RFI
RETE FERROVIARIA ITALIANA
GRUPPO FERROVIE DELLO STATO ITALIANE

Official Global Rail Carrier
EXPO
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High-speed traffic on ballasted track

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GRUPPO FERROVIE DELLO STATO ITALIANE

HS current situation

- 90.000 train-km / day
- operated
  - at 300 km/h by ca. 90 train-sets
  - at 250 km/h by ca. 50 train-sets

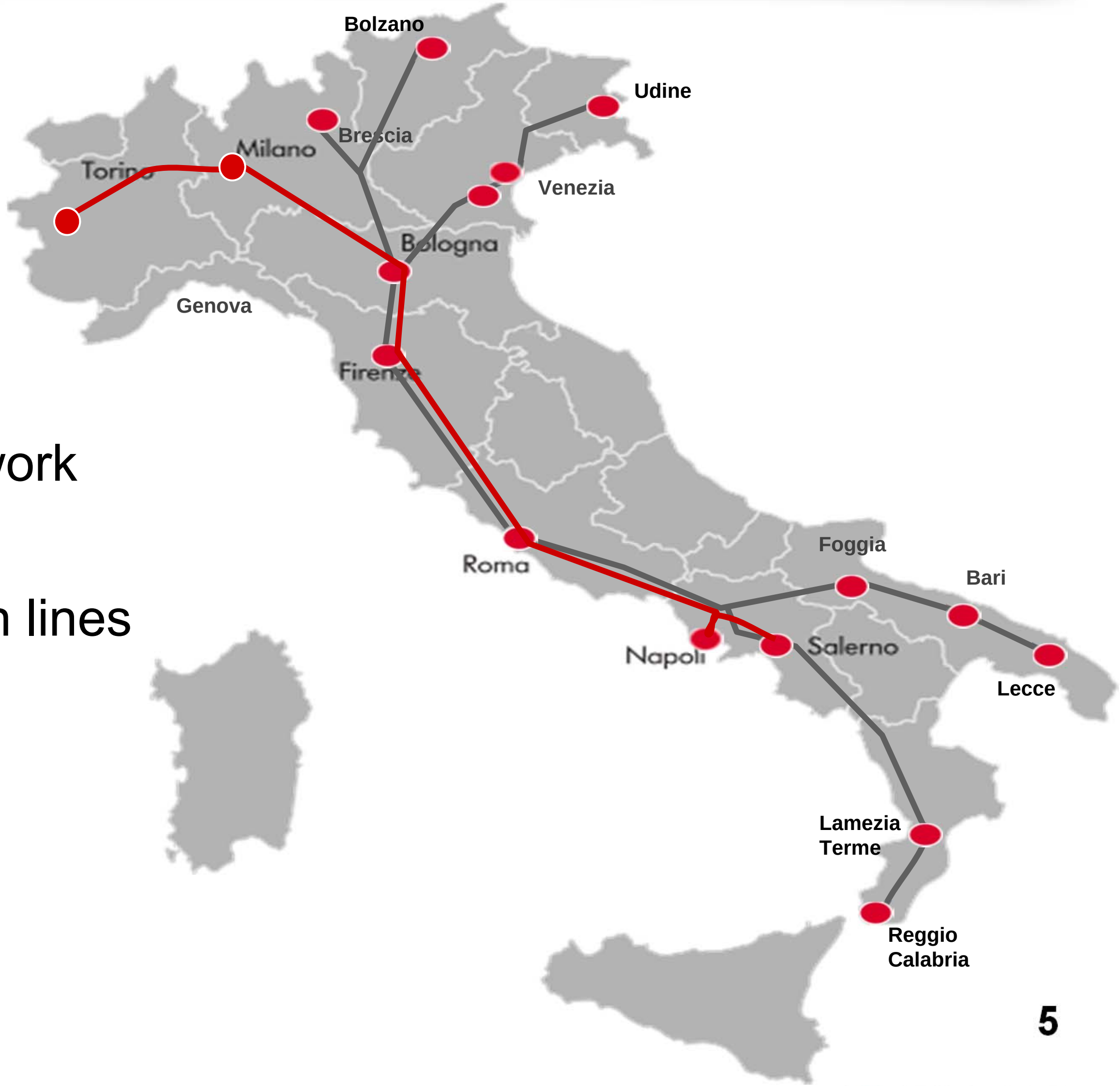
HS current situation

HS current situation

- 1000 km HS lines
- in operation since
  - < 2000 Florence- Rome
  - 2005 Rome-Naples
  - 2006 Turin- Novara
  - 2008 Naples-Salerno
  - 2008 Novara-Milan
  - 2008 Milan-Bologna
  - 2009 Bologna-Florence
  - 2016 Milan-Brescia (planned)

HS current situation

- the HS train service covers
  - not only the HS network
  - but also the CR main lines network



HS current situation

experiences on HS ballasted tracks at 300 km/h

experiences on HS ballasted tracks at 300 km/h

- as for the track maintenance, changes are expected at 300 km/h in respect of conventional tracks (max 200 km/h)
  - in principle the changes **potentially** affect any technical aspect
  - but it is important to recognize what aspects are **really** affected and what others aren't, so as to ensure the appropriate level of safety and effectiveness
- the experiences gathered after 10 years HS operation enabled us to draw some conclusions …

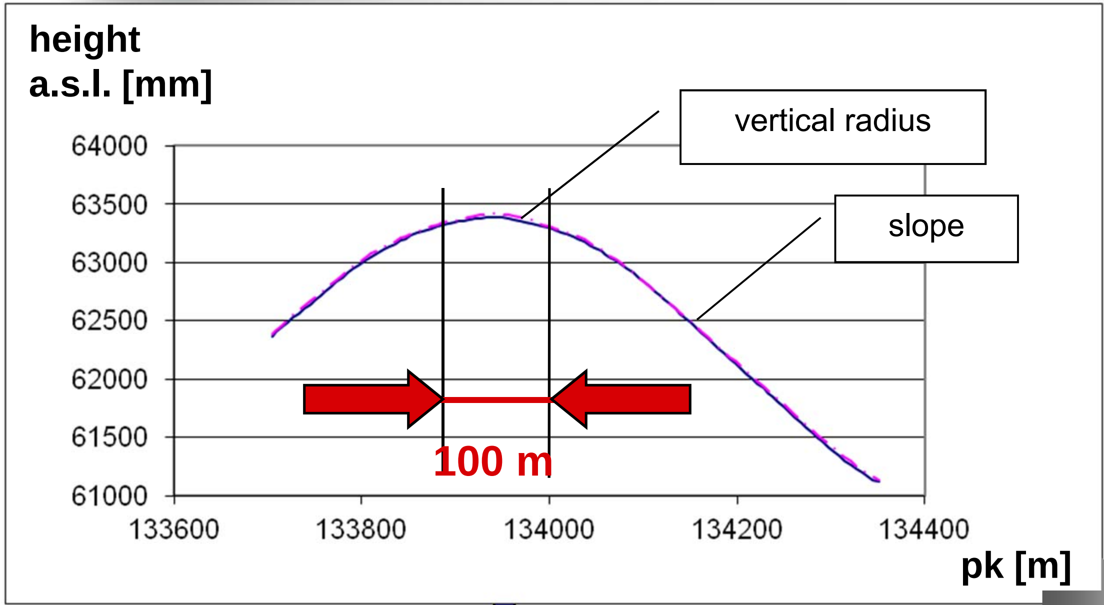
experiences on HS ballasted tracks at 300 km/h

- aspects that become relevant as the speed increases from 200 km/h to 300 km/h …..
  - the long wavelength geometrical defects (λ > 25 m) that affect the topographic real position of the track in respect of the theoretical track layout
  - the very short wavelength longitudinal defects (λ < 6 m)
  - the aerodynamic features of the track in respect of the stability of the ballast grains
- a series of up-dates of the technical rules has been accordingly implemented in the maintenance organization

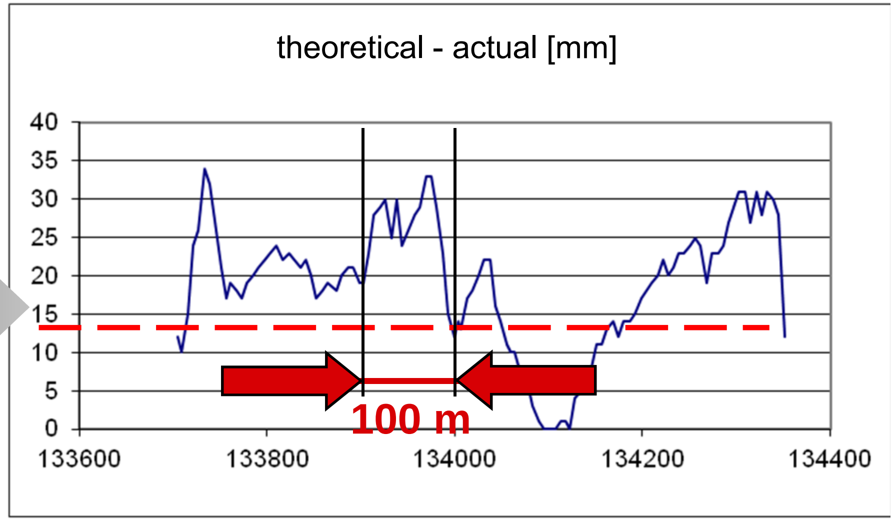
experiences on HS ballasted tracks at 300 km/h

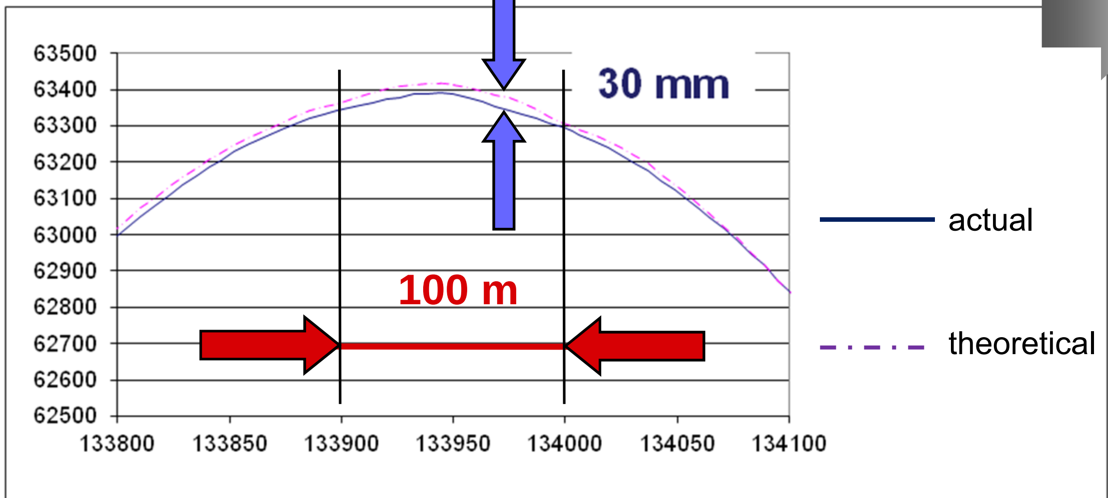
- long wavelength geometrical defects (λ > 25 m)
  - longitudinal level defects due to settlements of the upper layer of the formation and/or track settlements in the ballast bed
  - typically localized in the transition zones between embankment and rigid formations
    - invert of a tunnel
    - bridge deck
  - long wavelength geometrical defects are evidenced through the classic measuring cars by post processing the geometric data
  - but for their precise appreciation a topographic survey is better suited
  - <u>the alignment geometrical quality is hardly affected by long wave geometrical defects</u>

experiences on HS ballasted tracks at 300 km/h



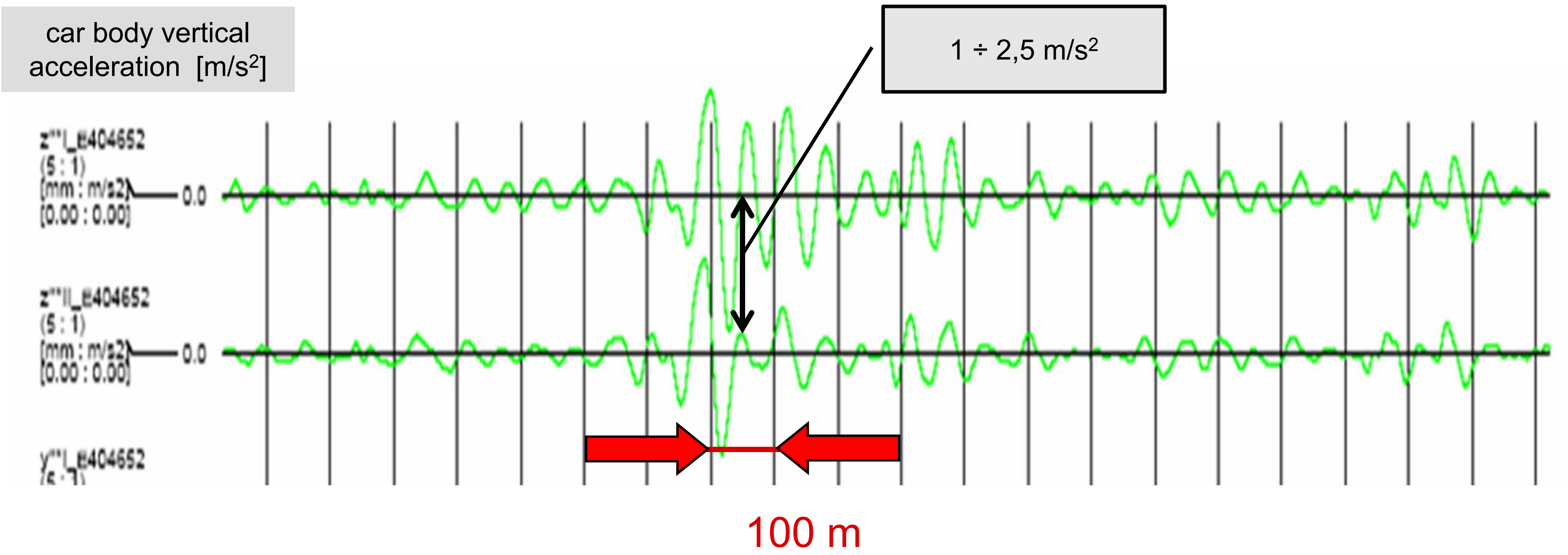
long wavelength geometrical defects





experiences on HS ballasted tracks at 300 km/h

- long wavelength geometrical defects and deviations from the track original layout cause vertical accelerations in the car body of the high speed trains and affect their ride quality and comfort



experiences on HS ballasted tracks at 300 km/h

- the procedure to repair these defects is more complex than in the case of geometry defects on a conventional line
- the repair implies a topographic survey to ascertain the real position of the track in respect of the theoretical layout
- sometimes putting the track back to its theoretical position is not convenient
  - because to much effort should be applied, in terms of entity of track displacements and volumes of new ballast to add
- in that case a new optimized track layout must be studied and realized

experiences on HS ballasted tracks at 300 km/h

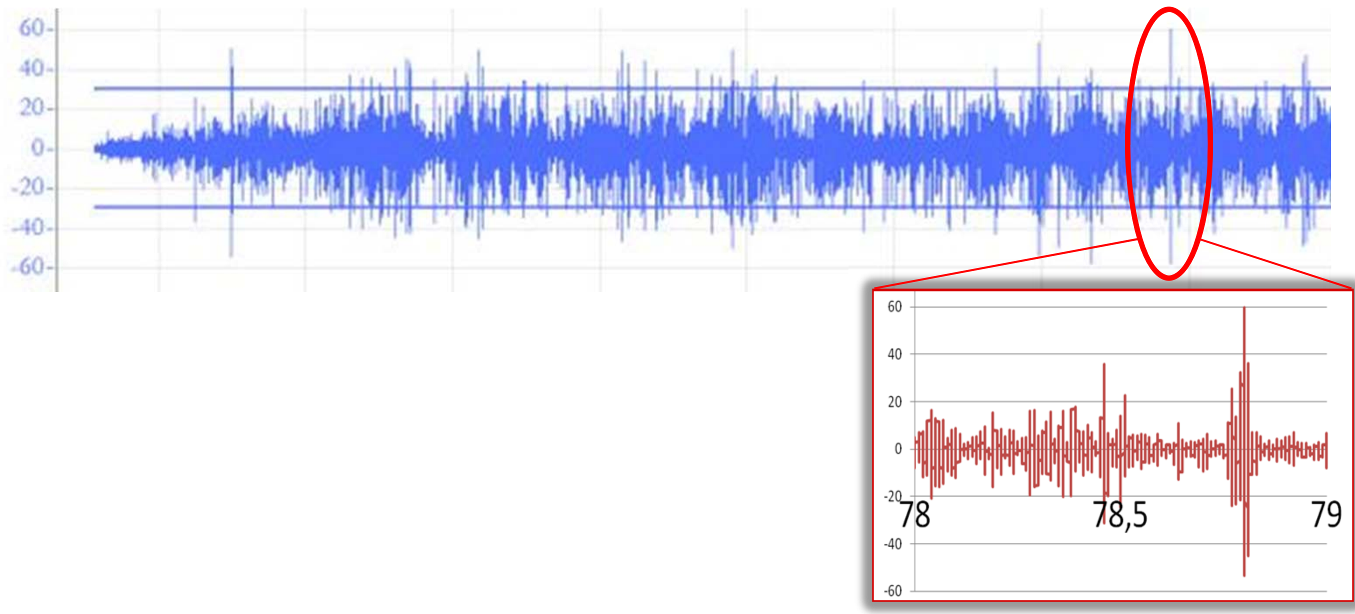
- very short wavelength longitudinal defects ($\lambda < 6$ m)
  - due to localized deconsolidation of single sleepers, or short clusters of sleepers; the deconsolidation consists of a void occurring between the sleeper lower surface and the ballast
  - sometimes triggered by precise phenomena such as geometry defects on the running table of the rail, presence of extra masses suspended on the track frame (for instance, locking devices), etc.
  - but quite often the occurrence of these defects is rather erratic and can be hardly related to precise causes
  - <u>the alignment geometrical quality is not affected by such phenomena</u>

experiences on HS ballasted tracks at 300 km/h

experiences on HS ballasted tracks at 300 km/h

- very short wavelength longitudinal defects can cause relevant vertical accelerations in the bogies of high speed trains and can affect their endurance to fatigue stresses

bogie vertical acceleration [m/s²]

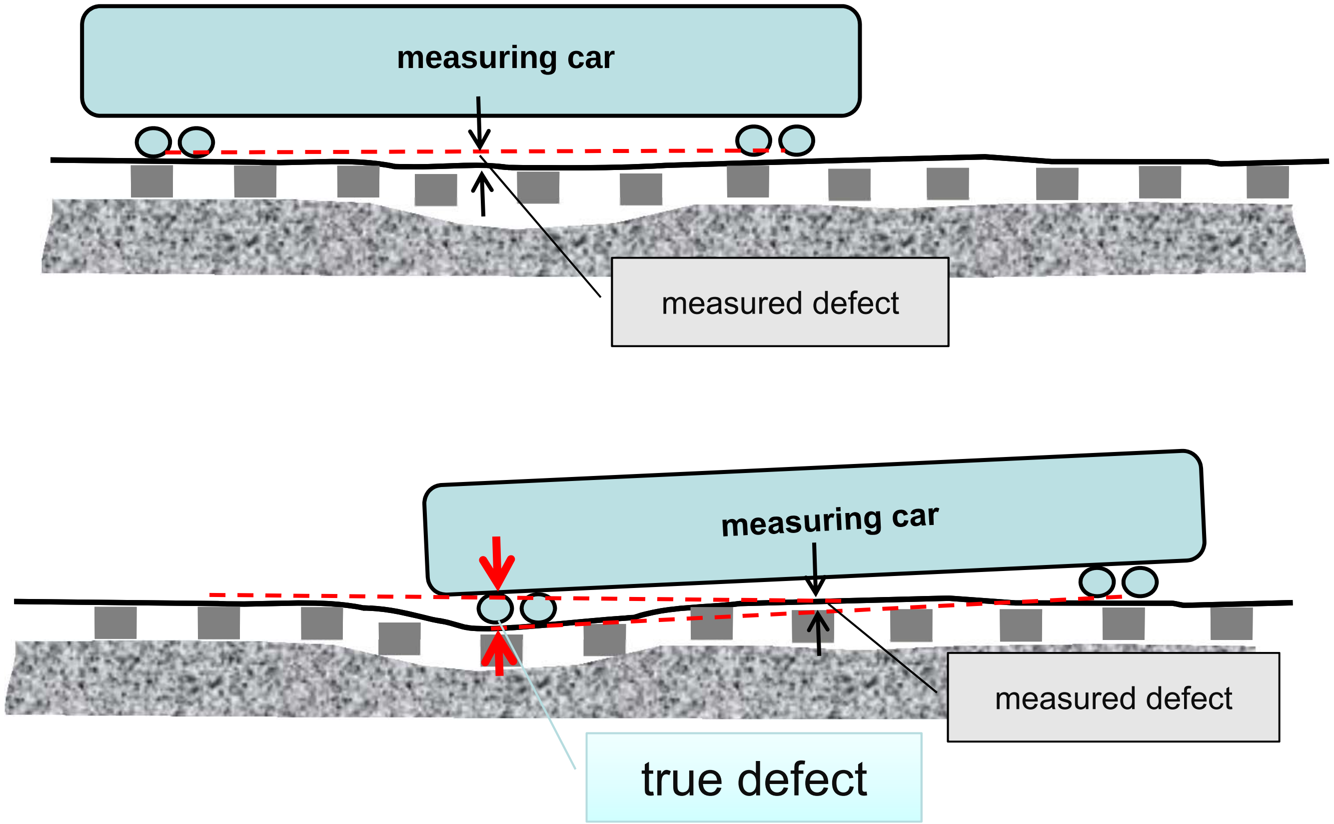


detail

experiences on HS ballasted tracks at 300 km/h

- the actions to repair the very short wave defects are not complex and much resemble those for a geometry defect in a conventional line
- the difficulty rather resides in the detection of these defects, since the conventional geometry diagnostic is not suited to spot them
- neither is the visual inspection of the track, apart from the occurrence of white spots in the ballast, since these defects show up only under passing axles

experiences on HS ballasted tracks at 300 km/h



experiences on HS ballasted tracks at 300 km/h

- a technique has been developed to spot the very short wavelength defects

- the technique is based on the measurement of vertical accelerations on the bogies of diagnostic trains

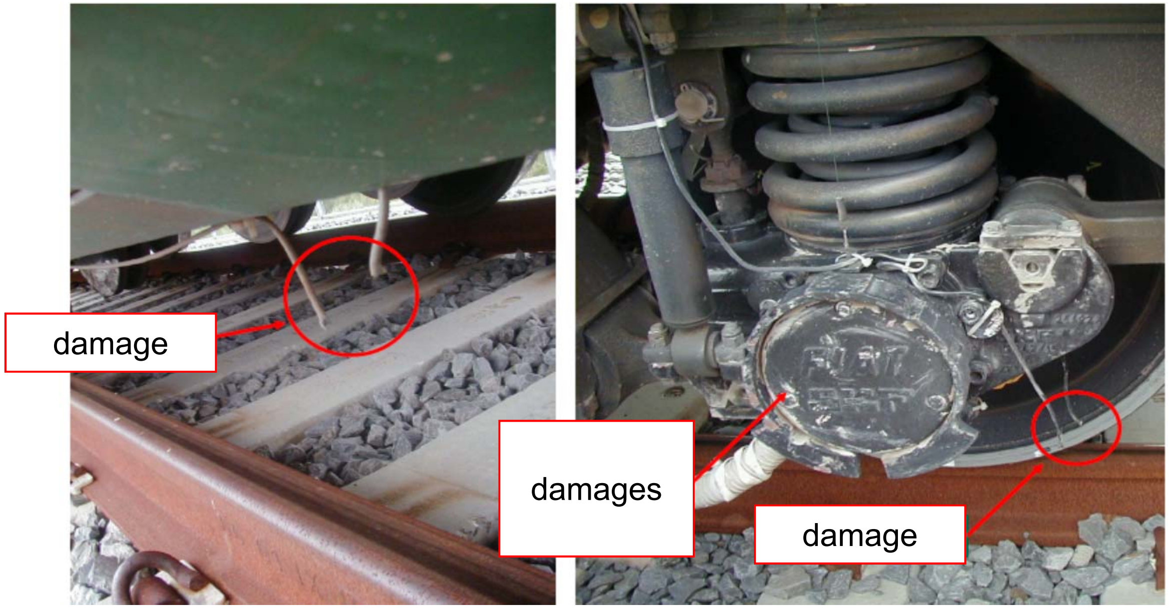
  - a 40 Hz low pass filter is applied, instead of the standard 20 Hz low pass filter, with the aim of capturing the complete acceleration information

experiences on HS ballasted tracks at 300 km/h

- the aerodynamic features of the track in respect of the stability of the ballast grains
  - for train speeds higher than ca. 270 km/h the ballast grains tend to be dragged by the airflow established in the underbelly of HS trains
  - dragged ballast grains hit other ballast grains causing them to jump up and to be dragged as well
  - the phenomenon is strictly related
    - to the average speed and turbulence intensity of the underbelly air flow (influence of the rolling stock)
    - to the apparent roughness of the track (influence of the infrastructure)

experiences on HS ballasted tracks at 300 km/h

- flown ballast grains can hit parts of the under structure of the trains causing damages to devices and plants and possibly also undermine the safety of the zones surrounding the HS lines

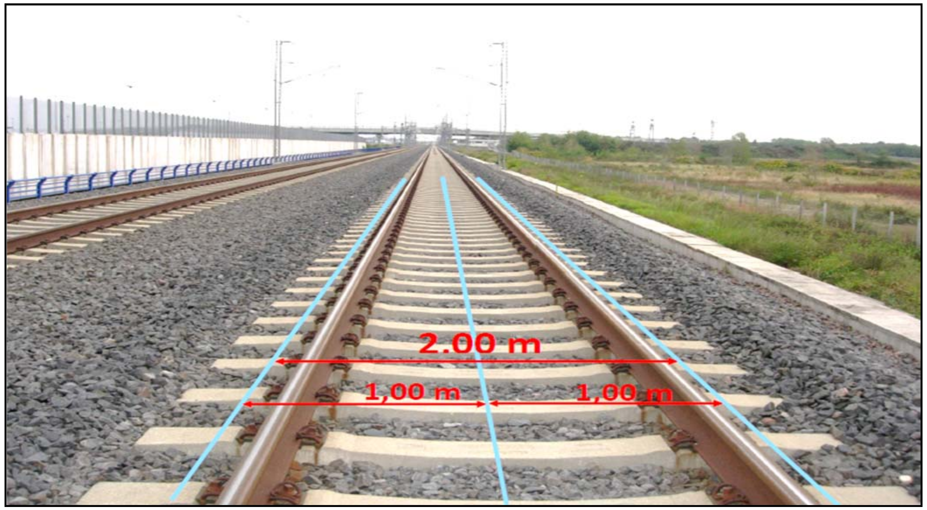


experiences on HS ballasted tracks at 300 km/h

- the actions to avoid the ballast pick up consist of a special ballast profile
- the ballast level is lowered 3 to 5 cm below the sleeper upper surface for a 2 m width, symmetric in respect of the track center
  - in the Italian HS network only mono-bloc concrete sleepers are used
- in addition, a vibrating table under a vertical load is applied that somehow engrains the ballast particles
- this provision has demonstrated to be resolving during test runs performed up to a speed of 330 km/h,
  - and is deemed to be effective also for higher speeds, at least up to 350 km/h, according to extrapolation of experimental data

experiences on HS ballasted tracks at 300 km/h

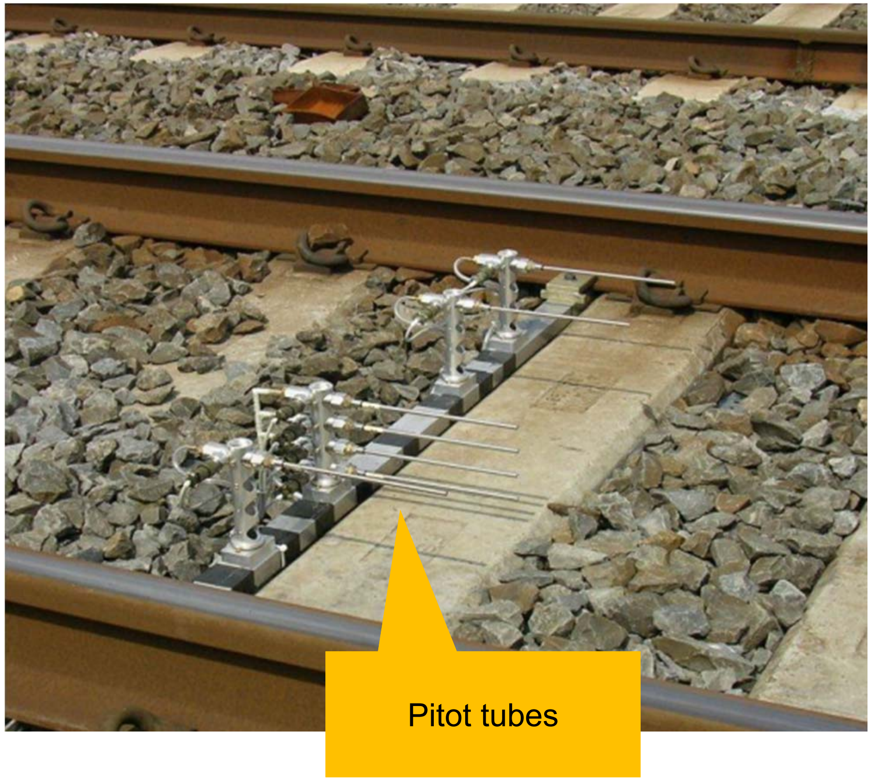
ballast lowering

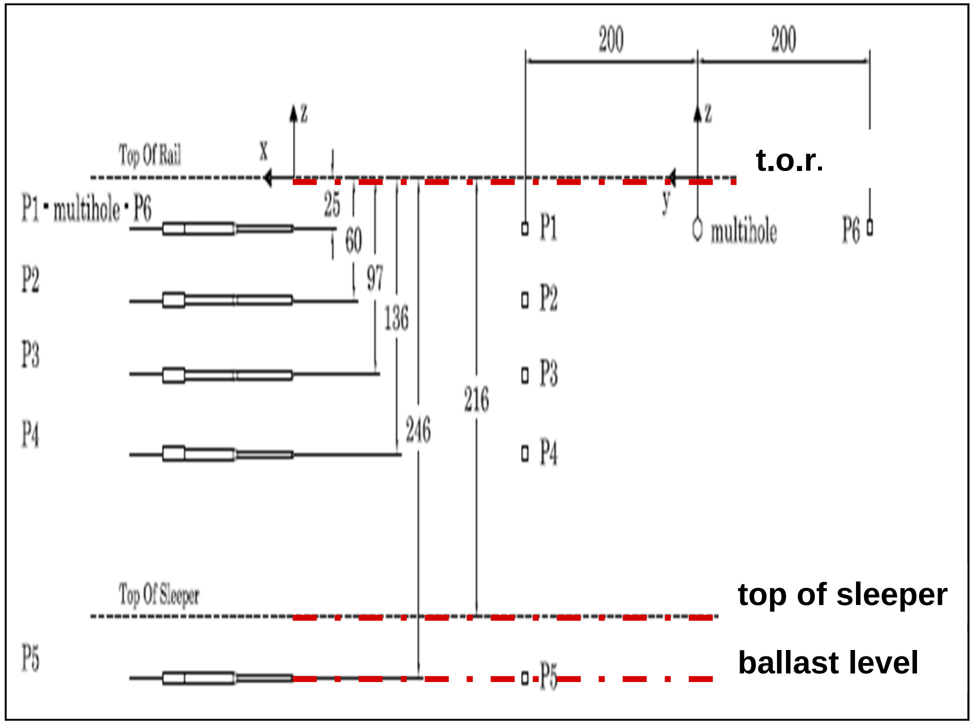


experiences on HS ballasted tracks at 300 km/h

ballast lowering

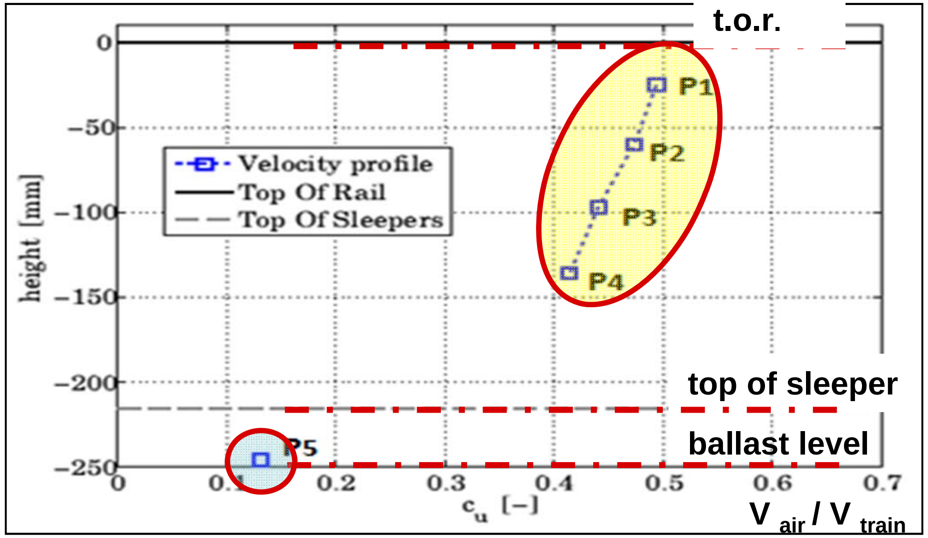
underbelly airflow measurements

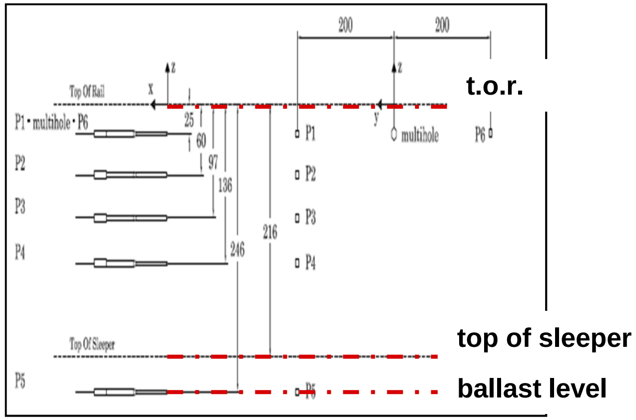


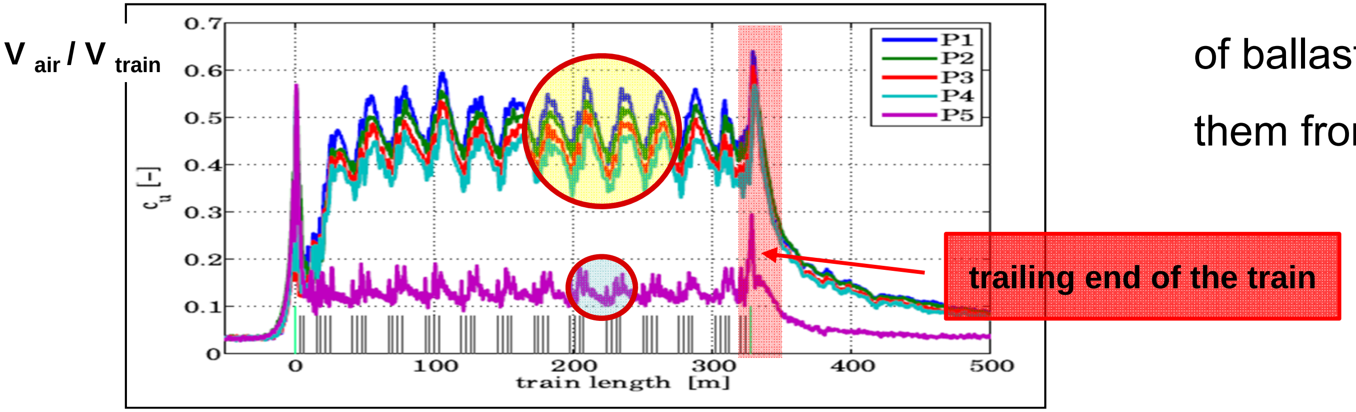


experiences on HS ballasted tracks at 300 km/h

underbelly airflow measurements







the ballast lowering significantly reduces the air speed at the level of ballast grains and prevents them from being dragged

future perspectives for ballasted tracks up to 350 km/h

- RFI has also engaged in ascertaining under what conditions a HS traffic at 350 km/h on ballasted track can be conceived

- aiming at elevating the performances of the HS system without major modifications of he infrastructure, such as:
  - modifications of the curve radii
  - modifications of the track components
  - etc.

future perspectives for ballasted tracks up to 350 km/h

- first, a preliminary overview was performed to point out the main technical parameters subject to verification

- then, a research program has been launched based on
  - theoretical numeric simulations
  - extension of data collected from test runs of instrumented HS ETR500 trains running at a max test speed of 330 km/h

future perspectives for ballasted tracks up to 350 km/h

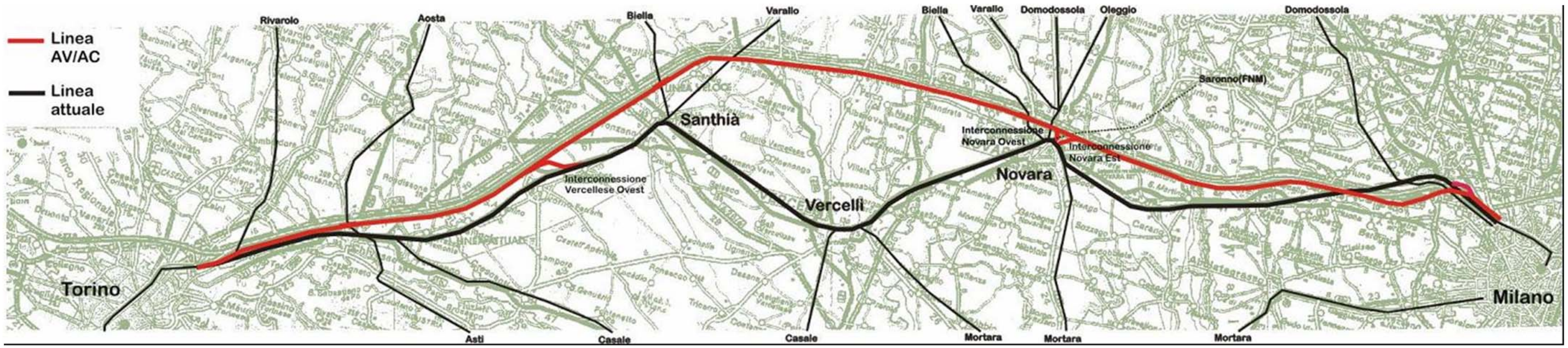
- the research covered all technical aspects relevant for the safety and regularity of operation
  - train/track interaction (running dynamics)
  - track and S&C components
  - locking devices
  - civil engineering (viaducts and bridges, noise barriers, etc.)
  - pressure in tunnels
  - noise and vibrations
  - quality of current collection at 25 kV
  - signalization systems (ERTMS)

future perspectives for ballasted tracks up to 350 km/h

- as for the ballasted track the study pointed out that become crucial
  - very long wavelength LL defects ($\lambda > 75$ m)
  - very short wavelength LL defects ($\lambda < 6$ m)
  - ballast pickup
- new more refined maintenance procedures will be implemented
  - all geometric quality parameters will receive lower limit values
  - the short wavelength LL defects ($\lambda = 3 \div 25$ m) will be divided in two ranges: $\lambda = 3 \div 12$ m and $\lambda = 12 \div 25$ m, that will correspondingly receive new limit values
  - the preparation of the ballast profile will be regulated in a more precise and traceable way

future perspectives for ballasted tracks up to 350 km/h

- test runs on the HS line Turin-Milan are planned during the 2nd half of 2015



future perspectives for ballasted tracks up to 350 km/h

- instrumented ETR1000 HS trains will run at max reference speed of 350 km/h, that implies the max test speed 385 km/h (reference speed + 35 km/h, according to RST TSI)
- data will be gathered from onboard of the test trains and from the terrain
  - S&C, locking devices, noise barriers, bridge decks, …. have been conveniently instrumented
- so as to confirm and possibly re-focus the conclusions of the preliminary study