Bridging the gap between operations and long term asset investment

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

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
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!

[2] TAMCL Market study Asset Investment Planning Solutions, 2018
[3] Gartner Hype Cycle for Utility Industry IT, 2018
ABOUT

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

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

**Signalling & Crossings**
- Strategies
- Financial resources

**Structures**
- Strategies
- Financial resources

**Earthworks**
- Strategies
- Financial resources

**Electrification**
- Strategies
- Financial resources

**Strong baseline:**
- Existing models developed internally
- Sophisticated, calibrated & mature
- Simulation is SOP

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**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]

**Digital twins**

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

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

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

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

**Predictive analytics**

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"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).

[2] Le et al 2017
[3] Boudreau et Poirier
[6] Sharma et al 2018
[8] Capra et a 2006
[9] A. Magnien, RailTopoModel, UIC, 2019
ABOUT

COSMO TECH

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
Cosmo Tech’s ASSET solution

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

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

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[1] Structures Modelling Overview, Matthew Hamer, Network Rail, 2017
[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
[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 resilience, 2017
Cosmo Tech’s ASSET solution

Asset investment and maintenance workflow

Example of the conductor rail of an electrified route section

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

[Diagram showing the workflow process]

Example of the conductor rail of an electrified route section

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**

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

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

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Cosmo Tech’s ASSET solution

Asset investment and maintenance workflow

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Asset investment and maintenance workflow

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![Diagram of asset investment and maintenance workflow](http://www.imeche.org)

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

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

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[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

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
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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
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Asset financial lifecycle workflow

![Diagram showing asset financial lifecycle workflow]

Workflow relevant for capital-intensive industries

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

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

- **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.

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

“How will the RAB value evolve”?
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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witold.krasny@cosmotech.com