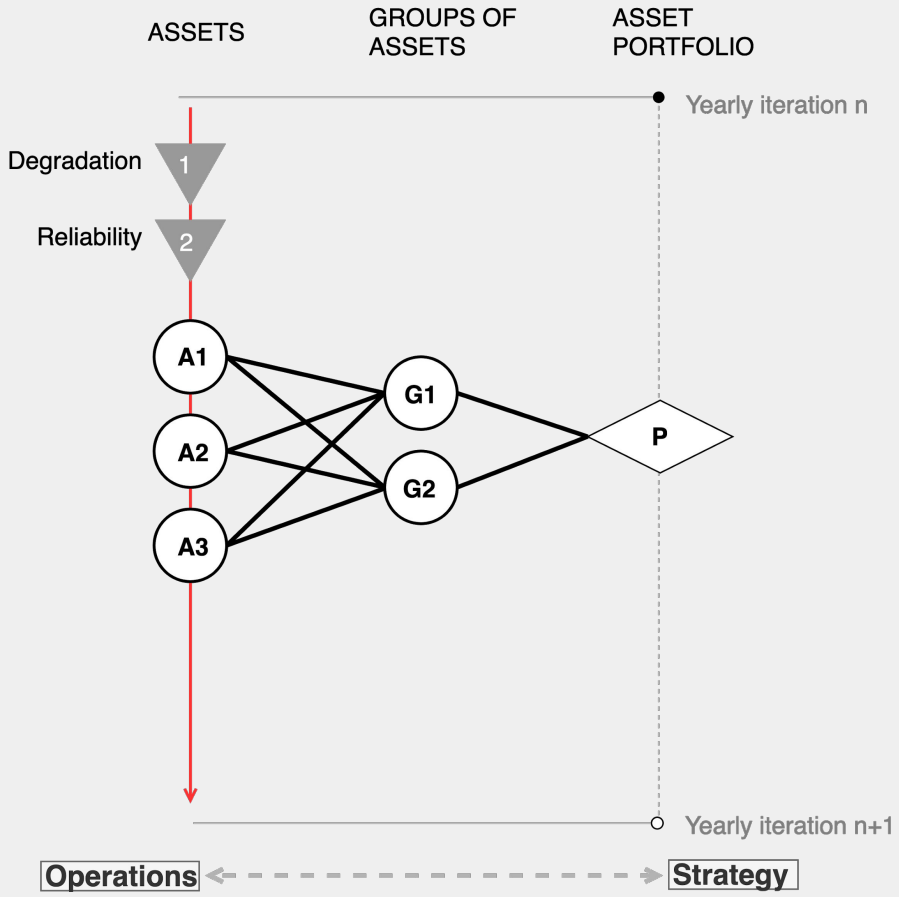


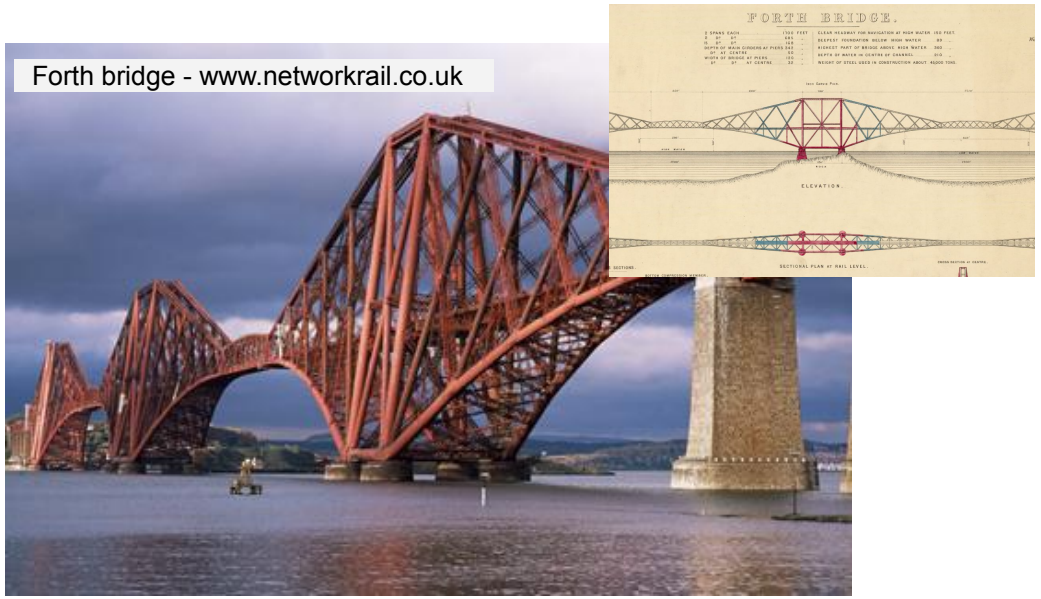



- Asset degradation workflow
- Interventions workflow
- Asset financial lifecycle workflow *(off-scope on NR use case)*

# Cosmo Tech's ASSET solution

## Asset degradation and reliability workflow



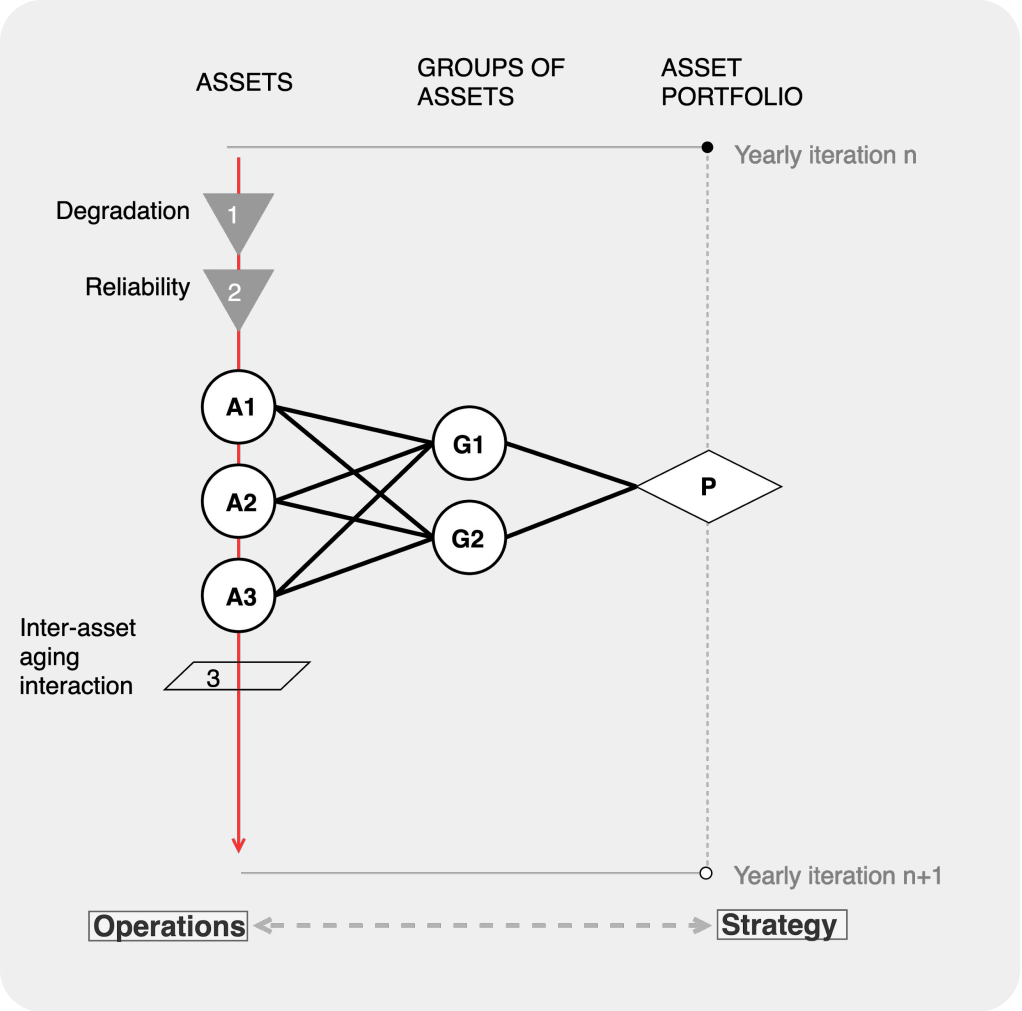

**Example of a metallic girder of the bridge's deck [1,2]**

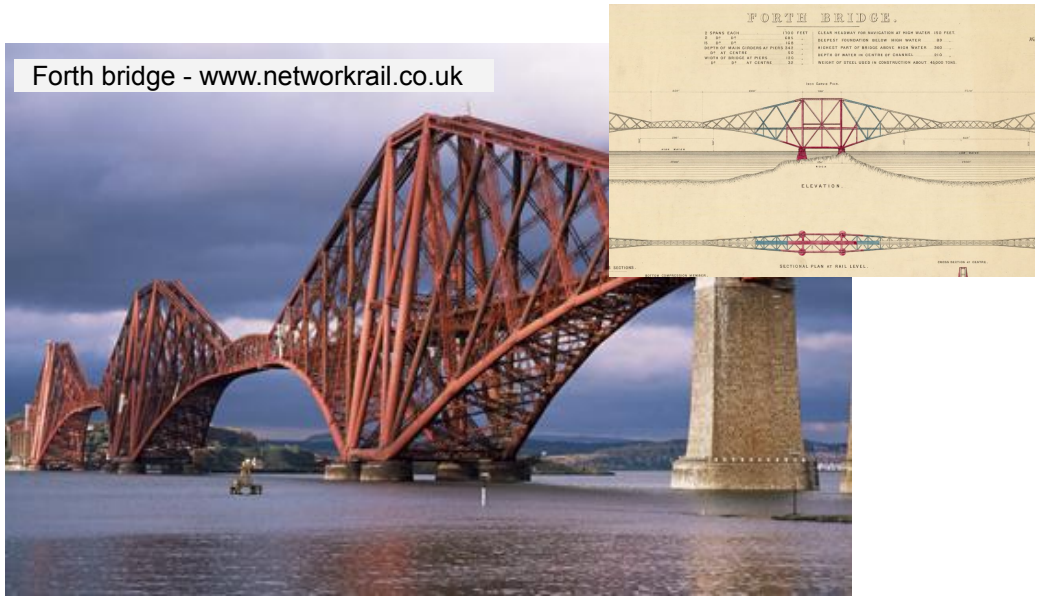
1. Asset degradation based on **yearly transition probability** matrix
2. Probabilistic draw of **defects / failures based on degradation** (weekly iteration)


[1] Structures Modelling Overview, Matthew Hamer, Network Rail, 2017
[2] N. W. Wellalage et al., *Bridge Deterioration Modelling by Markov Chain Monte Carlo (MCMC) Simulation Method,* Engineering Asset Management, 2015.
[3] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset degradation and reliability workflow



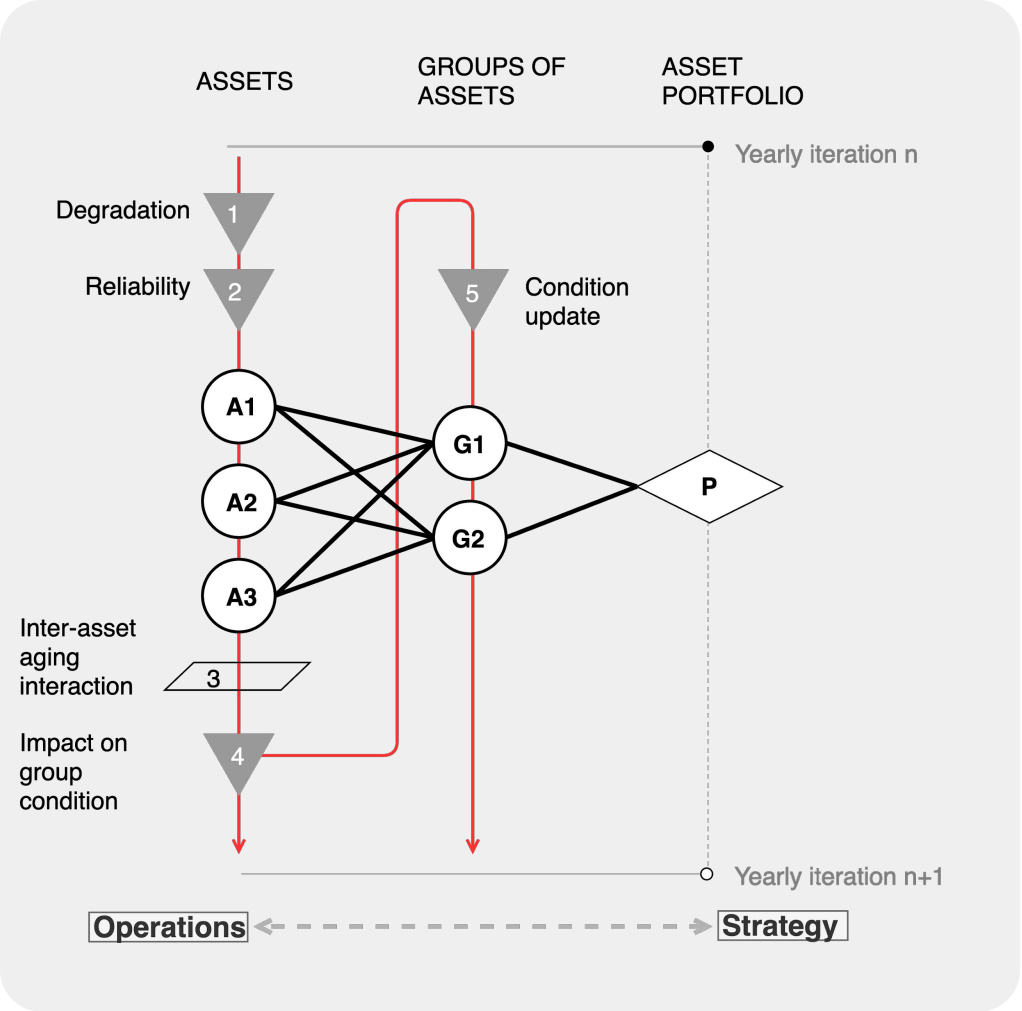

**Example of a metallic girder of the bridge's deck [1,2]**

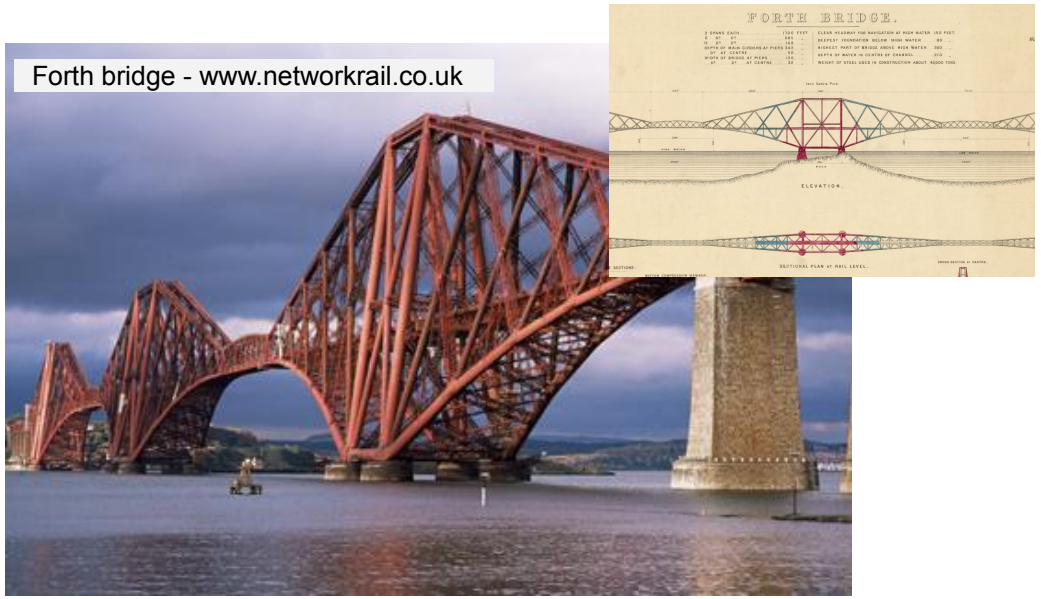
3 Interplay between aging elements - *non activated on NR use case* [3]


[1] Structures Modelling Overview, Matthew Hamer, Network Rail, 2017
[2] N. W. Wellalage et al., *Bridge Deterioration Modelling by Markov Chain Monte Carlo (MCMC) Simulation Method,* Engineering Asset Management, 2015.
[3] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset degradation and reliability workflow




## Example of a metallic girder of the bridge's deck [1,2]

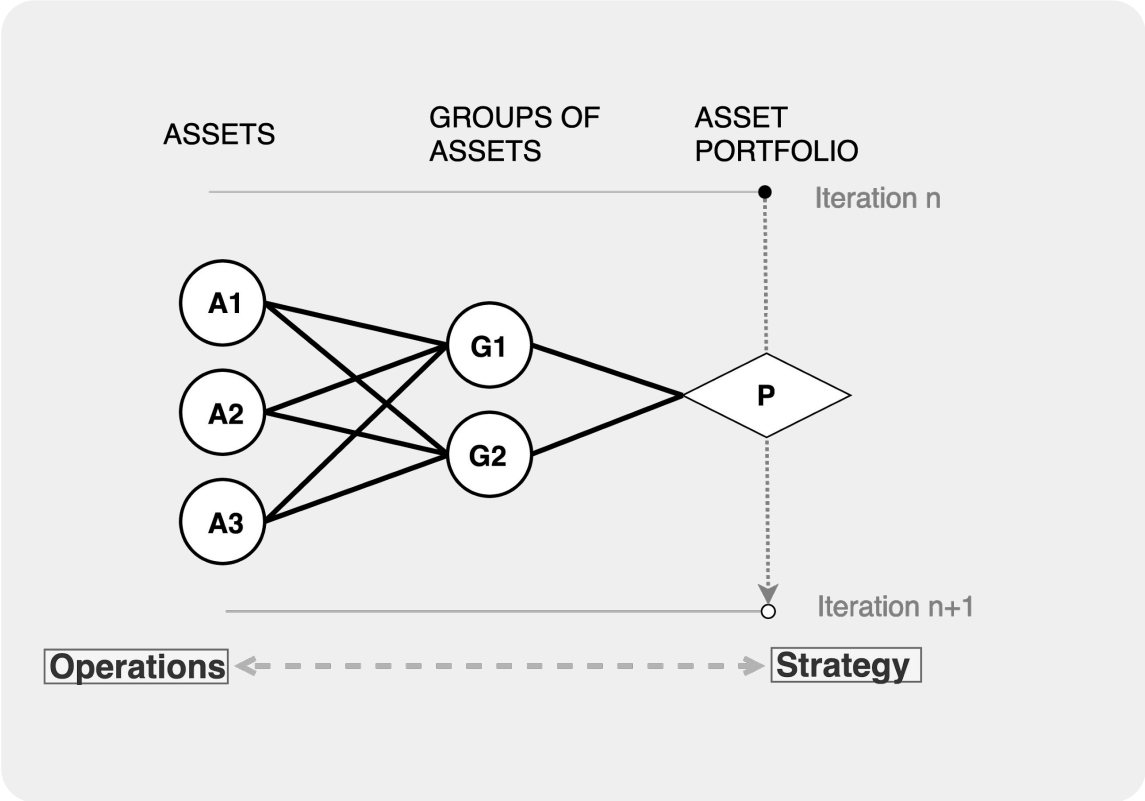
4 is the condition of the girder triggering a deck capability update?

5 Capability of deck : remaining life = years -1


[1] Structures Modelling Overview, Matthew Hamer, Network Rail, 2017
[2] N. W. Wellalage et al., *Bridge Deterioration Modelling by Markov Chain Monte Carlo (MCMC) Simulation Method,* Engineering Asset Management, 2015.
[3] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

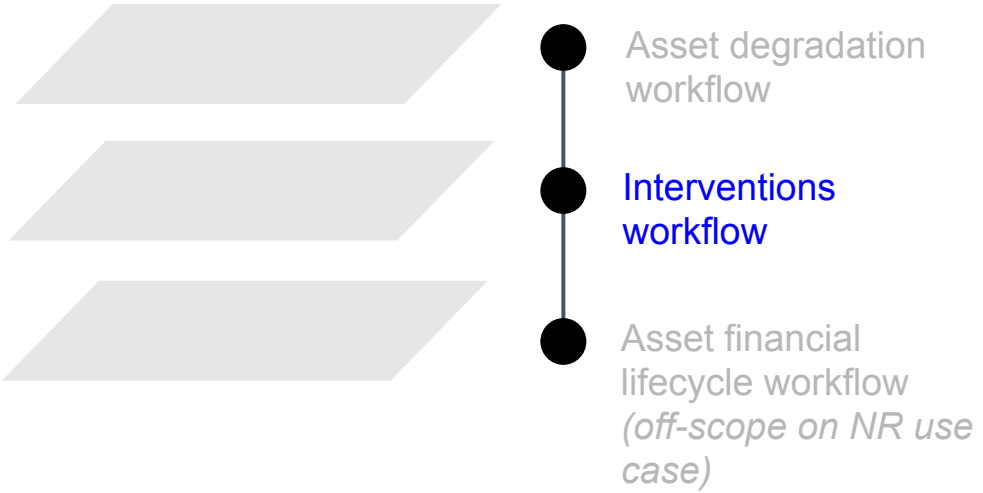
# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





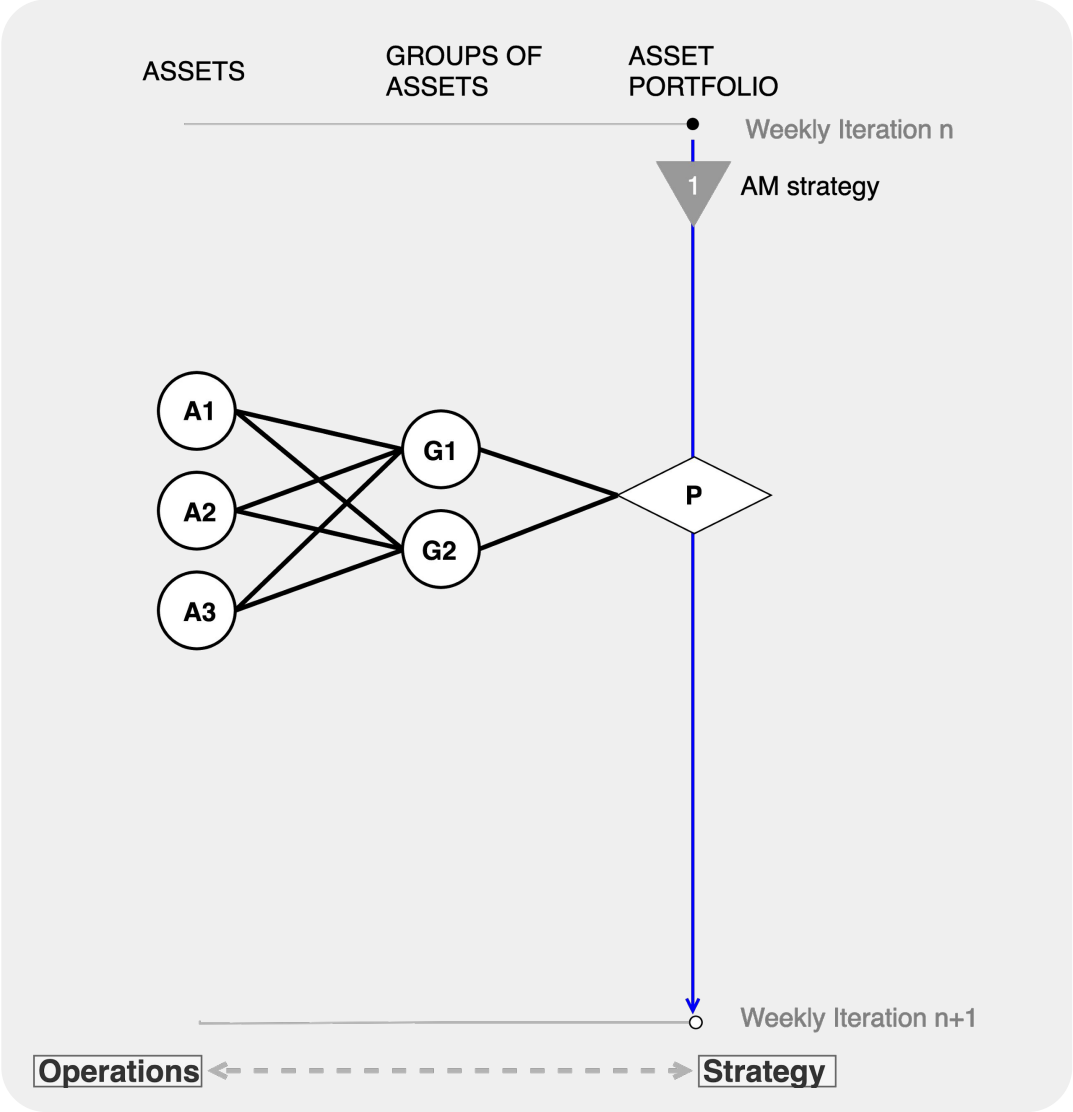
## Example of the conductor rail of an electrified route section




[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





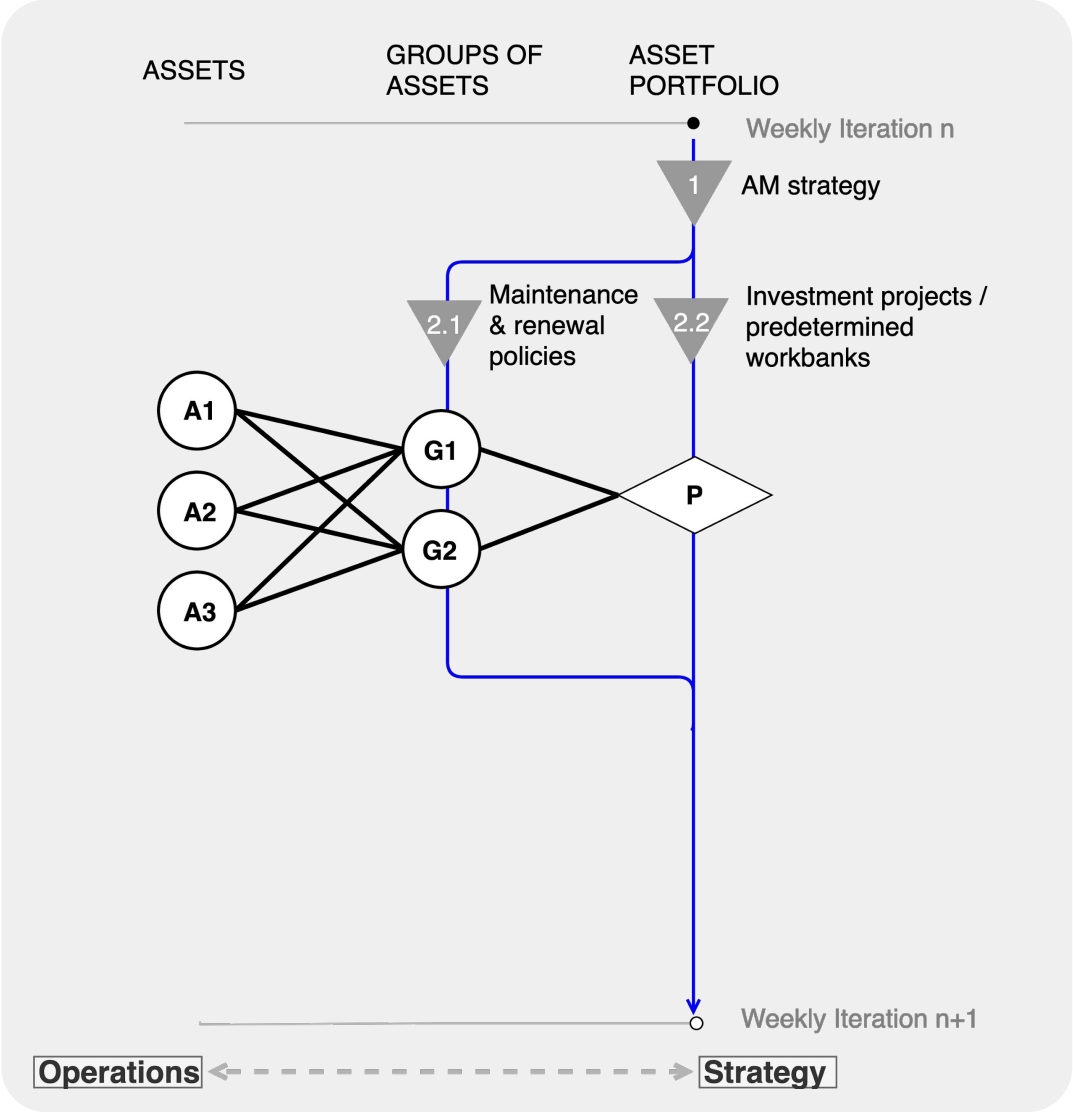
**Example of the conductor rail of an electrified route section**

1 Sustainment plan based on curative works, maintenance, investments

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





**Example of the conductor rail of an electrified route section**

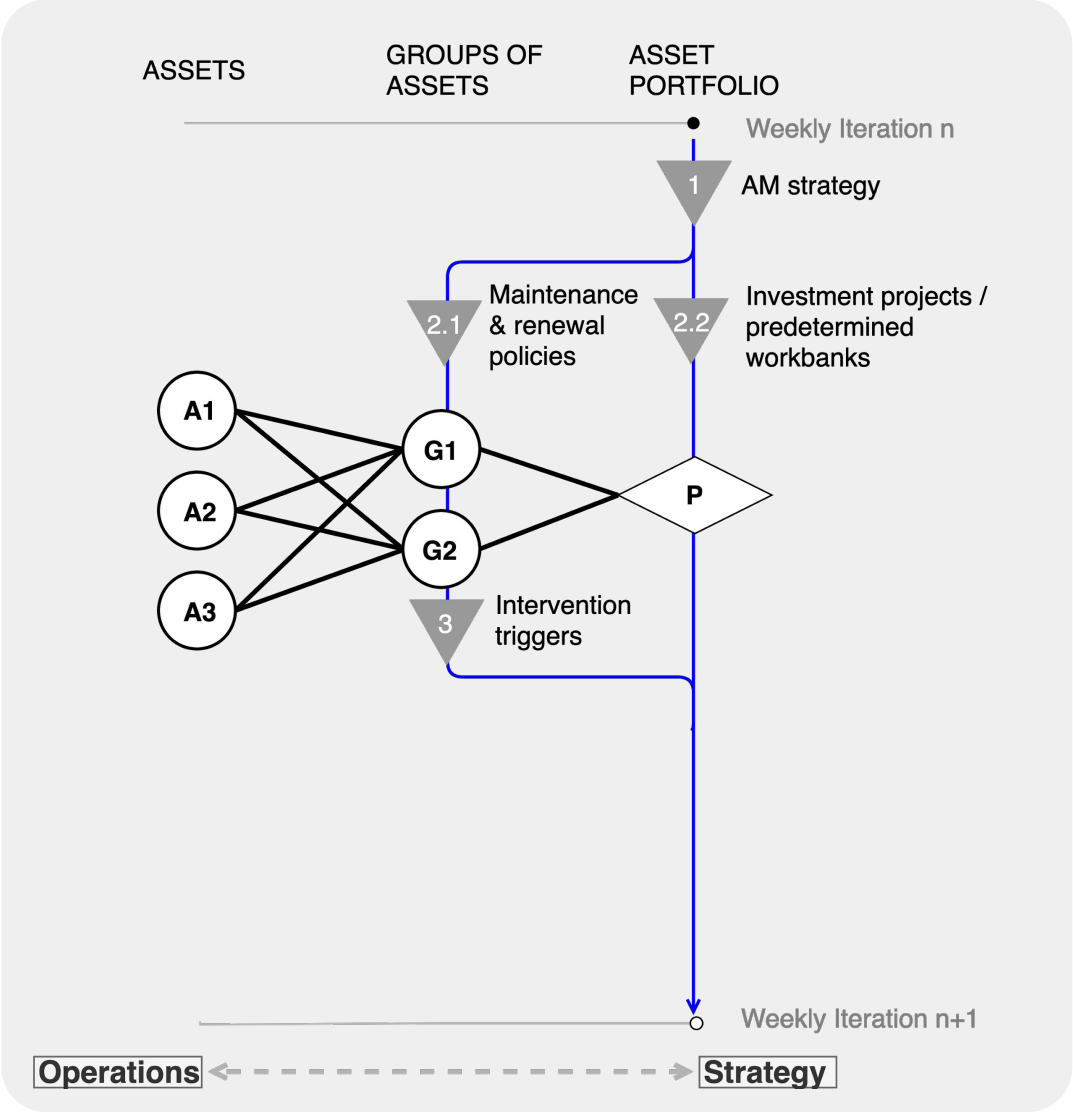
2.1 Renewal / refurbishment of conductor rail

2.2 Commissioning / decommissioning of conductor rail
Predetermined renewals

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





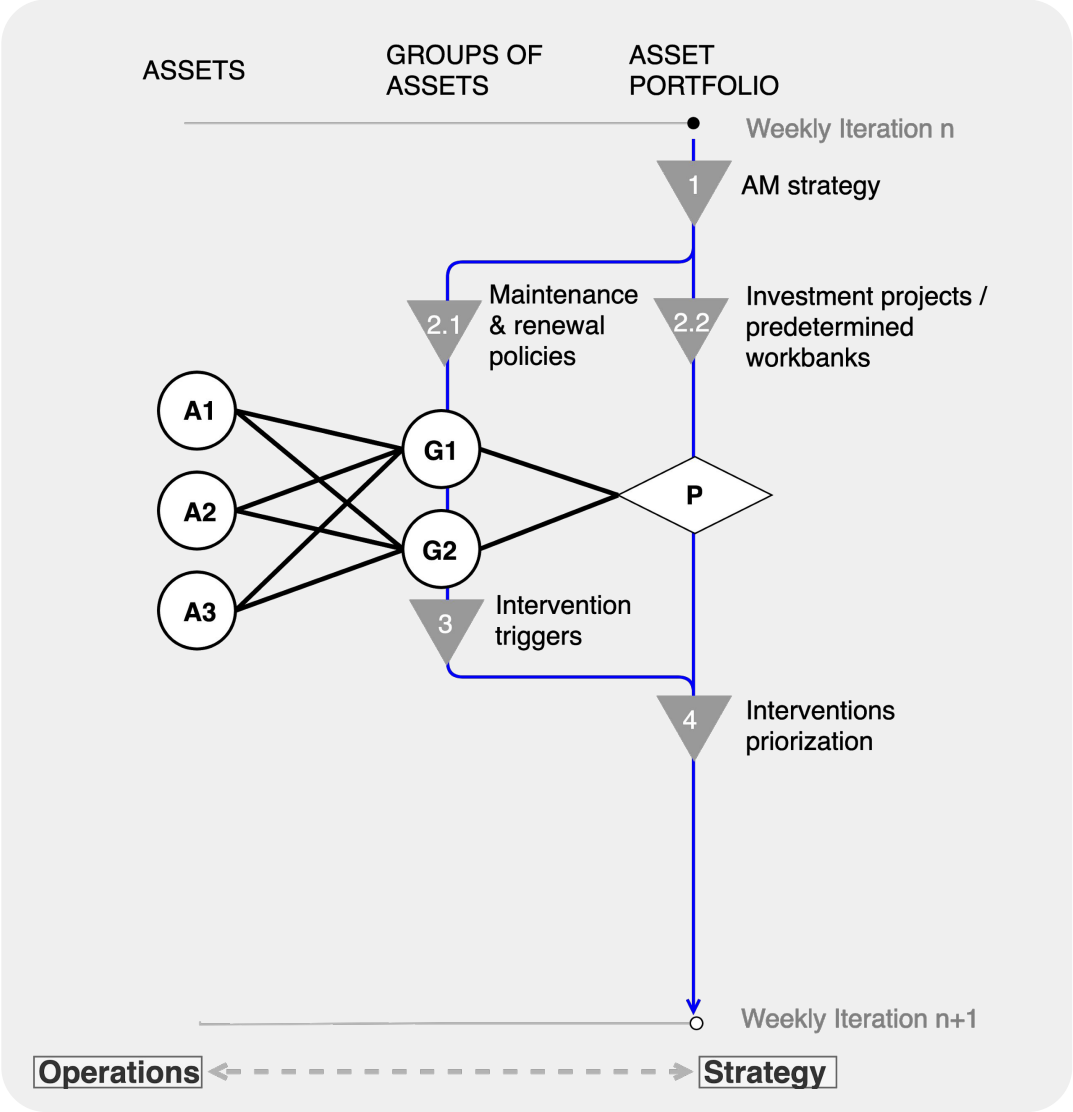
**Example of the conductor rail of an electrified route section**

3 Intervention triggers based on
- conductor rail wear thresholds
- conductor rail age thresholds

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





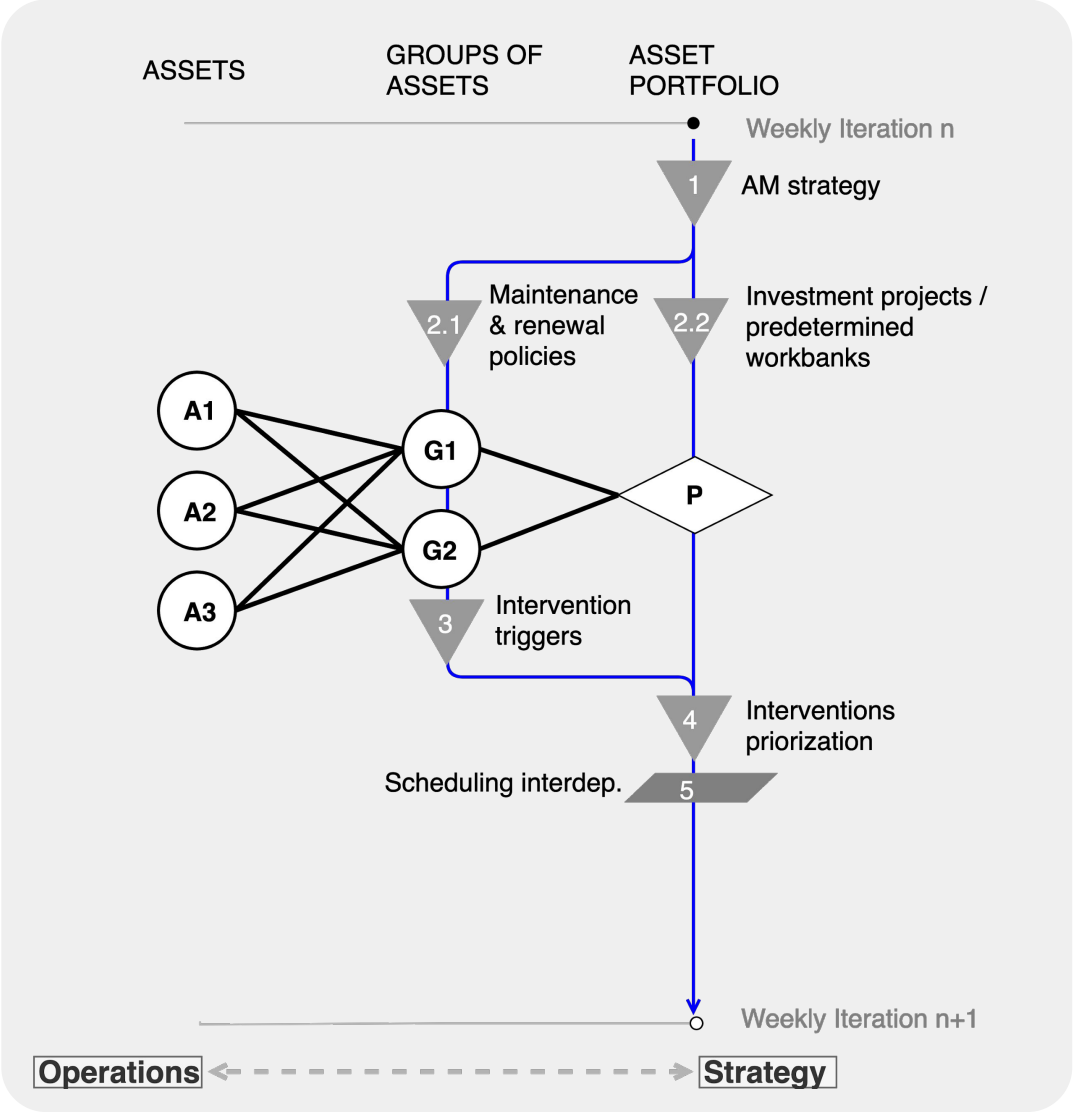
**Example of the conductor rail of an electrified route section**

4 Intervention prioritization based on asset criticality and route criticality

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





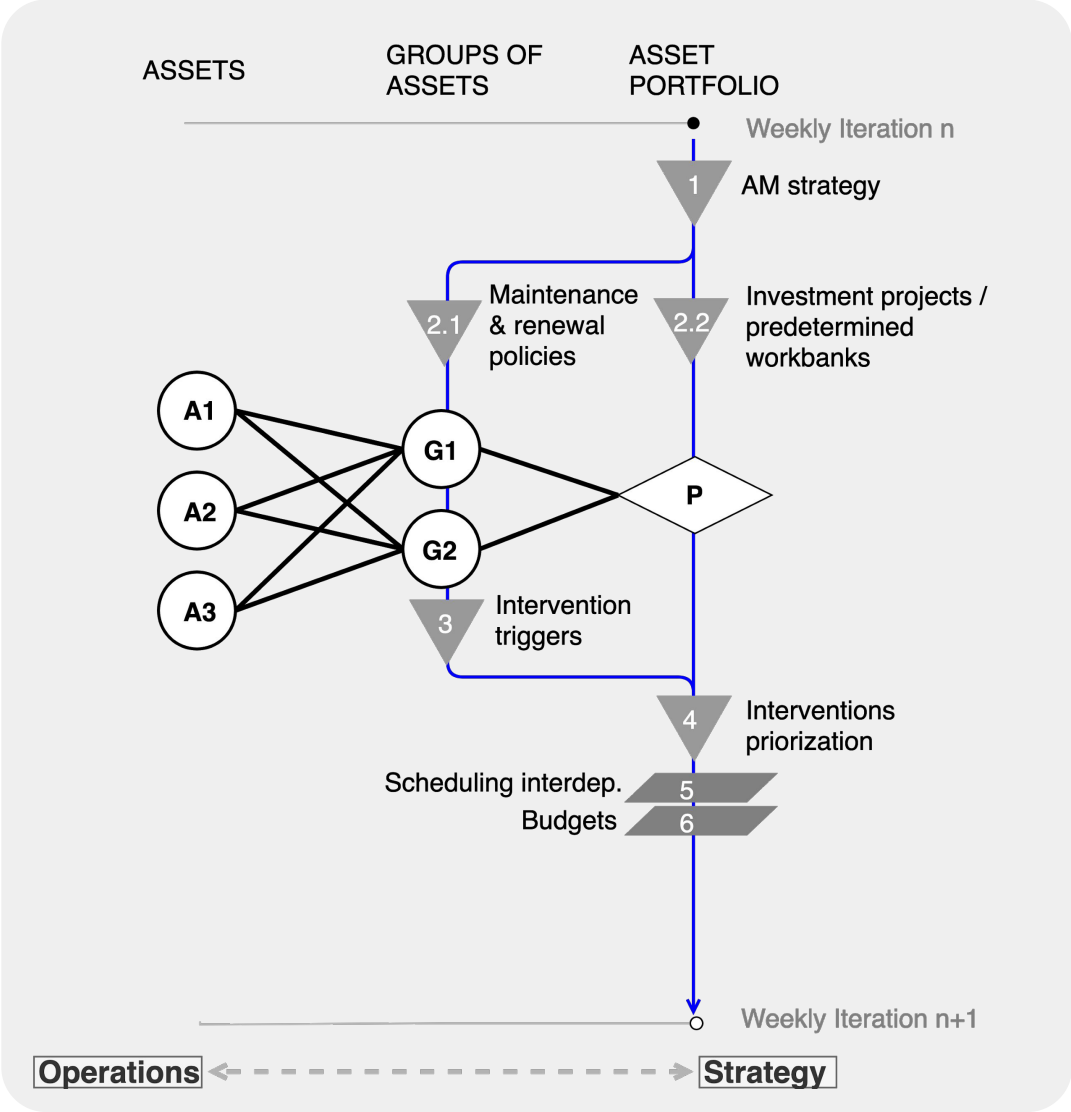
**Example of the conductor rail of an electrified route section**

5 Operations-compatible interventions : **per route section**
Major works as sum of sequenced minor works

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





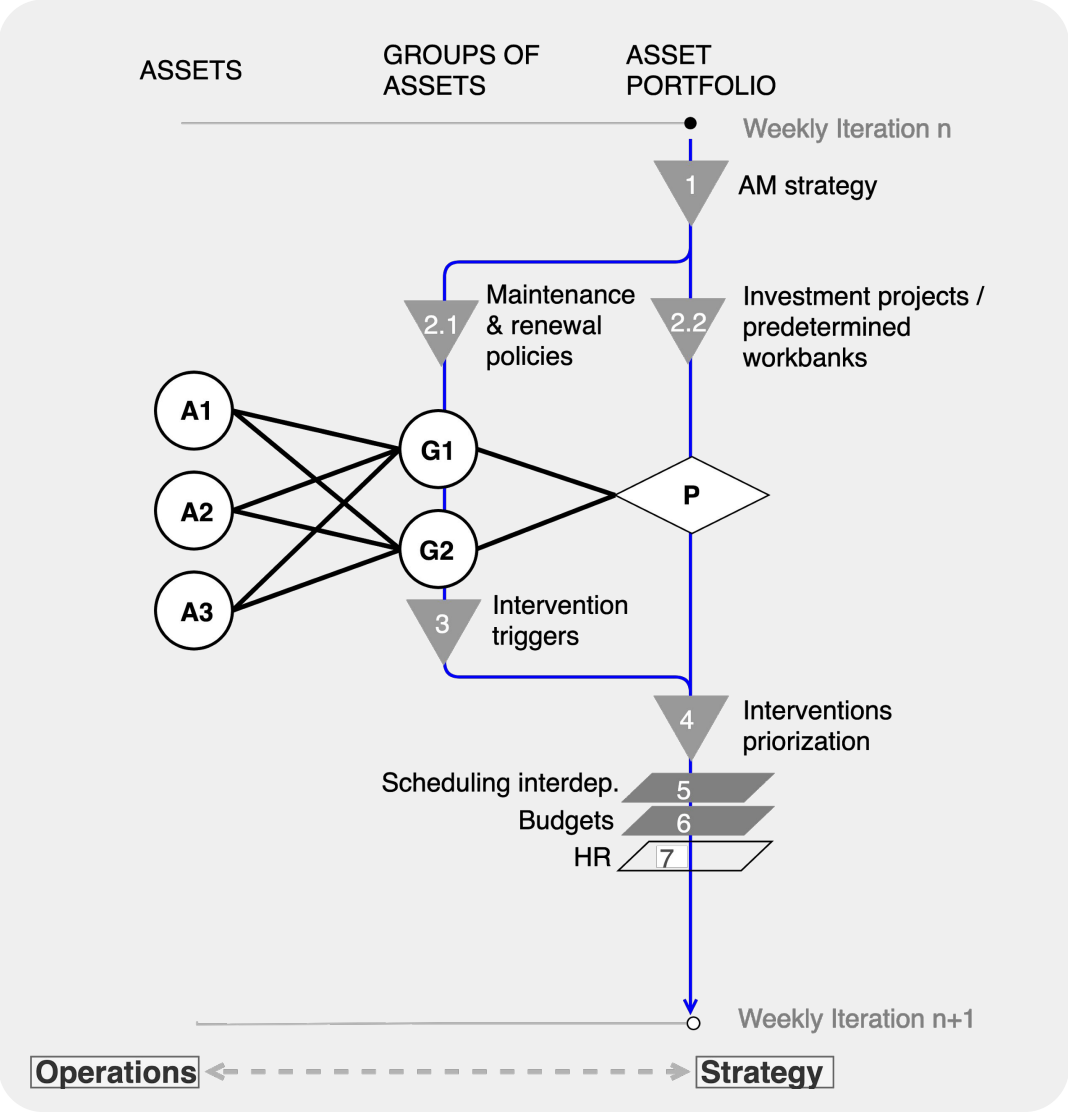
**Example of the conductor rail of an electrified route section**

6 Budgets
- per route or
- on global envelope network wide

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





**Example of the conductor rail of an electrified route section**

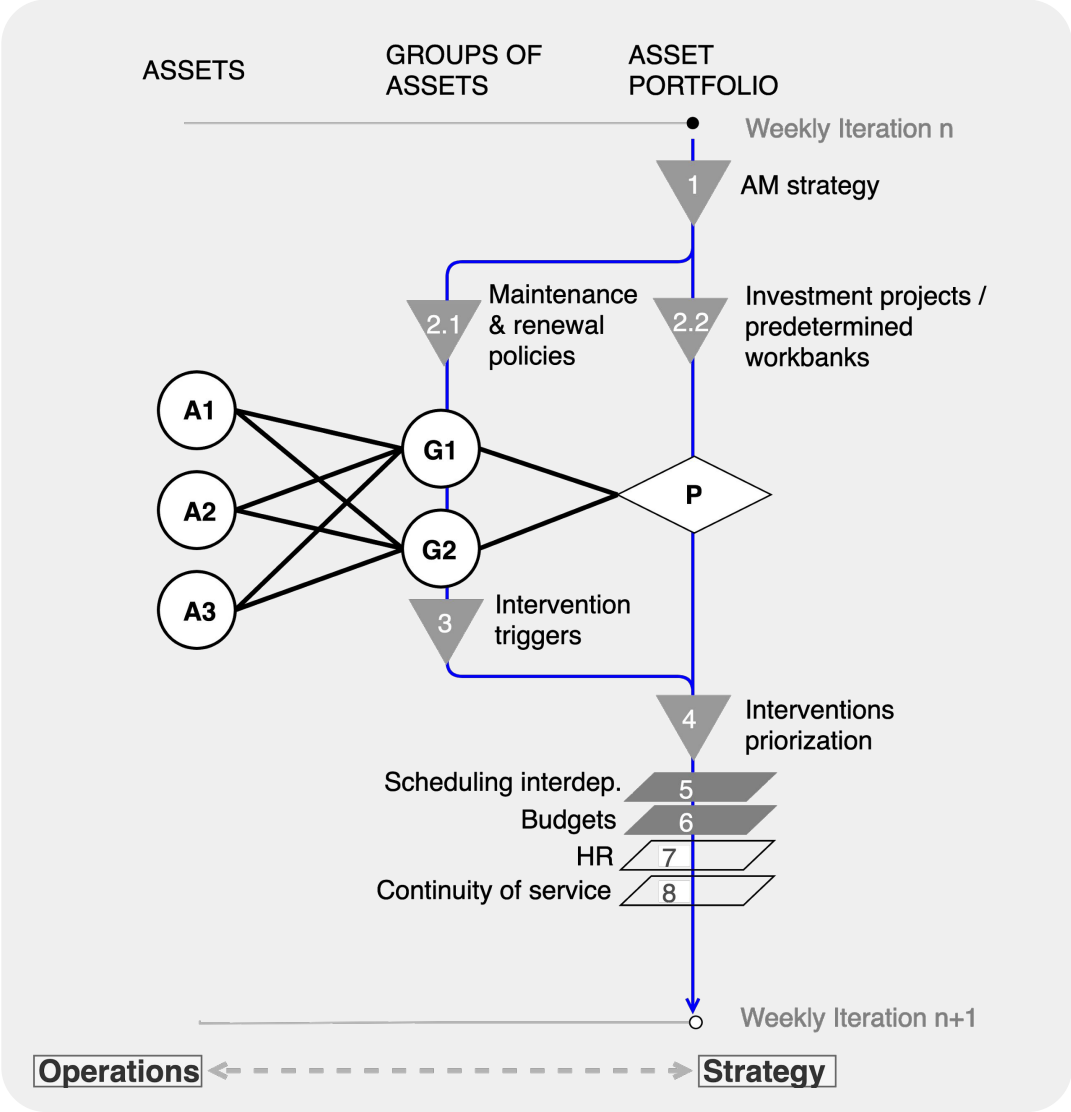
7 Human Resource sufficiency [1] - *non activated on NR use case*

- Internal workforce / suppliers
- per required skill
- per geographical reach

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





**Example of the conductor rail of an electrified route section**

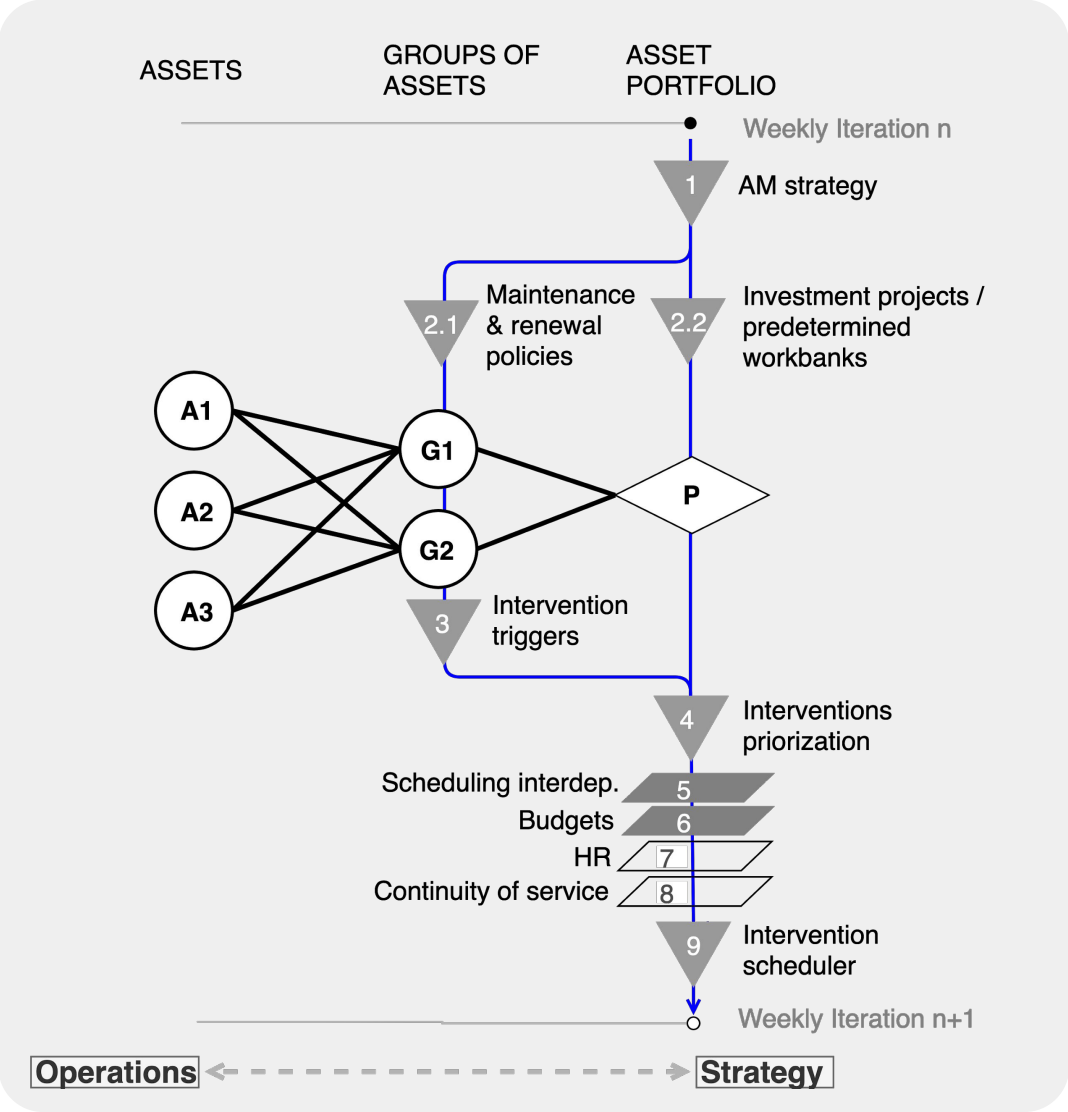
8 Continuity of service scheduling constraints [1] - *non activated on NR use case*

- network redundancy

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





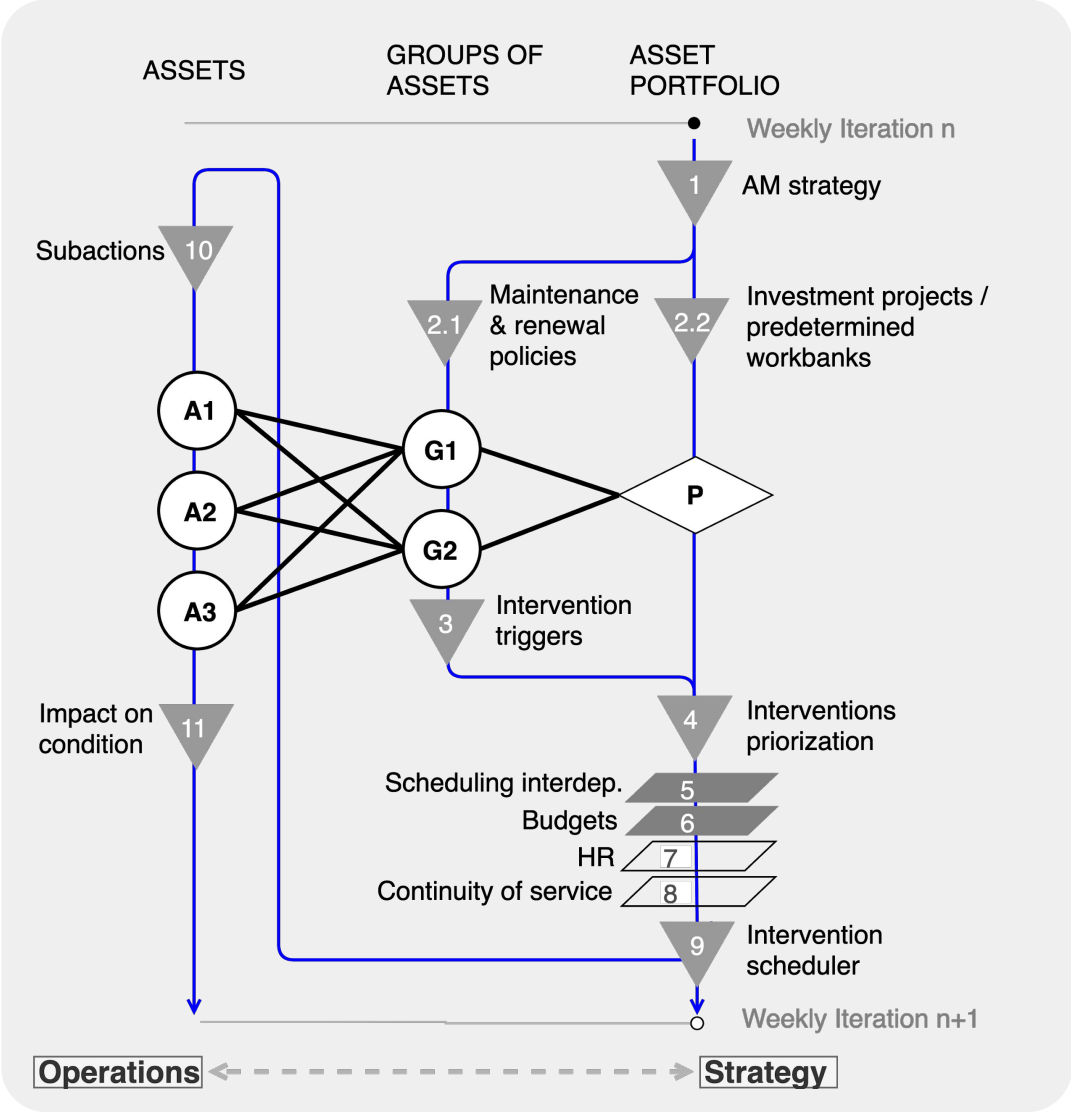
**Example of the conductor rail of an electrified route section**

9 Conflicts management, multi-constrained scheduler

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset investment and maintenance workflow





## Example of the conductor rail of an electrified route section

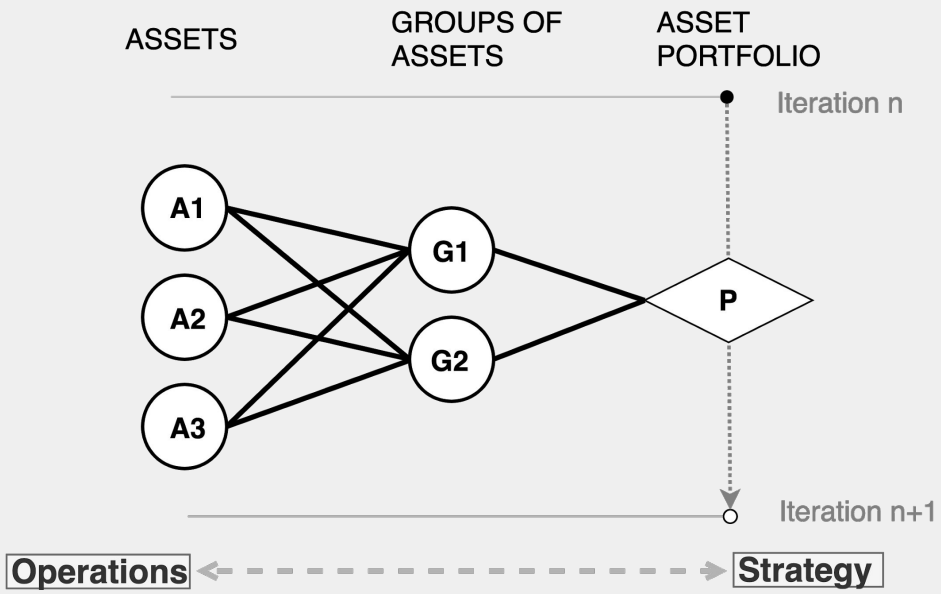
**10** Maintenance, replacement, commissioning & decommissioning subactions
Minor works

**11** Absolute / relative impact of intervention on asset condition

[1] Lacroix & Stevenin, A digital model of physical assets for long term network resiliency, 2017

# Cosmo Tech's ASSET solution

## Asset financial lifecycle workflow

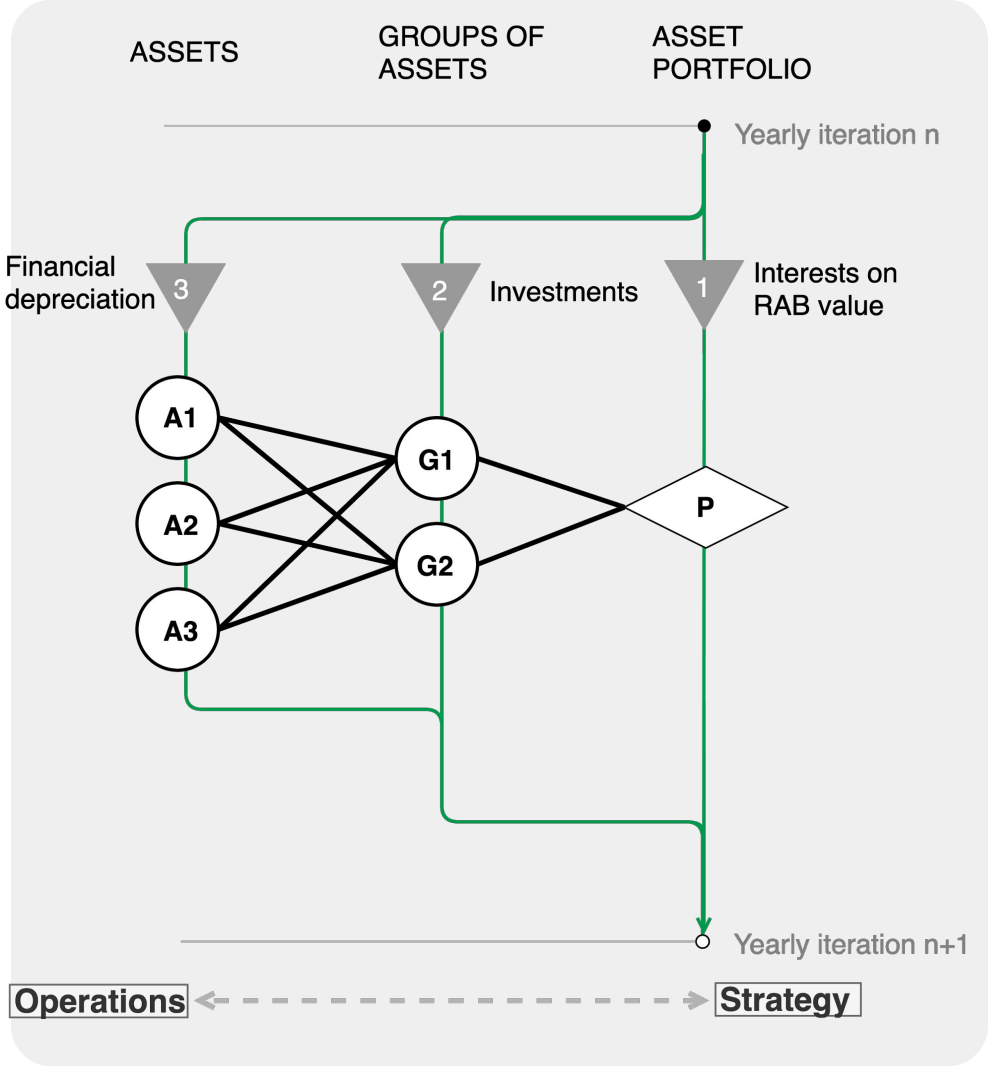



## Workflow relevant for capital-intensive industries

- Asset degradation workflow
- Interventions workflow
- Asset financial lifecycle workflow *(off-scope on NR use case)*

# Cosmo Tech's ASSET solution

## Asset financial lifecycle workflow

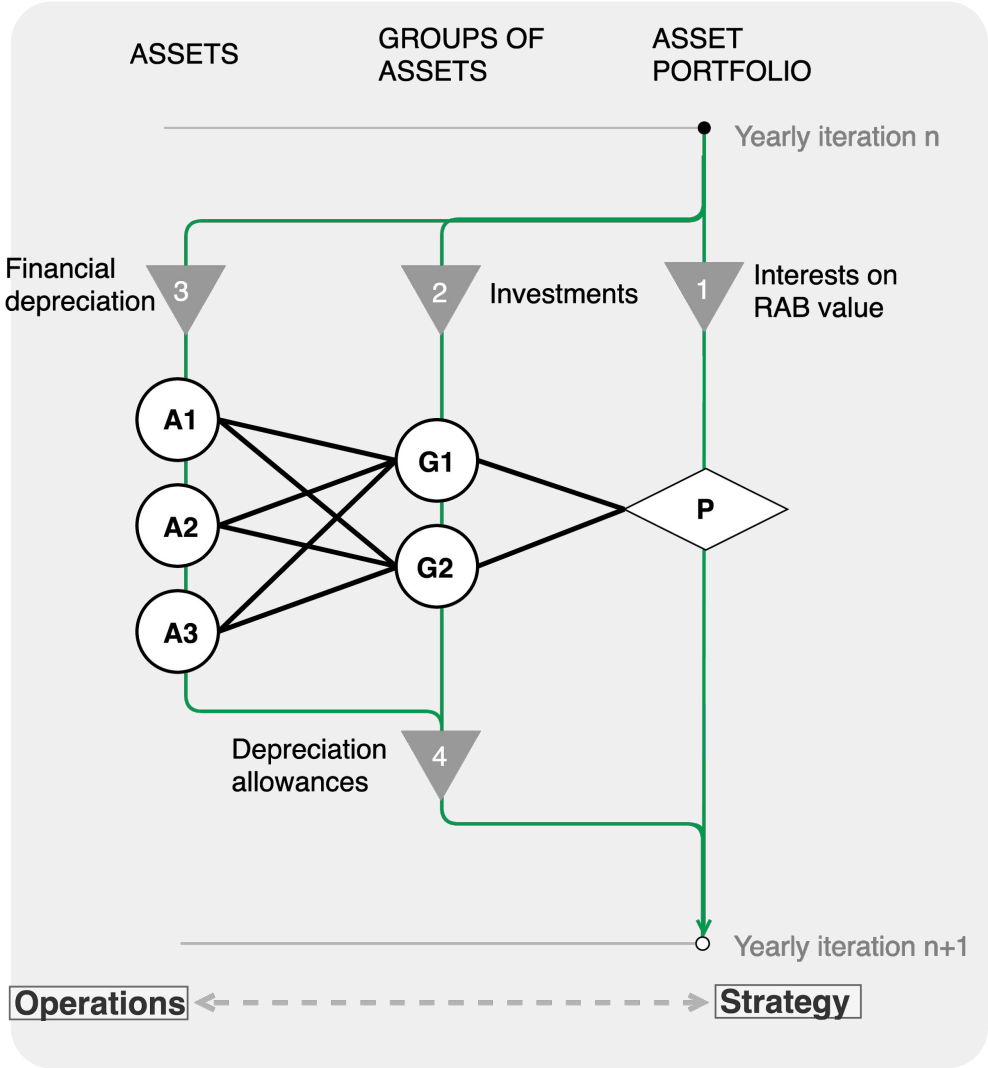



## Workflow relevant for capital-intensive industries

1. Interests are computed from the instantaneous **RAB value** considering WACC
2. the sum of CAPEX **investments** is taken into account
3. The financial value of each asset is **depreciated** on basis of their **financial lifetime**

# Cosmo Tech's ASSET solution

## Asset financial lifecycle workflow

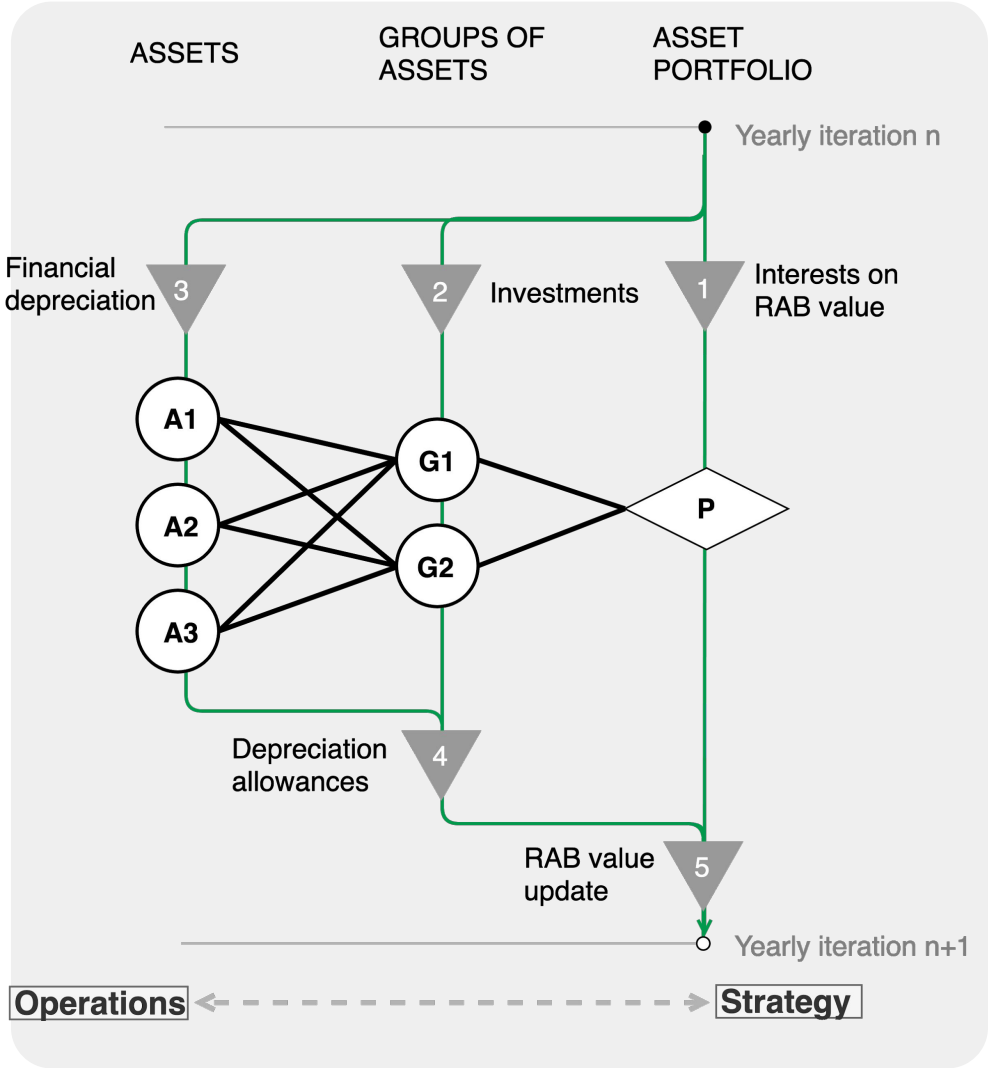



**Workflow relevant for capital-intensive industries**

4 **Depreciation allowances** are computed from individual asset **financial depreciations** and **replacements of non-depreciated assets / groups of assets**

# Cosmo Tech's ASSET solution

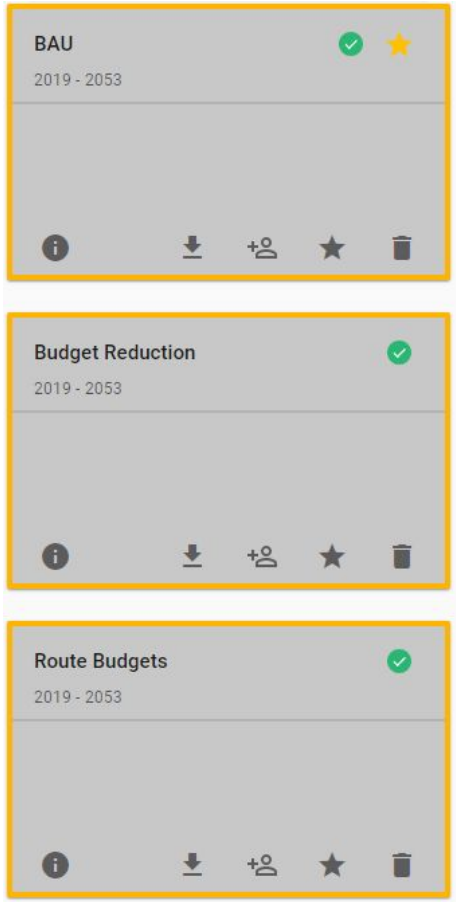
## Asset financial lifecycle workflow




**Workflow relevant for capital-intensive industries**

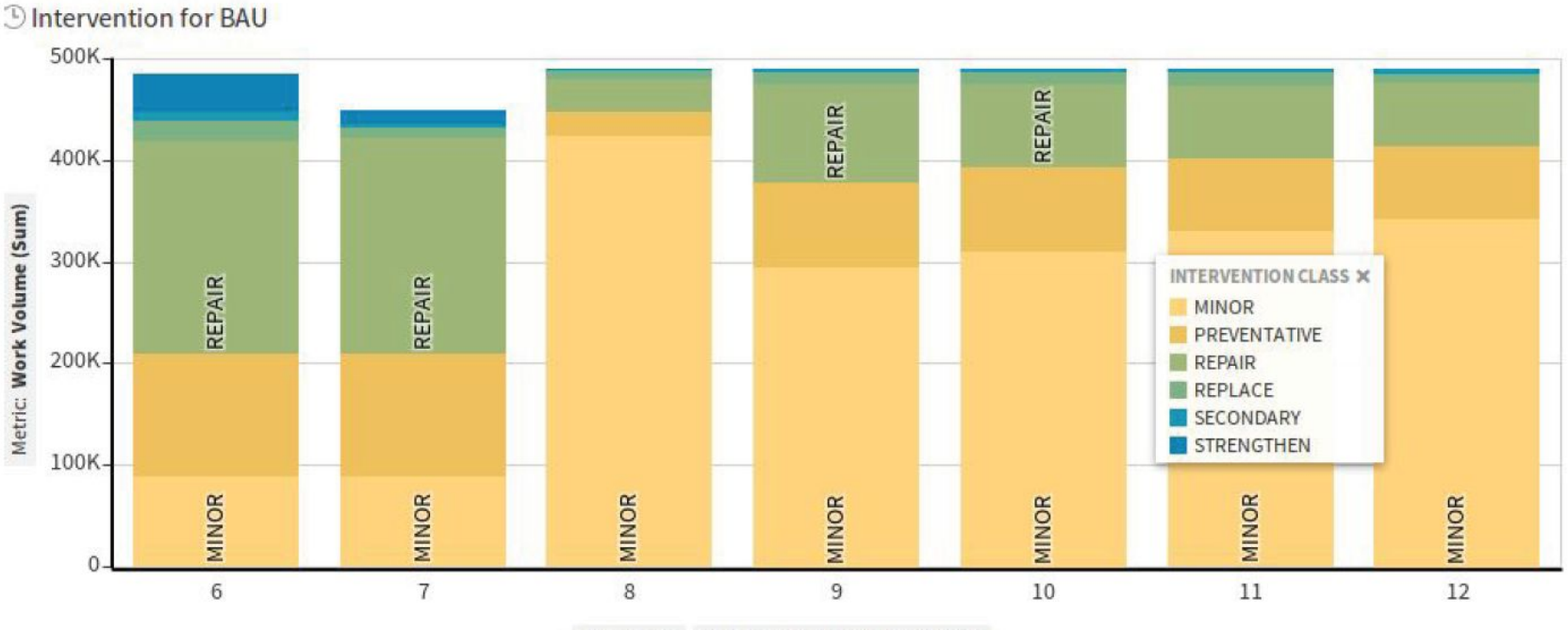
5 the **Regulated Asset Base is updated** after assets are incrementally depreciated and renewals / commissioning / decommissioning are taken into account

# Results




**Simulation outputs per scenario:**

- Intervention volumes and associated costs
- Asset condition (per asset and aggregated)



# BENEFITS

- **Integrated planning is underway**
  - Strategic decision making : CAPEX projects optimally planned / prioritized
  - Operational decision making : plan feasibility can be tested against multiple scheduling constraints

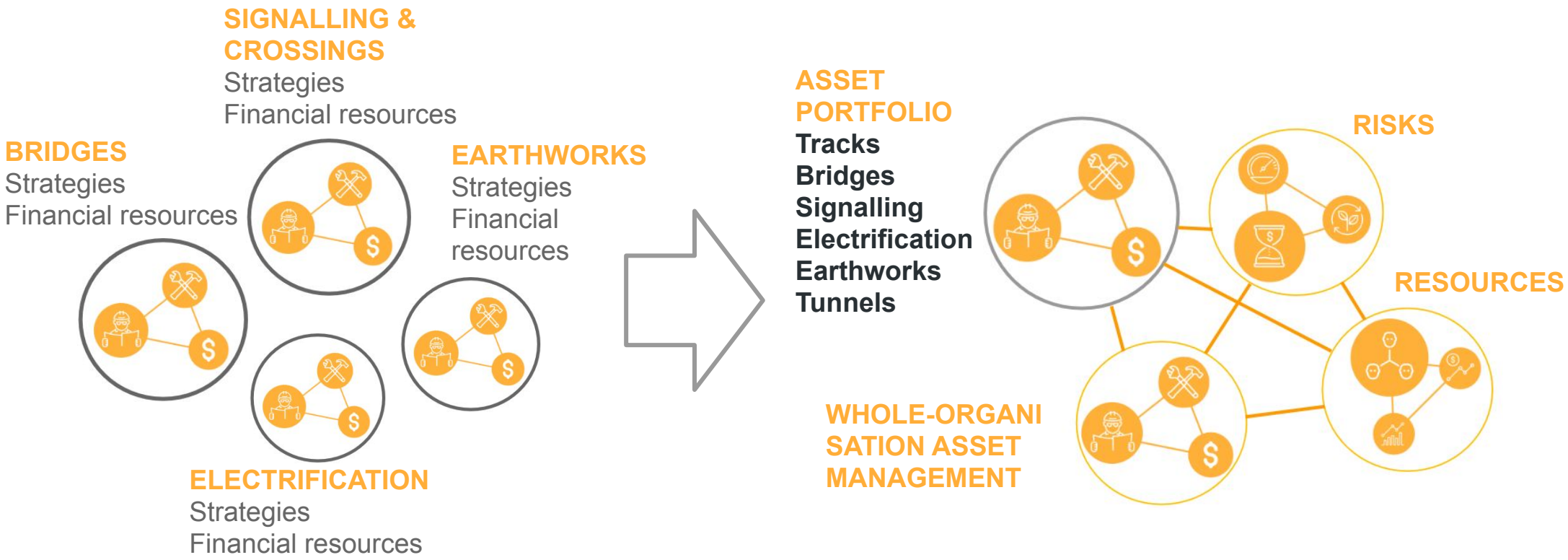


- Asset degradation workflow
- Interventions workflow
- Asset financial lifecycle workflow *(off-scope on NR use case)*

- **Methods / technology**
  - common & unified modelling methodology
  - maintainable platform
  - evolutivity of model


-

# BENEFITS




- Simulation of **unified asset management strategy**
- Coupling **whole-enterprise resources & constraints**
- Coupling **interventions scheduling across asset classes**

# BENEFITS

## Current use cases

The scope of OPEX allocation is changing

**“How will the global condition of the asset portfolio evolve?”**

An cut in investment volumes - X million GBP/year is foreseen starting 2025

**“On which asset class should I act in order to reach this objective?”**
**“What will be the consequence on quality of service indicators, risk indicators, HR sufficiency? ”**

By 2024, human resources will show a decreasing trend of approximately X% per year.

**“How will plan sufficiency indicators evolve?**
**What is the impact on performance, risks?“**

# BENEFITS

## Current use cases

A decrease in OPEX budgets by X% is foreseen before 2050.

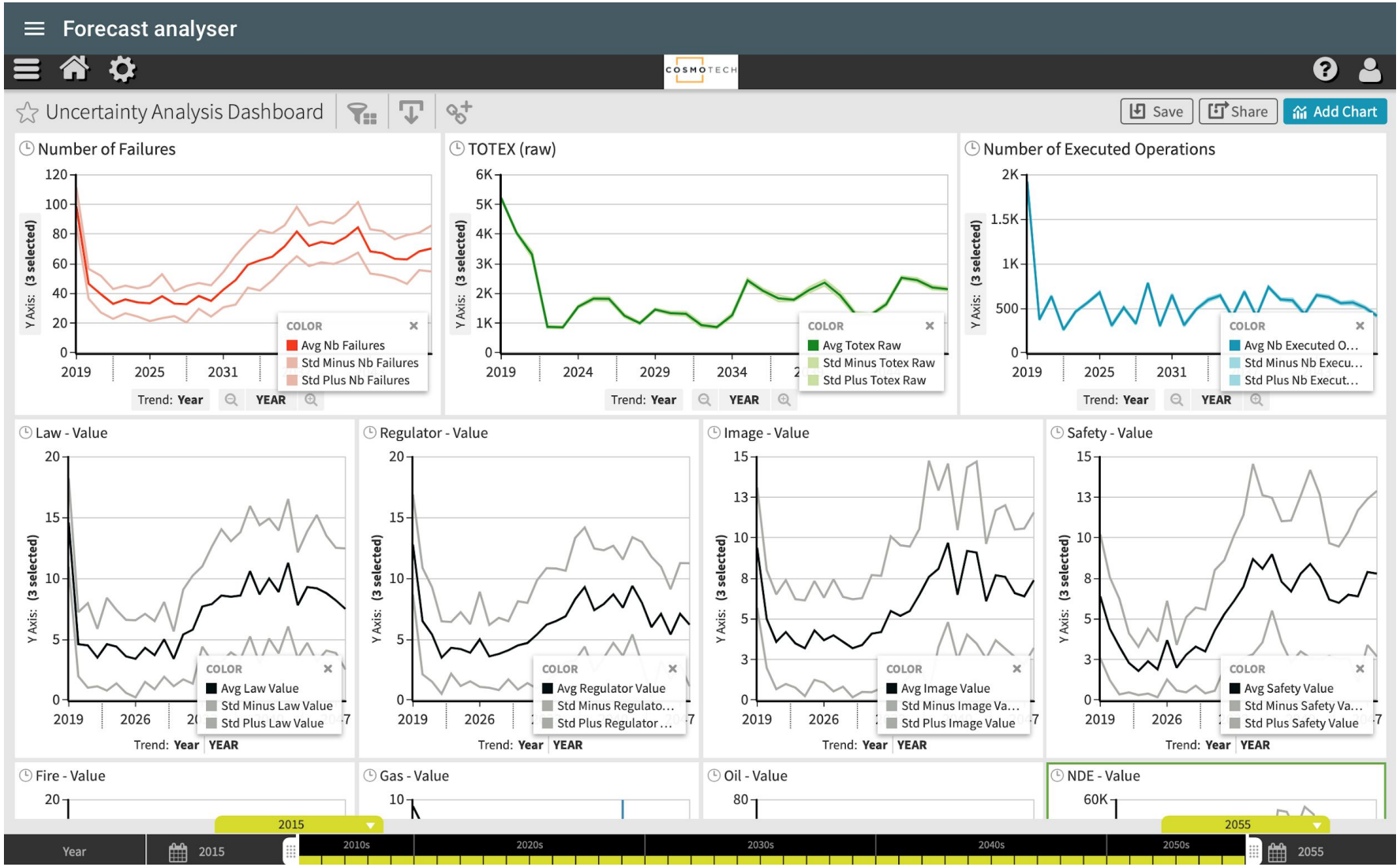
**“Is it feasible?”**
**“Which is the optimal investment/maintenance trade-off guaranteeing constant performance“**
**“Which is the consequence on risk indicators, HR sufficiency?”**

A major project of network extension is foreseen before 2035 constraining the global CAPEX envelope as well as constraining the OPEX envelope post commissioning

**“Which is the consequence on quality of service indicators, risk indicators?”**
**“How will the RAB value evolve”?**

**“How will asset condition indicators evolve on the existing infrastructure perimeter”?**

# BENEFITS Apprehending uncertainty at overall system level



# Take aways

#1
Complex systems modelling approach is an enabler to **reach integrated planning**

#2
A consistent modeling platform allows the design, evolutivity, maintainability of a **unified modelling approach for asset investment simulation and optimization**

#3
System-wide sensitivity analysis is the enabler for the **handling of uncertainties**

# Thanks for your attention!
# Questions are welcome!

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## Acknowledgement

NetworkRail

Matthew Hamer, Sunny Modhara, Joel Bradshaw, Samuel Chew, Julian Williams, Andy Kirwan

COSMOTECH

Mathieu Ippersiel, Cyril Vuillecard, Paul Duvivier, Aaron Forshaw, Pierre Alexis Gros, Julien Chauvet, Michelle Alonda, Margreet Bruinsma, Dylan Kissane, Sarah Paronto