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Sustainable Development, Global Change & Ecosystem

D8.1- Assessment - Position of integrator

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PU	Public	PU
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D8.1.1 Objective and state of the art

Objective

The objective of this paper is to define the impact of WIDEM on the system integrator side.
The expected benefits which can be obtained are a reduction of the wheelset mass of 20% and an increase of the periodicity of the ultrasonic inspection from 300.000 to 450.000km. Are these results useful for the system integrator**?** The impact is to be considered at construction, operation and maintenance level.

State of the art

For the integrator the first issue concerning wheelset is safety :

The existing referential wheelset standards in European Community is more or less issued from reports of ERRI B136.
These design rules are all issued from the experience of the railways administrations however there is no direct notion of reliability in the global axle assessments, design rules are based on a pass or fail criteria, although reliability notions are present in the admissible stresses for the axle. It means that a non compliance with a criteria is a non acceptance of the corresponding product.

For example, the report 11 gives for axle:

- A method to determine the efforts applied on the axle corresponding torques according rolling stock parameters.
- Recommendation on the axle :
  - geometry of the axle shape.
  - Press fitted interface requirement.
- Value of admissible stress for one material and a method for these values determination.

It means that new global method of wheelset design shall be compared accurately and validated according to the existing referential. It is one main interest of WIDEM project to give a global method of designing and maintaining a wheelset taking into account .

Link to safety are based on compliance with the state of the art standards and not to forget, the certification and acceptance procedure throughout EC is an important thing for integrator because rolling stock have to be interoperable and developments are less and less focused on one customer.
Up to now acceptance procedure are not the same according the operator EU. It is based obviously on a referential of common standards, however some points are completed by operator technical specifications. it means that for the same application wheelset are different according countries on one hand and certification costs are important on other hand.

For the system integrator, the second issue is rolling stock cost according to customer technical specification of performance. The cost is obviously the cost of the rolling stock itself however also the impact on the system i.e. operation and maintenance.

D8.1.2 Wheelset mass saving interest

The saving of mass is and important issue for system integrator, the assessment of the project is :

- at constant safety we save 200kg.

(what does “at constant safety” means exactly today! Because we have now no safety criteria in term of failure probability).
This mass has an influence at two levels : overall masses of the rolling stock (axleload) and unsprung masses.

Overall mass of rolling stock.

Wheelset has an medium impact on the axleload and the mass saving can be used by system integrator on different ways. We will take an example of a 15t axleload vehicle 200kg per wheelset represents a mass saving of 1,3%. Three possibilities is offered to the integrator :

- to decrease axleload of the rolling stock which is interesting for the life cycle cost of rolling stock and tracks.
- to increase payload staying with the same axleload which is interesting for the operators.
- to decrease the rolling stock cost by avoiding to use expensive light material instead of conventional steel mainly in the carbody interior or sometimes light alloy parts in the bogie.

Cost of the vehicle.

Concerning the cost of the wheelset mass saving should have a positive impact however difficult to evaluate.
An important point for the system integrator is written in the state of the art. The wheelset standardisation can be applied at several levels : interoperability interface, acceptance criteria and certification, parts interface and parts all these aspects particularly at component level standardisation is a driver for reducing construction cost.

Life cycle cost.

This cost is shared in two parts infrastructure and operation.

Infrastructure, track damaging criteria.

The track damage is function on one hand of the vertical forces on the track generated the rolling stock which are related to axle load.
Axle load in vertical direction
Guiding forces in the wheel rail contact plane.
Wheel wear is related to the energy dissipated in the contact patch, usually expressed as the product of the creep force (T) and the creepage (γ). The creepage is mostly depending on :

- the position of the wheel in the track (yaw angle and offset) which is related to the links between axleboxes and bogie frame).
- the wheel and rail profile.
- the wheel rail friction coefficient.

If we consider a given configuration of primary suspension, wheel rail profile and friction coefficient, a parametric analysis in quasistatic curving in 300m curve shows that variation of 10% or –10% of non suspended mass (in this case 1446 Kg) doesn’t gives any significant results for guiding forces and track shift forces. See table 8.1.2

Vehicle configuration	Guiding force variation in %	Track shift force variation in %	Profile wear variation in %
Reference	1	1,00	1,00
Unsprung mass +10%	1,05	1,01	1,01
Unsprung mass –10%	0,95	1,00	0,99
Cx & Cy new*	1,14	1,05	1,05
Unsprung mass +10%	1,18	1,06	1,05
Unsprung mass –10%	1,07	1,04	1,04

Table 8.1.2

* Cx and Cy are primary longitudinal and lateral stiffness.

Life cycle cost, operation cost.

Wheel wear.

Wheel wear as seen in the next paragraph this 10% gives only small variation of this index. A variation of the primary longitudinal and lateral stiffness has a far more important impact.
One important point concerning wheel life cycle cost is the wear radius of the wheel which is generally between 30 and 40mm (50mm in extreme case). The mass saving can be used to increase admissible wheel wear radius only if low part gage constraint and other integration constraint concerning transmission and braking … are taken into consideration in the vehicle design.

Maintenance parts

for rolling stock maintenance the cost and reduction of parts number is an important issue.
Modbogie subproject had treated partially this topic on maintenance parts standardisation which includes wheelset and gives some recommendations for Interoperable high speed train and locomotive applications.

Braking

The impact of braking energy given by a mass decrease of 200kg per axle is existing however seems to be low in term of friction wear and life duration even if the mass considered is rotating.

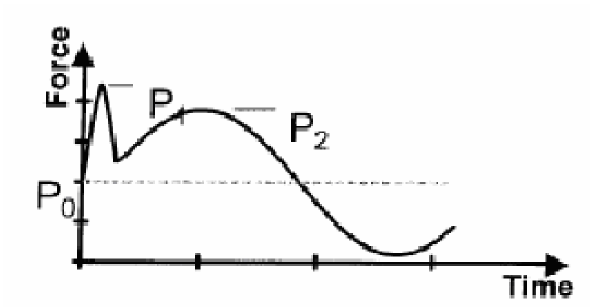
Energy

Concerning energy consumption, to find relevant information is difficult. One Figures, written in a paper of British railway review “Modern Railways May 2008: Vol65 N°716 p59, comes from one operator Ian Walmsley who is Engineering Development Manager at Porterbrook . The following evaluation was : “*the energy needed to carry around one tonne of train mass for 100 miles is about 3,4kilowatt hours. This translate to about £200 per year to which we need to add the track access charge which is another £576 per tonne and per year*”

Unsprung mass saving.

Track damaging criteria

The main damage to the track is the dynamic effect of the unsprung mass which is named the “hammer blow” effect and cause large impact forces. These forces occurs in vertical when there is a track local defect or a flat on the wheel surface and in lateral at discrete events when there is a change of direction (switches crossing,.
On a theoretical point of view this point was treated formerly by British Rail with a simplified vertical model named P2.



P0 is the static load of the wheel, P1 the first peak which appears in the gradient discontinuity is the wheel rail effort taking into consideration the herzian stiffness and P2 the second peak taking into consideration the track stiffness including rail, sleepers and ballast.

$$P_2 = P_0 + 2\alpha V \sqrt{\frac{m_u}{m_u + m_t}} \times \left(1 - \frac{c_t \pi}{4\sqrt{k_t (m_u + m_t)}}\right) \times \sqrt{k_t m_u}$$

Where

2α = the total joint angle (radians)

V = the vehicle speed (m/s)

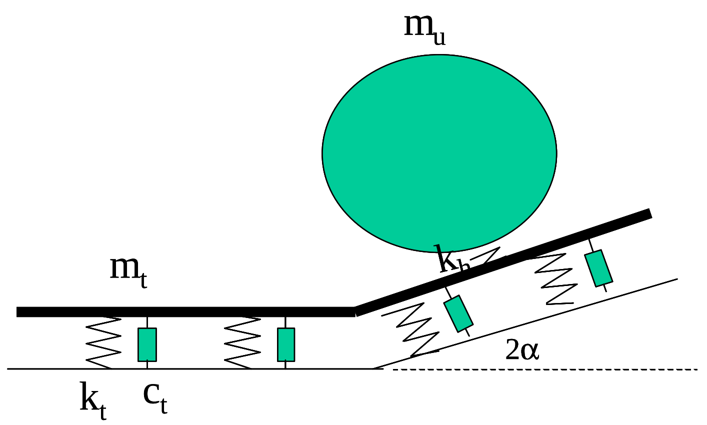
k_H = the Hertzian contact stiffness (N/m)

m_u = the vehicle unsprung mass (kg/wheel)

m_t = the effective track mass (kg)

c_t = the effective track damping (Ns/m)

k_t = the effective track stiffness (N/m).



For the lateral impact the same approach exists.

$$F = \left(1 - \frac{\pi c}{2}\right) \alpha V \sqrt{k_t m_u}$$

Where

α = the kink angle (radians) (change of direction)

V = the vehicle speed (m/s)

m_u = the vehicle unsprung mass (kg)

k_t = the lateral track stiffness (N/m)

c = the ratio to critical of the track damping

In both model the effort is depending on the square root of the unsprung mass.
In the same vehicle and track configuration, if we consider variation of + or –10% of unsprung mass, we have roughly +/-5%. This value has no direct signification in term of cost. The important aspect after these simple theoretical consideration is the impact is the impact on the wheel and track wear.

These aspects are related to the global system in which vehicle track interface in given conditions of operation are in study especially in UK. Vehicle track interface strategic model have been developed to evaluate the global impact on wear and rail contact fatigue (RCF). These studies will without any doubt have an impact on track access charge in the next years.

D8.1.3 Increase of US inspection periodicity.

Maintenance

The impact of WIDEM is to increase the periodicity of axle US inspection. The result is to an increase of the periodicity of the ultrasonic inspection from 300.000 to 450.000km.
This inspection in workshop need at minimum :

- to disconnect device fixed on the axlebox end cover,
- to dismount axlebox end cover, remove seals .., axle end equipment device WSP and axle end cup on one or two sides of the axle depending on the case,
- to make the US inspection,
- to remount the parts and change the seals and reconnect the device.

This operation need for a trainset of approximately an average of 16 man hours and a one day trainset immobilisation in shop.
In addition, to increase the periodicity of US inspection brings more flexibility to maintenance and allow to optimise it by doing other operations.

References :

(1)Modbogie subcontract deliverable 4.1 a/b “Technical verification of selected solutions by simulation”.
(2)RSSB Scoping and development of the Vehicle-Track Interaction Strategic Model WP3 September 2005