BAHNSTROMVERSORGUNG IN EUROPA (EN 50388 UND TSI ENE)

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Wien, 9. November 2018

ÖSTERREICHISCHE VERKEHRSWISSENSCHAFTLICHE GESELLSCHAFT

SNCF RÉSEAU

1 -THE LEGAL FRAMEWORK ON INTEROPERABILITY

2 - THE EXAMPLE OF ELECTRIFICATION IN FRANCE: ALSO A QUESTION OF DOMESTIC INTEROPERABILITY

3 - THE EN 50388

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1 - THE LEGAL FRAMEWORK ON INTEROPERABILITY

The 4th Railway Package

Launched in 2013 – "Completing the Single European Railway Area"

Entry into Force 15.06.2016

EUROPEAN UNION AGENCY FOR RAILWAYS

"Market Pillar"

- Complete market opening
- Competitive Tendering
- Impartiality of infrastructure governance

"Technical Pillar"

- Vehicle authorisation
- Single safety certification
- ERTMS trackside approval
- One-Stop-Shop (OSS)

Courtesy: ERA

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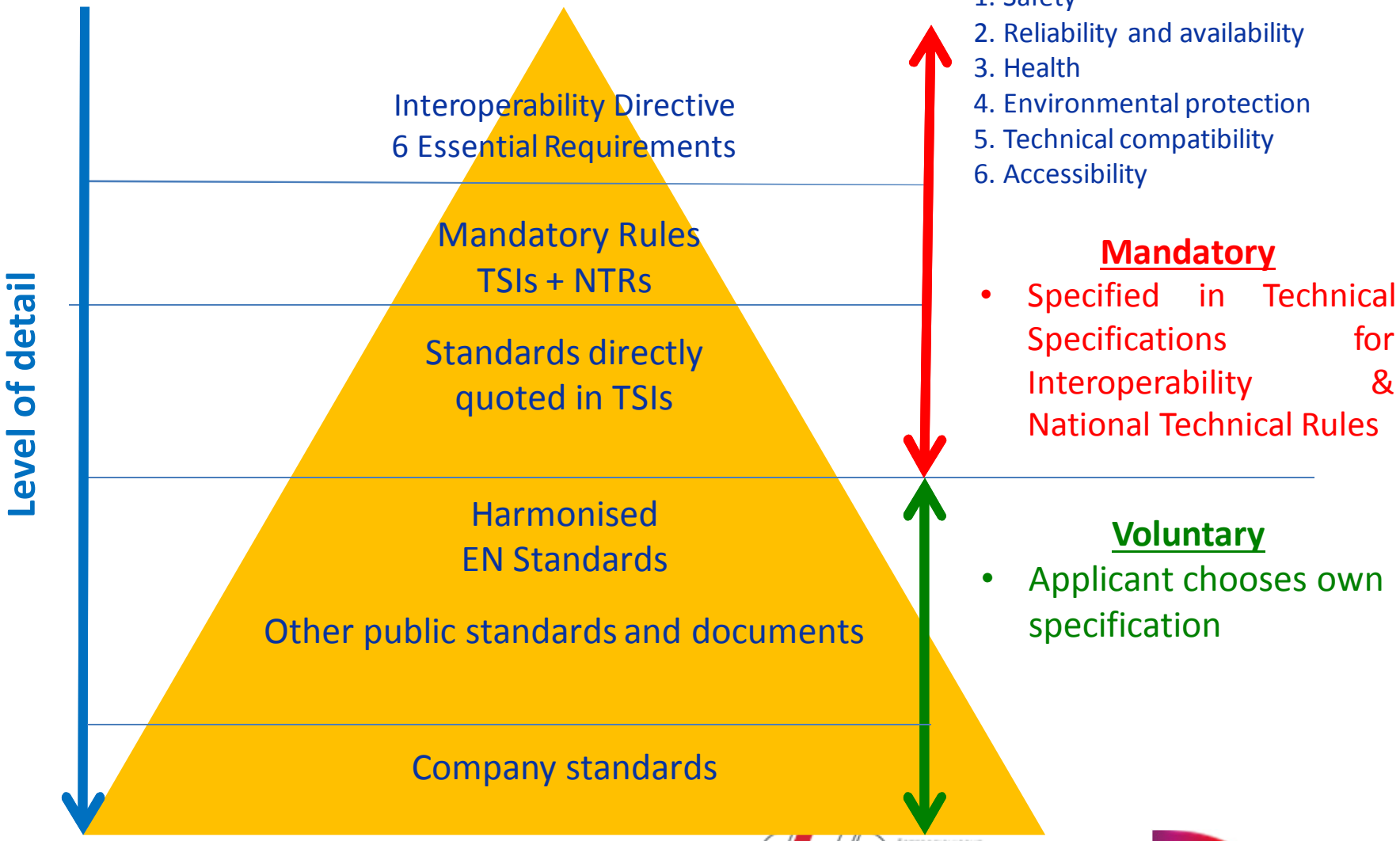
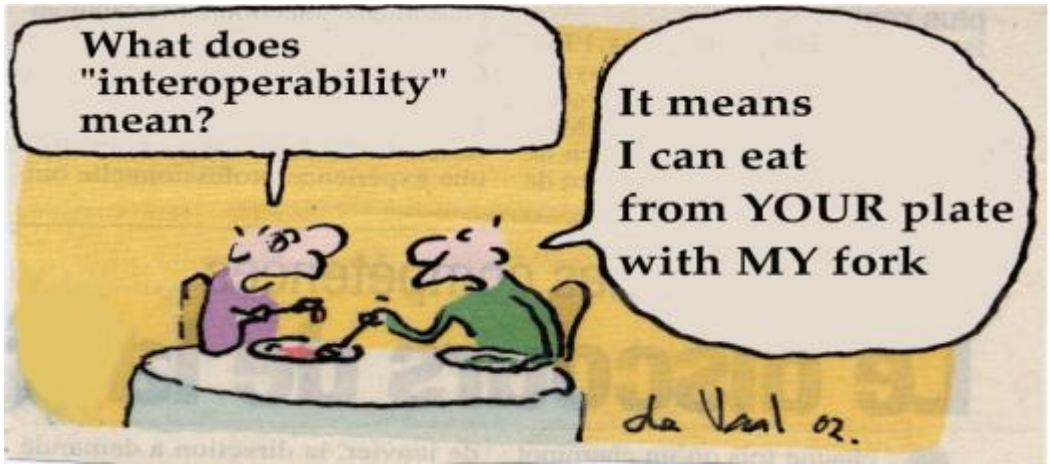
EU legal framework



Courtesy: ERA

Principle of interoperability

Interoperability is generally used to refer to the *uninterrupted movement of trains*



but also…

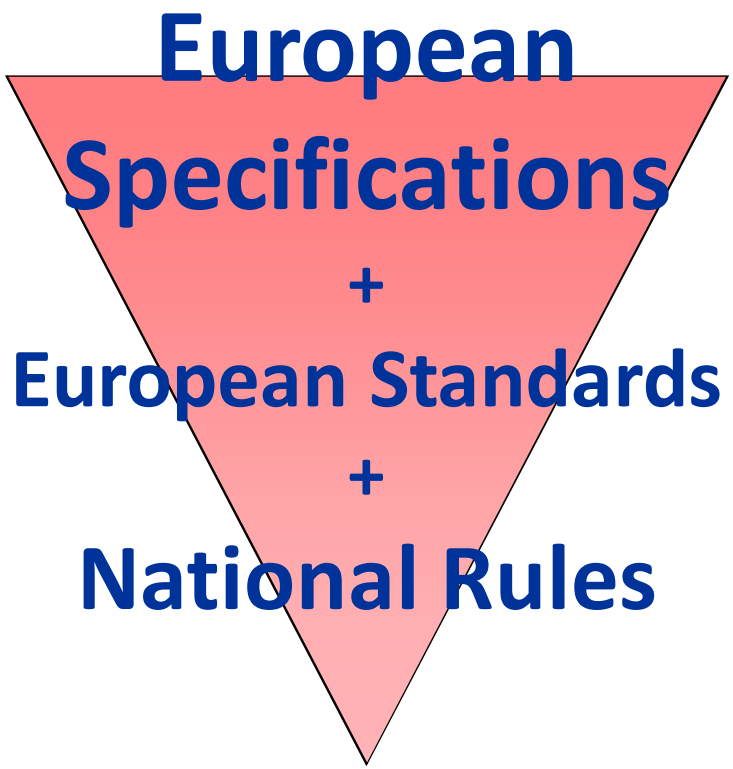
- An **optimal level** of **technical harmonisation** *(infra & rolling stock)*
- Knowledge of the **technical characteristics** of the **network** *(RINF)*
- Clear rules of **certification**

Courtesy: ERA

From national visions to European interoperability

YESTERDAY

TODAY



Courtesy: ERA

New Approach and Interoperability

The Interoperability Directive (ID) has adopted the principles of new approach Directives:

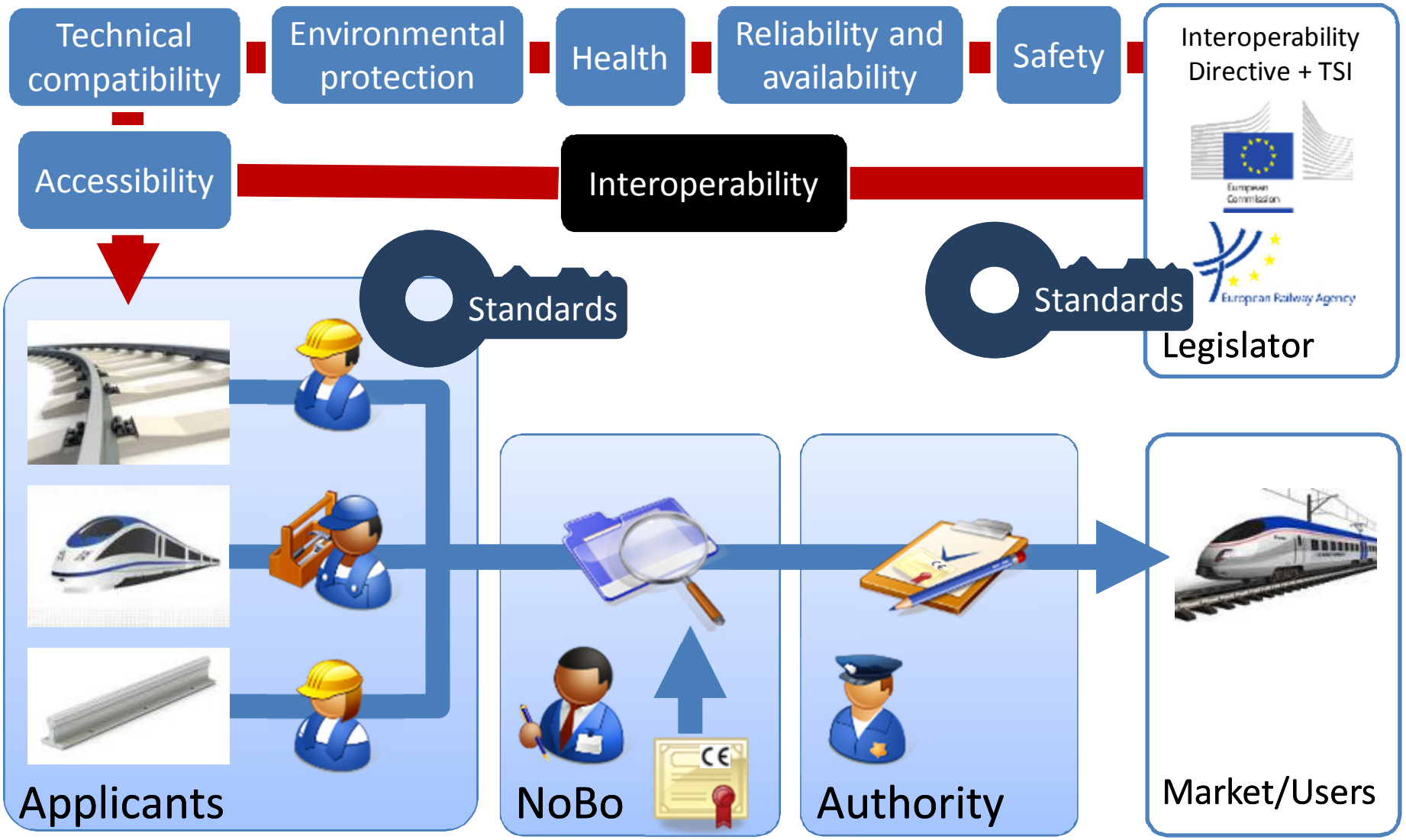
- Essential requirements (ERs) in Interoperability Directive

Technical compatibility, health, safety, environment, reliability and avaibility

- The **applicant** shall meet all ERs applicable to the product.
- Voluntary **harmonised standards give presumption of conformity**
- The **NoBo** checks conformity against the TSI requirements and the **applicant** declares conformity with all applicable legislation.

Courtesy: ERA

New Approach: application to railways



Source: ERA

Technical Specifications Interoperability
TSI basics

- Goal: Interoperability
- TSIs must not exhaustively cover all ERs
  - Aspects not critical for interoperability → **new approach applies**.
  - No national rules apply except for open points and specific cases.
- TSI is law

  Deviation impossible, derogation very time consuming.
- As concise as possible – as extensive as necessary!
  - only contain requirements for regulatory, technical or operational conditions which are critical to **interoperability** (basic parameters)
  - only functional requirements - **no technical solutions required**

➔ **Most possible flexibility (= responsibility!) for the players**

Source: ERA

Technical Specifications Interoperability

Content of TSIs

Chapter 1: → Introduction

Chapter 2: → Scope and Definition of Subsystem

Chapter 3: → Essential Requirements (ER)

Chapter 4: → Characterisation of Subsystem

Functional and technical specifications of the subsystem related to its BPs and the interfaces with other subsystems

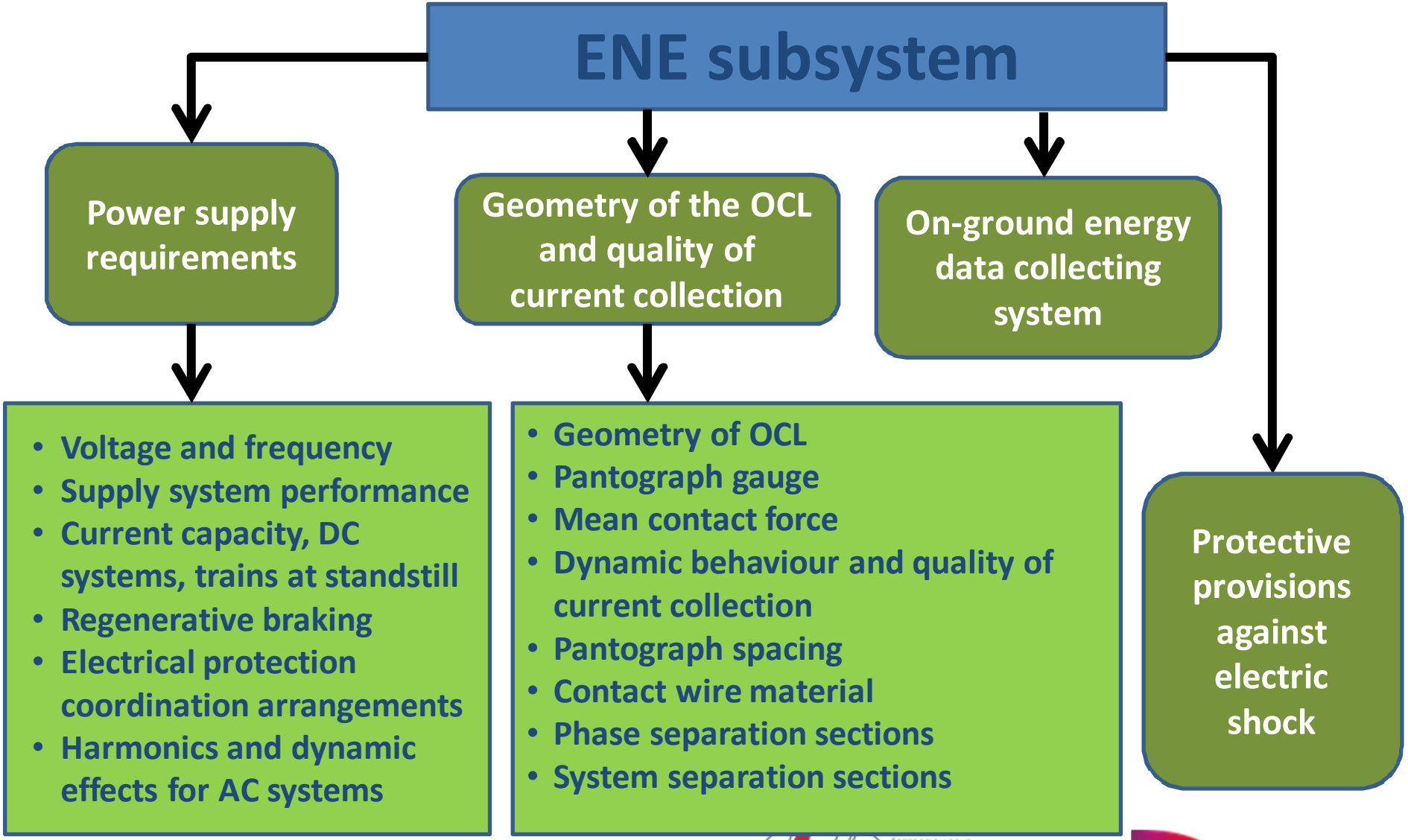
Chapter 5: → Interoperability Constituents

Chapter 6: → Assessment of Constituents and Subsystems

Chapter 7: → Implementation. Specific cases

Courtesy: ERA

Energy TSI: chapter 4



Source: ERA

Energy subsystem
Interfaces with other SUBSYSTEMS

- **Interface with Rolling Stock subsystem,**

  (e.g. Voltage and frequency & Operation within range of voltages and frequencies)
- **Interface with Infrastructure subsystem,**

  (e.g. Pantographs gauge & Structure gauge)
- **Interface with Control - command and signalling** (interface specified in the CCS TSI and the LOC & PAS TSI)
- **Interface with Operation and traffic management**

  (e.g. Maximum train current & Train composition)

Source: ERA

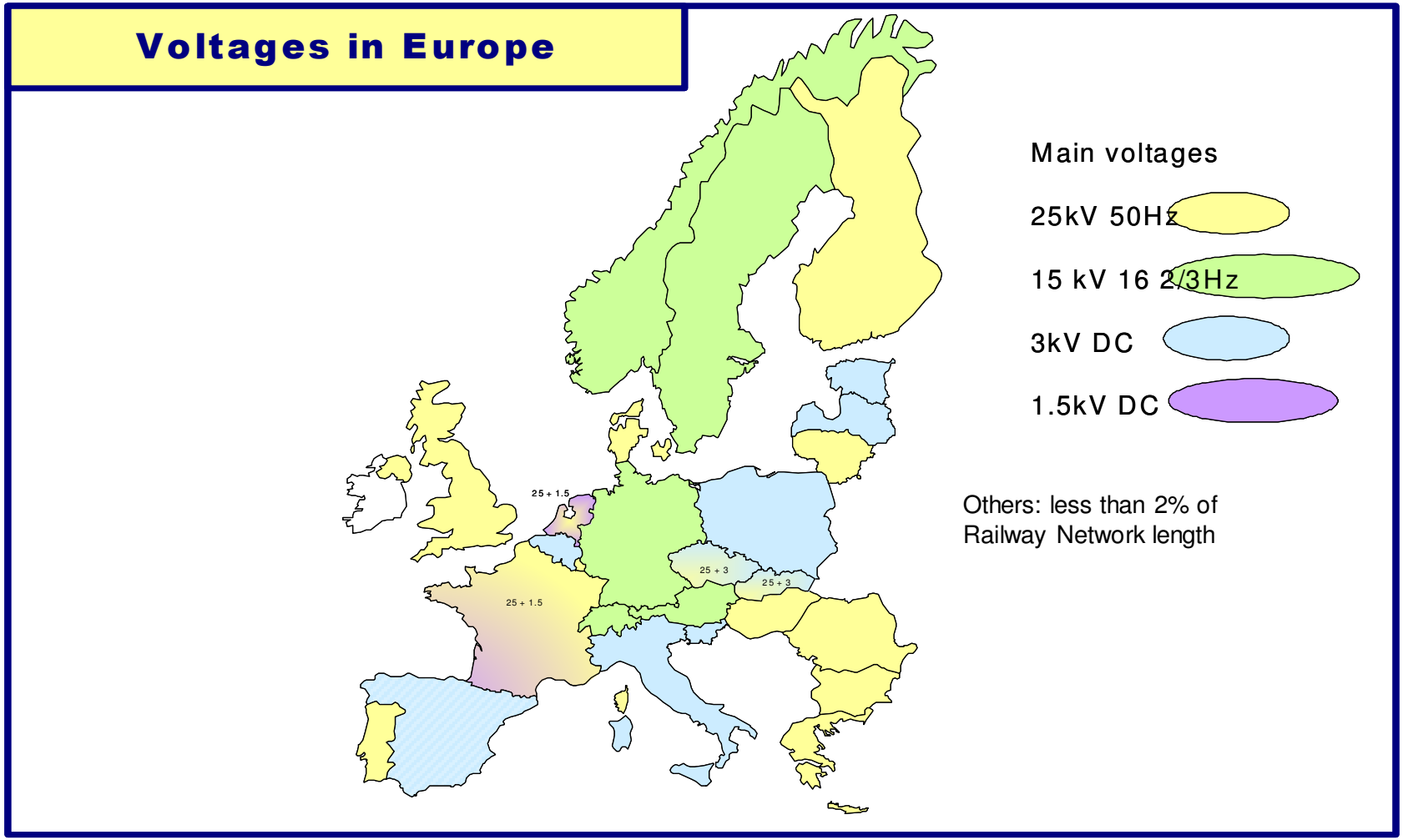
use of pantographs panhead

Implementation rules for 1435 mm

- ***New lines** with speed **>250 km/h** shall accommodate **both 1600 mm** and **1950 mm** pantographs (at least 1600mm)*
- ***Renewed or upgraded lines** with speed **≥ 250 km/h** shall accommodate **at least 1600 mm** pantograph.*
- ***Other cases:** the OCL shall be designed for use by **at least one of** the pantographs :**1600 mm or 1950 mm.***
- **Track gauge systems different than 1435mm**
- *The OCL shall be designed for use by at least one of the 3 pantographs(**1600 mm or 1950 mm or 2260 mm).***

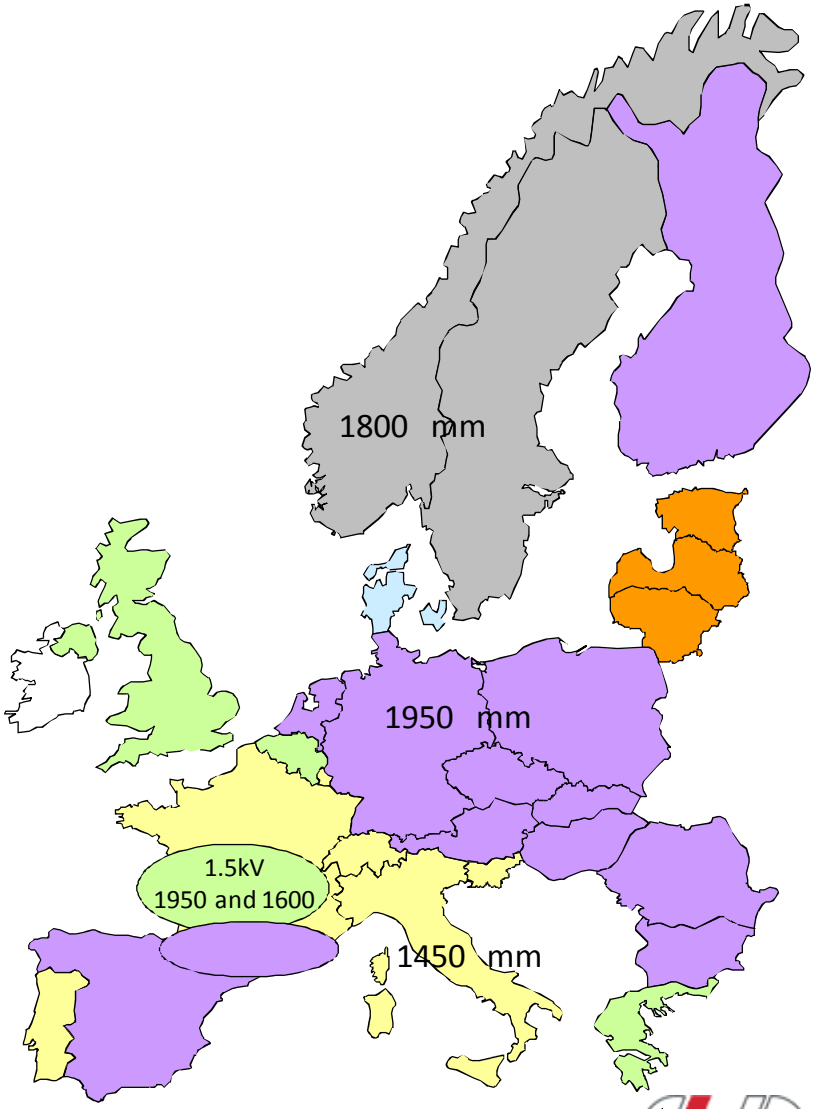
Source: ERA

Voltage & Frequency in Europe

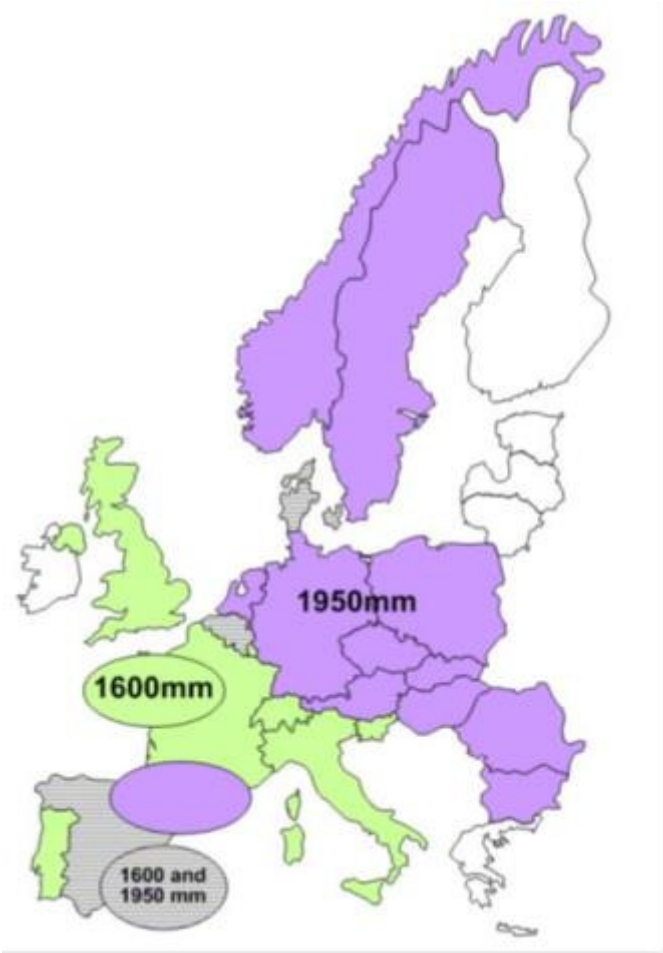


Courtesy ERA

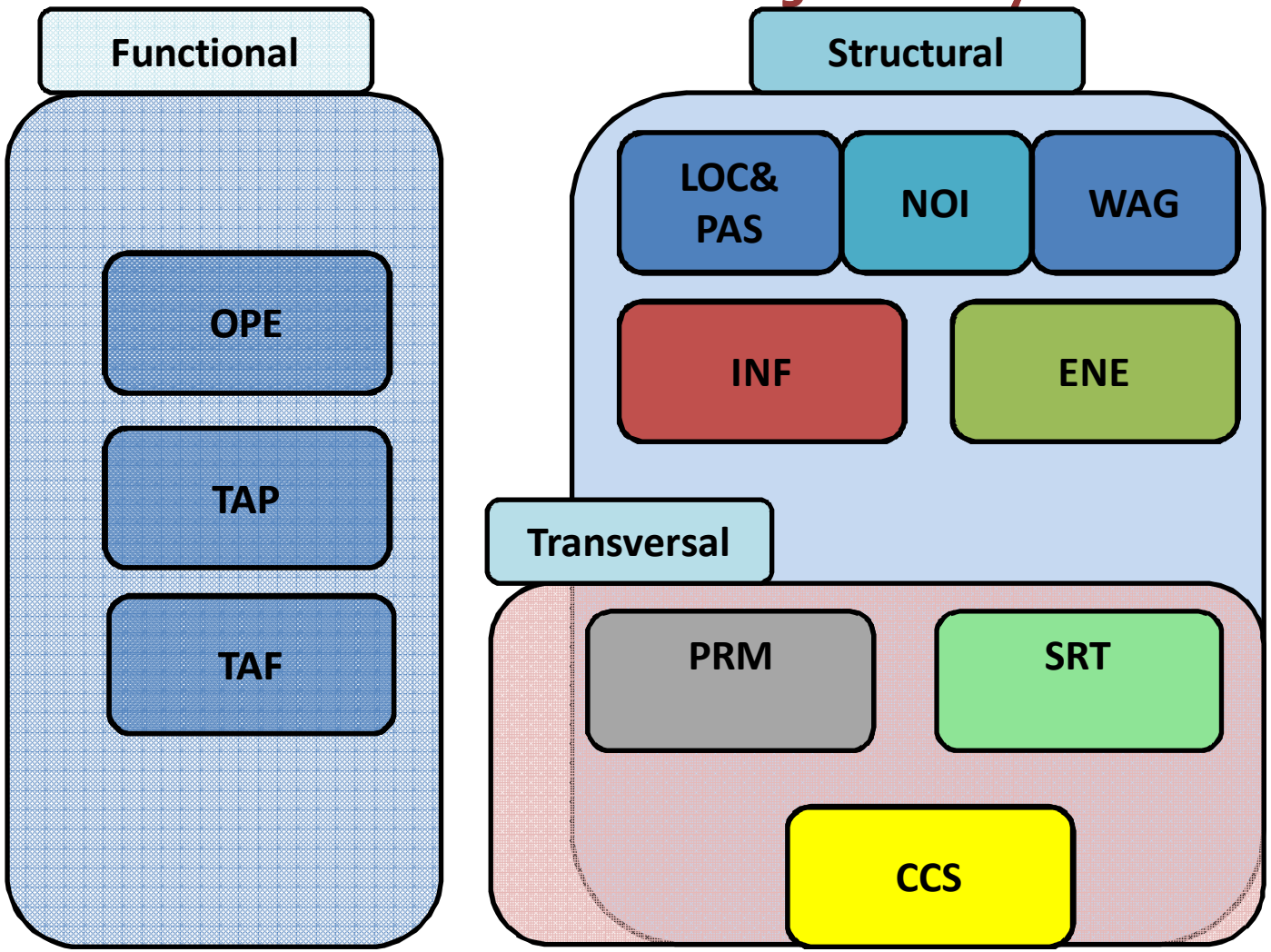
Accepted Pantographs heads: status before TSI application



Pantographs: target very soon

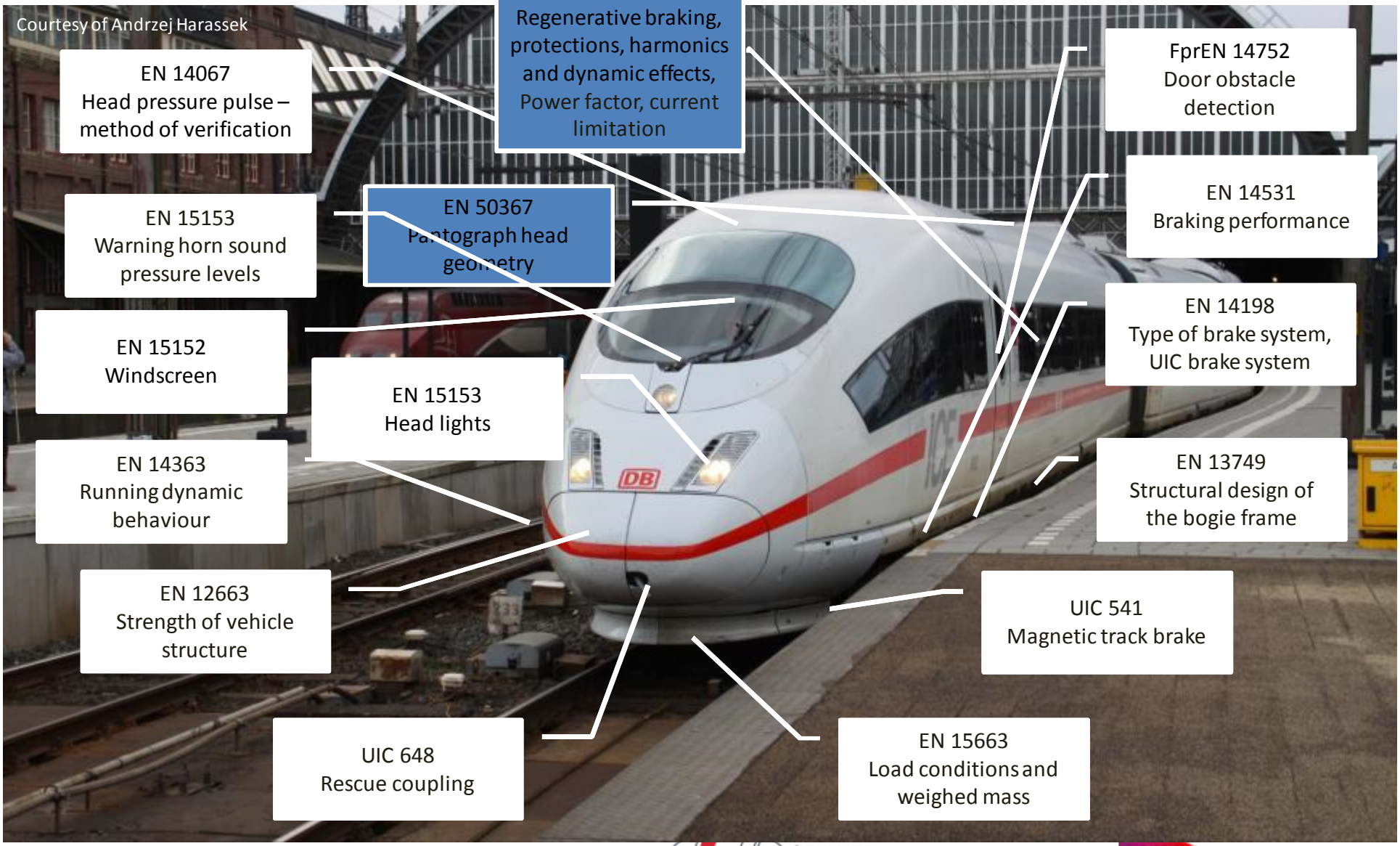


Applicable TSIs
The situation from 1st January 2015

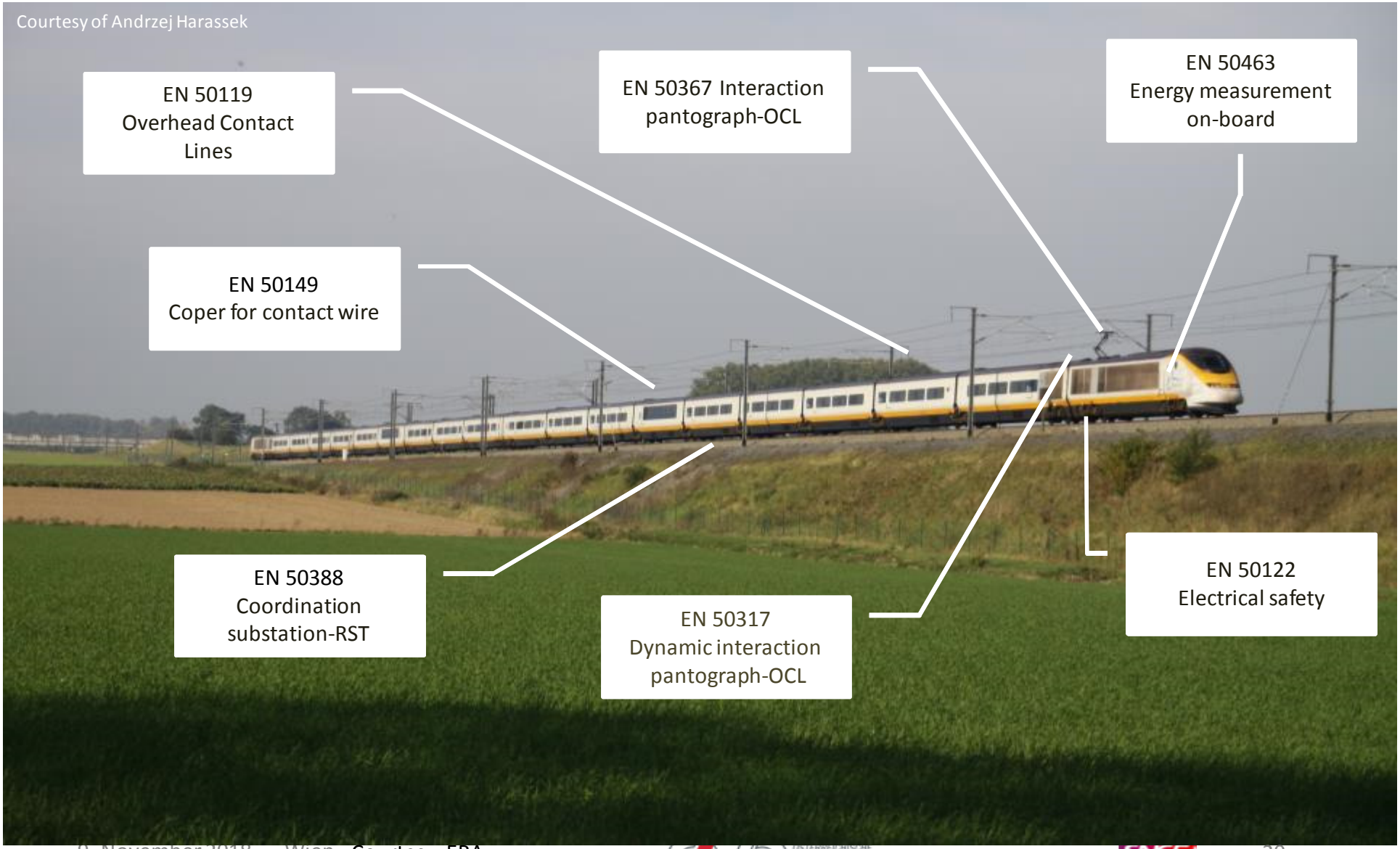


Courtesy: ERA

Standards for rolling stock



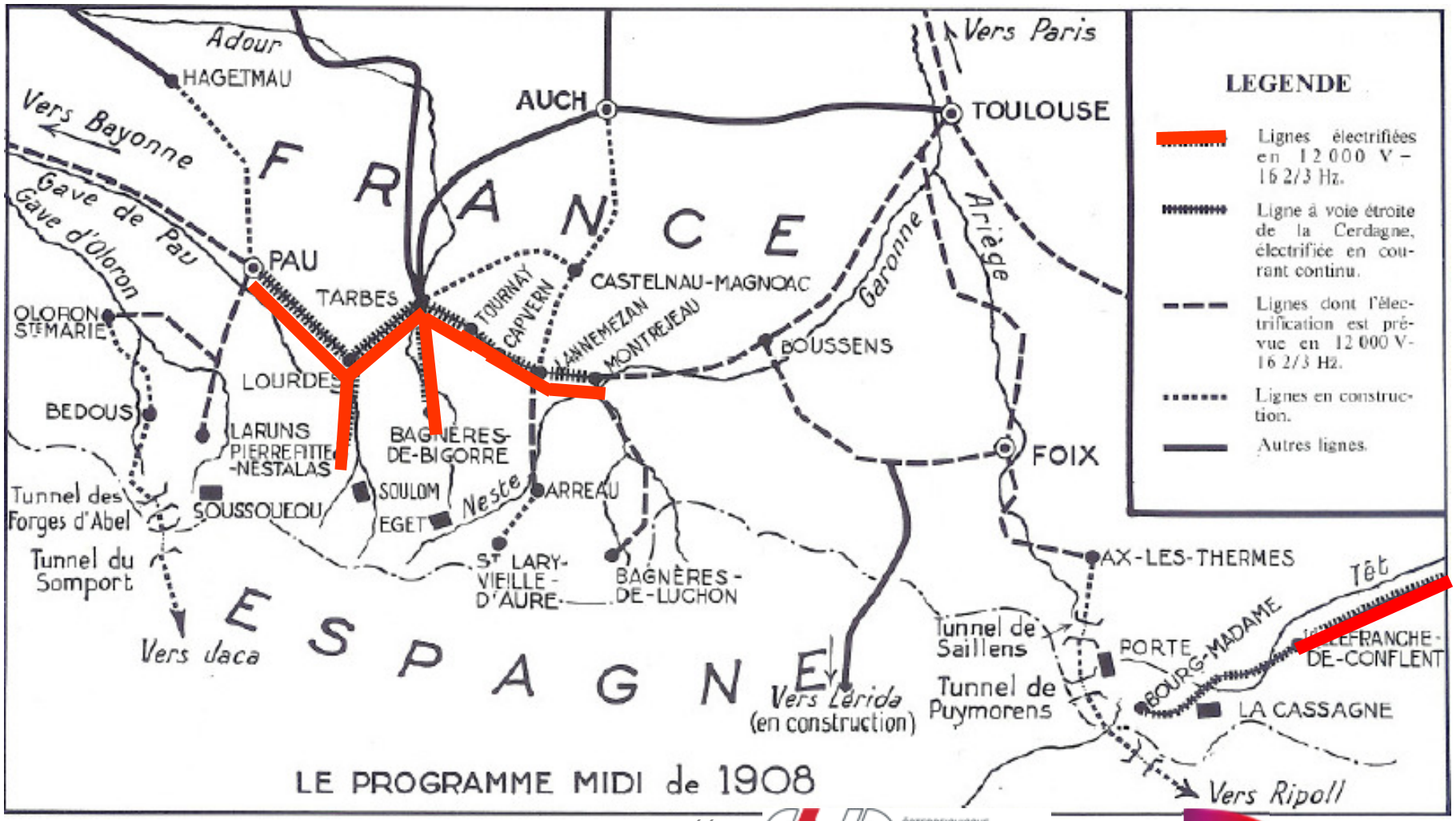
Standards for energy



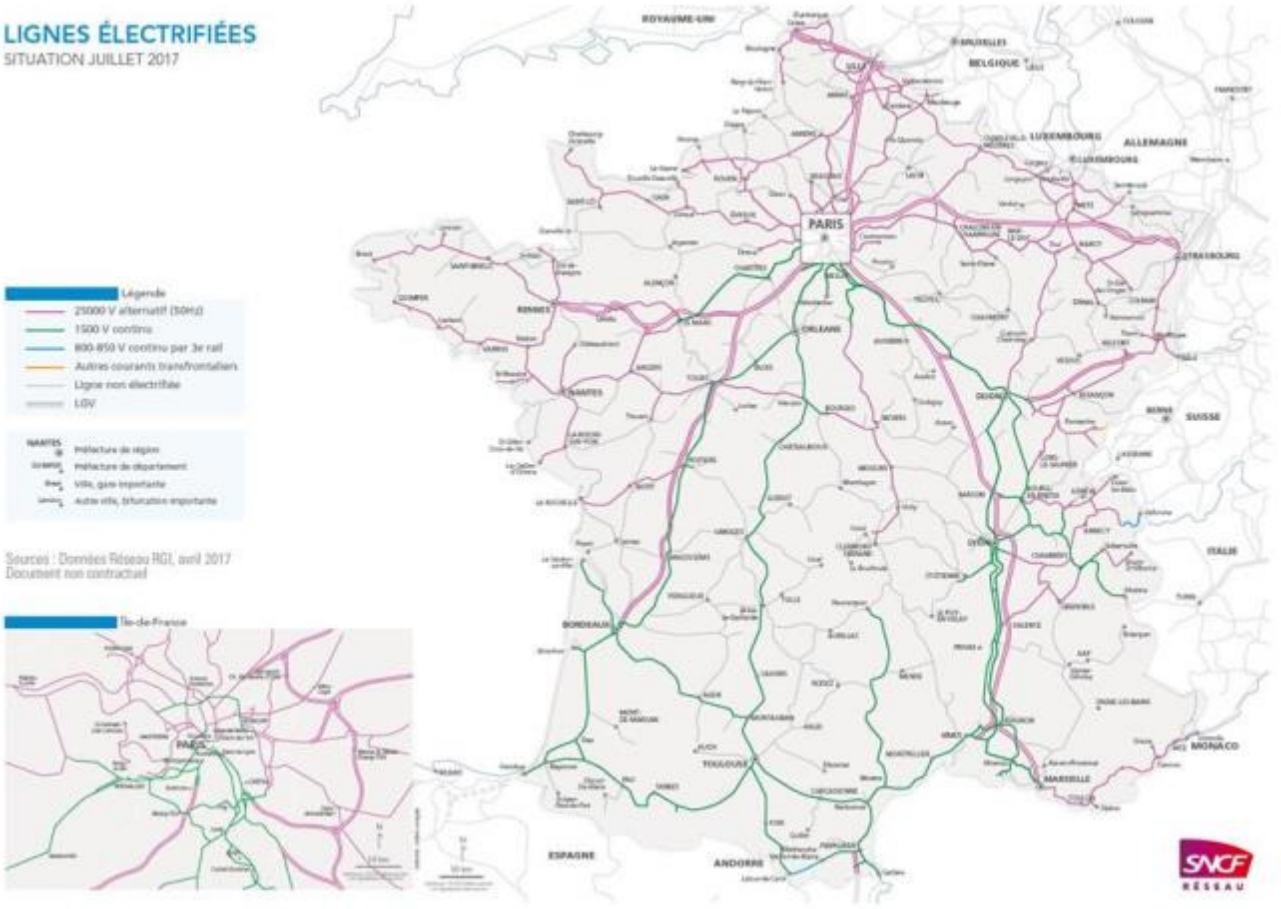
Courtesy: ERA

2 - THE EXAMPLE OF ELECTRIFICATION IN FRANCE: ALSO A QUESTION OF DOMESTIC INTEROPERABILITY

In 1908, the French « MIDI » network chooses 12kV–16 2/3Hz



Electrification of the French rail network



Network route : 51217 km

electrified : 34143 OHL km or 15087 route km

1500V : 12531 km

25 kV 50 Hz : 21453 km

750 V, 3 kV, 15kV : 159 km

High Speed lines : 4104 km

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3 - THE EN 50388

Bahnanwendungen - Ortsfeste Anlagen und Bahnfahrzeuge - Technische Kriterien für die Koordination zwischen Anlagen der Bahnenergieversorgung und Fahrzeugen zum Erreichen der Interoperabilität Teil 1: Allgemeines

Bahnanwendungen -
Ortsfeste Anlagen und Bahnfahrzeuge -
Technische Kriterien für die Koordination zwischen Anlagen der Bahnenergieversorgung und Fahrzeugen zum Erreichen der Interoperabilität
Teil 2: Stabilität und Oberschwingungen

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How to operate all together?

EN 50388

How to deal with the interface between traction- unit and power supply system?

Part 1

- Versions in 2005 and 2012
- Work in progress for a future version 2019
- An IEC standard based on this document:

  IEC 62313: 2009
- Request for Standard issued by ERA RfS N°46 on the definition of other parameters and their corresponding assessment methods which could be used as indexes of the quality of power supply performance

Part 2

dedicated to stability and harmonics

new document

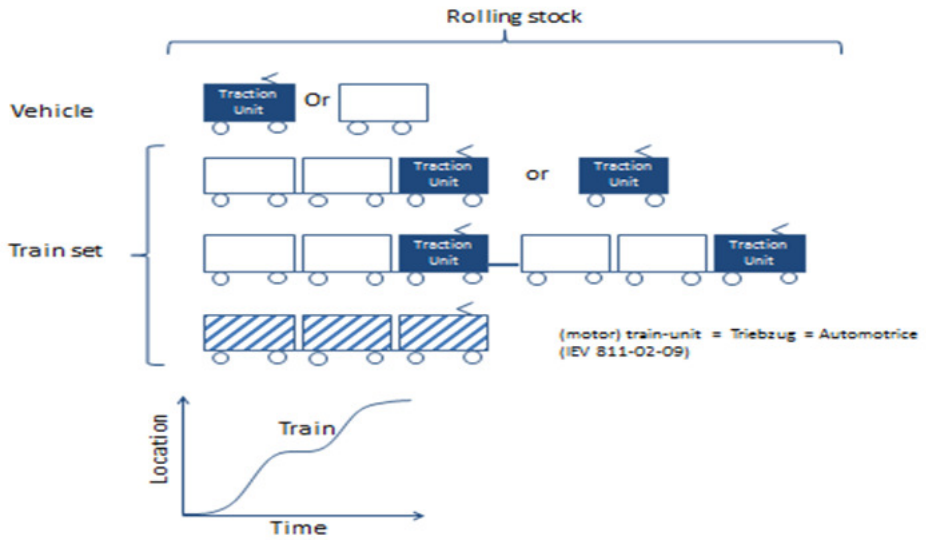
EN 50388 main changes

For 2019 version:

- Evolution due to experience particularly with notified bodies
- Necessity of a very precise clarification of the assessment
- Evolution of TSI , with discussion on performance

EN 50388 Clarification of terms

Subclause	English term	German term	French term
3.1.22	Vehicle	Fahrzeug	**Véhicule**
3.1.14	Rolling stock	Bahnfahrzeuge	**Matériel roulant**
3.1.18	Train set	Zugverband	**Train (composition)**
3.1.17	Traction unit	Triebfahrzeugeinheit	**Unité motrice**
For information	Train (train path)	Zug (Zugfahrt)	**Train (circulation)**
For information	**(motor) Train-unit**	**Triebzug**	**Automotrice**



EN 50388-1

- **5 Separation sections**
- 5.1 Non system or phase separation sections (such as 15 to 15 or 25 to 25 kV)
- 5.2 System separation sections (such as DC to AC or 25 to 15kV)

To avoid any short circuit between adjacent sections, how do the circuit breakers and pantographs act when passing through separation sections?

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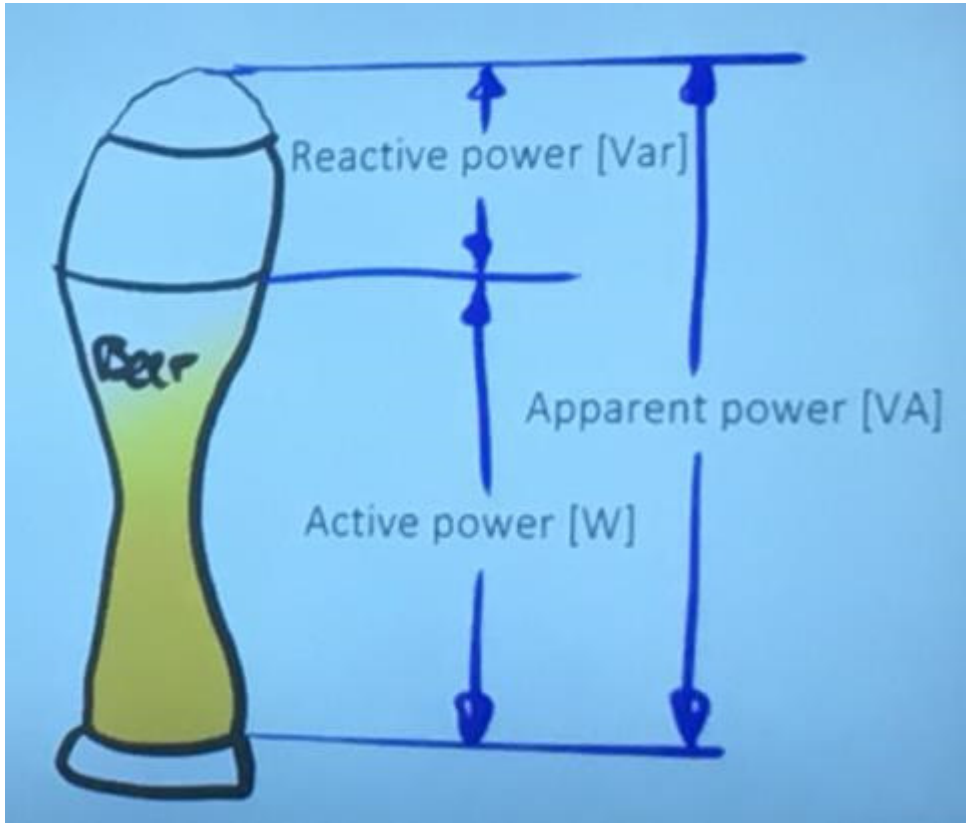
- **6 Power factor of a traction unit**
- 6.1 general requirements
  Unity is asked
  General tolerance of 3%
- 6.2 Exceptions (traction, regenerative braking, standstill, de-icing)
  <u>traction:</u> PF between 0,95 and 1 if U < Umax1
  <u>regenerative braking:</u> free between Umax1 and Umax2 unless stability is maintained
  <u>standstill:</u> allowance to decrease to 0,8 for power less than 15% of max power at wheel
  <u>de-icing</u>: no limitation



By courtesy of ÖBB

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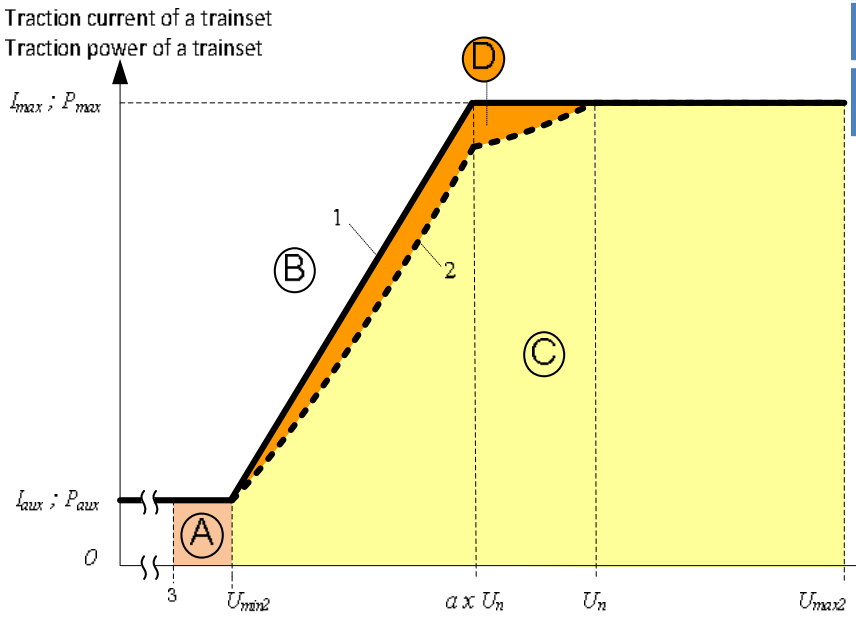
Train set current and power limitation

- 7.1 Current limitation function of the train set as a function of infrastructure register information *on board current limitation function required, value given by the RINF*
- 7.2 Automatic current or power regulation function of the train set as a function of line voltage

	Current							
Traction power supply system	Max current	Step 1	Step 2	Step 3	Step 4	Step 5 [a]	Step 6 [a]	**Step 7** [1]
AC 25 kV	680 A	480 A	400 A	320 A	240 A			
AC 15 kV	unlimited	900 A	700 A	450 A				
DC 3 kV [b]	2600 A	2000 A	1350 A	1000 A				
DC 1,5 kV	5300 A	4000 A	2700 A	2000 A				
DC 0,75 kV	6800 A	4000 A						

[a] Step 5 to 7 are kept for future revision

[b] DC 3 kV will be completed later



A No traction

B Current level exceeded

C Allowable current levels

D Allowable current levels

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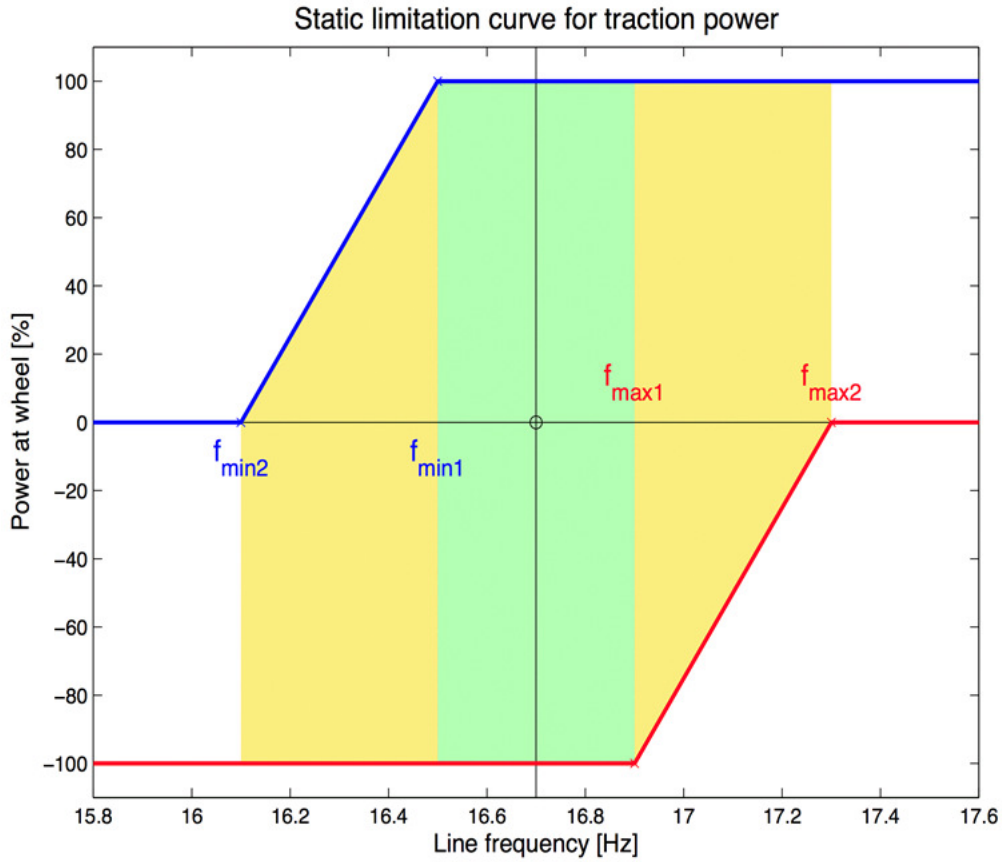
- 7.3 Automatic power or current limitation function of the train set as a function of frequency variation



For ac 16,7 Hz only with no synchronous connection to 50Hz

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- **8 Requirements for performance of power supply**
- 8.1 General
  to meet the required performance with a chosen robustness in normal and downgraded operating conditions
- 8.2 Quality index
  choice of a quality index by the IM which describes the impact of low voltage on the operating conditions
- 8.3 Voltage limits
  design study demonstrates that U panto > Umin 1 (12kV for 15kV system) for any train
- 8.4 Acceptance criteria
  NoBo checks that the study exists, that 8.3 requirement is fulfilled and that the choice of index is done

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- **9 Type and characterization of traction power supply system**

Type of traction power supply system: declaration of possible choices for the IM (voltage, separation sections, max train set current, regenerative braking, specific cases)

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10 Harmonics and dynamic effects

- 10.1 Objectives
  explanation of the concept and generic process

Part 2: for known technologies and known phenomena, explanation, guidelines and quantitative requirements are given

To minimize the risks of instability and their consequences of traffic collapse

- 10.2 General

  Overvoltages caused by: system instability, harmonics, low frequency oscillations, multiple zero crossings, ….

- 10.3 Procedure for new elements during its life time
  follow a flow chart which allows a complete study with the right parties involved (IM, operator, manufacturers)

- 10.4 Compatibility study

  precise flowchart allowing a strong minimization of the risk

- 10.5 Methodology and acceptance criteria
  concerns mainly AC , less DC

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- **11 Coordination of protection**
- 11.2 Protection against short-circuits

Maximum contact line-rail short-circuit level: 40kA for 15kV 16,7Hz

If CB on board has a breaking capacity <40kA delayed tripping on board

Traction power supply system	When any internal defect fault occurs within the traction units Sequence of tripping for:	
	Substation feeder circuit breaker	Traction unit circuit breaker
AC25 000 V 50 Hz	Immediate tripping	Immediate tripping
AC15 000 V16,7 Hz	Immediate tripping	Primary side of the transformer: See text above Secondary side of the transformer: Immediate tripping

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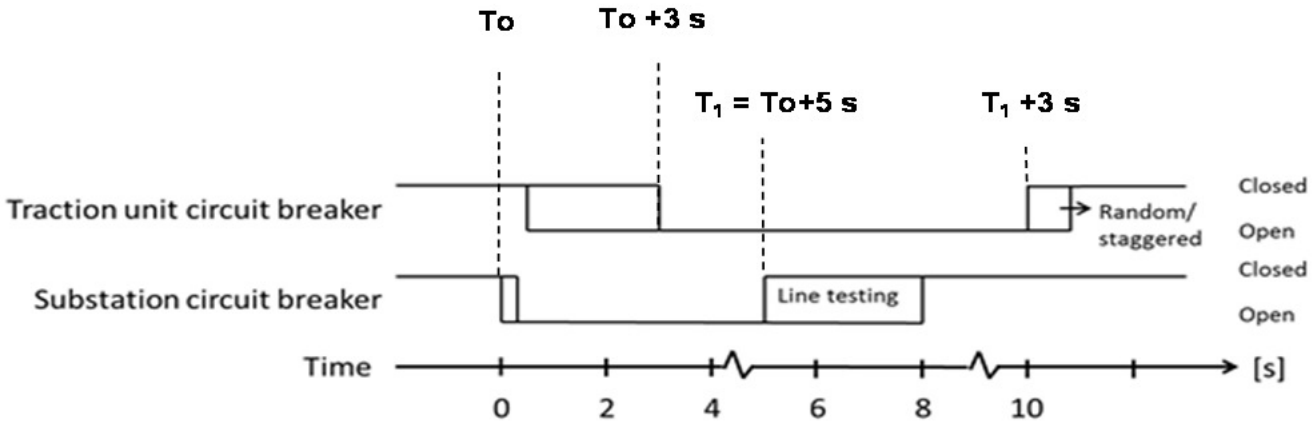
- 11.3 closing or auto reclosing of circuit breakers



- 11.4 Maximum inrush current of AC traction unit
  max peak inrush current when closure:
  2,0 kA for 15 kV 16,7 Hz; 1,0 kA for 25 kV 50 Hz
  successive closures of traction units CBs shall be random or staggered to avoid tripping in the substation

- 11.5 DC electrification systems, transient current during closure
  to avoid tripping in substation, max di/dt

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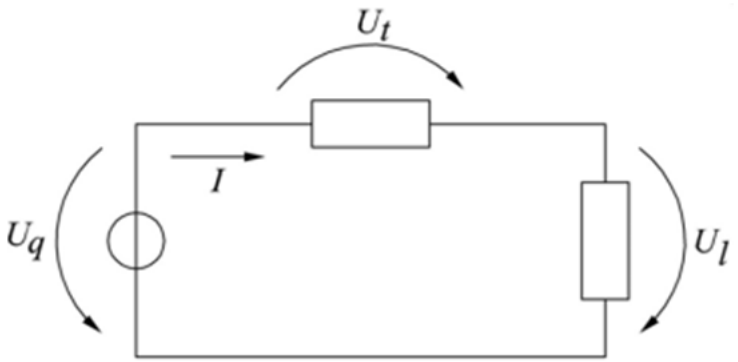
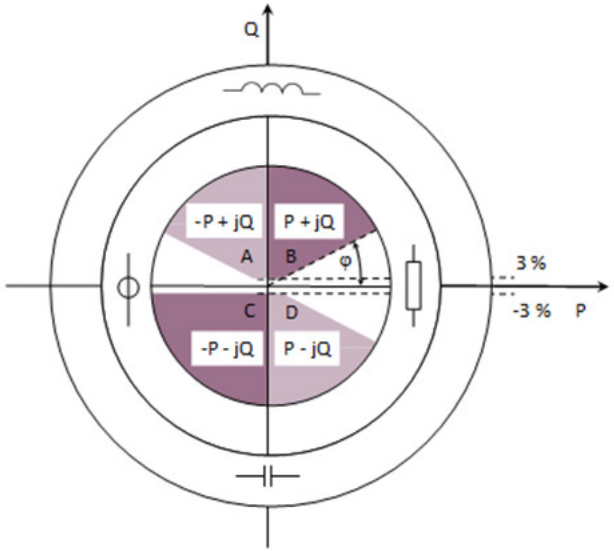
- **12 Regenerative braking**
- 12.1 General conditions on the use of regenerative braking
  - *substations have to supply the line*
  - *no short circuit on line*
  - *Uline<Umax2 (18kV for 15kV system)*
  - *Trains shall be able to brake by other means*
- *AC lines have to accept; DC may accept*
- *RINF shall be informed where non accepted*

EN 50388 – 1 we should not forget that…



Sign convention

$$\underline{S} = P + jQ = S \cdot e^{j\phi} = \underline{U} \cdot \underline{I}^{*} = j\omega L \cdot \underline{I} \cdot \underline{I}^{*} = j\omega L \cdot I^{2} = jQ_L$$



THE EN 50388

Bahnanwendungen -
Ortsfeste Anlagen und Bahnfahrzeuge -
Technische Kriterien für die Koordination zwischen Anlagen der Bahnenergieversorgung und Fahrzeugen zum Erreichen der Interoperabilität
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Teil 2: Stabilität und Oberschwingungen

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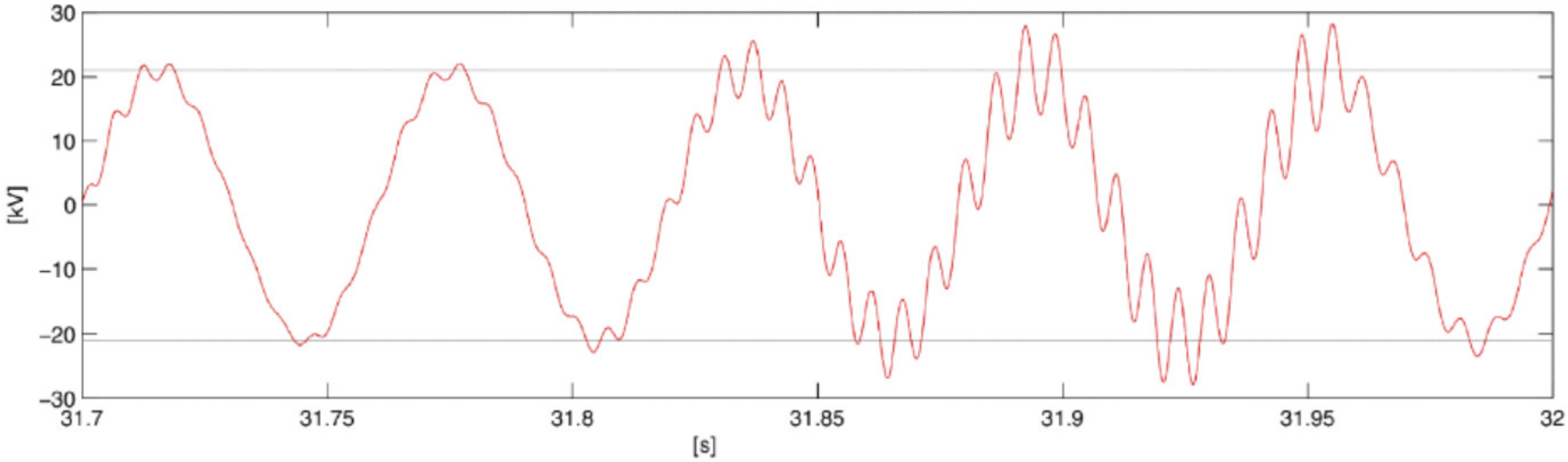
prEN 50388-2

Three main interaction issues:

- Electrical resonance stability
- Overvoltages caused by harmonics
- Low frequency stability

Electrical resonance stability

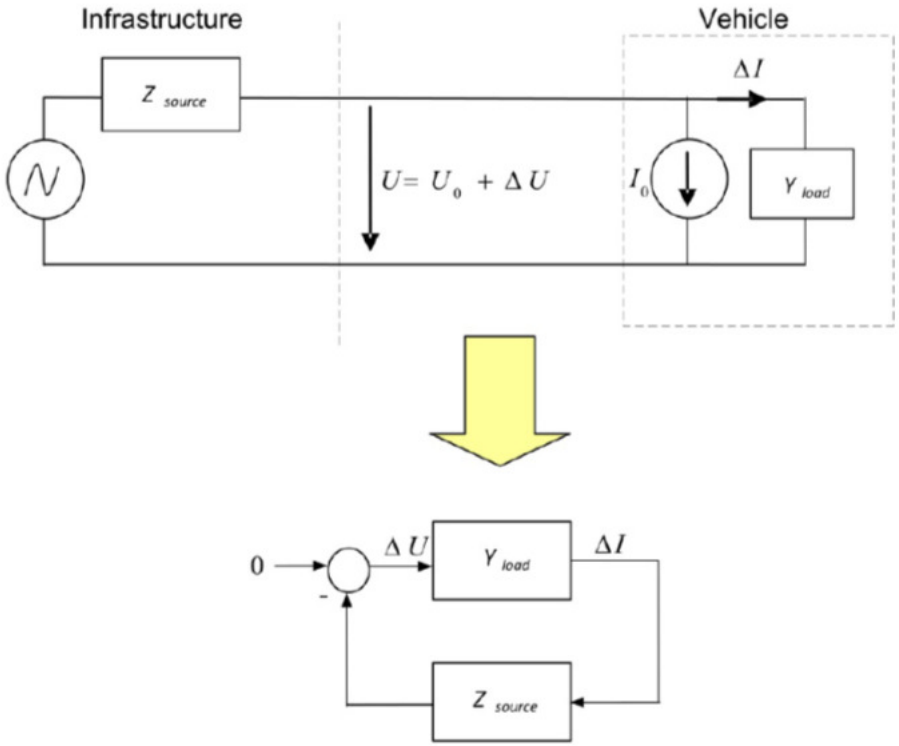
Measured phenomenum with a large number of shielded cables:



Source: prEN 50388-2

Electrical resonance stability

Interaction between electrical infrastructure and traction unit: simplified system block diagram (vehicle and infrastructure)



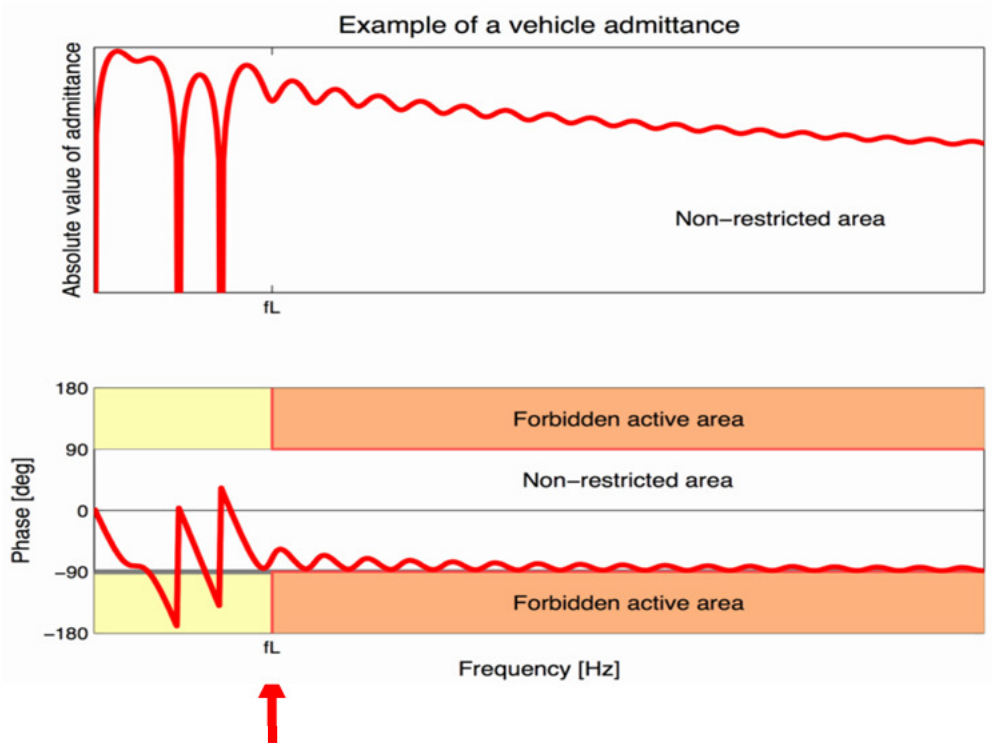
amplification of voltage distorsion

Source: prEN 50388-2

Electrical resonance stability

Acceptance of a new traction unit

illustrates the requirements for the frequency response of a traction unit. and forbidden zones of phase angles

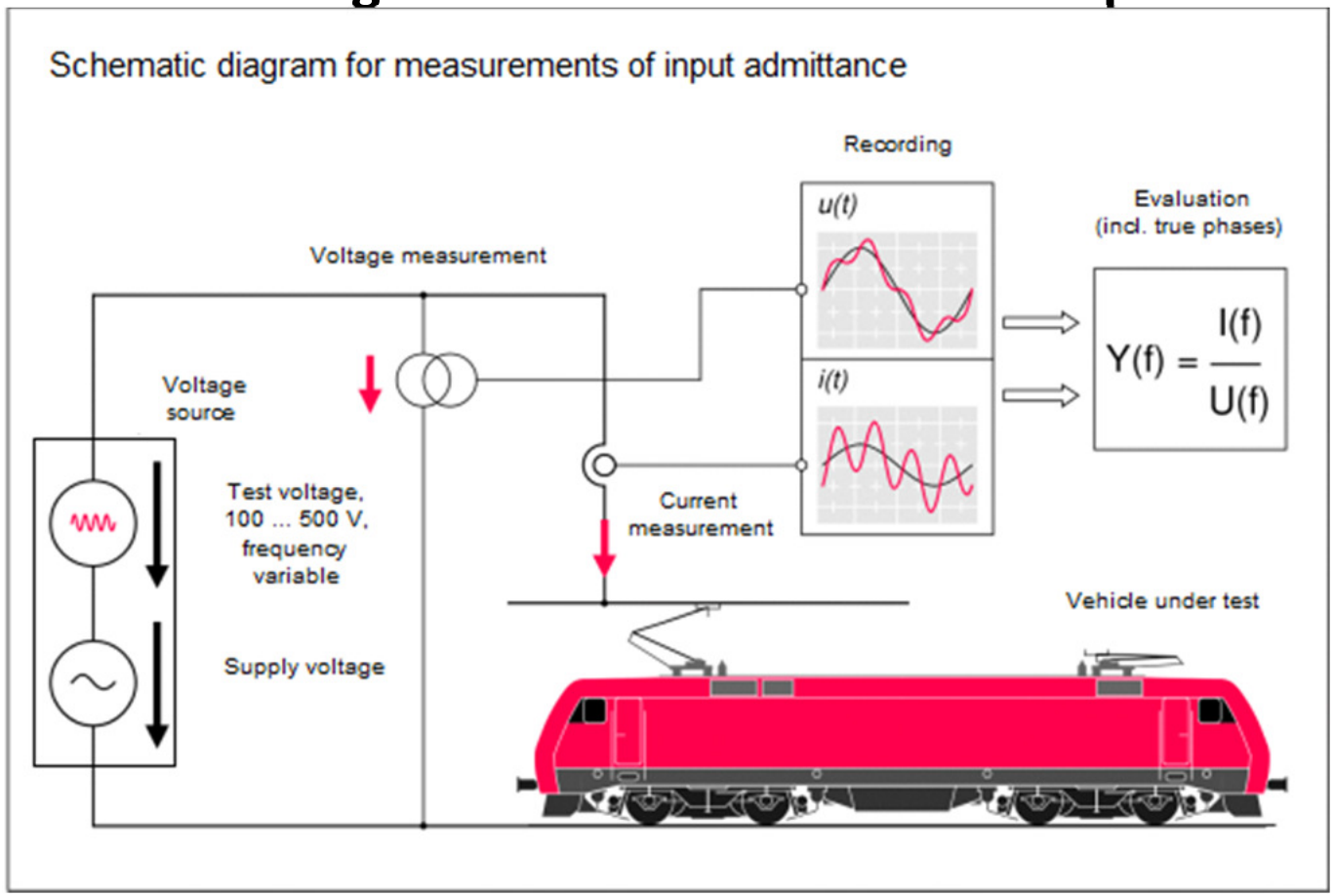


Example: 83 Hz for 16,7 Hz and 300 Hz for 25kV

Source: prEN 50388-2

Electrical resonance stability

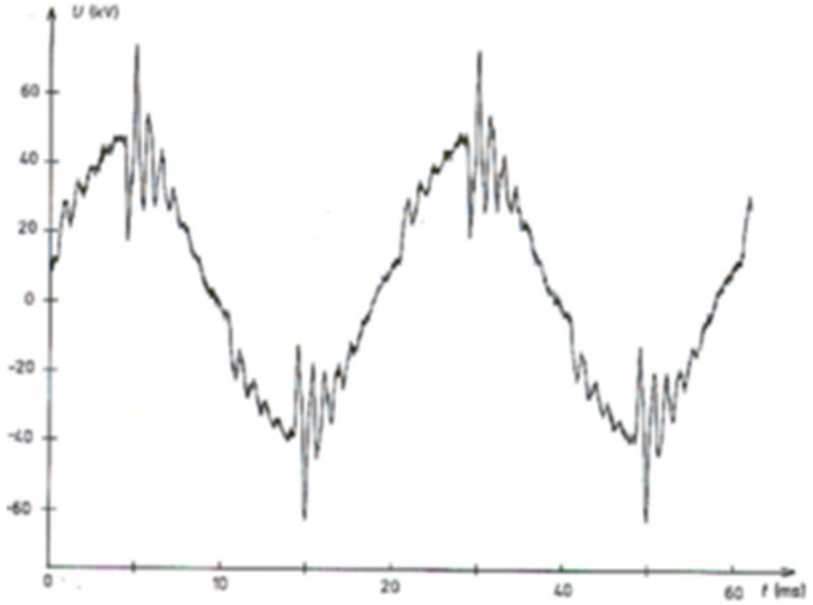
schematic diagram for measurements of input admittance



Source: prEN 50388-2

Overvoltages caused by harmonics

Measured phenomena:

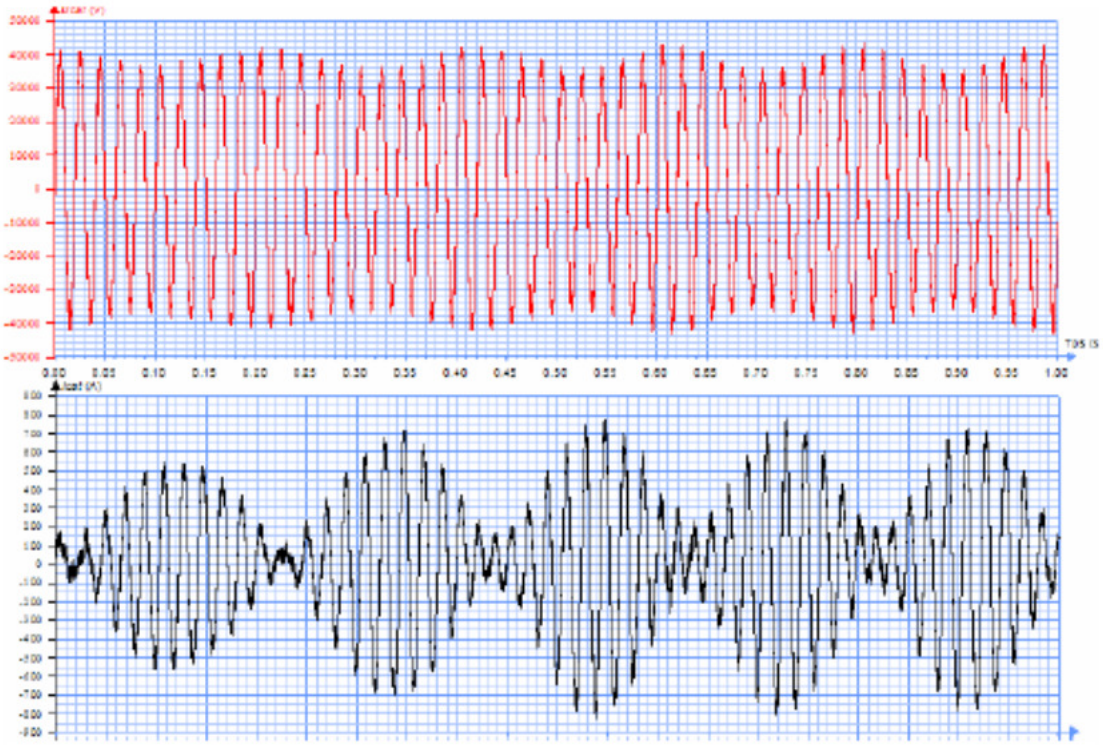


By courtesy of SNCF 25 kV 50 Hz, St Raphaël 2005

By courtesy of SBB

Low frequency power oscillations

Measured phenomena



voltage

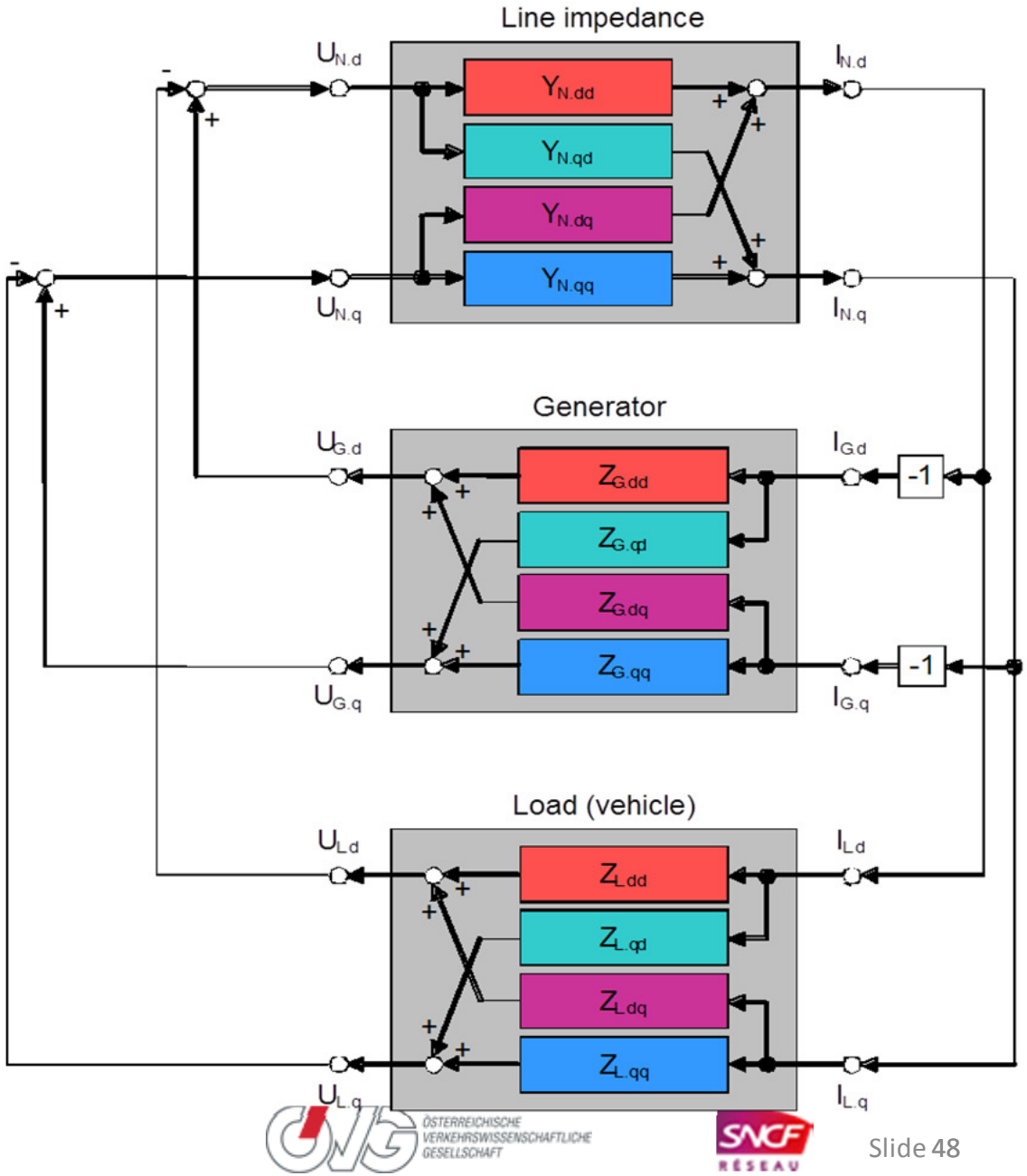
current

Source: prEN 50388-2

Low frequency stability

Interaction between infrastructure and traction unit

Linearized model



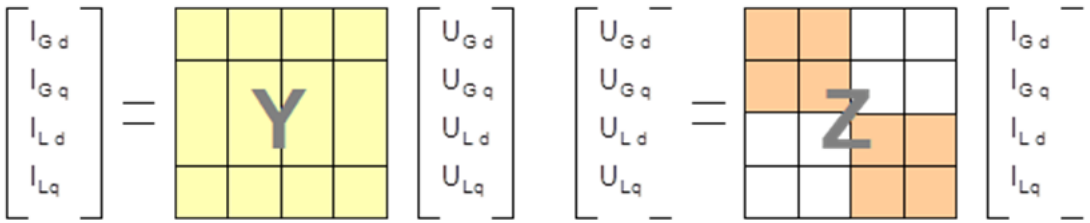
source: prEN 50388-2

Method of acceptance

The standard gives «simple» on which criterai are given allowing, through simulations and measurement to decrease dramatically the risk of unstabilities on when operating under ac 15 or 25kV

Y: network admittance matrix (for one ω)

Z: nonlinear components impedance matrix



fully occupied

2x2 blocks on the diagonal

Vielen Dank für ihre Aufmerksamkeit