MAIN LINE

MAINLINE Final Workshop

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SEVENTH FRAMEWORK PROGRAMME

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Replacement of assets

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How can we improve replacement of obsolete assets ?

- Investigate new construction methods

  What methods are used?

  - well known methods (launching, railway bridge carrier, railway cranes, etc.)
  - light weight re-decking systems (cfrp or LC)
  - new construction materials for whole bridge structures
  - Modular S&C method

- Plan and optimise the construction process connected to LCCA

  Gaps

  - Where is need for development? What are the special demands from railway owners?
  - Minimum of traffic interruptions and environmental impact
  - Strategies for cost-effective track renewal

- Deliver input regarding data to the development of LCC models and decision support systems for infrastructure managers

  To help infrastructure managers to decide when to replace

  - give advice on quality parameters (partial replacement vs. renewal)
  - Including long term maintenance strategies

Workflow / Process of analysis

Bridge team

TrV, COWI, LTU, DB, SKM, NR, Skanska

Track team

COMSA, Skanska, TUGraz, TrV, NR, TCDD

Review of replacement techniques across Europe focussing on those offering more effectiveness

Identify room for improvement considering new technologies

• Logistics planning ● Track possession

•European standard bridge — Bridge Team

•Track alignment (quality of installation)
•stiffness variation — Track Team

Guideline for replacement of obsolete infrastructure

Planning process plays a key role in renewal projects

Optimisation leads to the following benefits:

- **Savings up to 60%** due to a reduction of compensation fees to TOCs, better work planning, better bids of contractors, etc.
- **Less operational impact** given that there is more time to negotiate with TOCs, **better planning of alternative transport/routes**, early notice to passengers, etc.
- **Better planning of resources** to comply with specifications of the line (e.g. rules of the line in UK). It also enables the bundling of construction capacities, which can result in an additional 10 to 15% cost reduction.

How can we help to optimize the planning process ?

Optimisation of planning process

Need for precise planning

- Long planning periods (5 years and more)
- Asset management system to allow construction planning along lines
- Help to identify typical critical issues for replacement activities
  - Rerouting possibilities, knowledge of the sites condition…
- Use of best practice methods (or standard bridge types?)

Preplanning can have a strong influence on length of track possession and vice versa

- Proposal for an easy to use calculation for track possession cost
- Altenatives need to be compared in an early phase of the project
- Environmental aspects should be included also in the planning phase (e.g. noise reduction)

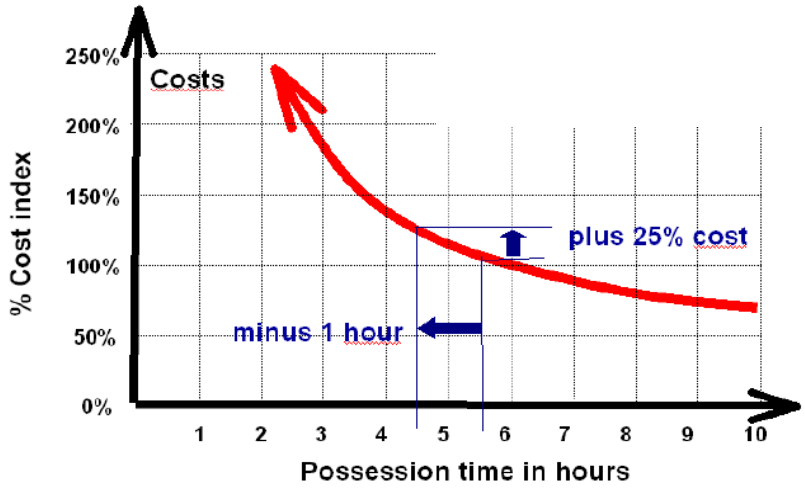
Management of replacement works

- The Guideline presents a management system for IM to handlle infratsrucuture projects
- Procurement process

Track possession

Planning is strongly dependent on length track possession :

- Reduction of one hour of track possession can increase costs by 25%.
- However, once track possession is 8 hours there is little difference in works costs (21x8, 2x48+5x8…) but in operation impact.
- Trend is to tailor track possession to work, so a tool to evalaute the cost of different possession regime is useful.



New simplified method for track possession calculation was developed:

- It accounts for cost of alternative transport (e.g. bus), cost of passenger disturbance, etc.

Advantages and disadvantages of different procurement processes

Design-bid-build

- The IM appoints a consultant to design the project and prepare contract documents and then invites tenders from contractors
- The contractor who makes the most acceptable offer will carry out the replacement work
- Construction work is overseen either by the IM or the design consultant

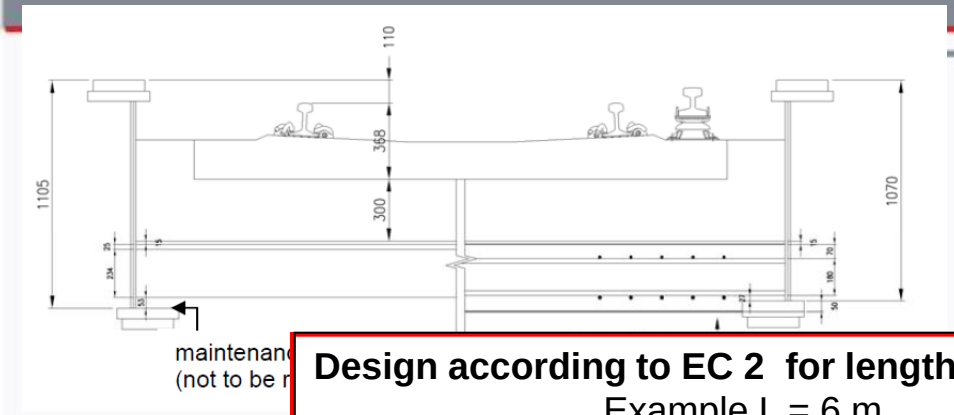
  - The design team is impartial and looks out for the interests of the owner
  - As the general contractor is brought to the team post design, there is little opportunity for input on effective alternates being presented.

Design & build

- The design and construction services are contracted by a single entity for the IM

  - Reduces the delivery schedule by overlapping the design phase and construction phase of a project
  - Limits the clients' involvement in the design
  - Difficult selection of contractor: evaluation criteria hardly to justify
  - No comparison of project cost possible
  - General contractor is involved in design, input on effective alternates possible- achieves innovation
  - Design–build saves time and money for the owner

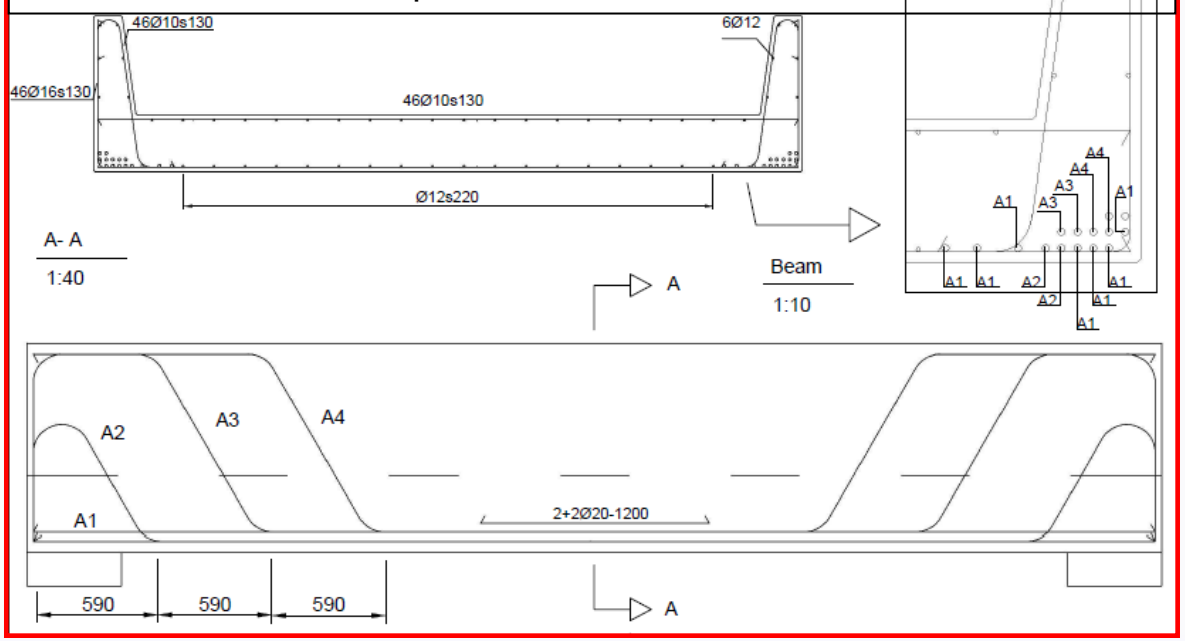
Short standard bridges – typical replacement situation in the European railway network

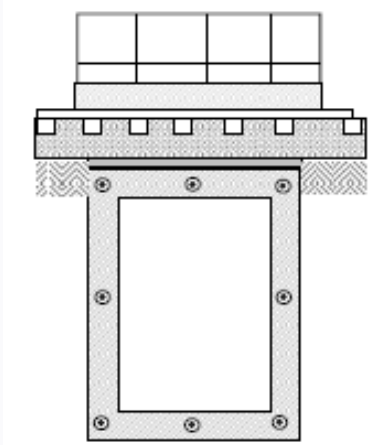


Reinforced Concrete Slab	Segmental Fully Encased Filler Beam Deck
Up to 6m	Between 5m and up to 15m

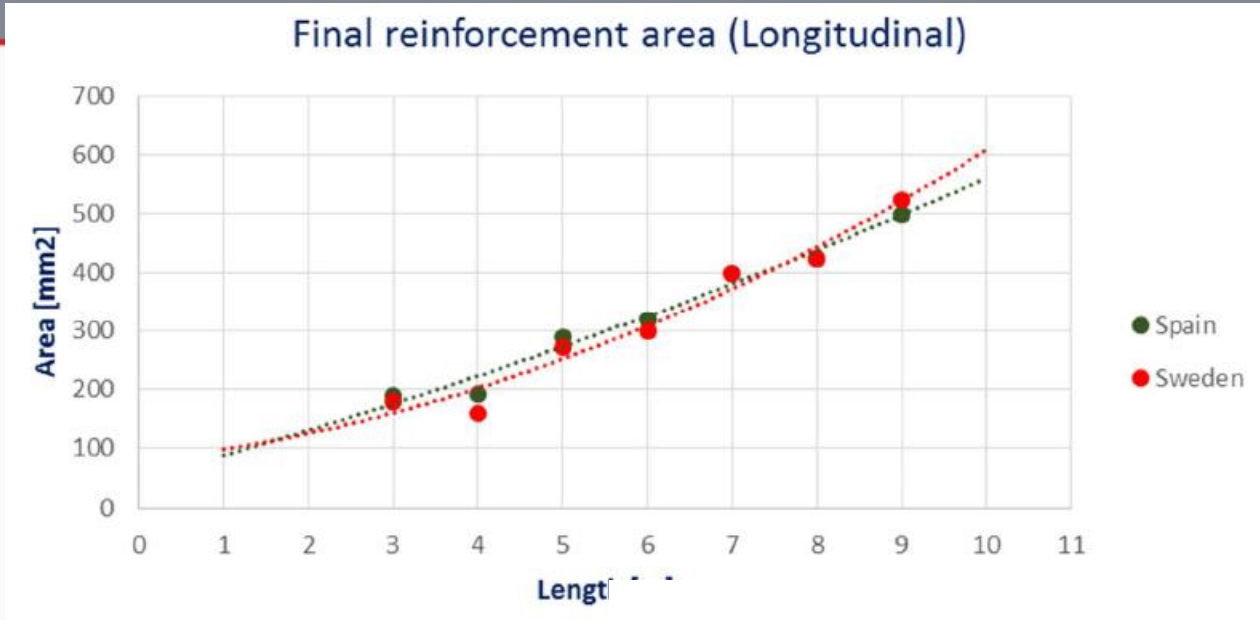
Design according to EC 2 for lengths L = 3 – 9 m

Example L = 6 m





Short standard bridge – Comparison



Only minor differences in designs according to Spanish and Swedish National Annexes

	SPAIN	SWEDEN
Classification coefficient (α)	1,21	1,33
Safety factor (γ_d)	1,10	1,00
Dynamic factor (Φ)	Φ_3=1,69	Φ_2=1,46
Load factor for SLS (ξ)	0,85	0,89
Ballast height deviation ($G_{k,sup}$)	+/- 30%	+/-10%
Load factor (LM71)	1,45	1,50
Maximum crack width (w_{max})	**0,4 mm**	0,3 mm

Example of methods description in D3.1
Replacement with railway by horizontal launching

a) Preparation of ground works before launching new bridge.

b) Ground works completed and launching beams installed.

c) Hydraulic jacks installed on launching beams, the bridge is lifted 5 cm and moved into permanent position.

d) Bridge moved into final position - launching beams visible.

Table with main parameters for decision taking

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

Comparision table for bridge replacement techniques

++ = yes + = may work — = no	Mobile Cranes	Rail Mounted Crane	Rail Mounted Bridge Carrier	Longitudinal Launching	Horizontal Launching	Deck Replacement
1. Bridge length						
1.1 Less than 5 m	++	++	++	++	++	++
1.2 5-20 m	++	++	++	++	++	++
1.3 More than 20 m	+	+	+	+	++	++
2. Bridge type to be exchanged						
2.1 Reinforced concrete beam bridge	+	+	++	++	++	++
2.2 Steel truss	++	++	+	++	++	++
2.3 Steel beam	++	++	++	++	++	++
2.4 Arch	+	+	+	+	+	+
2.5 Other	+	+	+	+	+	+
3. Track possession time						
3.1 Between 6-12 h	+	+	+	-	+	+
3.2 Between 12-24 h	++	++	++	+	++	+
3.3 Between 24-60 h	++	++	++	++	++	++
3.4 More than 60 h	++	++	++	++	++	++

4. Available funding

4.1 Very restricted funding

4.2 Normal funding

4.3 Money is not the problem

6. The bridge runs over

6.1 Water

6.2 A rural route

6.3 A highway

6.4 A street in a city

6.5 Agricultural land

7. Available working site

7.1 Small

7.2 Normal

8. Electrified line

8.1 Electrified line

8.2 No electricity

Best practice on M&R strategies

1. Integrated M&R strategy with systematic, transparent and objective decision-making processes
2. LCC: leading principle in M&R strategy
3. Definition of strategic performance goals and its monitoring
4. Prioritisation criteria: importance of the line
5. **Optimisation of work planning and scheduling**
6. **Bundling of construction and maintenance capacities**
7. **Standardisation of robust and proven innovations**
8. **Improvement of construction –and renewal- methods (including logistics and track quality)**

AREA OF STUDY
MAINLINE

Clustering of resources

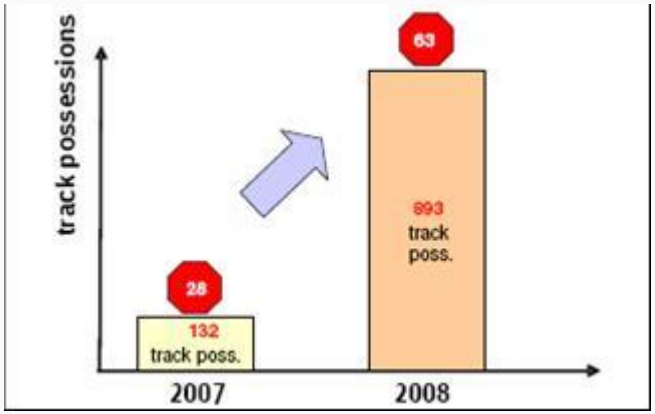
Bundling of activities leads to signficant cost reductions (e.g. 15% in Austrian Federal Railways) due to:

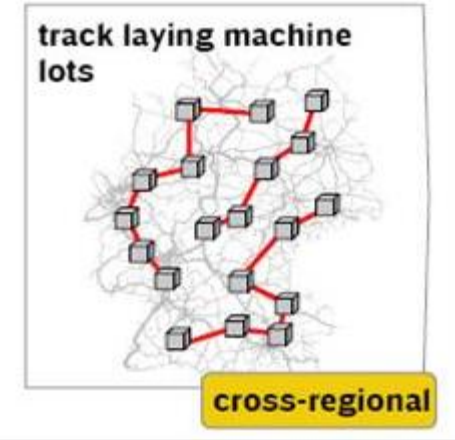
Higher efficency of machinery
(less time loss due to transport)

Increase of track possession length
(corridor concept)

Combination of interventions
(e.g. tamping & grinding)

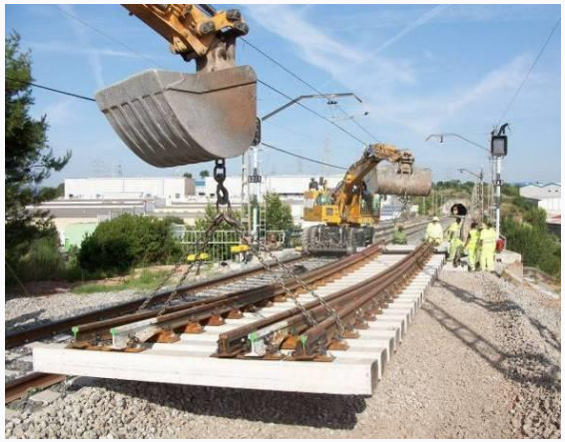
LCC vs Bundling





S&C replacement methods review: Methods analysed

Excavators



Road cranes

Railway cranes

Crane-beam systems

Portal cranes (UWG/Geismar-Fasseta)

Modular switch

S&C replacement methods review: Analysis

Four renewal phases:

- Pre-renewal works
- Removal of old switch and site preparation
- Installation of the new switch
- Post-renewal activities

Three types of data:

- Output
- Labour
- Machinery

TIME AND RESOURCES REQUIRED ACCORDING TO METHOD USED	PRE-ASSEMBLED S&C							MODULAR S&C
	Crane	Excavators	Crane	Crane	Excavators	Indep. cranes (UWG system)	Crane-beam (DESEC)	
	DB	TCDD	JBV	TRV	COMSA	MAV	SKANSKA	NR
B. REMOVAL OF THE OLD SWITCH AND SITE PREPARATION ***(Beginning of track possession)***								
B.1 Dismantling of the old switch (including dismantling of signalling and points machines) + ***B.2a Removal of upper part of the ballast layer***		3/4 working hours (wooden/ concrete sleepers)	4 working hours		3 working hours		5 working hours	
B.1 Dismantling of the old switch (including dismantling of signalling and points machines) + ***B.2b Removal of complete layer of old ballast***	4 working hours	4/5 working hours (wooden/ concrete sleepers)	6 working hours	2 shifts (16 h) / 9 working hours	6 working hours	4 working hours	9 working hours	1 shift (8h) / 4,5 working hours
TOTAL HOURS	*B1+B2b* **4h**	*B1+B2a* **3/4h (w/c)** *B1+B2b* **4/5h (w/c)**	*B1+B2a* **4h** *B1+B2b* **6h**	*B1+B2b* **9h**	*B1+B2a* **3h** *B1+B2b* **6h**	*B1+B2b* **4h**	*B1+B2a* **5h** *B1+B2b* **9h**	*B1+B2b* **4,5h**
WORK FORCE	*B1+B2b* **10 + 4 (safety) + 2(signalling)**	*B1+B2a/B2b* **10 +2 (safety) + 2(signalling)**	*B1+B2a/B2b* **5 +2 (safety) + 2 (signalling)**	*B1+B2a/B2b* **8 + 3 (safety) + 3 (signalling)**	*B1+B2a/B2b* **10 +2 (safety) + 2(signalling)**	*B1+B2a/B2b* **13 +2 (safety) + 2(signalling)**	*B1+B2a/B2b* **10 +2 (safety) + 4(signalling)**	*B1+B2b* **6 + 4 (safety) + 2 (signalling)**

TIME AND RESOURCES REQUIRED ACCORDING TO METHOD USED	PRE-ASSEMBLED S&C							MODULAR S&C
	Crane	Excavators	Crane	Crane	Excavators	Indep. cranes (UWG system)	Crane-beam (DESEC)	
	DB	TCDD	JBV	TRV	COMSA	MAV	SKANSKA	NR
D. POST-RENEWAL ACTIVITES ***(Opening of the line with temporary speed restriction)***								
D.1 Welding and stress release (5)	1 shift (8 hours)	1 shift (8 hours)	3 shifts (21 hours)		1 shift (8 hours)	1 shift (8 hours)	7 working hours (8)	
D.2 Final track restoration	1 shift (8 hours)		1 shift (8 hours)	1 shift (8 hours)	1 shift (8 hours)	1 shift (8 hours)		1 shift (8 hours)
D.3 Final inspection and acceptance		1 hour inspect. during 7 days						
TOTAL HOURS	*D1+D2+D3* **16h**	*D1+D2+D3* **15h**	*D1+D2+D3* **29h**	*D2+D3* **8h**	*D1+D2+D3* **16h**	*D1+D2+D3* **16h**	*D1+D2+D3* **7h**	*D2+D3* **8h**
WORK FORCE	*D1* **4 (welders) + 2 (safety)** *D2+D3* **- 2 (topograph) + 2 (safety) + 2 (perman. way engineers)**	*D1* **4 (welders) + 2 (safety)** *D3* **- 1 (permanent way engineer)**	*D1* **2 (welders) + 1 (safety)** *D2+D3* **- 2 (topograph) + 1 (safety) + 1 (perman. way engineer)**	*D2+D3* **- 2 (topograph) + 2 (safety) + 2 (perman. way engineers)**	*D1* **4 (welders) + 2 (safety)** *D2+D3* **- 2 (topograph) + 2 (safety) + 2 (perman. way engineers)**	*D1* **4 (welders) + 2 (safety)** *D2+D3* **- 2 (topograph) + 2 (safety) + 2 (perman. way engineers)**	*D1+D2+D3* **10 +2 (safety) + 4(signalling) + 2 (topograph) + 4 (welders))**	*D2+D3* **- 2 (topograph) + 2 (safety) + 2 (perman. way engineers)**
MACHINERY REQUIRED	*D2* **- S&C Tamper -Ballast regulator -Topographic equipment**	*D2* **- S&C Tamper -Ballast regulator -Topographic equipment**	*D2* **- S&C Tamper -Ballast regulator -Topographic equipment**	*D2* **- S&C Tamper -Ballast regulator -Topographic equipment**	*D2* **- S&C Tamper -Topographic equipment)**	*D2* **- S&C Tamper -Topographic equipment**	*D2* **- S&C Tamper -Ballast regulator -Topographic equipment - Hopper wagons+loco(5)**	*D2* **- S&C Tamper -Ballast regulator -Topographic equipment**

B1 **- Kirow Crane** *B2b* **- Automated ballast collector - Hopper wagons+loco -Grader -Roller**

S&C replacement methods review: Conclusions

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

+++ Excellent
++ Average
+ Poor

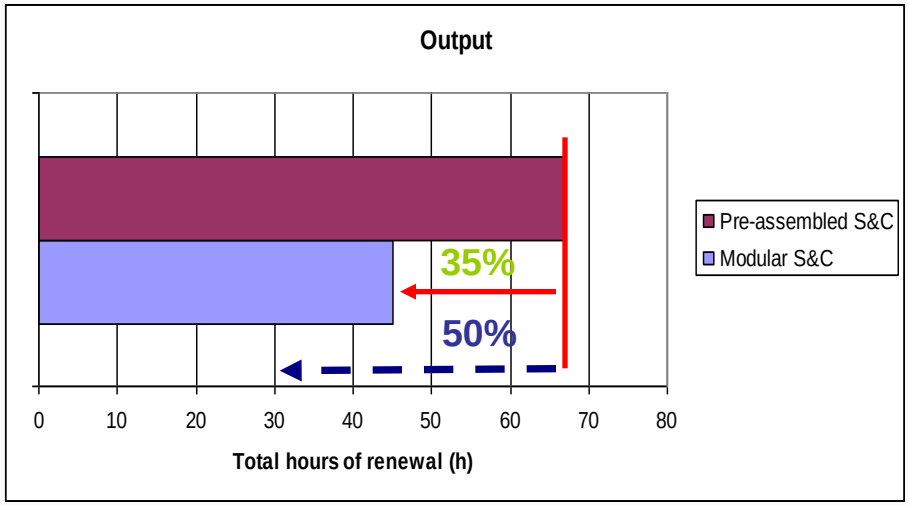
Logistic and design improvements for S&C renewal optimisation

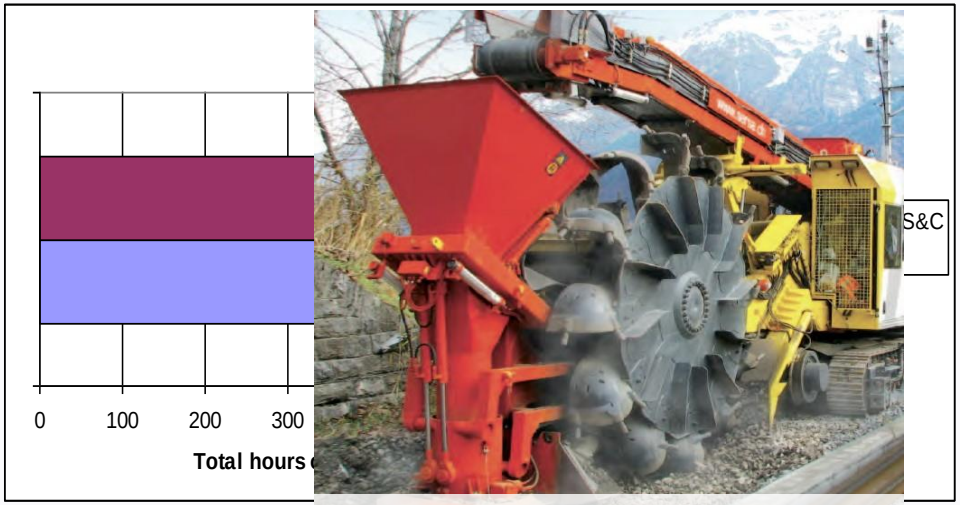
1. Modular S&C concept
2. Automated ballast collector
3. Track stiffness variation
4. Lighter S&C (synthetic sleepers)
5. Quality of installation

Modular switch (I)

Modular **S&C reduces by 35 to 50%* the total duration of the works and by 50% labour required**. This savings come from:

- Assembled once at the factory, assuring quality
- Quicker commisioning
- Avoids to negotiate with landowners
- Faster transfer from WTW to final location
- **Further 15%**
  - Specific handling systems
  - Transport incl. driving devices





Automated ballast collector

Modular switch (II)

Barriers of the use of the modular S&C:

- High investment costs (IMs less availability in relation to railway cranes)
- Distance between factory and worksite (not always an option)
- Pre-assembly method is well-known and its efficiency proven

Modular S&C method is specially suitable when:

- There are **lineside space constraints**
- There are **not trackside access roads**
- **Minimum track closure times** are required
- **Minimum labour cost**

Track Stiffness Variation and synthetic sleepers

Optimisation of track stiffness in a turnout leads to a **reduction of dynamic forces**, **which turns into a better performance** switch with **less maintenance needs**.

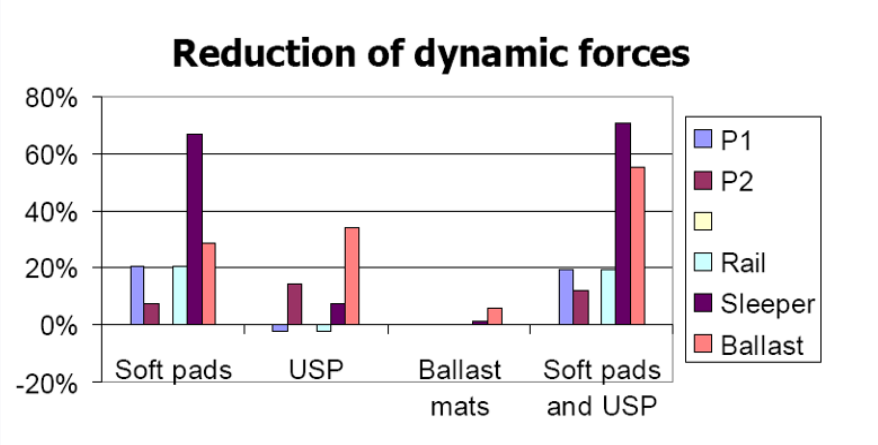
Soft pads
(rail damage)

USP
(sleeper/ ballast)

Both
(interaction!))

P1 forces: impact load related to rail damage (RCF)

P2 forces: impact load related to sleeper and ballast damage.



Turnouts provided with synthetic light sleepers enable:

- **Quicker replacement**
- **Less deflection** during transport (longer panels)
- **Higher performance** than wooden sleepers (durabilty, bending moments, isolation, etc.)

Track Quality (Practice guidelines)

Undertake all welds during track possession

- Employing **more efficient** replacement methods
- Pre-assembling the complete turnout and **laying it as a whole**

Correct handling of the switch

- **Choose the right method**

Complete ballast renewal and site preparation

- **Avoid weak support condition**, it jeopardizes its service life

Incorporate robust and proven innovations leading to higher initial quality (**USP, 60E1 rail, etc.)**.

Avoid piecemeal renewal

- It leads to **lower quality**, due to components of varying age and condition.

Guideline for replacement of elderly infrastructure

The reader will find:

- How to roughly estimate track possession costs
- Advice on how to assure a reliable planning process
- Best practice methods for the replacement of railway infra-structure for risk minimization
- The effect of national annexes to Eurocodes on bridge design
- Strategies for maintenance and renewal of track and switches & crossings

Open questions:

- Fibre reinforced polymers (frp) long term studies needed; work on design codes for bridges made form frp
- USP in switches & crossings

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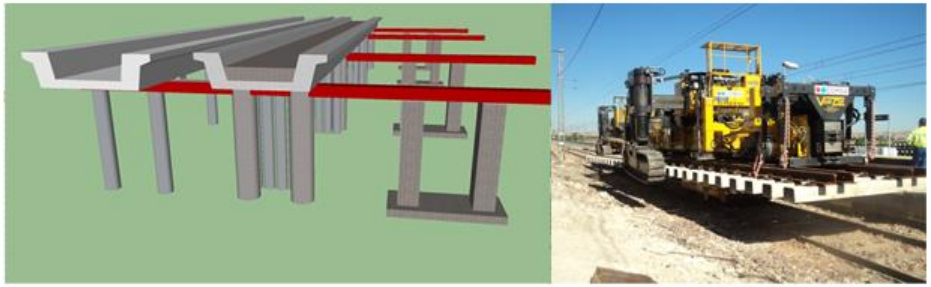
MAINtenance, renewal and Improvement of rail transport iNfrastructure to reduce Economic and environmental impacts

Collaborative project (Small or medium-scale focused research project)

Theme SST.2011.5.2-6.: Cost-effective improvement of rail transport infrastructure



Deliverable 3.4:
Guideline for replacement of elderly rail infrastructure