What is asset management?

- Asset Management is:
  "The coordinated activities of an organisation to realise value from physical assets"

Definition from International Standard ISO 55000.
Why is asset management important?

- Asset Management helps Infrastructure Managers to:
  - Prioritise and justify works
  - Spend efficiently
  - Coordinate access/possessions
  - Define levels of safety and service
Degradation - Context

Asset Life

Identification & Feasibility → Planning & Design → Construction → Operation → Disposal

Performance Cycles

Initial or restored performance → Maintenance, Repair/Rehab → Performance after deterioration

Deterioration and/or damage
Degradation - Context

After Frangopol and co-workers, ca. 2000 -
Example: Loss of coating

\[
\frac{A_{pr}(t)}{A_{pr0}} = 1 - \left( \frac{0.6t^2}{T_L^2} - \frac{0.1t}{T_L} \right)
\]
Example: Track Condition

\[ Q_t = Q_n \times e^{b \times t} \]

Deterioration rate, \( b \), influenced by:
- Track alignment
- Subsoil condition
- Ballast quality
- Transport load
- …..
• Substantial progress on deterioration and performance modelling
  – Both physical and empirical models
  – Wide range of input conditions
  – Profiles suitable for LCA/LCC analysis
• Developed both condition and capacity based criteria for:
  – Soil cuttings
  – Track
  – Metallic bridges
  – Concrete lined tunnels
• Wide range of profiles developed for LCAT modelling
  – Representative condition-based profiles
  – Some capacity-based profiles (they need to be case specific)
  – Selection of intervention strategies
• Model validation has been carried out and could be extended as
  more field data become available
Global view of the E11 strain of deformed Åby Bridge under 250 kN axle load (including self-weight)
Loading to failure
Loading to failure – Abacus model

**Test Program**
- Tests with trains (Aug 2012)
- Move to new foundation (Oct 2012)
- Dynamic tests (June 2013)
- Static test (Aug 2013)
- Strengthening (Sep 2013)
- Test to failure (Sep 2013 or 2014)
## Bridge Replacement

### a) Preparation of ground works before launching new bridge.

### b) Ground works completed and launching beams installed.

### c) Hydraulic jacks install the bridge is lifted 5 cm and is in position.

### Table with main parameters for decision taking

<table>
<thead>
<tr>
<th>Track possession</th>
<th>☒ 10 days ☐ 1 month roadway below the track has to be closed for ~2 to 3 month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement</td>
<td>☒ full Replacement ☐ partial Replacement</td>
</tr>
<tr>
<td>Design life/durability</td>
<td>☒ 100 years ☐ 50 years ☐ 10 years</td>
</tr>
<tr>
<td>Risk</td>
<td>☒ negligible risk (well-known technology, standard) ☐ minor risk ☐ major risk</td>
</tr>
</tbody>
</table>

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## Bridge Replacement – Comparison Table

++ = yes  
+   = may work  
─  = no  

<table>
<thead>
<tr>
<th>Mobile Cranes</th>
<th>Rail Mounted Crane</th>
<th>Rail Mounted Bridge Carrier</th>
<th>Longitudinal Launching</th>
<th>Horizontal Launching</th>
<th>Deck Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bridge length</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Less than 5 m</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>1.2 5-20 m</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>1.3 More than 20 m</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>2. Bridge type to be exchanged</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2.1 Reinforced concrete beam bridge</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>2.2 Steel truss</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>2.3 Steel beam</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>2.4 Arch</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2.5 Other</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3. Track possession time</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3.1 Between 6-12 h</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>3.2 Between 12-24 h</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>3.3 Between 24-60 h</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>3.4 More than 60 h</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
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S&C Replacement Methods

Excavators

Road cranes

Railway cranes

Crane-beam systems

Portal cranes (UWG/Geismar-Fasseta)

Modular switch
## S&C Replacement: Comparison Table

<table>
<thead>
<tr>
<th></th>
<th>Output (duration of track possession; total S&amp;C duration)</th>
<th>Need of lineside space (for S&amp;C pre-assembly)</th>
<th>Availability of the system (is the machinery required widely available? Is its use extended?)</th>
<th>Labour (number of workers required for installation)</th>
<th>Machinery Cost (cost related to the use of machinery)</th>
<th>Quality of installation (is the switch carefully handled during transport and installation?)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excavators</strong></td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td><strong>Road Cranes</strong></td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td><strong>Railway cranes</strong></td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>(Kirow, etc.)</td>
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<tr>
<td><strong>Crane-beam systems</strong></td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+++</td>
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<tr>
<td>(Desec TL1200, VAIACAR, etc.)</td>
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</tr>
<tr>
<td><strong>Portal Cranes</strong></td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++ (UWG)</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>(UWG, Fasseta, etc.)</td>
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<tr>
<td><strong>Modular switch</strong></td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
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<td>+++</td>
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</tbody>
</table>

+++ Excellent performance
++ Average performance
+ Poor performance
Monitoring Āby Bridge

Figures:
• (a) The setup for photometric measurements
• (b) Cables from sensors for measurements
• (c) Optical measurements of strains in the critical riveted connection between transverse and longitudinal beam (Blanksvard et al, 2014)
## Data compatibility gaps and potential solutions

<table>
<thead>
<tr>
<th>Identified Gap</th>
<th>Potential Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of consistent and reliable inspection data across Europe</td>
<td>Standardisation of the inspection assessment through a commonly accepted framework</td>
</tr>
<tr>
<td>Lack of established models</td>
<td>Use of field inspection data to develop empirical models; hybrid models</td>
</tr>
<tr>
<td>High cost of continuous monitoring and limitations of periodic inspection.</td>
<td>Monitor specific input parameters and avoid excess amount of data</td>
</tr>
<tr>
<td>Combining monitoring data (quantitative) with examination information (qualitative)</td>
<td>Develop appropriate decision support tools to combine all available information in an effective way</td>
</tr>
</tbody>
</table>
The Life Cycle Assessment Tool (LCAT) can compare different maintenance/replacement strategies for railway infrastructure based on a life cycle evaluation, which quantifies:

- Direct economic costs
- Availability (delay costs / user cost)
- Environmental impact costs

The LCAT is a series of prototype models that:

- Are written using Microsoft Excel.
- Are flexible to suit different users across Europe.
- Can be adapted by users.
What is the LCAT?

- Soil Cuttings
- Track
- Metal Bridges
LCAT – Inputs

- Initial Condition
- Intervention triggers
- Intervention benefits
- Intervention costs

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LCAT – Processing

Inputs

Deterioration data
Environmental Impact data
Cost data

Outputs
LCAT – Outputs

- Financial Costs
- Environmental Impact
- Operational Impact
- Condition Profile
LCAT – Example Output

Marcillo Bridges Model

Summary of Costs by Condition

<table>
<thead>
<tr>
<th>Years</th>
<th>01-05</th>
<th>06-10</th>
<th>11-15</th>
<th>16-20</th>
<th>21-25</th>
<th>26-30</th>
<th>31-35</th>
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<th>71-75</th>
<th>76-80</th>
<th>81-85</th>
<th>86-90</th>
<th>91-95</th>
<th>96-100</th>
<th>101-05</th>
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<td>2</td>
<td>Repainting Element Painting</td>
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<td>All Interventions</td>
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<td>Financial Impacts</td>
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<tr>
<td>Cash</td>
<td>48,750</td>
<td>18,750</td>
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<td>10</td>
<td>48,750</td>
<td>10</td>
</tr>
</tbody>
</table>

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Dissemination

- IABMAS conference, Shanghai, 2014.
- MAINLINE book of final outputs.
- MAINLINE USB with LCATs.
- MAINLINE website.
Conclusions (1)

- The basis of future degradation profiles have been created for track, metallic bridges and soil cuttings.

- Methods for extending the life of assets have been identified, including advanced assessment and physical strengthening.

- Comparison tables aid the selection of appropriate replacement techniques for bridges and switches & crossings.

- Monitoring and examination provides evidence for extending asset life.
Conclusions (2)

- The LCAT is flexible to ensure relevance to all users.
- The LCAT is ‘open-source’, so there is no hidden code.
- Environmental and operational costs allow detailed evaluation between similar schemes.
- Outputs from individual schemes can be rolled-up to provide a network view of applying a particular strategy.
Opportunities

• MAINLINE has highlighted opportunities for possible work in the areas below:
  
  – Data gathering from different asset types
  – Fusion of data with modelling
  – Creation of a consistent data hierarchy for assets in Europe
  – Creation of formal degradation curves for materials/elements
  – Further refinement of LCAT models
  – Creation of LCAT models for different assets
  – Promotion of Lowest Life-Cycle Costing principles
Thank you!