DYNAFREIGHT

Innovative technical solutions for improved train
DYNAmics and operation of longer FREIGHt Trains

Shift2Rail

Grant Agreement
Number: 730811

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DYNAFREIGHT: details

Budget: **999,822.50€**

Partners: **10**

Duration: **20 months**

Starting date: **Nov 16**

End date: **Jun 18**

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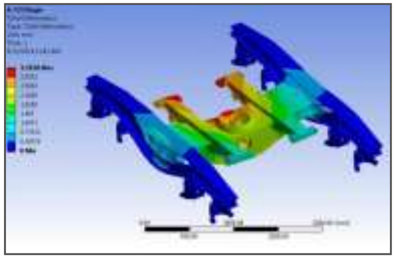
Main objectives



1. Freight running gear for locomotives

Design and development of necessary concepts for a loco freight bogie with reduced wheel and track wear, lower noise and LCC

2. Operation of long freight trains

Development of path for regular operation of long freight trains following the outcomes of MARATHON project

Main planned outcomes:

- Improved performances: traction, speed, running dynamics and wheel/rail efforts
- Reduced rail freight noise at the source
- Enhance capacity/traffic throughput with the operation of longer trains
- Reduction of operation and maintenance costs (reduce wheel and rail wear, smarter maintenance, etc.)

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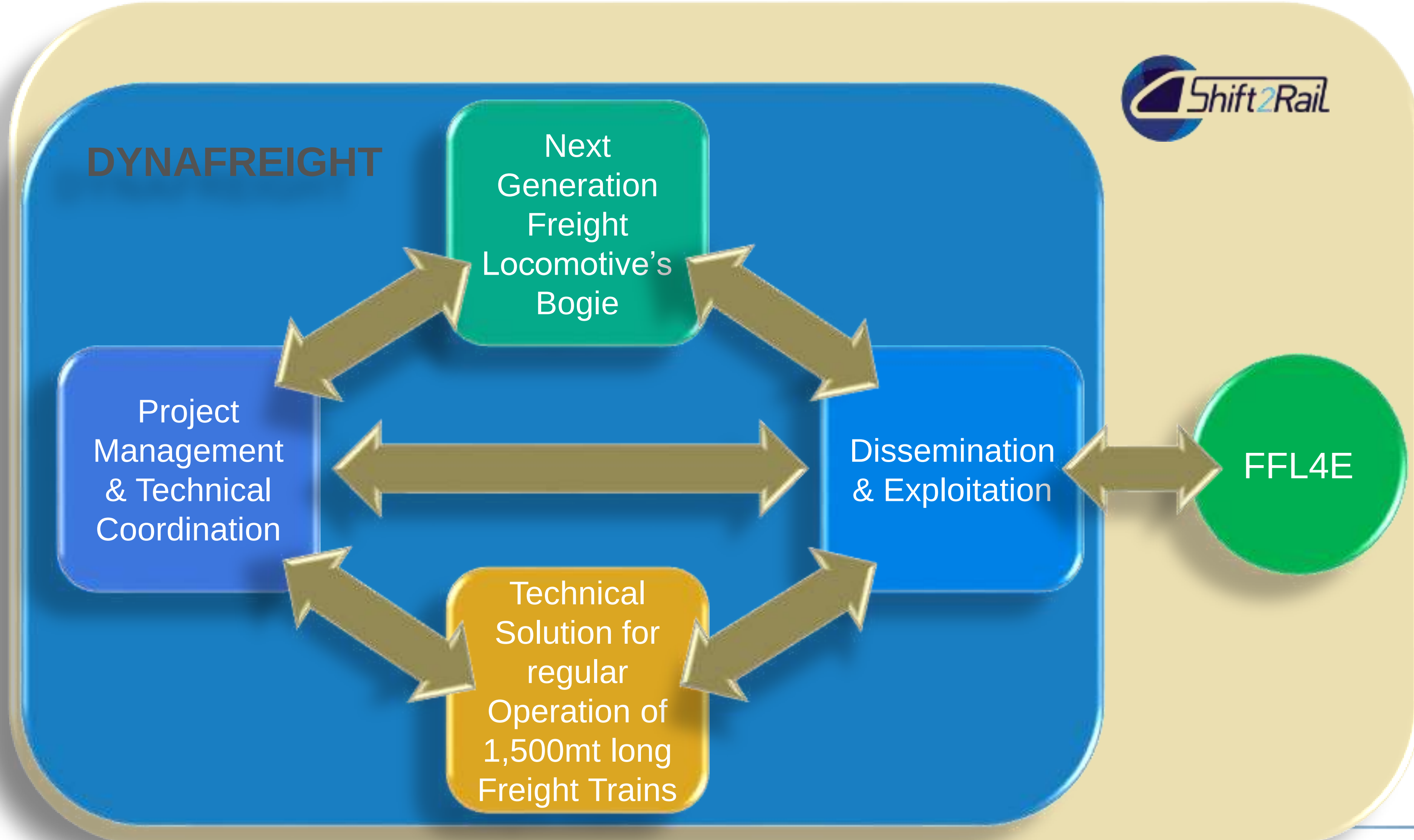
Project structure



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Technical objectives

The final goal is to provide the necessary inputs for the development of the next railway freight propulsion concepts within IP5 of Shift2Rrail.

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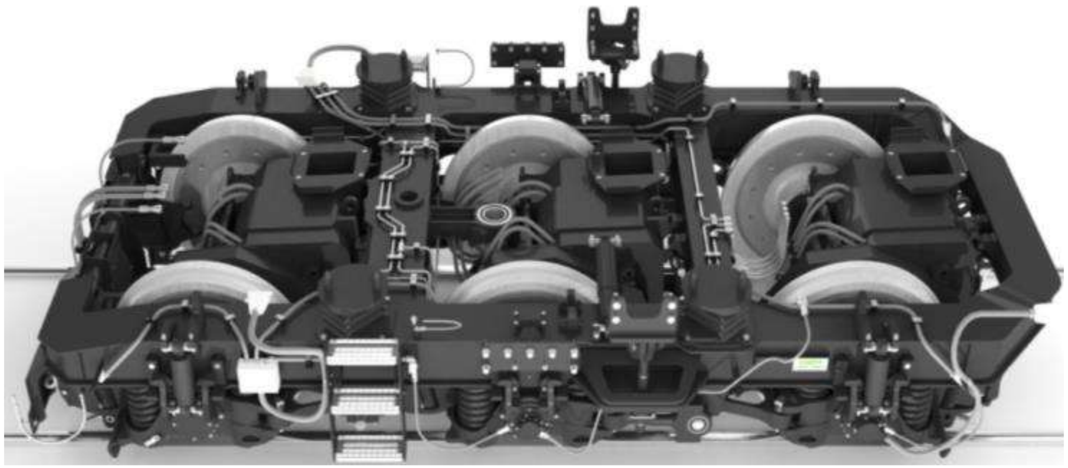
2 main technical objectives

- **Next Generation of Freight Locomotive's Bogie:** To specify, design and develop new concepts to be applied on future freight locomotive bogies (3-axle bogie).
  - Identification and evaluation of **lighter materials** to be used in a freight environment for bogie components.
  - To study and develop noise concepts to **reduce the overall noise level** caused by freight running gear.
  - To analyse **passive steering and active mechatronic systems** for improved curve negotiation.
  - To **monitor** the most maintenance-costly bogie elements, in order to reduce LCC.



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2 main technical objectives

- **Increase of train length**: to develop a technical solution for the regular operation of **up to1,500m long freight trains.**
  - To define and implement functional, technical and homologation requirements for a **radio remote controlled traction and braking system**.
  - To propose safety precautions in train configuration and brake application by analysing and **simulating the longitudinal forces and the derailment risk**.
  - To identify **adaptions needed in the infrastructure** for the operation of long freight trains up to 1,500m, which will be operated as double trains.

Expected Impact	How	Indicators & Values
Improved traction performance	Passive and Mechatronic Steering Systems – better curve behaviour	Reduction in rolling resistance in curves by 50%. Reduction in energy usage on railway lines with many tight curves by 10%.
Reduce noise emissions	Concepts for reducing running gear noise	Reduce noise emissions from the locomotive bogie by up to 2-3 dB.
Reduce wheel and track wear	Passive and Mechatronic Steering Systems	Track forces reduced by 10% . Increase of wheel life by 50% for lines with 5% of small curves (for non-aggressive lines lower influence). Reduction of track damages by 40%. Increase of hauling loads by 10%.
Reduce Life Cycle Costs (LCC)	Passive and Mechatronic Steering Systems. Monitoring	Decrease of costs for bogie maintenance by 25% . Decrease of costs for track maintenance by 5%.

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Expected Impact	How	Indicators & Values
Higher traffic throughput	Facilitating the way for long train operations	Increase of freight train throughput on standard corridors, increasing overall capacity by 80%.
Lower operating costs	Improved train dynamics (track access charges). Operation of long trains (reduction of the occupied train path and nº of drivers).	Decrease of operational costs of international freight trains (Euro/tonne-km) by 10%. Decrease of track access charges of international freight trains (Euro/tonne-km) by 16/20%.
Higher driving speeds	Mechatronic systems for radial steering of bogies will allow higher curving speeds. Long freight trains will allow higher average driving speeds.	The improved locomotive running gear can reduce transport time by 5% The decongestion due to long train operation can reduce transport time by about 5%

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Introduction on technical WP2

DYNAFREIGHT
WP 2 Next Generation of Freight Locomotive's Bogie

Different technical works to be developed, both to be used as input for future EU freight locos

FFL4E
Future Freight Loco for Europe

Consultancy between both projects for the same final goal on a medium term within S2R

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Future EU Freight Locomotives

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Introduction on technical WP3

Same technical works to be developed – specific task distribution between the 2 projects

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WP3 Technical Solution for regular Operation of 1,500mt long Freight Trains

FFL4E
Future Freight Loco for Europe – Long Trains

FFL4E with DYNAFREIGHT Input:
Demonstration of Long Freight Trains Operation in Summer 2018

Work in close collaboration for a common and short objective implementation

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Task 2.1 Light Materials Assessment - OVERVIEW

Work has focused on the following areas:

- Use of different steels but same basic design and construction method
- Different construction methods
  (manufactured sections, cast elements, different joining techniques, weld treatment…)
- More radical redesign including hydroforming, composite materials

Models have been set up to allow:

- Stress Analysis for the bogie frame [ANSYS]
- Assessment of the Vehicle Dynamics [VAMPIRE]

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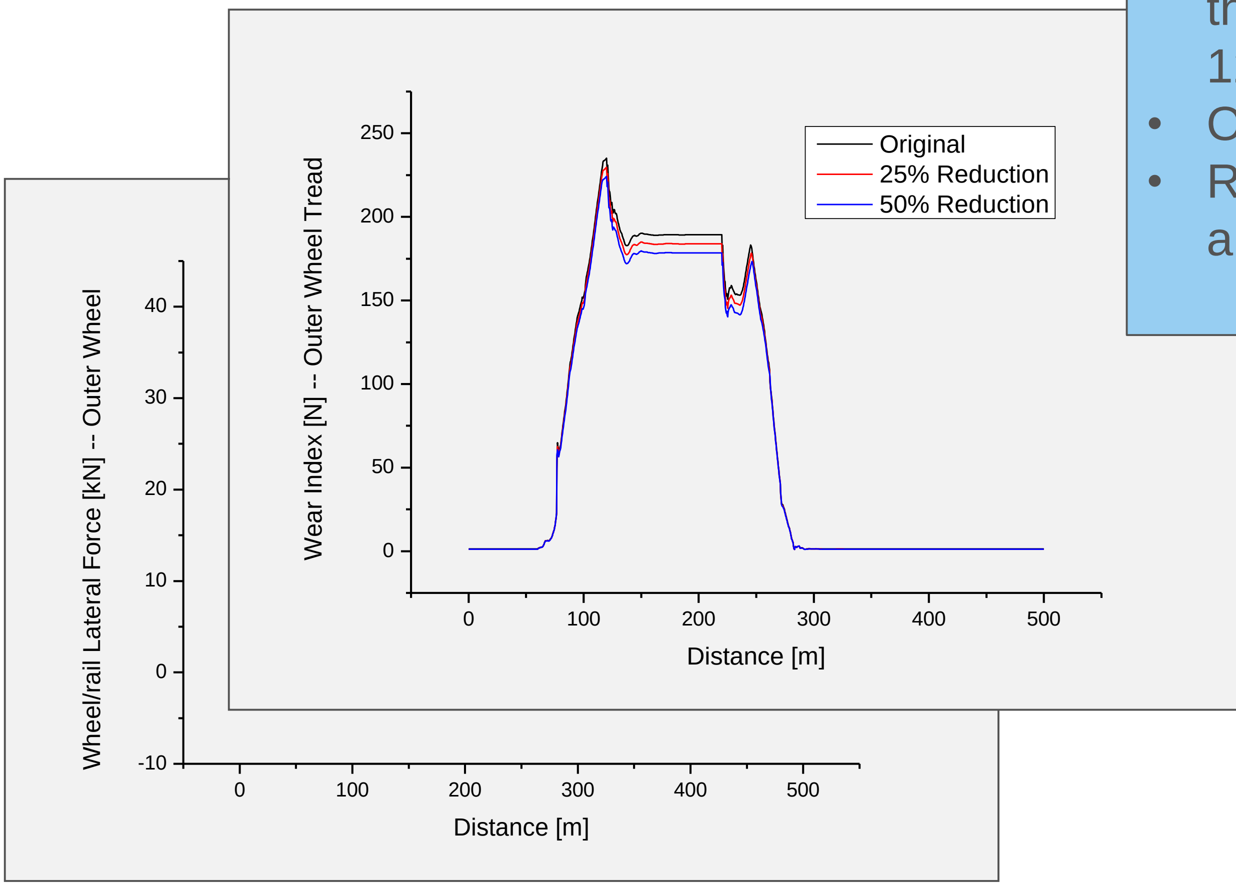
Vehicle Dynamics Analysis

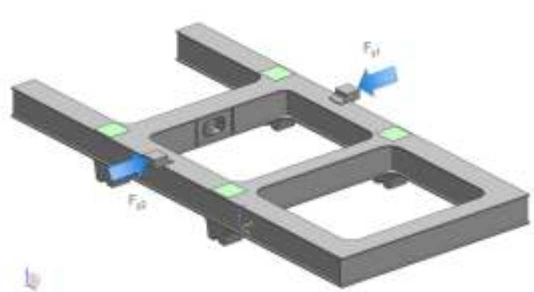
- Curve radius 600m; Speed 72km/h; Superelevation 90mm; Cant deficiency 60mm
- (60m transition - 100m constant radius - 60m transition)
- Bogie frame mass reduction of 25% and 50% considered

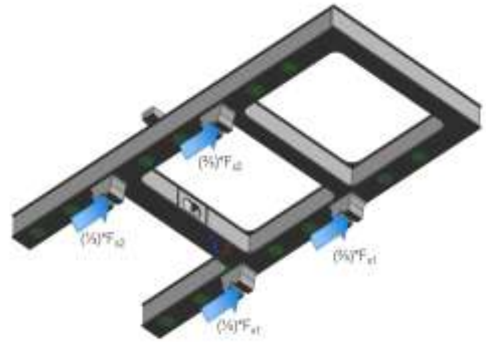
- Predicted wear reductions at the outer wheel tread of up to 12.5% achievable
- Only 7.5% reduction at flange
- Reductions at the inner wheels are not significant

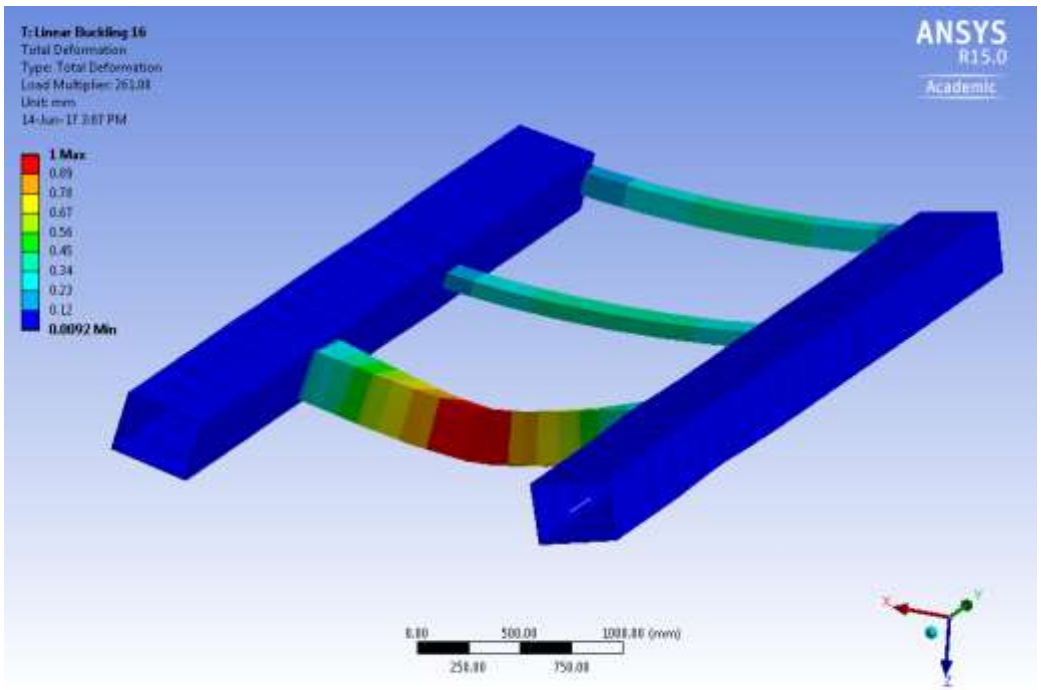


FE Analysis

21 load cases







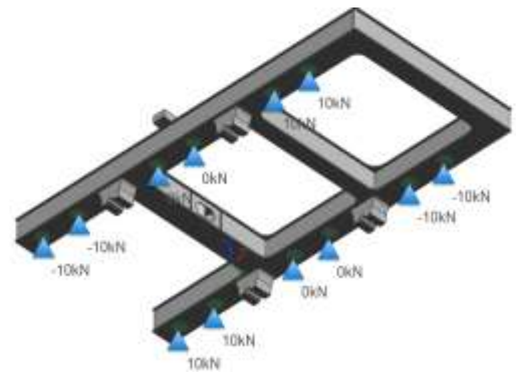


Figure 30 - Buckling mode, 261 factor on loads [load case 21 & 37% weight reduction]

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Summary of FE parametric study

mass saving	End beam W	End beam H	End beam t	Central beam W	Central beam H	Central beam t	Traction beam W	Traction beam H	Traction beam t	Side beam W	Side beam H	Side beam t	Criteria: max deformation	Criteria: lowest natural freq.	Criteria: Euler buckling x load	abs. normal stress
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[Hz]		[MPa]
5%	100	200	5	100	100	5	500	250	5	500	500	10	1.0	44	322	80
16%	160	160	5	160	160	7.5	500	400	7.5	500	500	7.5	0.7	59	871	46
17%	160	160	7.5	300	300	7.5	500	400	7.5	500	400	7.5	0.6	66	842	46
19%	160	160	5	300	300	7.5	500	300	7.5	500	400	7.5	0.6	66	556	55
24%	160	160	7.5	150	150	7.5	500	500	7.5	300	500	7.5	1.4	49	676	46
24%	160	160	7.5	300	300	7.5	500	400	7.5	400	350	7.5	0.7	60	739	51
29%	160	160	5	300	300	7.5	300	500	7.5	300	400	7.5	1.4	48	712	75
30%	100	200	7.5	100	100	7.5	500	250	7.5	250	500	7.5	2.3	41	323	73
31%	100	100	7.5	100	100	7.5	500	250	7.5	250	500	7.5	2.4	40	315	73
32%	160	160	7.5	160	100	7.5	400	300	7.5	400	300	7.5	1.3	53	398	76
35%	150	150	7.1	160	100	7.1	400	300	7.1	400	300	7.1	1.4	53	378	80
35%	150	150	6.3	160	100	7.1	400	300	7.1	400	300	7.1	1.4	53	377	80
36%	150	150	6.3	150	100	7.1	400	300	7.1	400	300	7.1	1.4	52	377	80
36%	150	120	6.3	150	100	7.1	400	300	7.1	400	300	7.1	1.4	52	375	80
36%	120	120	6.3	150	100	7.1	400	300	7.1	400	300	7.1	1.5	51	375	80
36%	120	120	6.3	160	80	7.1	400	300	7.1	400	300	7.1	1.5	51	374	80
36%	120	120	6.3	120	100	7.1	400	300	7.1	400	300	7.1	1.6	50	374	80
37%	120	120	6.3	160	80	7.1	350	300	7.1	400	300	7.1	1.6	49	348	91
37%	120	120	6.3	160	80	7.1	350	250	7.1	400	300	7.1	1.7	48	261	102
39%	100	100	5	100	80	7.1	300	200	7.1	400	300	7.1	2.4	40	163	137
40%	160	160	7.1	160	100	7.1	300	250	7.1	300	300	7.5	2.2	43	211	129
41%	100	100	7.1	160	100	7.1	300	250	7.1	300	300	7.5	2.4	42	208	129
41%	100	100	7.1	160	100	7.1	250	250	7.1	300	300	7.5	2.7	39	185	155

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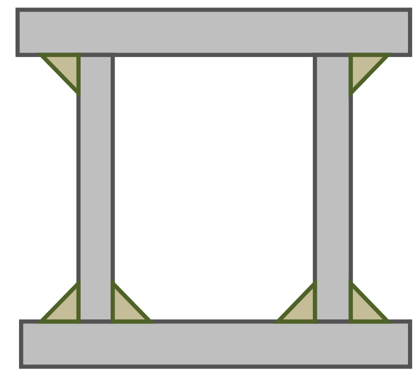
Potential Improved Designs

Option A

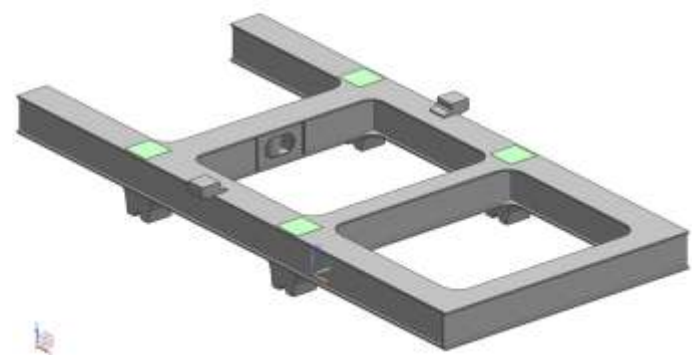
Current construction method with higher strength steel and improved weld techniques



The current S355 steel is however replaced by high strength steel.

Improve weld performance by:

- Improve predicability of weld quality by maximizing use of automatic welding and non-destructive testing.
- Use of weld treatment technics such a ultrasonic impact treatment to improve weld properties



Potential for economical weight reduction is small.

Potential Improved Designs

Options B and C

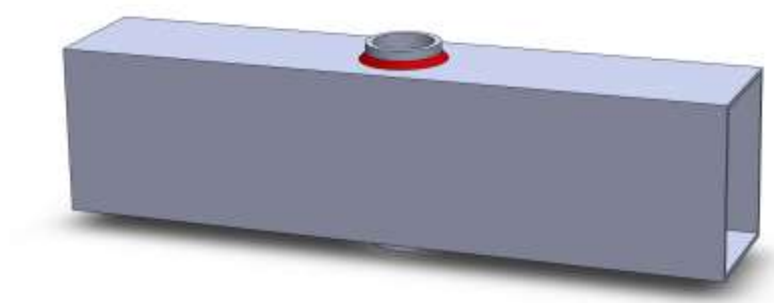
Replace the fabricated construction with commercial hollow sections

Good torsional stiffness using aligned rectangular or elliptical sections

Careful design reduces welding requirements (experience from offshore construction)

Possible inclusion of cast nodes and internal ribs

Potential for significant weight saving and cost savings



Potential Improved Designs

Option D

Use of cold-forming techniques such as hydroforming, electromagnetic forming and crimping.

Use of tubular sections formed via hydroforming to create beams with varying cross-section profiles to provide directional optimal beam stiffness and strength. Additionally, appropiate mounting surfaces can provided for mounting suspension and other components via welding or crimping.

Potential Improved Designs

Option E

Use of composite materials

Glass fibre and Carbon fibre have been considered and several experimental / prototype applications have

‘EUROBOGIE’ research project

Kawasaki ‘efWING’ bogie

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Conclusions

- Finite Element analysis suggest that 37% bogie frame mass reduction is achievable using higher strength steel with conventional fabricated construction
- Further mass reductions and cost reductions are possible if tubular sections are used, possibly also with novel techniques such as hydroforming and cast nodes
- Weld performance improvement techniques such as ultrasonic impact treatment should be considered
- Composite materials have very significant potential for mass reduction but failure modes are not well understood
- Vehicle Dynamics analysis shows that 12.5% reduction in wheel/rail wear is possible

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