C4R

Capacity for Rail

C4R Workshop on Dissemination

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SEVENTH FRAMEWORK PROGRAMME

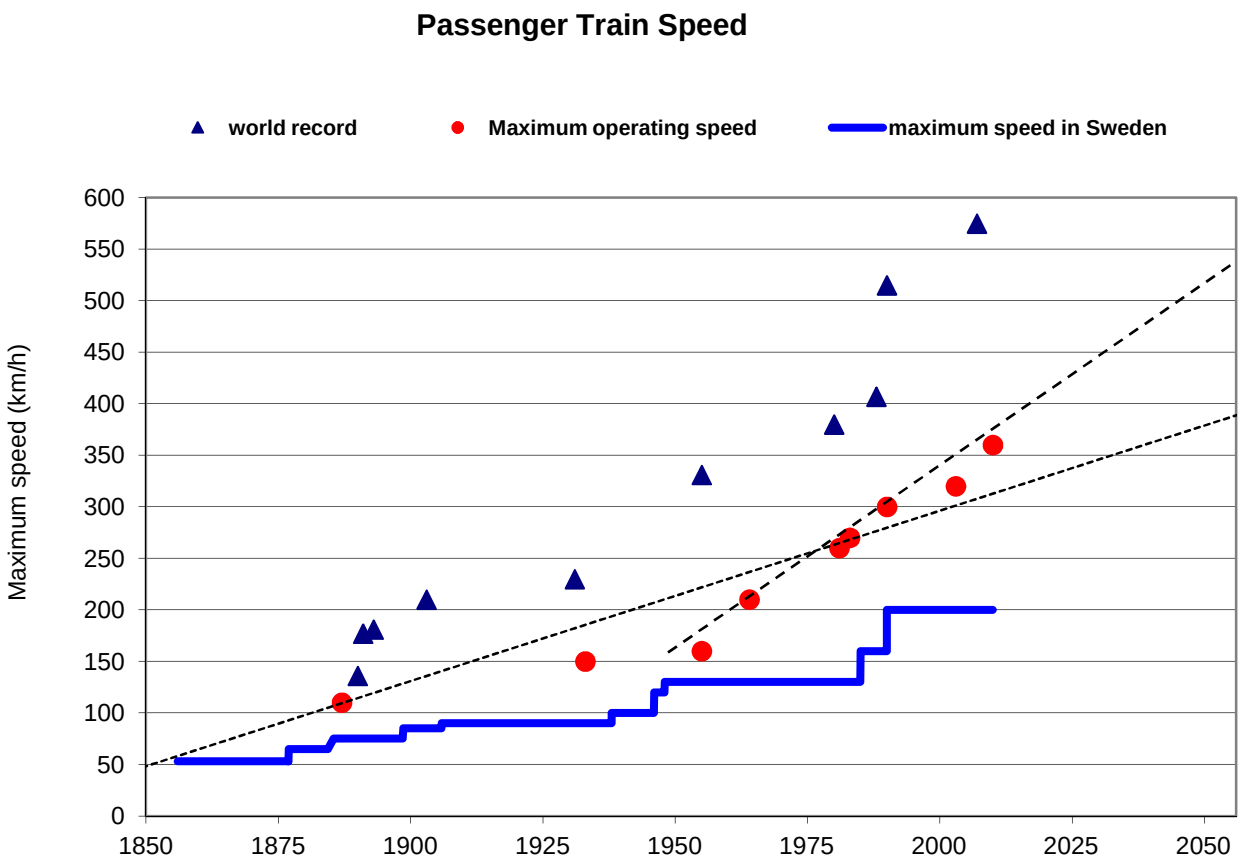
Contents of presentation

Contents

- Background and idea
- Objectives
- Traffic situations
- Infrastructure
  - substructure
  - structures
  - rail and S&C
- Maintenance routines
- Conclusions

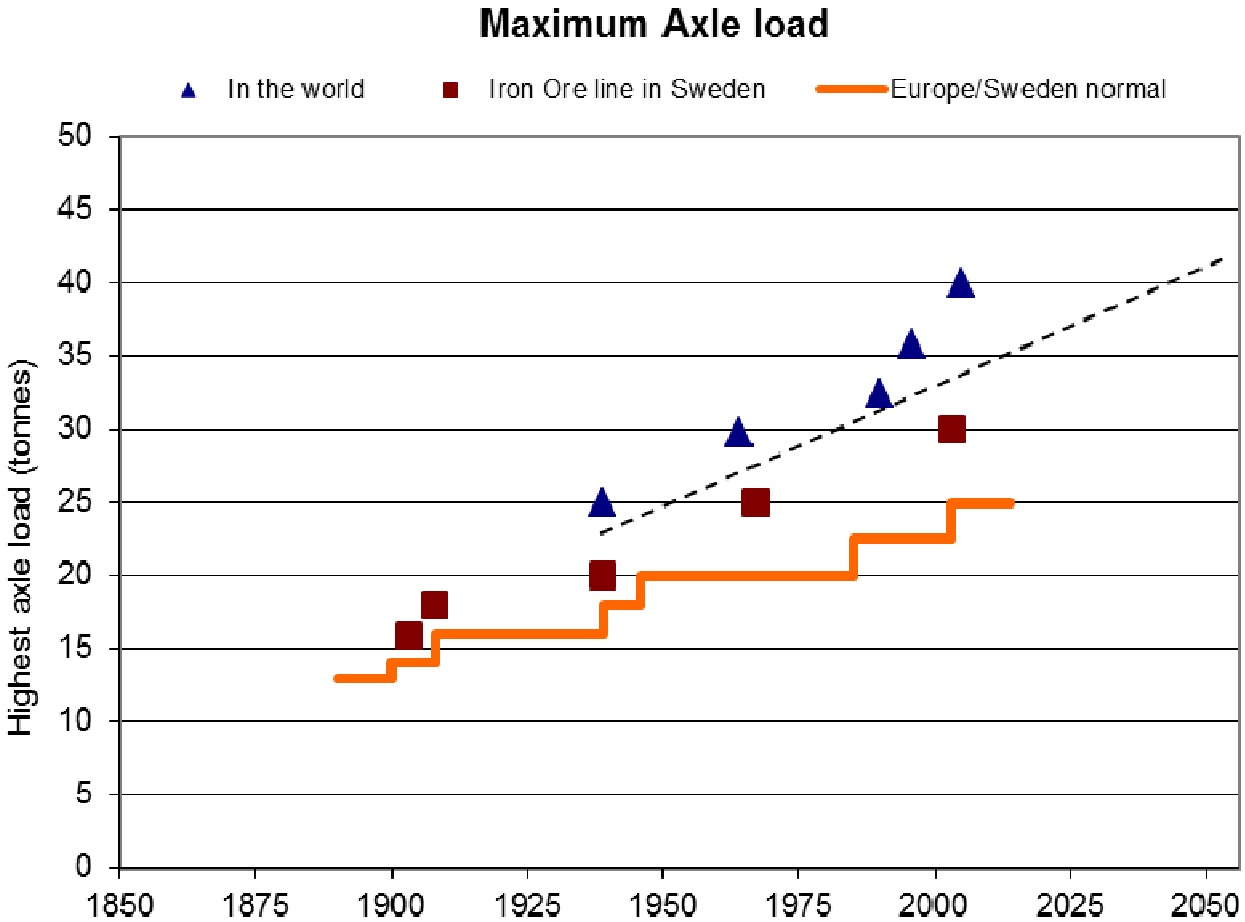
- *Background and idea*

Do you think the increase will stop 2015?



- *Background and idea*

Do you think the increase will stop 2015?



• *Background and idea*

The problem with overcrowded roads must be solved

• *Background and idea – existing lines*

Background:

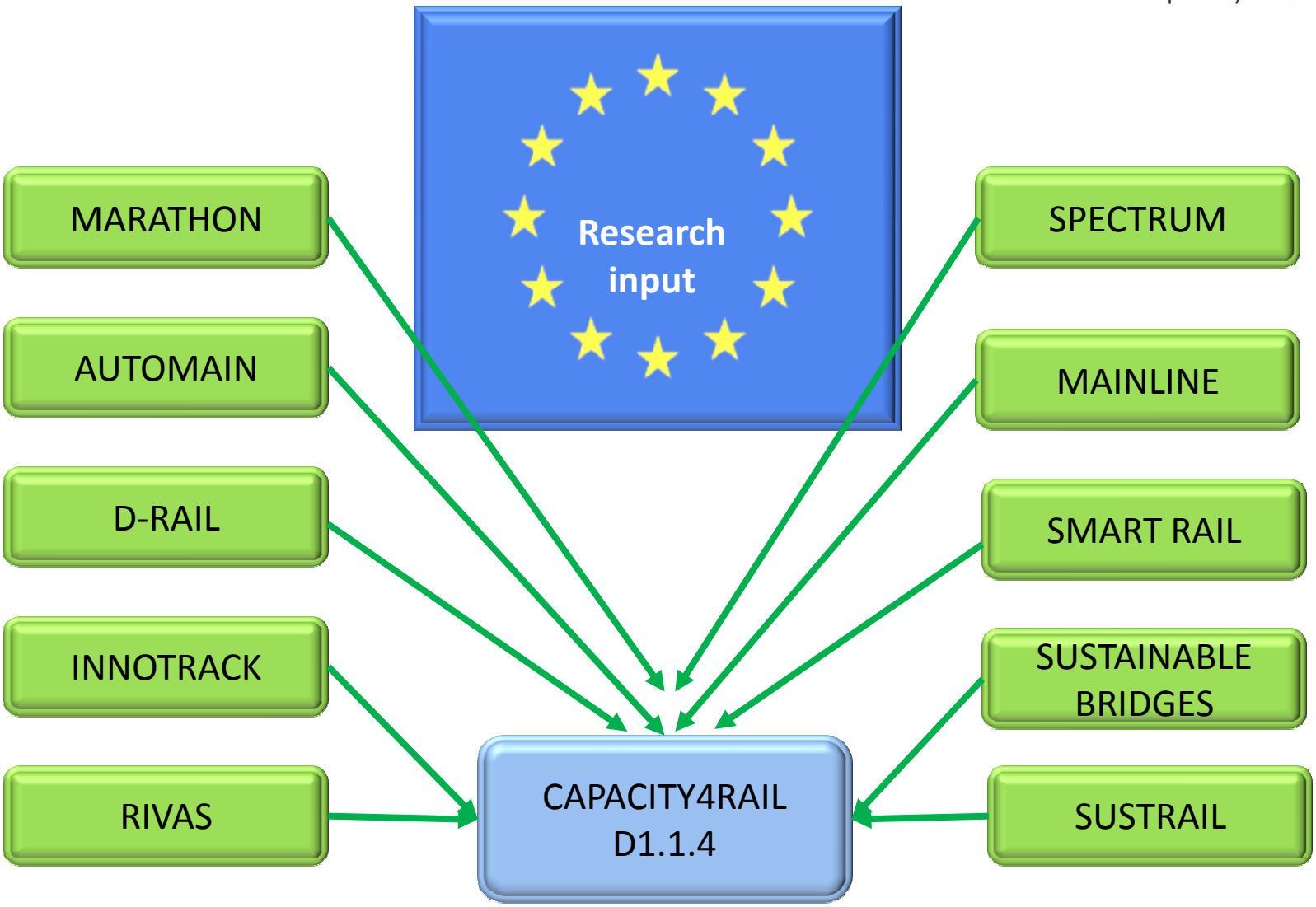
- Very few recently built railway lines are built specifically for freight traffic
- Today the trend is that the new built lines are for high speed operations and existing lines are left for freight
- These existing lines are built for the traffic demands from the time they where built
- This means that the railways have to upgrade existing lines in order to meet new demands from freight operators

• *Background and idea – meet demands*

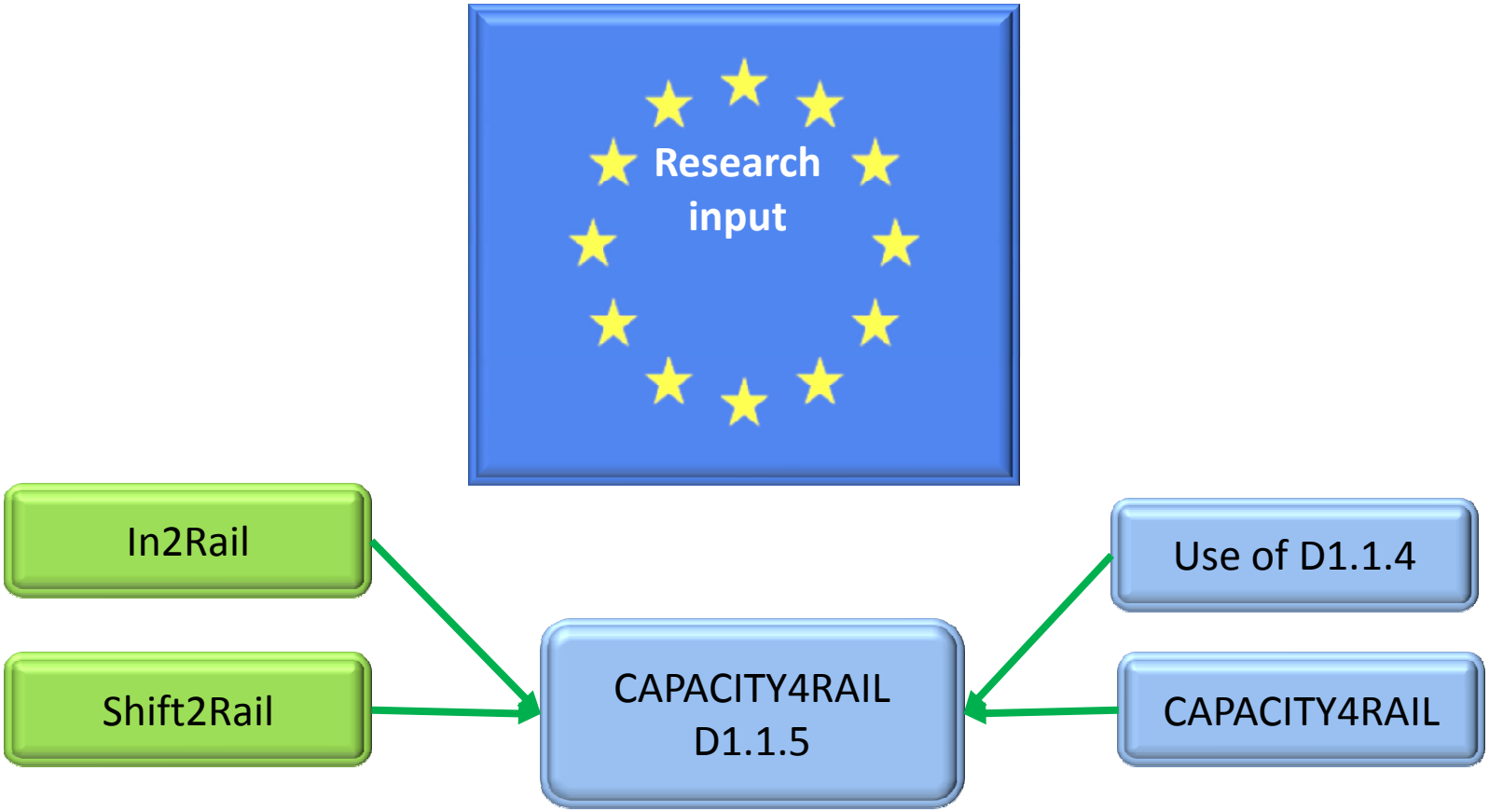
Background:

- Freight operators often comes with new proposals but they stop too often due to infrastructure restrictions.
- There are restrictions but also possibilities!
- When we upgrade to meet new demands we don't have any good guidelines or best praxis based on recent research and development.
- D1.1.4 is a guideline to support upgrading based on recent research and development.
- D1.1.5 is an upgraded version including findings from C4R and other new knowledge

Examples of EU-projects where we have new knowledge that can be used for upgrading



Examples of EU-projects where we have new knowledge that can be used for upgrading



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Objectives

The main objective is to give Infrastructure Managers a guideline so upgrading can be done

- Cost-effective
- Environmentally friendly
- Carried out in a standardised way

The guideline have clear recommendations when possible

Refer to latest knowledge or good real examples

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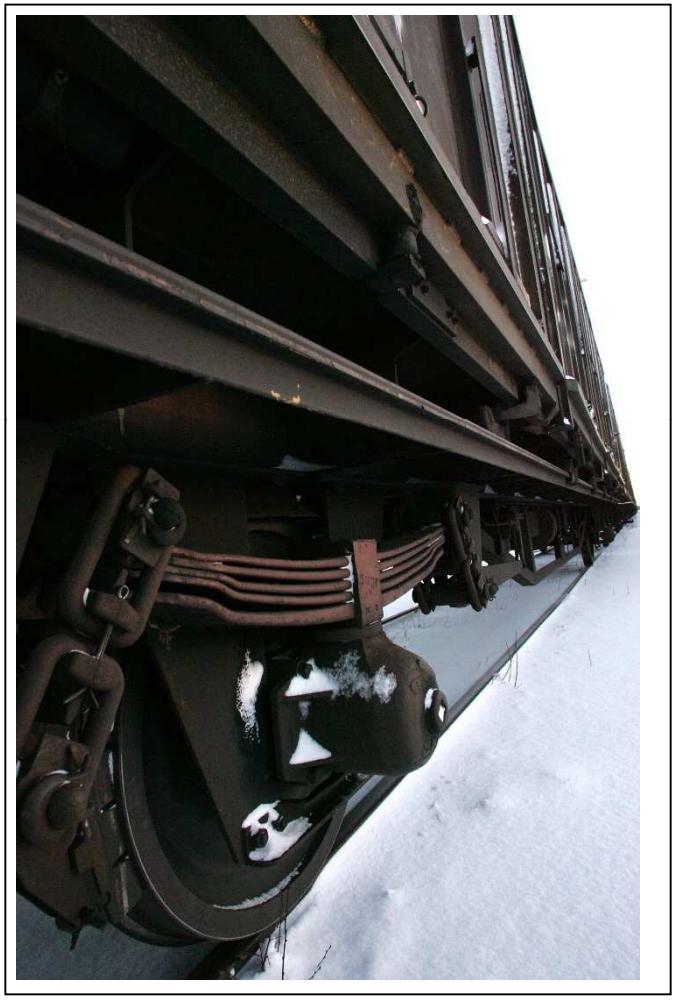
Traffic Situations

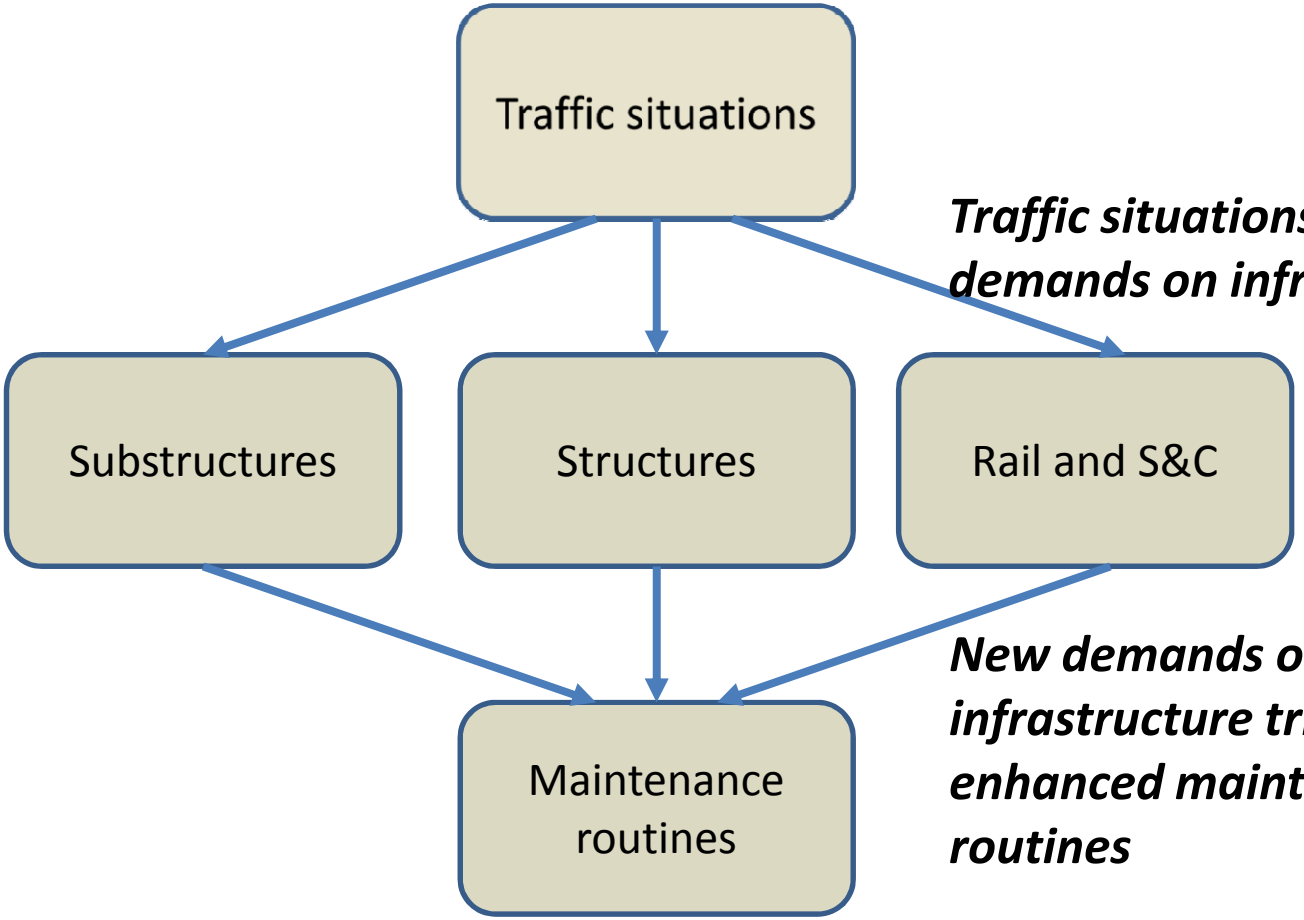
Traffic situations

- Longer trains
- Increased train weight
- Increased axleloads
- Higher speeds
- Increased loading gauge

Input from MARATHON, SPECTRUM, D-RAIL and other EU-projects



Workflow in 1.1.4



Traffic situations give demands on infrastructure

New demands on infrastructure triggers enhanced maintenance routines

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Contents of D1.1.4 – **Substructure**

This part is dealt into two parts namely

- Subgrade assessment
- Subgrade improvements

This part is the part where least international research has been carried out historically

- Why? Conditions vary a lot in different parts of Europe due to different substructure conditions and evaluation engineering traditions
- Valuable input comes from INNOTRACK SP2, Eurobalt2, RIVAS and national R&D

• Contents of D1.1.4 – Subgrade assessment

- We have evaluated several different methods like geo-radar, track stiffness measurements and other NDT investigation methods
- Assessing substructure condition
  - Subgrade condition and track geometry deterioration
  - Track stiffness and its impact on track behaviour
  - Influence of track stiffness and its variations
  - Role of track stiffness measurement in track maintenance and upgrading

• Contents of D1.1.4 – Subgrade assessment

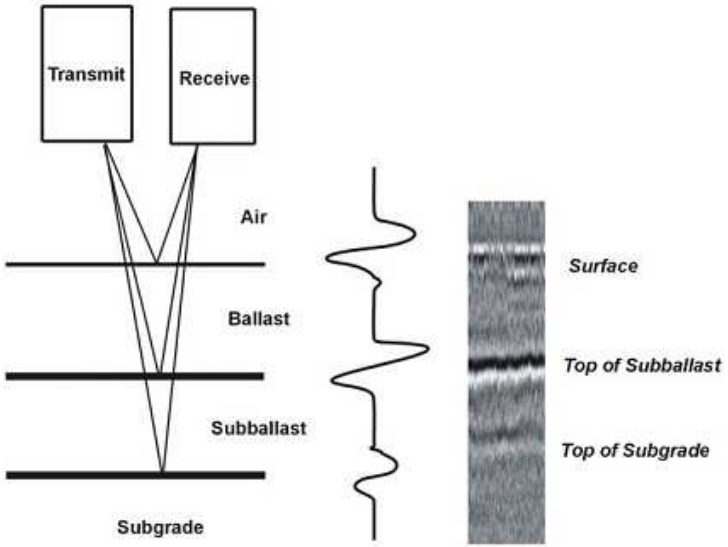
- Methods for subgrade quality assessment
  - Track substructure stiffness measurement
    - Standstill measurements
    - Rolling measurements
    - Outcome of different measurement techniques

• Contents of D1.1.4 – Subgrade assessment

- Methods for subgrade quality assessment
  - Geophysical inspection of substructure defects
    - GPR (Ground Penetrating Radar)
    - Resistivity profiling
    - Multielectrode method (resistivity tomography)
    - Seismic methods
    - Gravimetry
- Geomecanical investigation of substructure problems

Examples – GRP (ground penetrating radar)

GPR RAIL-SETUP WITH THREE PAIRS OF 1-GHZ HORN ANTENNAS



THE GENERATION OF A GPR PROFILE: A) TRANSMISSION PRINCIPLES; B) SINGLE GPR SCAN

Examples

- Stiffness measured with IMV100S

Motivation

<u>Future traffic demand</u>

- Longer trains
- Increased train weight
- Increase axle loads
- Higher speeds on freight trains
- Increased loading gauges

<u>Problems in the subgrade</u>

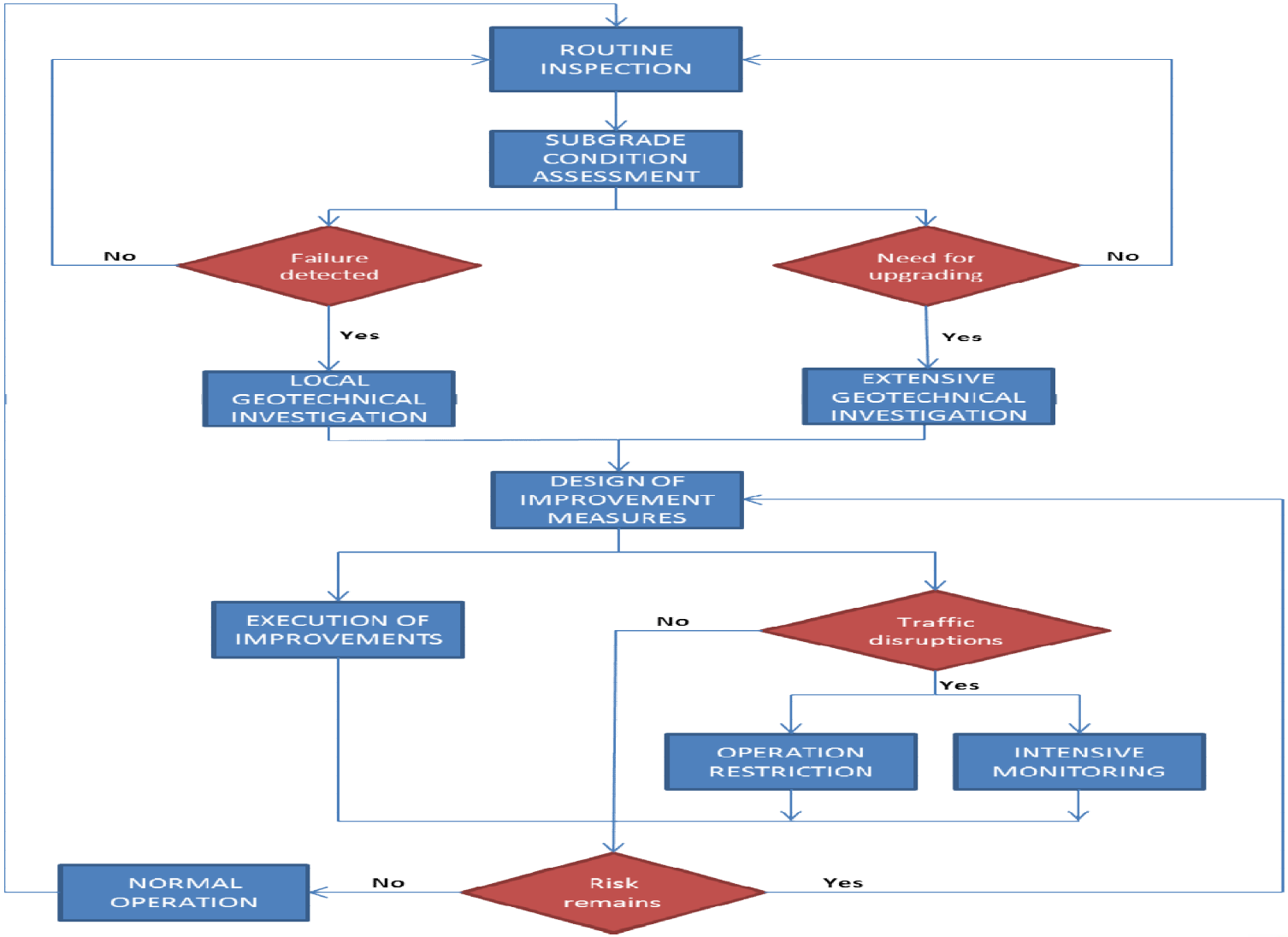
- Reduction of stability
- Increase of settlements
- Extensive vibrations
- Increased degradation

<u>Negative impact in rail operation:</u>

- Safety
- Reliability
- Economy
- Increased maintenance

Need for improving the subgrade bearing capacity, stability and durability

Flow chart for assessment, improvement and follow-up of subgrade



Decision factors

Total cost of the improvement

- Cost of the strengthening works
- Cost of traffic disruption
- Environmental impact

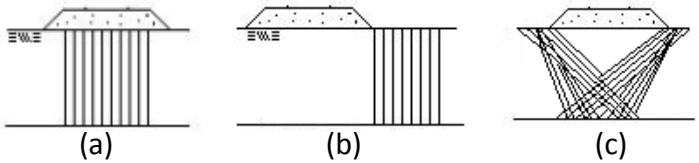
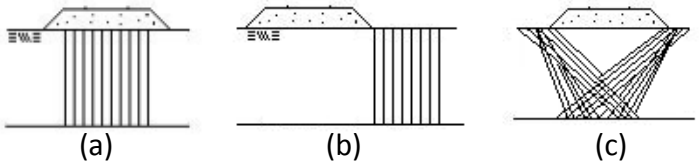
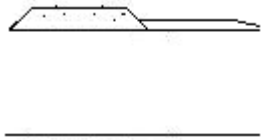
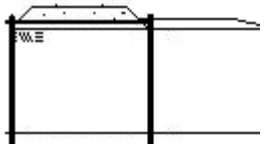
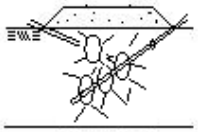
Two different approaches

1. Improvement from the track
   - Installation between the sleepers (~40cm) -> No or little traffic disruption
   - Remove of the track frame -> Long traffic disruption
   - Other problems: Safety, catenary, cable ducts, polluted ballast, etc.
2. Improvement from sides of railway embankment
   - Minor affection to train operation (train speed and axel load reduction)
   - Need of enough space besides the track

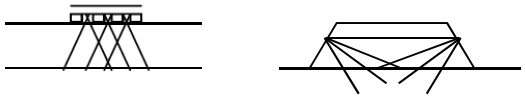
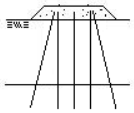
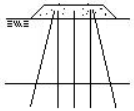
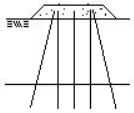
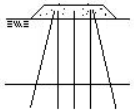
Follow up after installation

- Track geometry, pore pressure dissipation, long-term settlements

D1.1.4 – Section 4.1.2 Subgrade improvements

	Method	**Scheme**	ALLOW	TYPE OF	INCREASE OF	REDUCE OF	REDUCE OF	EXPERIEN.
1	Deep Mixing	 (a) (b) (c)	a-1 b-3 c-3	2	3	a-3 b-1 c-2	2	3
2	Jet grouting	 (a) (b) (c)	a-1 b-3 c-3	3	3	a-3 b-1 c-2	2	3
3	Stabilizing berms		3	2	3	1	1	3
4	Stabilizing berms combined with anchored walls		1	2	3	1	1	1
5	Compaction grouting		3	1	2	2	1	3

D1.1.4 – Section 4.1.2 Subgrade improvements

	Method	**Scheme**	ALLOW	TYPE OF	INCREASE OF	REDUCE OF	REDUCE OF	EXPERIEN.
6	Precast concrete slab on piles		1	3	3	3	1	1
7	Soil nailing	 (a) (b)	a-2 b-3	3	3	1	1	2
8	Vibrocompaction		1	1	3	2	1	3
9	Vibroreplacement		1	2	3	3	1	3
10	Grouted stone columns		1	2	3	3	1	2
11	Vibroconcrete columns		1	2	3	3	1	1

Other experiences in Spain

1) Hydraulic fracturing with injection of cement grout

Railway line Calatayud-Valencia (208+100 to 208+200)

Mixed traffic: 200km/h passenger + freight trains

2) Injections of bentonite and cement mortar

Railway line Teruel-Sagunto

Conventional passenger traffic

3) Injections of cement mortar and polyurethane resin in karst

Railway line Madrid-Seville

High-speed passenger traffic

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Contents of D1.1.4 – **Structures**

- Bridges
- Tunnels
- Culverts
- Retaining walls

Example of upgrading

A real example before

Sustainable Bridges and MAINLINE

Borlänge - Gothenburg line, from 22,5 => 25 tons

LKAB (iron ore) 30 tonnes

SSAB (steel) 25 tonnes

Logs 25-30 tonnes

Stora Enso
(paper products) 25 tonnes

Example of upgrading

A real example before Sustainable Bridges and MAINLINE 1999

Borlänge - Gothenburg line, from 22,5 => 25 tons

- Total number of bridges 550
- Special inspected bridges 450
- Number of bearing capacity calculated bridges 91
- Number of material tested bridges 35
- Number of strengthened bridges *) 48 => 9%
- Number of replaced bridges **) 24 => 4%

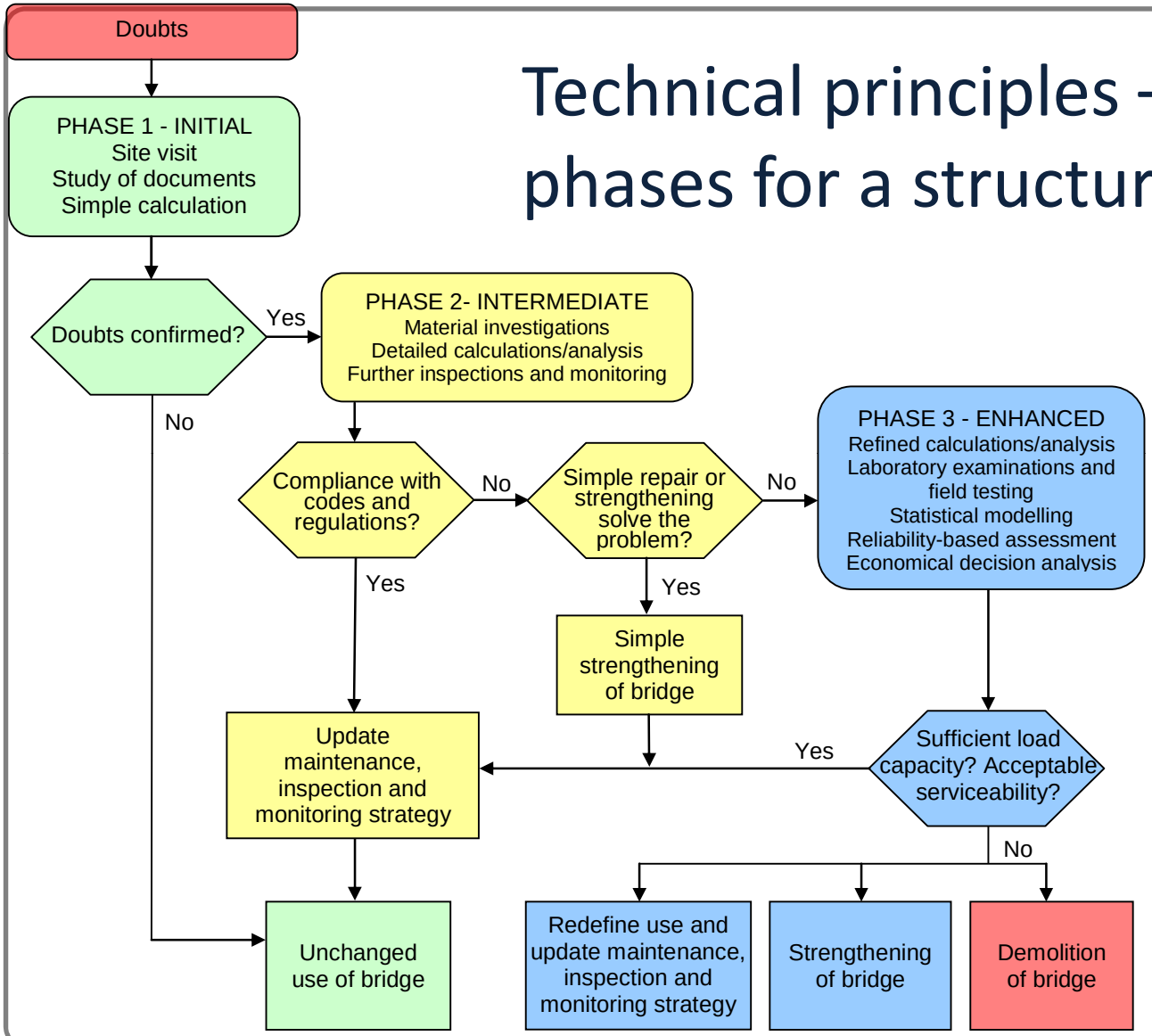
***) Corresponding figures from the Ore line 10 %**

****) Corresponding figures from the Ore line 14 %**

of witch 10 % were planned to be replaced of other reasons

=> With todays knowledge we would have done this much more cost-efficient

Technical principles – define phases for a structured approach



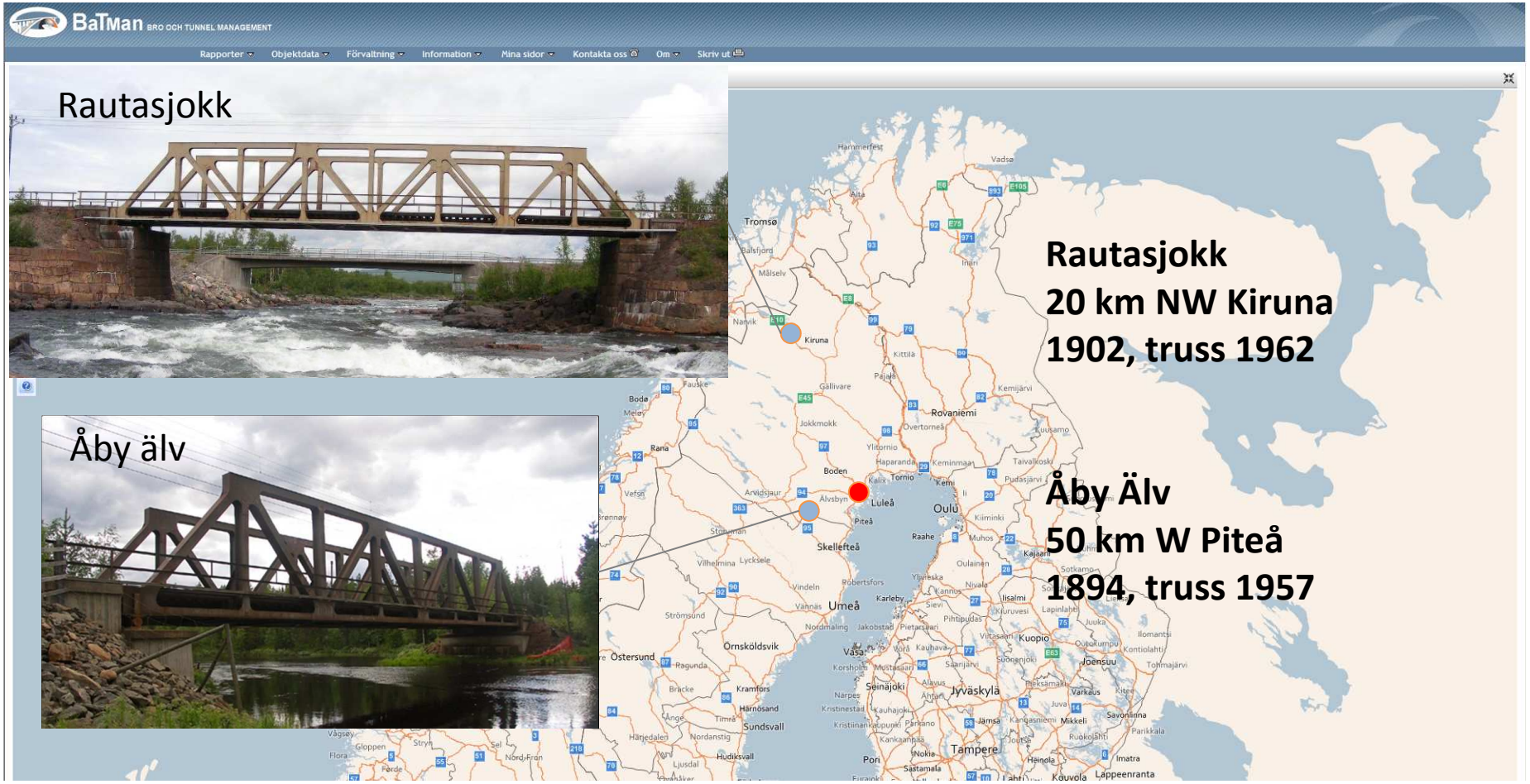
Flow chart for assessment of existing bridges. Three phases are identified: Initial, Intermediate and Enhanced, depending on the complexity of the questions involved. Taken from SB-LRA (2007).

Example from Sustainable Bridges

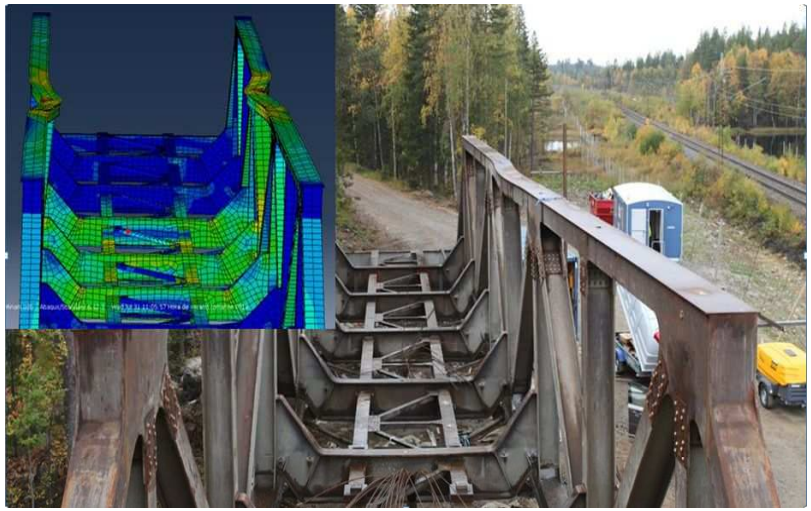
Concrete bridge – Örnsköldsvik, Sweden

WP3	Inspection and Condition Assessment
WP4	FE-analyses
WP6	Strengthening
WP7	Loading of slab through ballast and loading of strengthened main girders to failure

Examples from MAINLINE

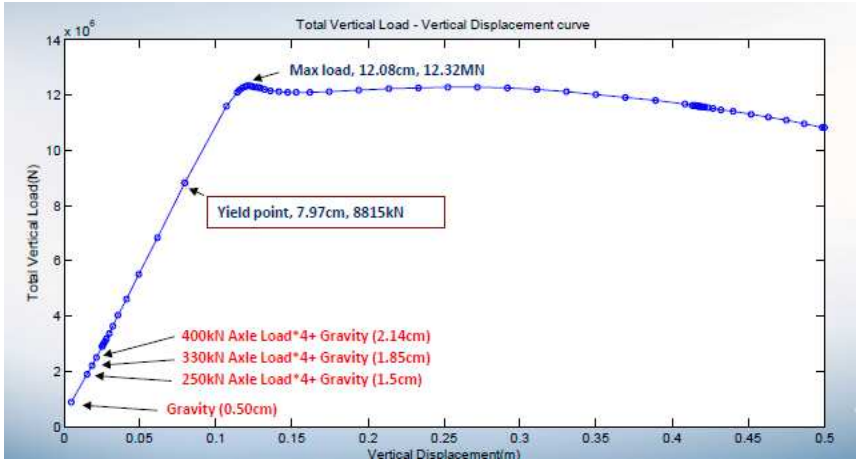


Example from MAINLINE



Åby bridge after failure.
It was caused by buckling of the top right girder.

Results from an advanced assessment of the Åby Bridge. It can be seen that the present axle load of 250 kN only represents a small part of the capacity of the bridge.



Conclusions from Sustainable Bridges and MAINLINE

- A majority of todays bridges have a large hidden capacity.
- The approach is to work in defined phases and apply a structured approach

Chapter about structures

Capacity for Rail

Other parts in this chapter

- Tunnels
- Culverts
- Retaining walls

Examples from Germany, Sweden and US

Jährod Tunnel in Germany being enlarged by the Tunnel-in-Tunnel method , Simon (2012).

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Contents of D1.1.4 – **Track and S&C**

- Can we use existing track degradation model(s)? Or shall we enhance an existing? Or do we have to create a new?
- We decided to use existing models in a more “intelligent” way!

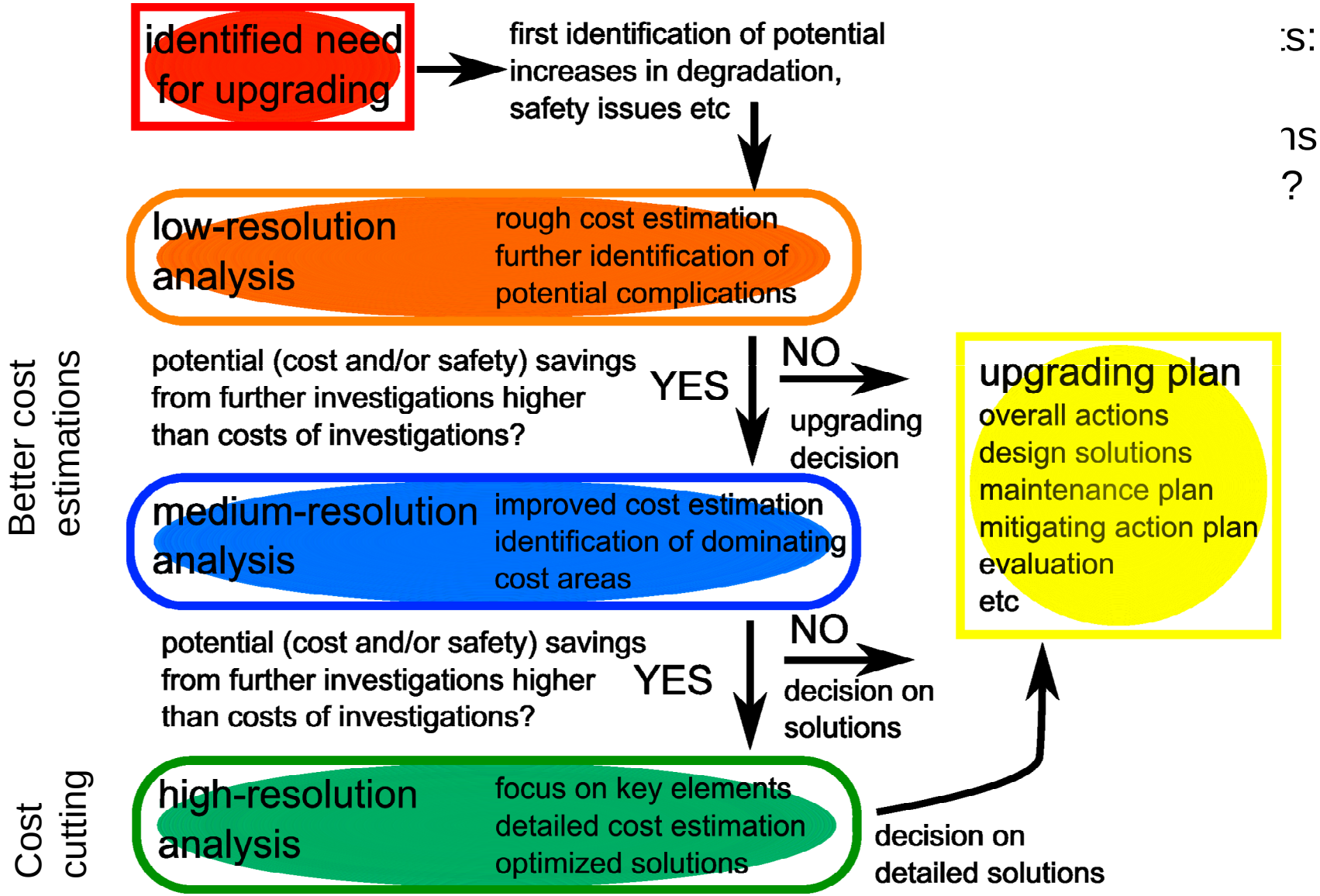
Track deterioration models, maintenance and cost

- Models for deterioration due to vertical settlement
- Models for deterioration due to wear and contact fatigue
- General deterioration models
- Other models
- Computer aided planning and prediction tools

Different phenomena

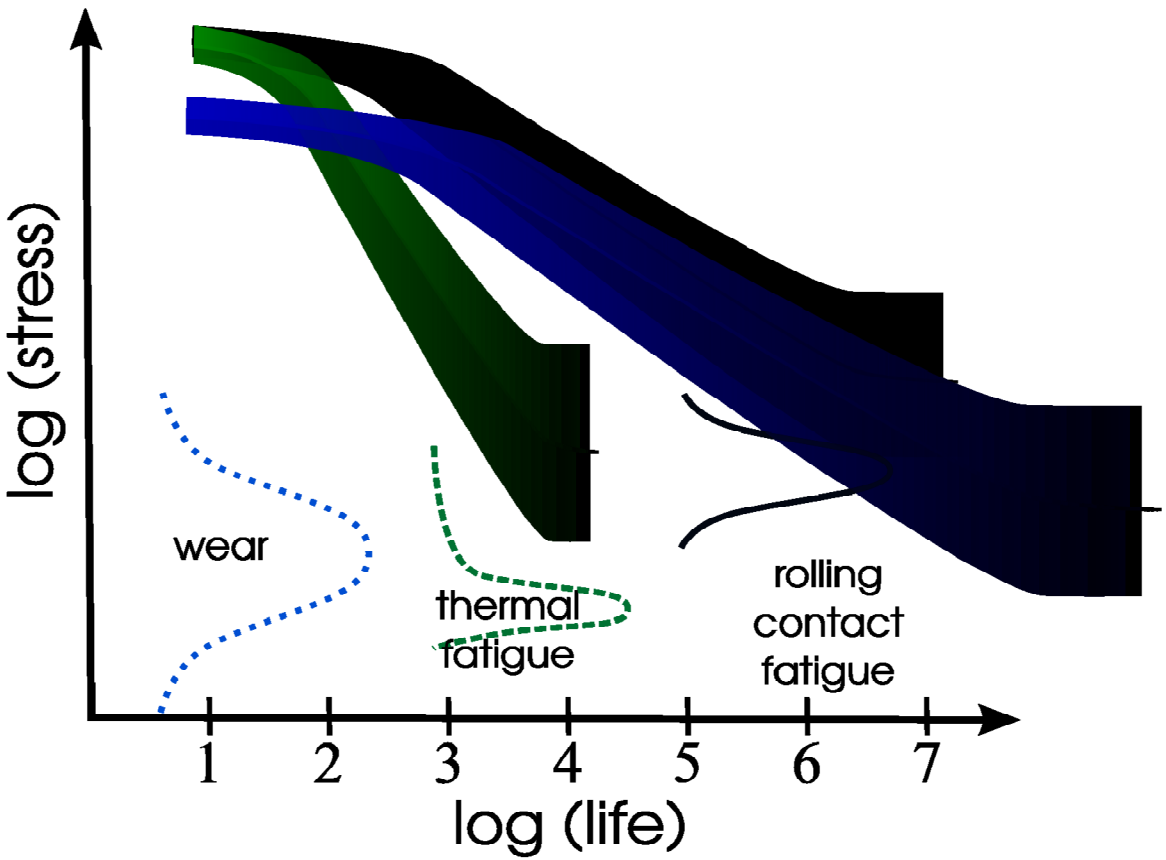
Deterioration phenomenon	Main influencing parameters	Important material/component parameters	Time to deterioration
Track settlements	Track forces (vertical and lateral)	Ballast (and sub-ballast) resistance	Medium
Sleeper damage	Vertical (impact) forces, support conditions	Reinforcement, sleeper design	Short if overloaded
Plastic flow	(Effective) stress magnitude	Yield limit, surface profile	Short
Wear	Contact load (pressure and frictional), sliding distance	Hardness	Medium
Plain fatigue	Stress amplitude	Fatigue limit, surface roughness	Medium – long
Surface initiated rolling contact fatigue	Frictional contact stresses	Hardness, ductility	Medium – long
Subsurface initiated rolling contact fatigue	Contact pressure	Material defects, fatigue limit	Long

Basic approach



Low- / medium resolution analyses

- Difficult part in LCC analysis is to estimate deterioration costs (infrastructure lifetime)
- Often based on Wöhler curve(s)
- Exponential load–life relations > sensitive
- Simplest version: approximate curve for overall deterioration based on experience
- Easy model, but requires **extensive** calibration data



Medium resolution analysis

- Examples are Network Rail variable track usage charge model, and Trafikverkets DeCays
- Basically consider
  - horizontal track damage (track geometry),
  - vertical track damage (track settlements),
  - RCF / Wear (combined or separate)
- Developed to define track access charges depending on the track friendliness of different vehicles
- Based on Wöhler curves which relate to vehicle parameters and deterioration of different track components
- The analysis gives indications on dominating problem for more refined analysis

Detailed resolution analysis

- Consequences of different types of upgrading
  - Increased speed
  - Increased axle load
  - Increased capacity outtake including longer trains
  - New vehicles
  - Improvement of the track structure
  - Upgraded maintenance procedures
- Different consequences on different parts of the track infrastructure and operative procedures
- Indication of means to predict deterioration / safety risks
- Means to prevent /mitigate upgrading issues
- **These are the analyses that will allow for improved solutions and save money!**

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Contents of D1.1.4 – **Maintenance routines**

A multitude of involved topics, e.g.

- Rail and wheel grade selection
- Grinding
- Wheel lathering
- Lubrication
- Crack detection
- Welding
- Strategies for maintenance
- Increased use of automated maintenance
- Consider use of new innovative maintenance concepts

Conclusions

Upgrading of existing lines is an important way for infrastructure to meet new freight operation and market demands in the future

To meet these demands in an economical, environmental and structured way there is a need for a guideline with latest research and best praxis

D1.1.4 and D1.1.5 will therefore play an important role to support Infrastructure Managers to meet new market demands

Thank you for your kind attention

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