MAIN
LINE

Workshop targeted to Central and Eastern Europe

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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

Partners and source of information

Questionnaire and Benchmark through **MAINLINE** partners:

- Germany (DB)
- Spain (COMSA)
- Turkey (TCDD)
- Hungary (MÁV)
- Czech Republic (SKANSKA)
- SKM (UK)
- COWI (DK)
- TU Graz (AT)
- Trafikverket (Sweden)
- Network Rail (UK)

UIC Track Expert Group

- Jernbaneverket (Norway)

Benchmark
New technologies for production and replacement

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
- stiffness variation

Track Team

Guideline for replacement of obsolete infrastructure

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

Identified typical situation for replacement

Individual traffic situations strongly influence the track possession and the choice of method

- Long stops possible, i.e. days
- Full bridge replacement

- Advanced preparation possible during short stops. Replacement in 1 day
- only partial replacement redecking

Lessons Learned

Methods to be presented in the guideline need to enable an LCC analysis and compare methods in connection to track possession. Cost particularities of each country should be taken into account

Identified room for improvement

- **Improve logistics in terms of bridge and S&C replacement**
  - BrIM (Bridge Information Modelling) in the railway environment
  - Collect the experience in the consortium
  - Improvement of small bridge replacement methods ---European standard bridge ??
  - Improve use of prefabrication and production methods

- **Quality**
  - Minimize track stiffness variation
  - Increase of output of replacement while assuring a good quality of installation
  - Develop track renewal strategies related to LCC

Guideline for replacement of elderly infrastructure

- **Outline available**
  - **Bridges**
  - Planning process – proposal for track possession cost calculation
  - Noise reduction
  - **Track**
  - Strategies for cost-effective track renewal
  - recomendations for noise reduction

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Planning process

Need for precise planning

- Long planning periods (5 years and more)
- Asset management system to allow construction planning along lines
- Knowlegde of the surroundings
  - Include environmental issues as soon as possible
  - Noise reduction
- Altenatives need to be compared

Preplanning has a strong influence on length of track possession

Proposal for an easy to use calculation

- Rough estimate of cost for track possession
- Individual figures can be added
- A line with
  1 M passengers/year per track-km
  = 114 per hour and track-km

  2 M freight-tons/year per track-km
  = 228 tons/hour per track-km

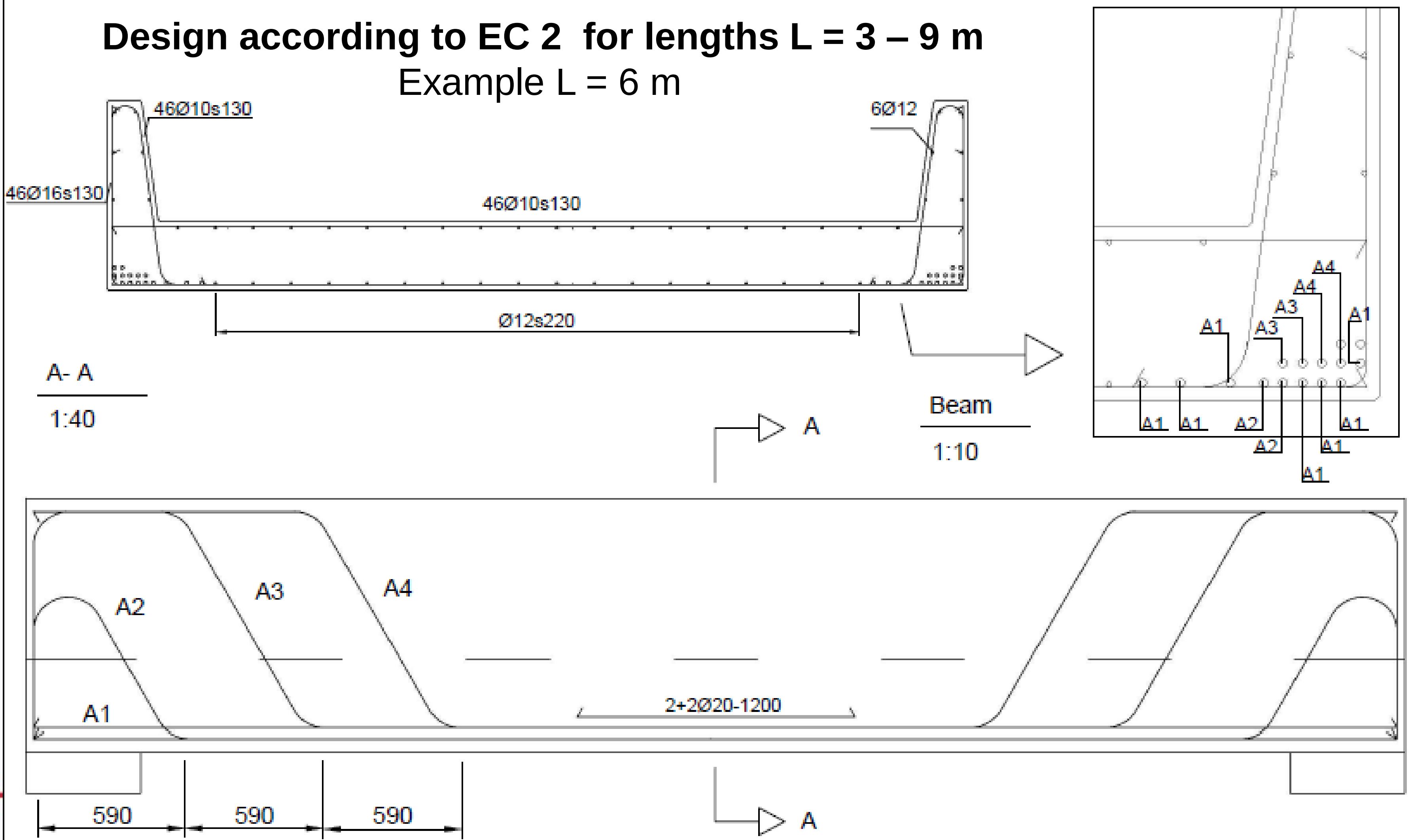
Track Possession Costs - Example

Planning time, years	0	0	1	1	
Posession time, hours	**24**	**72**	**24**	**72**	
Passenger cost per person and hour of delay, Euros	50	30	25	25	
Extra bus/train per hour and 50 passengers	300	200	50	50	
Total Passenger Cost for a Delay of 2 hours, kEuro	291	526	140	420	
Freight reroute cost per ton and hour, Euro	100	100	5	5	
Total Freight Cost, kEuro	550	1 650	55	80	
Total Cost, MEuro	**0,9**	**2,2**	**0,2**	**0,5**	

Short standard bridge –
Typical situation for replacement

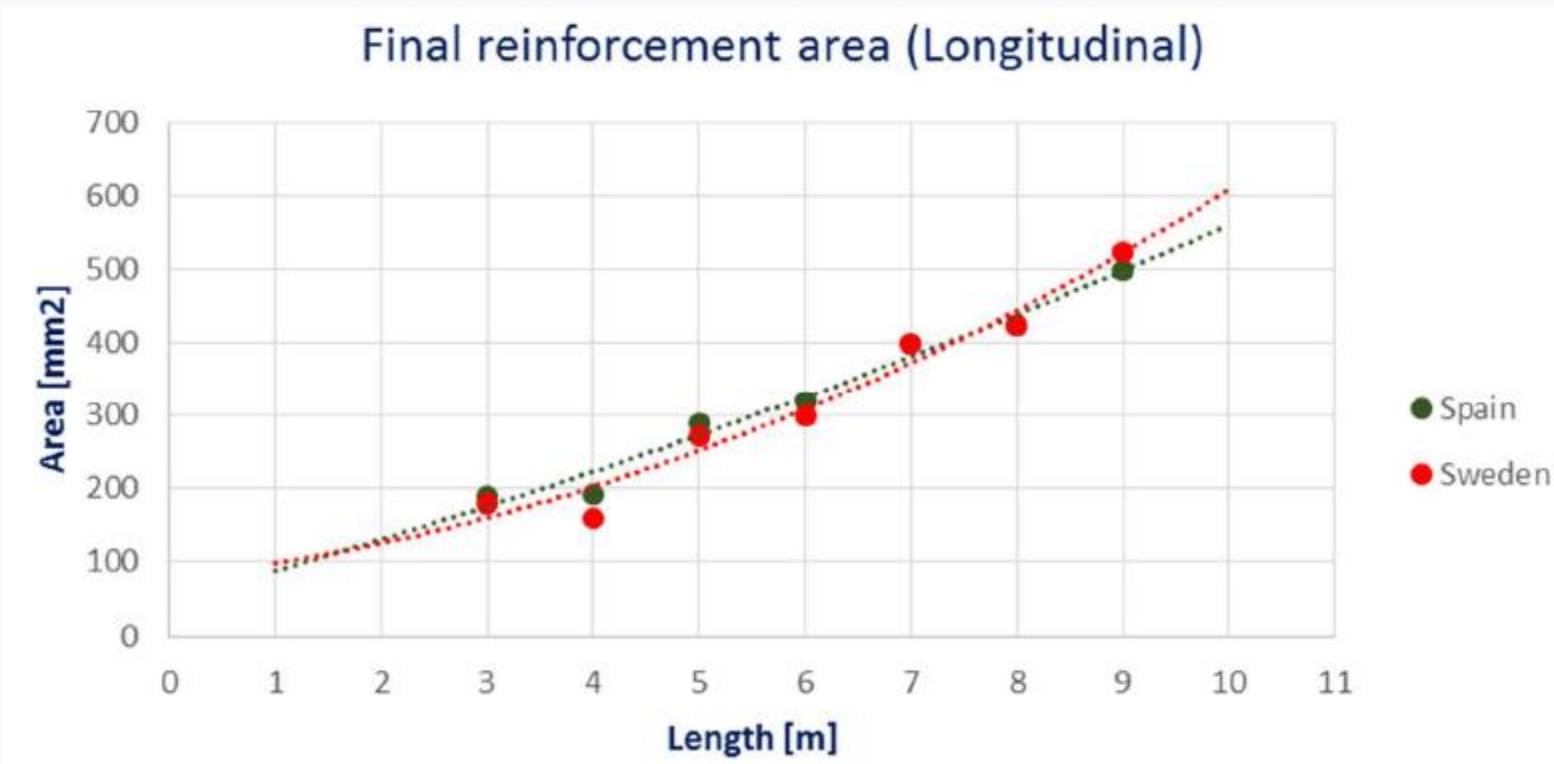
Design according to EC 2 for lengths L = 3 – 9 m

Example L = 6 m



Short standard bridge – Comparison

Small differences in designs according to Spanish and Swedish National Annexes



Short standard bridge – Comparison

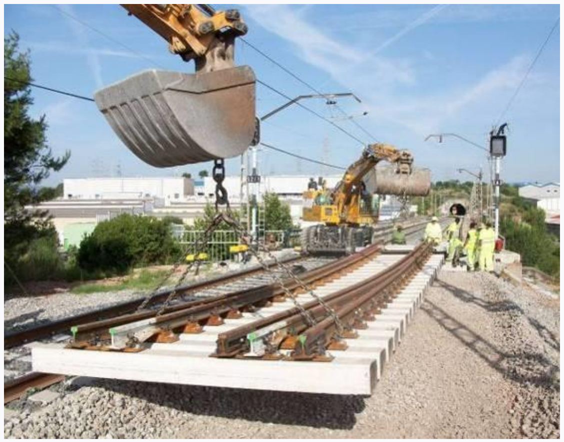
Small differences in designs according to Spanish and Swedish National Annexes

	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

Guideline need to consider these differences.

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)**
							...am (...ogies ...ons ...for ...port) ...ader ...tor ...er ...oco ...2b ...er ...r	*B1* **- Kirow Crane** *B2b* **- Automated ballast collector - Hopper wagons+loco -Grader -Roller**

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**

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 performance
++ Average performance
+ Poor performance

Logistic and design improvements for S&C renewal optimisation

1. **Modular S&C concept**
   (& Hybrid modular method)
2. **Automated ballast collector**
3. **Track stiffness variation**
4. **Lighter S&C (synthetic sleepers)**
5. **Quality of installation**
6. **Use of DTS**
7. **Reinforcement of subgrade/ballast layer**

Modular S&C

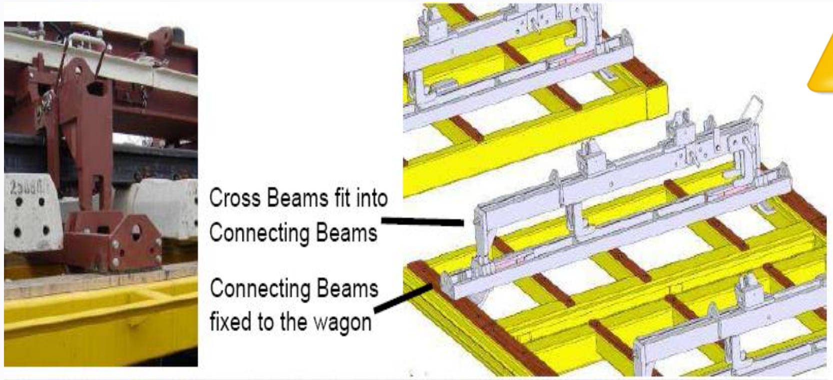
The modular switch has a potential to **halve the total duration of the works and to reduce significantly the labour required**, when compared to conventional replacement methods. This savings come from:

- The switch is **assembled only once** at the factory, assuring **quality of installation**.

- The **transfer** of the switch from the wagon to its final position is **faster**

- **Commissioning** can be done **quicker**

The modular switch concept also **avoids the need of negotiations with landowners**



Important remarks to further increase output

- When possible, **transport the switch panels from the factory provided with the driving devices**

- **Design specific handling systems to facilitate the transfer from wagon to the handling equipment** (i.e cranes)

Modular S&C

Barriers of the use of the modular S&C:

- Many IMs count with a **reduced number of tilting wagons** due to its high investment costs, which makes them not as widely available as railway cranes.

- The attractiveness of the method depends on the **distance between the assembly factory and the worksite**.

- **Pre-assembled method is quite straight-forward and it is proven for years**, also it is believed to offer **similar quality of installation** than when using modular concept..

Modular S&C method is specially suitable when:

- There are **lineside space constraints** (avoids landowner negotiation)

- There are **not trackside access roads** (facilitates materials transport)

- **Minimum track closure times** are required (p.e. high penalty fees)

- **Minimum labour cost** (i.e. high wages)

Hybrid Modular-Pre-assembled Method

To solve the **lack of tilting wagons**, a hybrid-modular-pre-assembled method can be used. In some cases, **some of the switch panels** can be transported by conventional **flat-bed wagons**, while **the rest of the panels are assembled at the lineside** of the works. This allows a **reduction of the required space** for the pre-assembly, but also of the **labour and time** associated to the transported turnout panel.

RES platform wagon used in Czech Republic to transport switch panels

Automated Ballast Collector (ABC)

The automated ballast collector **is commonly used in combination with the modular S&C method to minimize track possession times**. However, it can be use too with the **pre-assembled methods**.

The automated ballast collector **increases the efficiency of the ballast layer removal and site preparation**. Given that it is able to carry out the **excavation** (by means of an impeller with 1.3 m of maximum depth) **and compactation in one single working operation**.

ABC is specially suitable when:

- **Minimum track closure times** are required (p.e. high penalty fees)

- **Minimum labour cost** (i.e. high wages)

Track Stiffness Variation

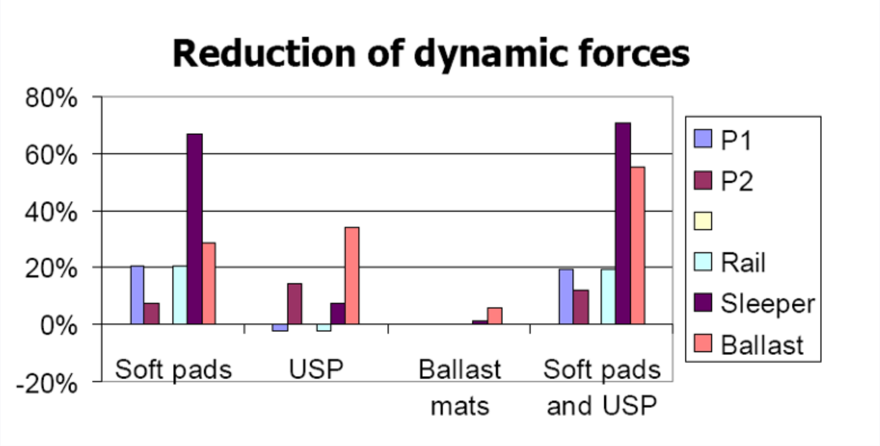
Along with geometry optimisation of the switch, the **optimisation of track stiffness** in a turnout leads to a **reduction of dynamic forces**, **which turns into a better performance** switch with **less maintenance needs**.

The most efficient solutions to minimize track stiffness variation are:

- Soft rail pads

- Hard USP

When **combining soft rail pads and USP** with the aim of achieving the minimum stiffness variation, **their combined effect must be studied** given that there are interactions between their elasticities



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

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

Lighter S&C (synthetic sleepers)

Turnouts provided with light sleepers (such as wood sleepers) **are quicker to replace**. **Cranes are able to lift longer switch panels, while deflection due to weight is also reduced**.

Synthetic sleepers (such as FFU sleepers) have the following benefits:

-Offer **similar weight** to beech sleepers, while offering much **higher resistance against weathering and chemical attacks** (2x or 3x life expectancy).

- **Improved mechanical properties** (2x bending resistance, 3x maximum static resistance, etc.)

- **High electrical resistance** (R33 is 72 KΩ while the required is 5 KΩ).

- The **accept existing fastening systems and screws**, are **easily repaired** and are **recyclable**.

Track Quality (Practice guidelines)

The following rules of thumb have been identified:

Undertake all welds during track possession. The pass of trains over provisionally clamped rails can cause high stress at the end of the rails, and hence should be avoided. Given time constraints, it should be achieved either by**:**

- **Employing more efficient replacement methods** (p.e. automated ballast collector modular S&C concept) **can provide additional time to complete all welds within the track closure times**

- **Pre-assembling the complete turnout and laying it as a whole**, by means of DESEC or portal cranes

Avoid piecemeal renewal. It is a **common practice in Eastern Europe (15% in some countries),** and it should be avoided given that it leads to a **lower quality** since S&C units end up with **components of varying age and condition**.

Track Quality (Practice guidelines)

Correct handling of the switch during transport and installation. Switch panels have to be lifted in a way they **do not suffer undue deformations and thus, stress**.

Most of replacement methods handle the switch panels properly. However, **excavators and road cranes** usually support the switch panels only by two points which leads to excessive deformations. Therefore, they should be only used for **short panels**.

Renewal of the complete layer of ballast and site preparation is mandatory in many administrations in order to **assure a good condition of the support layers**. A weak support condition of the switch will lead to excessive and differential settlements that will turn into high maintenance costs.

Use of Dynamic Track Stabiliser (DTS)

After the renewal of the switch, **Temporary Speed Restrictions** (TSR) **usually apply**, which can **last for up to a week** and imply, in some cases, **penalty fees**.

The use of the **Dynamic Track Stabiliser** was reported **only by TCDD** as a common method to **increase the speed** restriction, and even to **avoid the imposition of any TSR**.

The use of DTS after switch installation should be further analysed by IMs to **minimize operational impact** after the switch renewal (it equals to 100.000 T).

local speed limit zul v [km/h]	highest speed allowed [km/h] depending on the traffic passage [t]					
	≤ 25 000	> 25 000 ≤ 50 000	> 50 000 ≤ 100 000	> 100 000 ≤ 150 000	> 150 000 ≤ 200 000	≥ 200 000
≤ 70	zul v	zul v	zul v	zul v	zul v	zul v
> 70 ≤ 120	70	zul v	zul v	zul v	zul v	zul v
> 70 ≤ 120	70	70	zul v	zul v	zul v	zul v
> 120 ≤ 140	90	zul v	zul v	zul v	zul v	zul v
> 120 ≤ 140	90	90	zul v	zul v	zul v	zul v
> 140 ≤ 160	90	140	140	zul v	zul v	zul v
> 140 ≤ 160	90	110	110	zul v	zul v	zul v
> 160 ≤ 200	90	140	140	zul v	zul v	zul v
> 160 ≤ 200	90	110	160	160	160	zul v
> 200	90	140	140	zul v	zul v	zul v

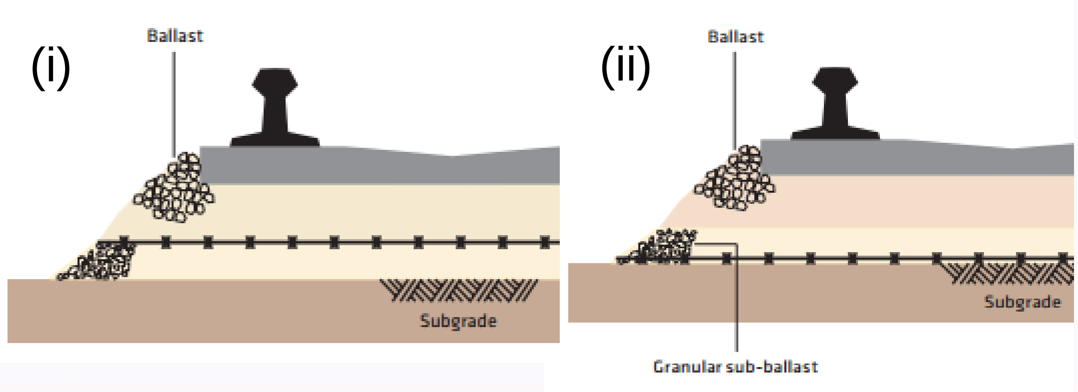
Geogrids

The inclusion of **geogrids below the ballast layer have been studied and tested** in several occasions in the recent years (such as SMARTRAIL project), specially as a solution for **soft soils and transition zones**.

The use of geogrids contributes to reduce track settlement, by either:

(i) **reducing ballast deformation** through the **mechanical stabilisation of on the ballast layer**.

(ii) **Improving track foundation** through the **mechanical stabilisation** of the **sub-ballast layer**.

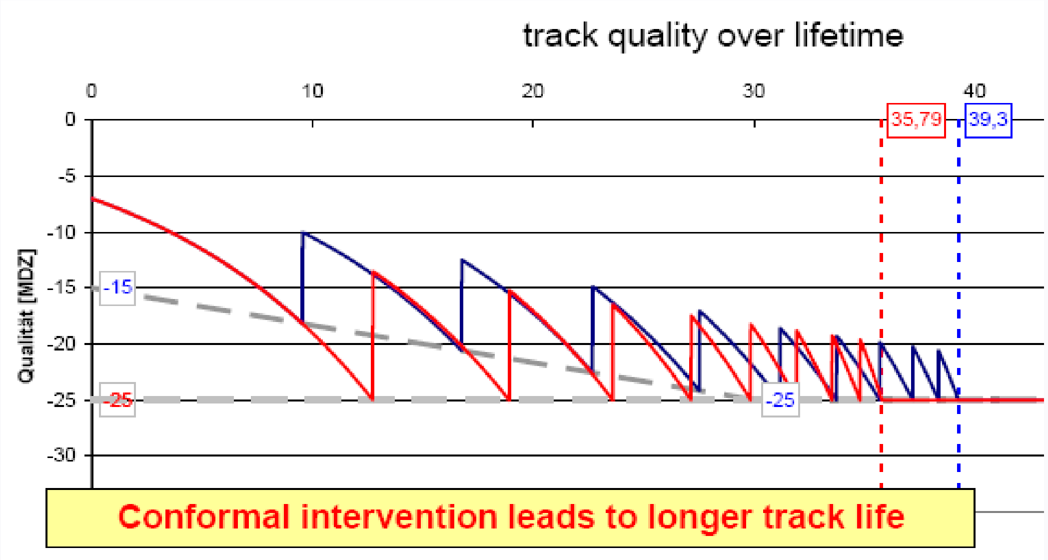


Geosynthetics have little effect on track stiffness:

Geogrids are able to reduce effectively track settlement, but are not suitable to homogenize track stiffness such in turnouts.

Conclusions

Renewal strategy cannot be separated from maintenance strategy if LCC approach is intended. Not an "absolute value" (i.e. year X).



Need of an **integrated maintenance and renewal strategy**

Guidelines for integrated renewal strategy:

Increase output of interventions (p.e. modular switch, ABC, bundling) and improve quality of the renewal (USP, noise, etc.)