C4R

Capacity for Rail

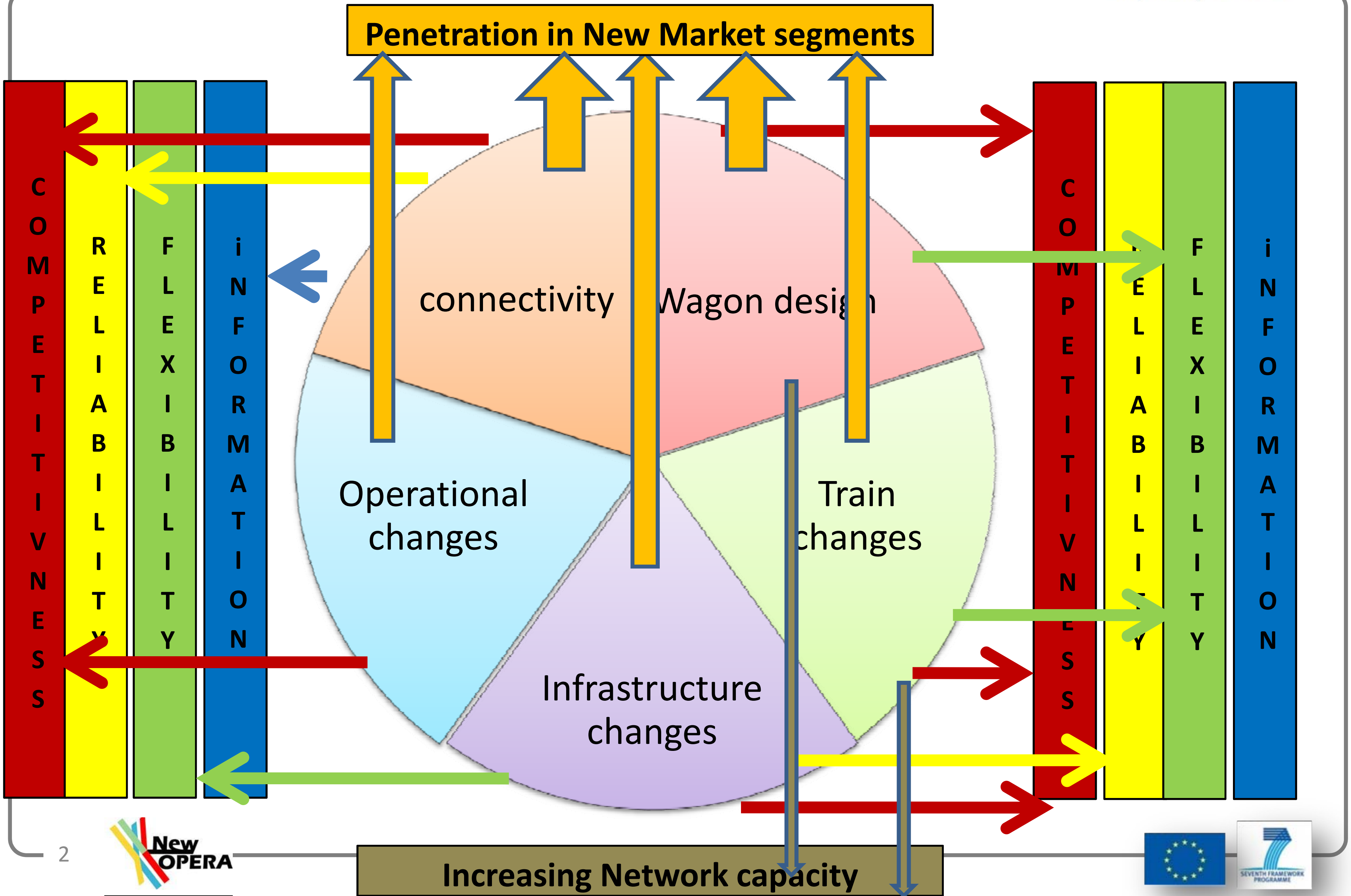
SP2 NOVEL RAIL FREIGHT VEHICLES

Interactive Workshop WP2.2 26th JUNE 2017

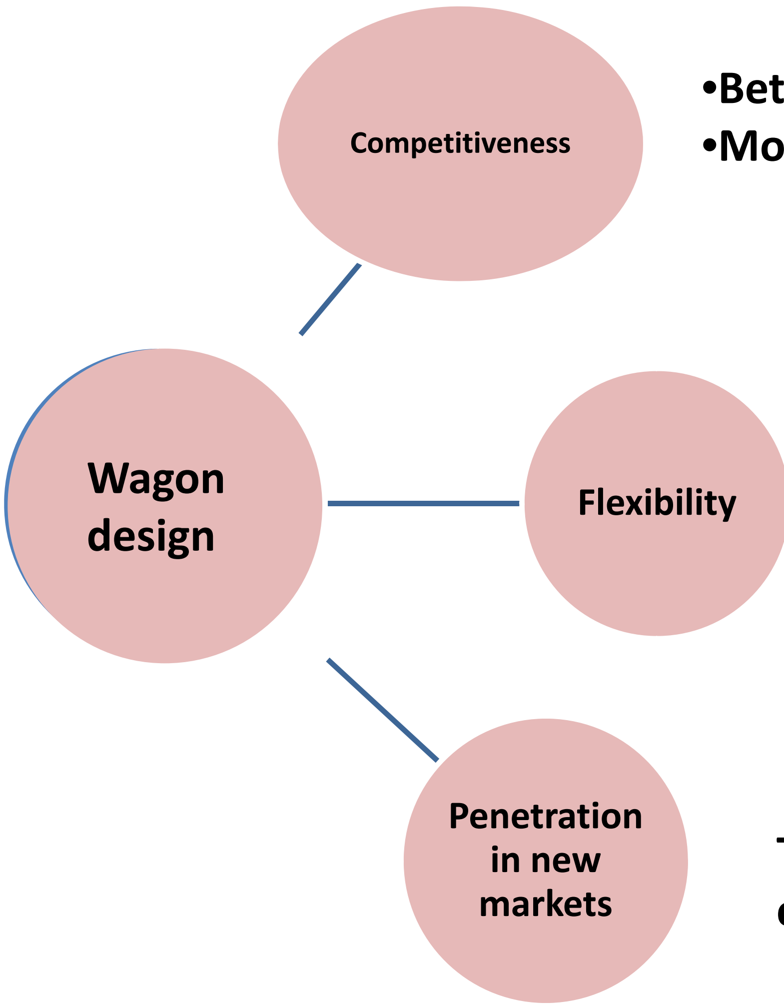
Armand. TOUBOL
WP 2.2.

SEVENTH FRAMEWORK PROGRAMME

General map of WP22 activity



Wagon design:objectives



- Better use of Train length
- More payload

45’ ILU on train optimized for 40’ ILU

Transportation of craneable and non craneable semi trailers

Wagon design for enhanced competitiveness

Multi-body wagons connected by Jacobs bogies and/or draw bars instead of UIC couplers

Wagons Lohr UIC
Blocs of 9 double platforms linked by draw bars

More usable length by withdrawal of some buffers replaced by drawbars inducing also a reduction of dead weight an increased payload

Wagon design for enhanced flexibility

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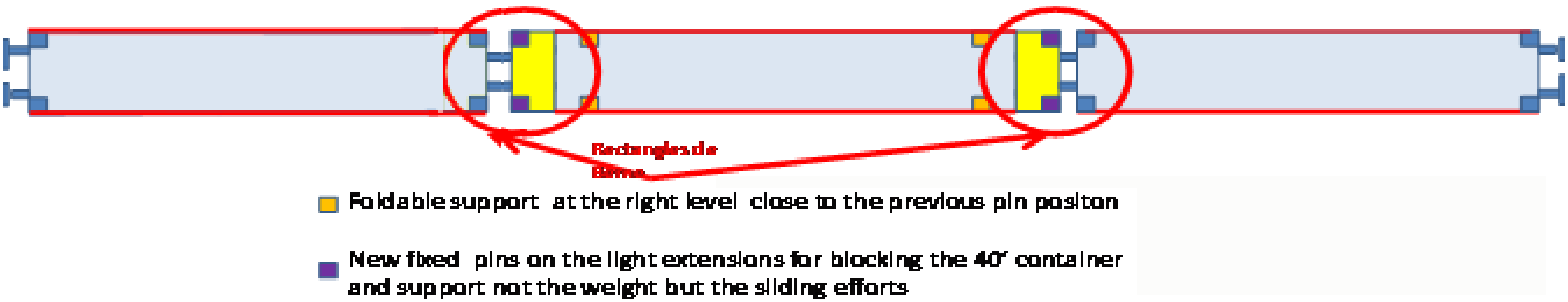
Blocks of 3 wagons with UIC couplers



On a train of flat wagons optimized for 20'/40' containers transport 30% of 45' containers or swap bodies can be carried without lengthening the train

Wagon design to penetrate in new markets

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• The rail freight transport tried in the past to penetrate the market of the semi trailer transport with horizontal transfer but the business model was not found and the number of rolling motorways decreased but for crossing the alps and the channel.

•The obstacle , beyond the financial viability was the acceptable loading gauge in certain countries.

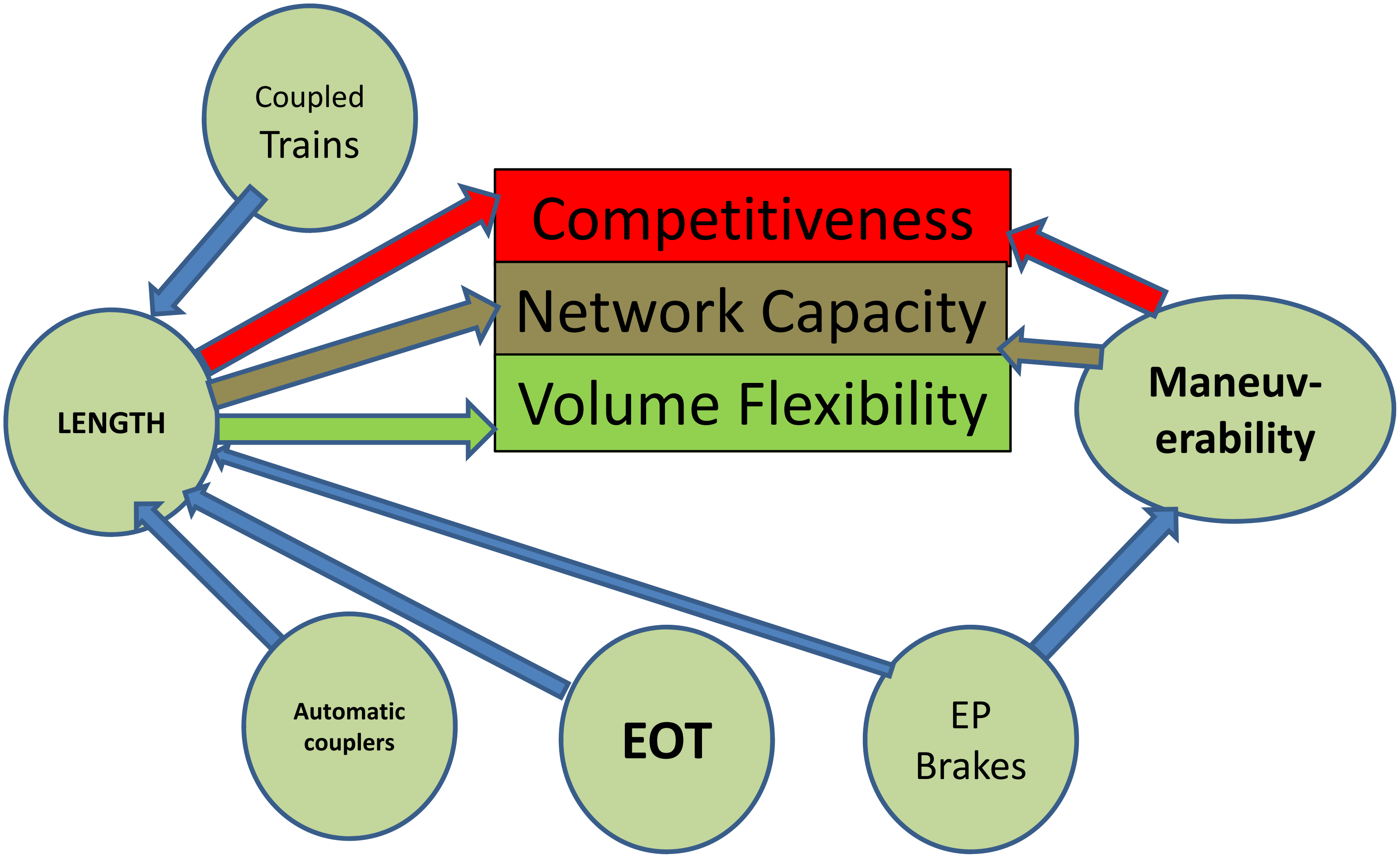
•Specific wagon designs have enabled P400 semitrailers to be transported by rail with smaller investments on the infrastructure than reprofiling all tunnels.

•This huge market 1,5M semi trailers running every day on European roads compared to less than 100000 craneable semitrailers used in combined transport show the large potential of that market.

•Cargo Beamer and Modalohr are already used on certain routes and with trains of 850m the business model on long routes becomes viable.

•These promising developments could be helped by a better knowledge of the infrastructure gauge and innovations on the possible ballast thickness reduction by replacement with new components.

TRAIN CHANGES Impacts



Details of the Impacts: EP braking

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EP Brakes allows synchronous braking and releasing.

-Longitudinal compression forces are drastically reduced

-The train may be lengthened safely up to the limit of the resistance of the couplers to the traction forces and up to the maximum length authorized to run on the rail tracks. It gives flexibility to volume changes demands.

-But EP brakes needs energy which can be provided by a continuous wire all along the train carrying also a bus of information and command.

-The EP brakes in the first phase will be an overlay on the classical pneumatic braking which will serve as a back up in case of default until the system demonstrates its reliability.

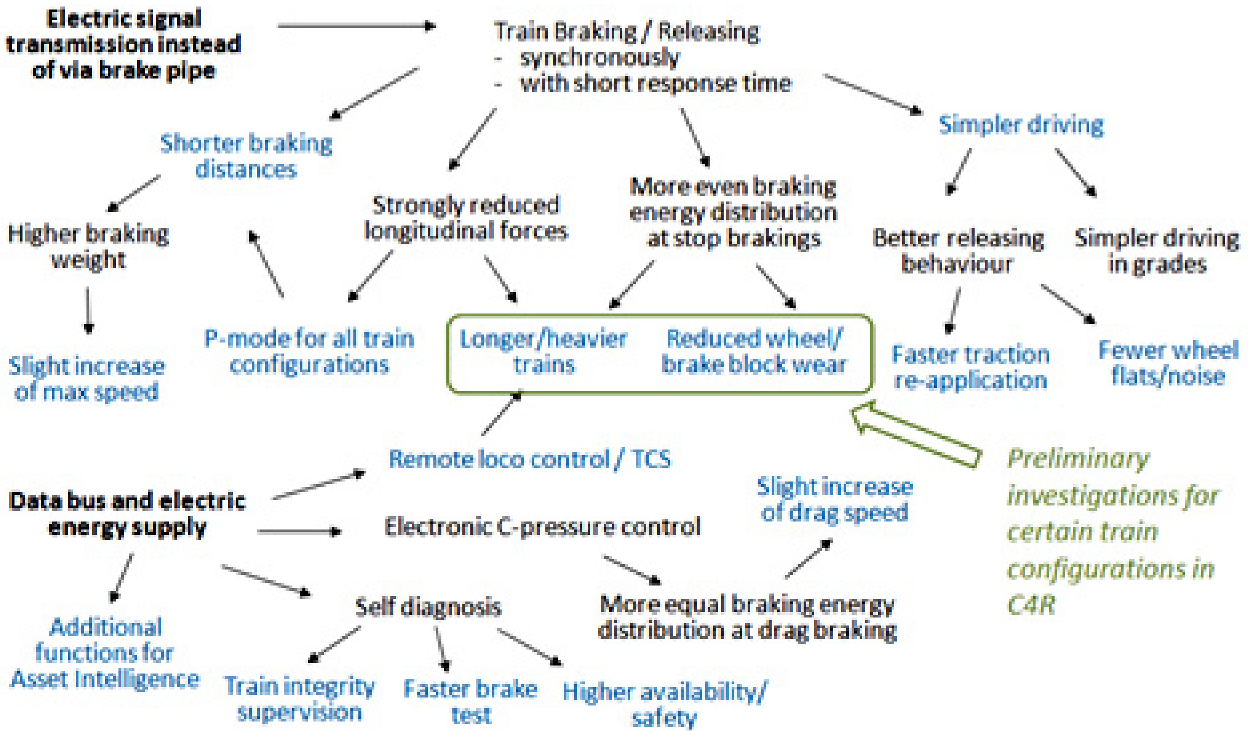
-The solution allows a few wagons with only pneumatic braking in the train as long as they are equipped with the wire

-EP braking gives more manoeuverability to the train and generates more capacity on the network.

-EP brakes reduces the temperature of the shoe and the wheel tread by around 100°C which might help in certain cases avoiding damage to the wheel tread.

New OPERA

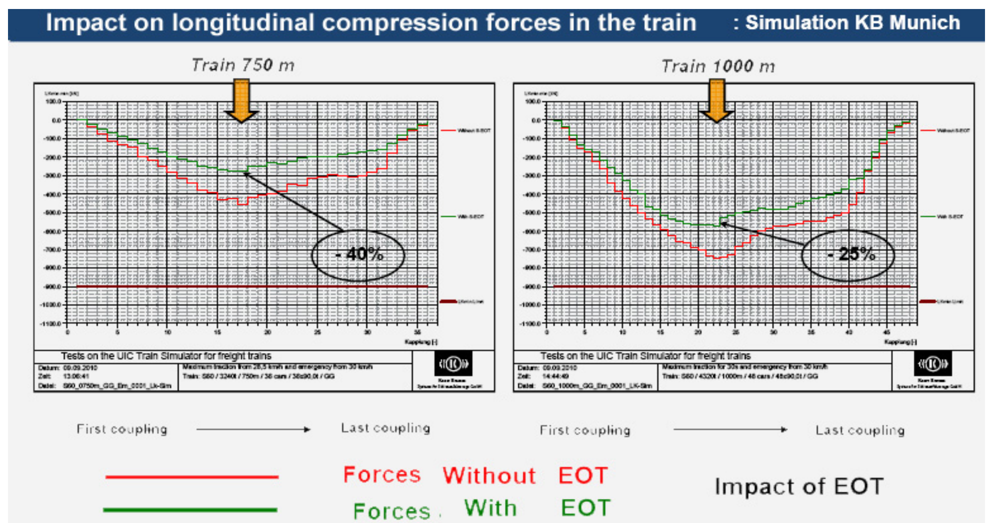
Advantages of Ep brakes



Details of the Impacts: End of Train (EOT)

•The EOT is easily adaptable on classical wagons at the end of the brake pipe. By detecting the first depression in the brake pipe it opens the brake pipe at the end progressively.

1. By helping the end of the train to brake rapidly it reduces the longitudinal compression forces and thus enables the train to be lengthened up to 1000m.
2. To reach the safety level required in transmission of the command radio solutions are being tested to back up the depression information coming through the brake pipe.
3. The EOT informs also on the integrity of the train and reduces the stoping distance.



Details of the Impacts: Automatic couplers

- The modern automatic coupler allows the brake pipe and the wire connexion.

- It allows lengthening the train because of its higher restance
- It can be decoupled simply and automatically either by remote control or by robot enabling automation of marshalling operations s it remains decoupled until any compression disapears.
- It simplifies and makes safer train operations.

- Its compatibility with UIC couplers authorize progressive introducction but with no benefits in the transition period.
- Its high cost would push to use it for coupled wagons by drawbars speeding up the introduction and reducing the cost by50% if the market allows such coupled wagons.

Details of the Impacts: Coupled trains with distributed traction

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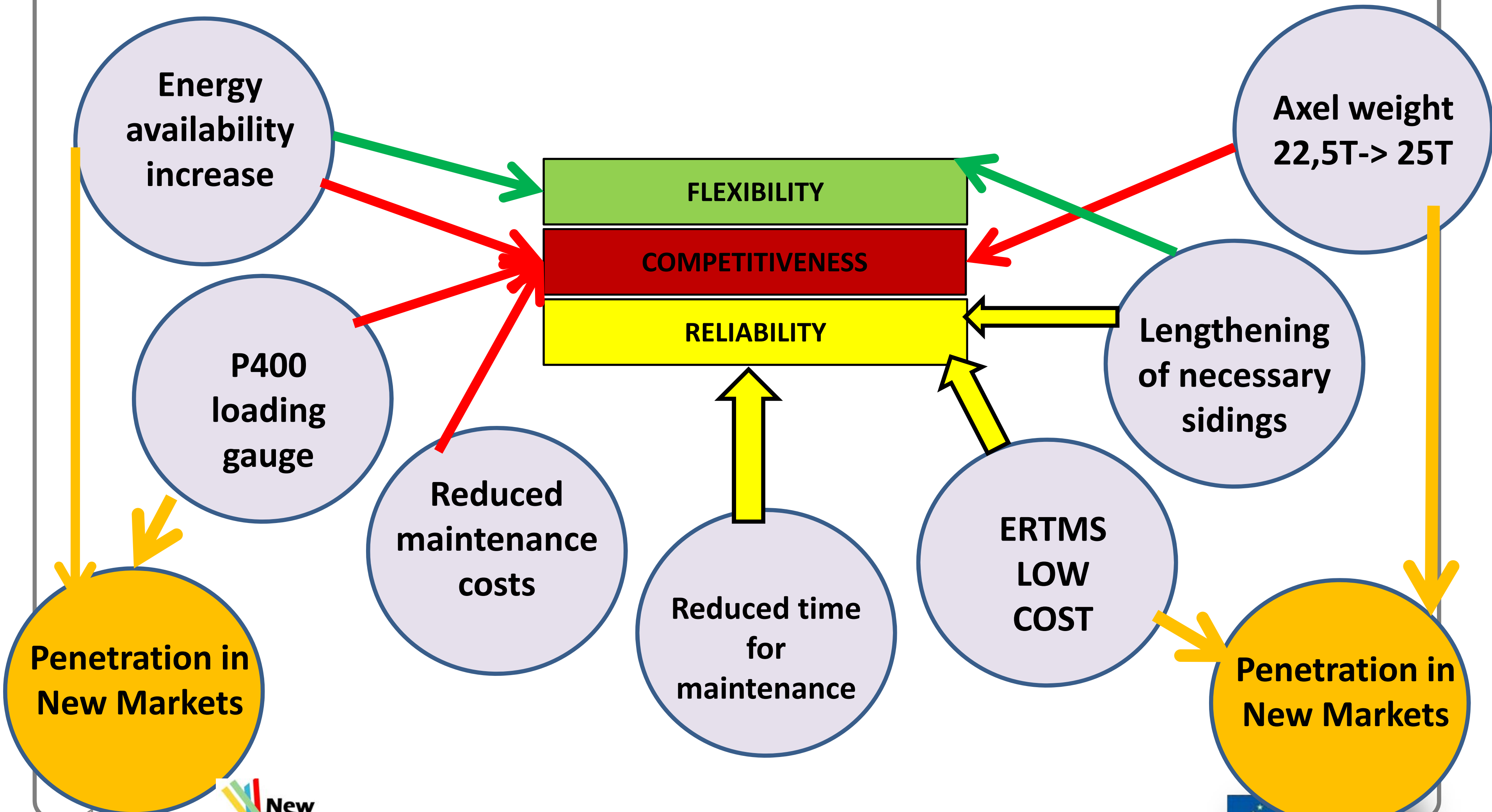
- Resulting from Marathon project such trains offer:
  - A quick coupling of two standard trains thus enabling to maintain the departure frequency from different terminals and the economy on the trunk travel
  - A capacity to reach with the power of only one locomotive a siding in case of a breakdown.
  - A significant increase of the network capacity (up to 40%) whatever signalling system is installed.
  - A significant cost reduction due to the single driver , the second locomotive being remote controled, and to the infrastructure Toll if it is based on the Network capacity utilization and not only on the tonnes-km
  - A very quick installation of the Marathon kit on the locomotives weighing only 300kg and totally isolated when the locomotive is used for a single classic train
  - No need of any modifications on the wagons
  - A quick learning for driving such long trains which offer the same stopping distances as classical trains and the same acceleration capacity because of the second active locomotive.
  - Needs checking certain points where the train must be obliged to stop as the tail of the train must not occupy critical points like switches or level crossings for instance.
  - A traffic management study is necessary to decide how many sidings have to be lengthened to allow overpassing such trains

Infrastructure Changes



Infrastructure Changes: details

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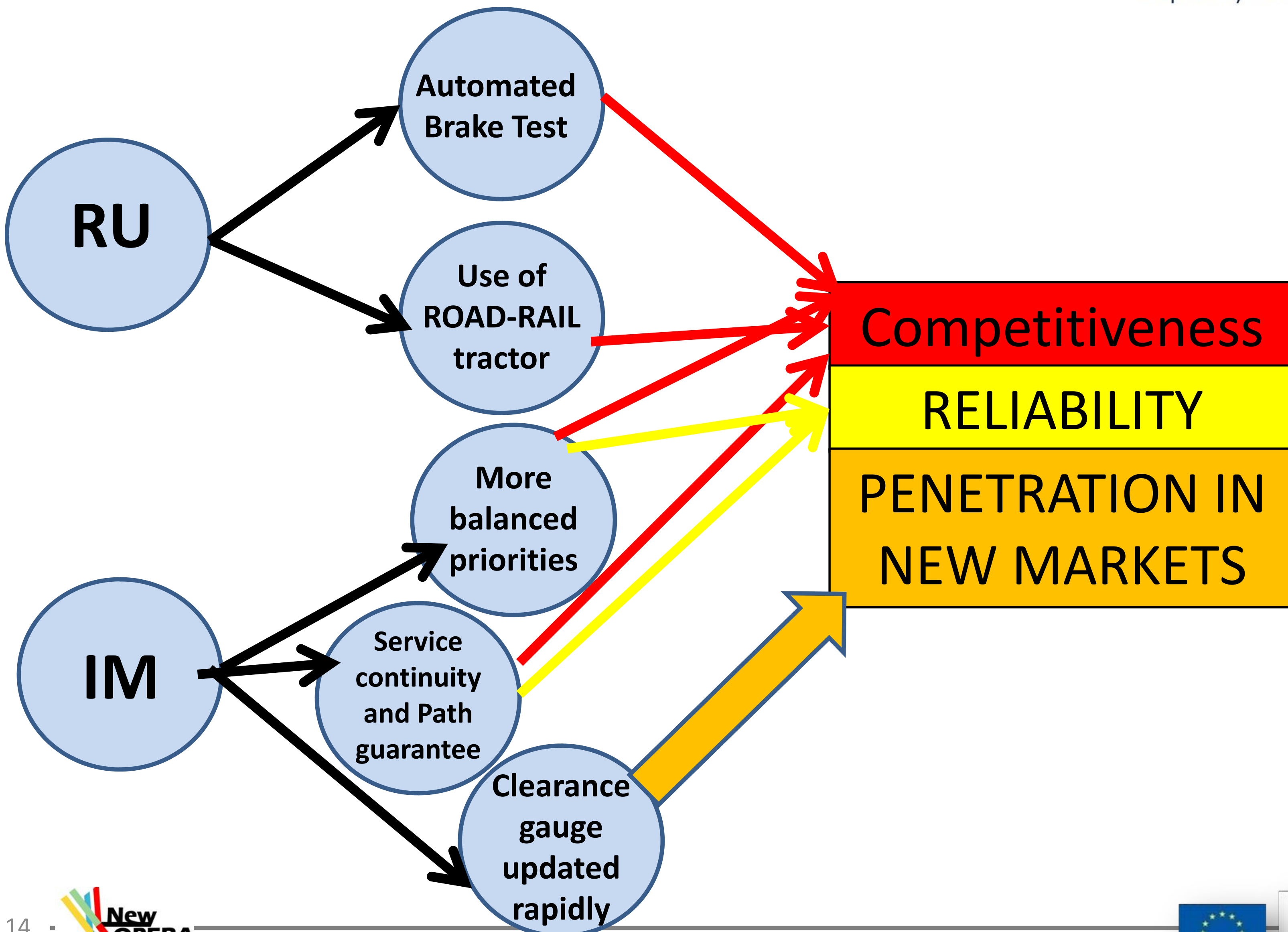
•The main changes suggested aim at allowing optimization of the use of the inftrastructure while reducing costs for the user and giving them a reliable and flexible service more competitive with Road and opening new markets.

- •Facing the gigaliners competition very developed in Sweden with trucks of 64T longer and coupled trains need adapted sidings, some signals to be moved, some signalling system to have their parameters adapted to the new length and some terminals adapted.
- •At the same time works periods must take more account of freight service continuity and where no competitive alternative routes can be proposed, works periods should be reduced with new technologies like the replacement of part of the ballast by Grave-bitumen with special slippers which should reduce maintenance costs significantly and increase the loading gauge.
- •Adapting infrastructure with small investments to allow to perform last mile deliveries by Road –rail tractor instead of shunting locomotives from the last mainline terminal will boost competitiveness.
- •Increase the loading gauge up to P400 the technique quoted here above and by quicker but accurate measurement opens the huge semitrailer transport with horizontal loading.
- •Finally enhance te official authorized axel weight on some routes used by heavy trains and ensure energy availability in order not to hamper the possible traffic s devlopment will increase the speed of develoment.

New OPERA

Operational Changes



Operational changes details

- The operational changes involve both Rus and Ims
    - **For the Rus the objective is to reduce all times lost :**
        - the automated brake test performed by the driver needs a smart box on the wagon and a detectectors on the brake cylinder and the wheels
        - The Road –Rail tractor used from the main line terminal (or siding) decrease drastically the cost of the last mile and enhance mutualisation of logistics movements of wagons
    - For **the IMs the objective is to boost Network attactiveness:**
        - Better balaNced priorities between freight and passengers in the drawing of the paths and operationally
        - Despite works having to be performed pats must be guaranteed to the user or an equivalent solution proposed. The service continuity must be secured
        - Clear and rapidly updated information on the structure gauge (including the safety margins linked to the accuracy of the works, allowing P400 trucks to be carried and ths allow the penetraion in new markets.

Capacity increase due to wagon/train modifications

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•For the car transportation business the introduction of the 6axels/5 bodies wagons and the automated brake test (15% increase of asset rotation alone) with predictive maintenance(5%) and asset rotation impacts a capacity increase up to 30% could be reached in the best case (according to car lengths)

•For the container transportation the new 5 bodies wagon with the same various progress as for the car transportation enables to reach up to 20% capacity increase

•For the 12 axel wagon for crane-able semi trailers the capacity increase could be up to 17,5%

Competitiveness

•But the major problem which is a serious drawback is the existence of a large available fleet of wagons for which the cost of modifications would be important. So unless the market increase strongly the probability of major structural modifications is low.

•Based on the estimated cost of these new wagons compared to new standard wagons cost a little margin may appear also on costs.

•However the automated brake test with an EOT device and connected devices on each wagon does not need high investment and generates a significant increase of capacity and competitiveness. It is the first improvement to be done together with a lengthening of the train with EOT.

Connectivity who are the interested stakeholders

- **This field is the largest,newest and most important field of development in line with freight digitalisation and IoT.**
- The choice of what connectivity is the first step to be undertaken but by whom?
- Several interested parties need different types of connectivity gathered in 4 groups
    1. shippers , forwarders, logistic operators, organisers of transport with Cargo focus
    2. intermodal operators and terminal operators: with transport progress and efficiency focus including transshipment and safety of operations
    3. railway undertakings, wagon owners, wagon keepers and ECM with transport progress, efficiency and safety focus
    4. infrastructure managers with a focus on train management, incidents resolution, status of infrastructure, safety of infrastructure equipment and control of specific risks

- All these stakeholders must monitor the smooth progress in the supply chain, inform in real time the final customer on the time of arrival of its cargo and on the good status of the cargo.
- For that purpose they must be informed in due time of any incident on the progress of the train, know the position of their cargo, its status and its security. They must be informed of the new ETA by the RU to reorganize the supply chain following links.
- For the cargo, regular average positioning, temperature control, security status and bump detection are standard needs today.
- From the RU they need the ETA and a real time ETA updating in case of incident. They need a precise positioning in case of an alarm from the cargo monitoring system in order to react quickly if necessary to preserve the cargo.

Connectivity needs for Intermodal operators and Terminal operators

- Intermodal operators are interested in:
  - Knowing in advance the arrival of the train to ensure a smooth and efficient transit in the terminal which means a rough positioning to check if the train is approximately on time. But nearing the arrival more precise elements should be obtained from the IM
  - Knowing the precise train composition
  - Checking the cargo status when needed because of the nature of the cargo: temperature for instance with an alarm from the sensor then transmitted rapidly to take action if critical, dangerous cargo which has to be put aside or tightly controlled
  - Terminal operators need to provide all necessary elements for the next link of the transport or supply chain.

Connectivity needs for Rus, Wagon owners and Keepers, ECM

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- For Rus the main needs is the positioning of their train, the status of their Rolling Stock (Locomotive and Wagons), the efficiency of their operations specifically at the departure of the terminals, the loading status of their wagons to ensure safety. New needs will appear with the train automation projects for the marshalling, for the last mile and finally for the main travel.
- For the Wagon Keeper, the wagon owner and the ECM the main needs are the positioning of the wagons, the monitoring of the status of the wagons and their components to ensure safety and organize predictive mainetenance to increase the reliability. All these informations have to be transferred to the RU. These informations are also essential to manage the fleet of wagons to serve spot orders.

New OPERA

Connectivity needs for Infrastructure Managers

- For the IMs two different categories of needs exist:
  - The monitoring of the infrastructure status in order to manage intelligently the maintenance works
  - The precise positioning of the trains on their routes to control the smooth movements of the trains, to avoid useless stops of freight trains hampering the capacity of the network, to analyze and resolve circulation problems in case of incidents

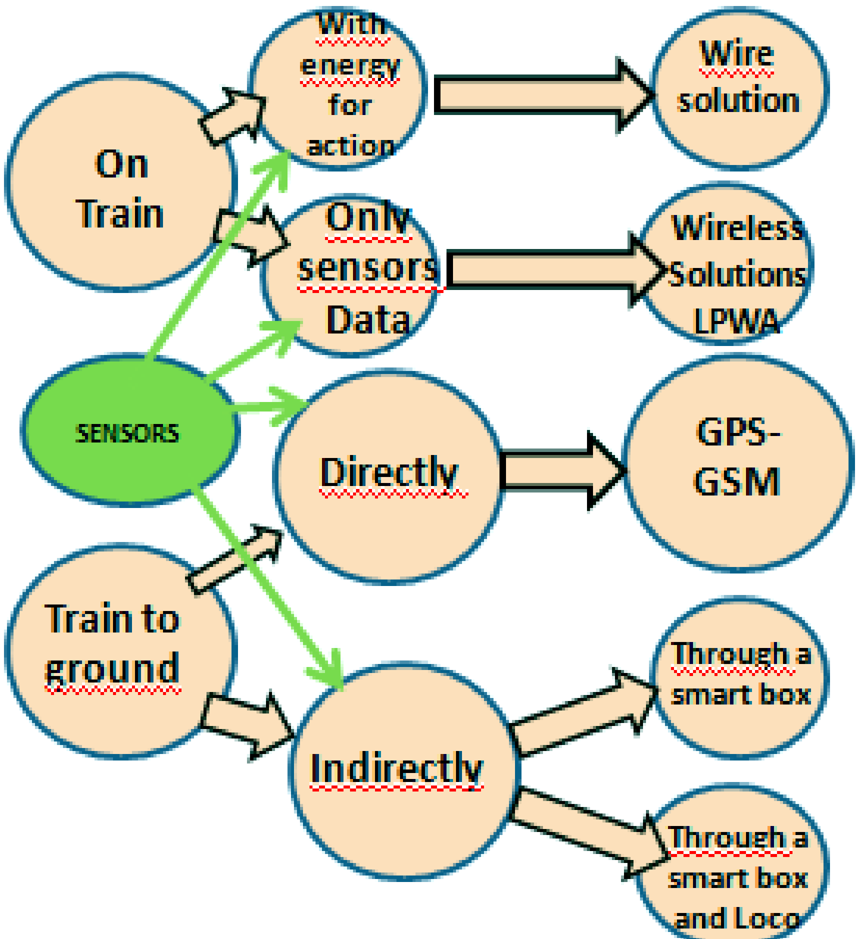
How to categorize these needs

- The main parameters are the following
  - The need of significant energy availability on board the wagon → **WC**
  - The need of precise and frequent positioning → **GPS HEC**
  - The need of less precise positioning, less frequent data update → **LEC**
  - The possible latency before sending data → **consolidation in smart box and in Loco before sending by GSM**
  - The need of large volume of data to transfer → **Consolidation in smart box by LPWA and emission by GSM**
  - The need of saving energy of the long life batteries is an important driver

WC: Wired connectivity HEC: High energy connectivity LEC: low energy connectivity

LPWA : Low Power Wide Area

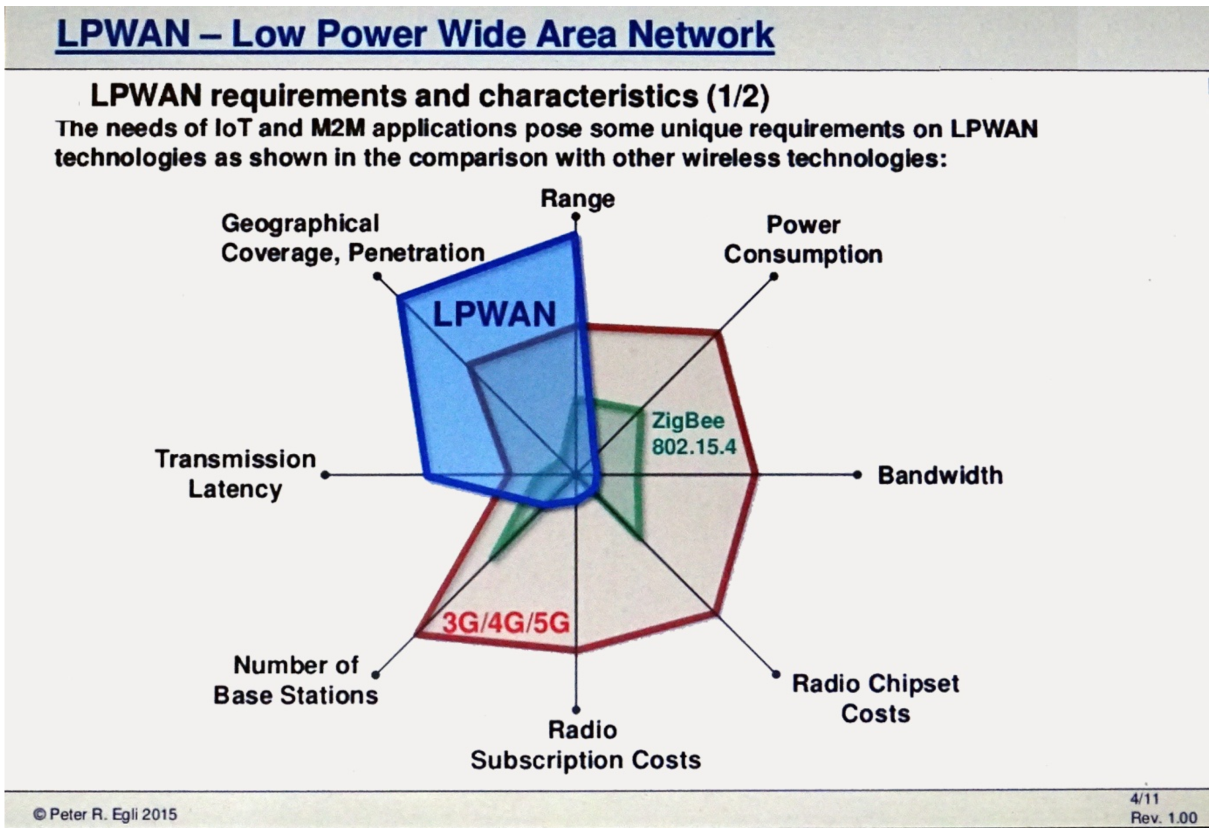
CONNECTIVITY SOLUTIONS



latency	volume	Position accuracy	Energy needed	cost
0	+++	+++	No PB	+
+	+	--	+	+
0	+++	+++	+++	+++
++	++	--	++	++
++	++	--	+	+

Review of the solutions

- A very representative analysis of the possible solutions is in the following picture



Review of the solutions

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- The detailed features of the long range low power network :

LPWAN – Low Power Wide Area Network

LPWAN requirements and characteristics (2/2)

Characteristic	Target Value for LPWAN Technologies
Long range	5 – 40km in the open field
Ultra low power	Battery lifetime of 10 years
Throughput	Depends on the application, but typically a few hundred bit / s or less
Radio chipset costs	$2 or less
Radio subscription costs	$1 per device and year
Transmission latency	Not a primary requirement for LPWAN. IoT applications are typically insensitive to latency.
Required number of base stations for coverage	Very low. LPWAN base stations are able to serve thousands of devices.
Geographic coverage, penetration	Excellent coverage also in remote and rural areas. Good in-building and in-ground penetration (e.g. for reading power meters).

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Comparison Between Technologies

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COMPARAISON - principales technologies LPWAN

Vertical M2M

Functionalities	LORAWAN	SIGFOX	LTE Cat 1	LTE M	NB - LTE
Modulation	SS chip	UNB / GFSK / BPSK	OFDMA	OFDMA	OFDMA
Band Width	500 – 125 KHz	100 Hz	20 MHz	20 – 1.4 MHz	200 KHz
Data Flow	290bps – 50Kbps	100 bit / sec 12 / 8 bytes Max	10 Mbit /se	200 kbps – 1 Mbps	Environ 20K bit / sec
Message max. per day	Unlimited	UL: 140 msgs / day	Unlimited	Unlimited	Unlimite
Emission power	20 dBm	20 dBm	23 – 46 dBm	23/30 dBm	20 dBm
Connection efficiency	154 dB	151 dB	130 dB+	146 dB	150 dB
Battery life time 2000mAh	105 mois	90 mois		19 mois	
Energy efficiency	Très élevée	Très élevée	Basse	Moyenne	Moyenne haute
Immunity against interferences	Très haute	Basse	Moyenne	Moyenne	Basse
Compatibility	Oui	Non	Oui	Oui	Non
Security	Oui	Non	Oui	Oui	Oui
Mobility/ Positioning	Oui	Mobilité réduite, pas de localisation	Mobilité	Mobilité	Mobilité réduite, pas de localisation

Source: LoRAWAN Alliance, 2015

www.vertical-m2m.com/fr

Best solution for the needs described

- If high Energy is needed on the wagon for EP brakes, for reefers the wire solution is compulsory with automatic couplers insuring energy and bus of information continuity.
- However in that solution a wireless low power network on the wagon is recommended for the connection with the various devices incorporating IoT

- If no significant energy is needed the best solution is the smart box concentrating informations from the devices, sending them with a certain latency to the locomotive by a mesh system creating a train network . The locomotive sends by GSM the information for treatment by the fixed base and distribution to interested stakeholders. The smartbox battery targets a life time of 8 years .

Costs

- Low power wide Area networks (LPWAN)reduce drastically the costs and the energy consumption but with latency, less accuracy of positioning and less data to be sent.
- For critical situations (temperature alarm or breakdown of a safety component) , the system may use its resources to send urgent messages to the driver of the train to take action and inform the fixed bases.
- The costs are extremely variable according to the services expected: they can be as low as 30€ per year for a single device using only direct LPWA for its connection with the base with some latency up to 8€/wagon /day for a full service with 25sensors, a smartbox GSM connected and equipment for automated brake test and accurate positioning.

Cost Benefit conclusion on connectivity

- The impacts on the quality of information forwarded to the end customer, on the reliability due to an intelligent predictive maintenance, on the asset utilisation because of more transparency on the use of the wagons, on the train operation because of a possible brake test done by the sole driver, on the possible easy train lengthening because of multiple solutions to communicate with EOT are generating a global profitability of more than 7%.
- The main challenge is to avoid incompatibility of protocoles that would hinder the development of the various technologies presently emerging and between which the batlle is harsh to become the widespread standard.

Conclusion for IMs

- New solutions for high speed control of the network infrastructure, inside the structure devices informing regularily on the status of the infrastructure will enable more intelligent maintenance generating significant economies.
- Informations more accurate on train positioning, possible train lengthening, getting extremely cheaply accurate information on the use of certain sidings will boost the possible use of the infrastructure.

General conclusions

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- New longer wagons offering a longer usable length for the same global length, lighter wagons by a reduced number of bogies and by lighter braking systems due to pneumatic brake transmission to the brake cylinders pressing the shoes on the wheel , longer trains with EOT device, coupled trains for long haul, rail-road solutions for the last mile , automated marshalling for trains equipped with central couplers remotely (or by robot) decouplable, connectivity for better service to customer, enhanced reliability by predictive maintenance, provide a lot of ways to boost rail freight transport competitiveness. Better knowledge of the structure gauge will enable to penetrate in the non craneable semi trailer transport which is quite huge.
- The challenge will be to spread the added value to those supporting the investments and to trgigger these investments.
- The next step for rail freight transport is automation starting on last mile single track line.

What remains to be done ?

It has been clear that many challenges are in front of us:

- The noise challenge for which this project has not been able to provide innovative solutions and for which research on the adequate shoe composition is still necessary as the present solutions are not affordable by the wagon operators
- The automation challenge which is the next step if we consider connectivity as already largely progressing
- The changes in the infrastructure structure to reduce time and costs allowed to maintenance creating capacity for the traffics
- The introduction of trustees to pilot exchange of offers of transport with transport demands thanks to the development of bigdata treament thus optimizing resources of all kinds and reducing costs
- The better knowledge of infrastructure to allow transport of semi trailers on rail without major investments.

- The road seems long but each step will boost the Rail freight traffics

Capacity for Rail

Thank you for your kind attention

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