Effective infrastructure for passenger rail services – international good practice and need for new solutions

Andrzej Massel, Ph.D., Eng.

Instytut Kolejnictwa

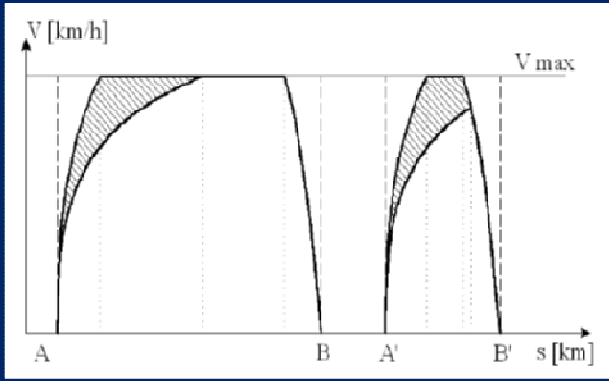
Agenda

- Problem – commercial speed versus maximum speed
- Railway infrastructure in Poland
- International good practice
- Need for research
- Conclusions

Maximum speed vs. average speed

- Speed qualification in the railway transport based on the differentiation of two essential speed types:
  - maximum speeds, which are possible to be obtained depending on the structure and condition of railway lines, rail signalling systems, power supply systems and rolling stock used;
  - average speeds, which characterise a course of the operational processes on railways

Utilisisation of design speed according to ECA



movement of trains with different acceleration indicators in short and long districts

- European Court of Audit (2018) on European high-speed lines:
  - Trains run at only around 45 % of the line's design speed (usually at the level of 300 km/h).
  - Only two lines operate at average (commercial) speeds of more than 200 km/h, and no lines operate at an average speed above 250 km/h.
  - The lowest speed yield on a completed high-speed line is on the Madrid-León high-speed line (39 % of design speed).
  - The cross-border Figueres - Perpignan section only operates at 36 % of its design speed

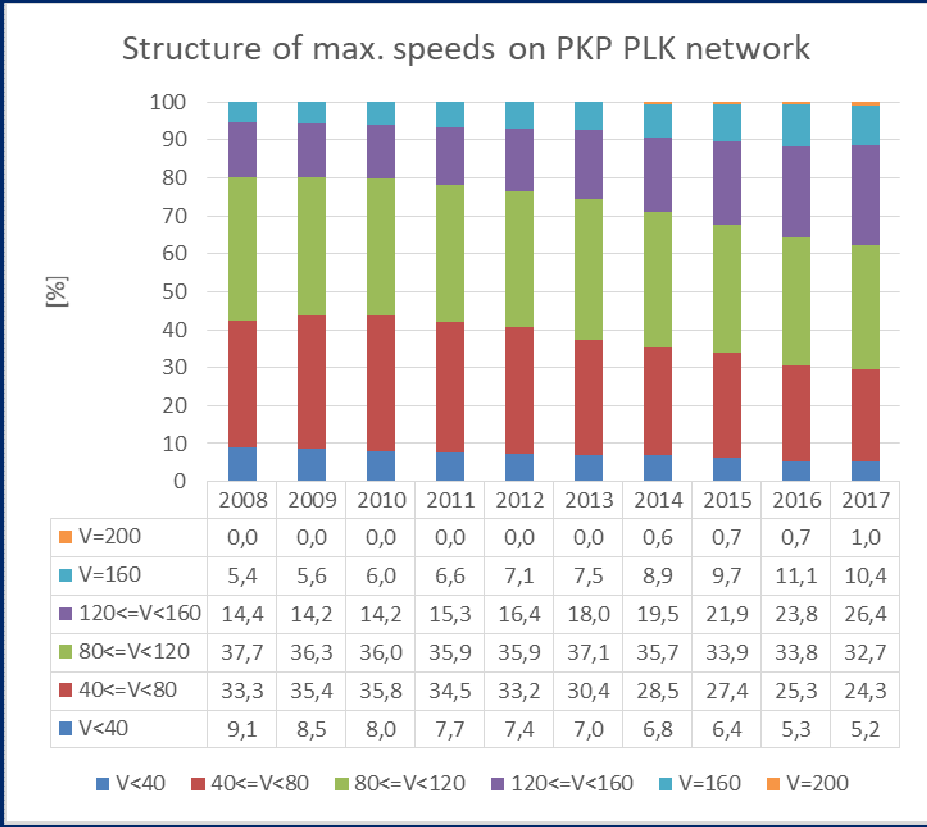
The problems

- What factors influence the utlisisation of the maximum line speed on existing (conventional) and newly-built (high speed) railway lines ?
- What lessons can be learned from recognised international good practice ?
- How to make the best use of the existing and newly-built railway infrastructure ?

The railway infrastructure in Poland

- The technical condition of the railway network in Poland is not uniform.
- The overall condition has been recently improved as a result of the maintenance activities, repair works and investment tasks.
- The percentage of railway line tracks graded as **good** in terms of technical condition:
  - 36.0% of the total track length in December 2010,
  - 58.9% of the total track length in December 2017.
- The percentage of railway line tracks graded as **unsatisfactory**:
  - 29.0% of the total track length in 2010
  - 15.6% of the total track length in 2017.

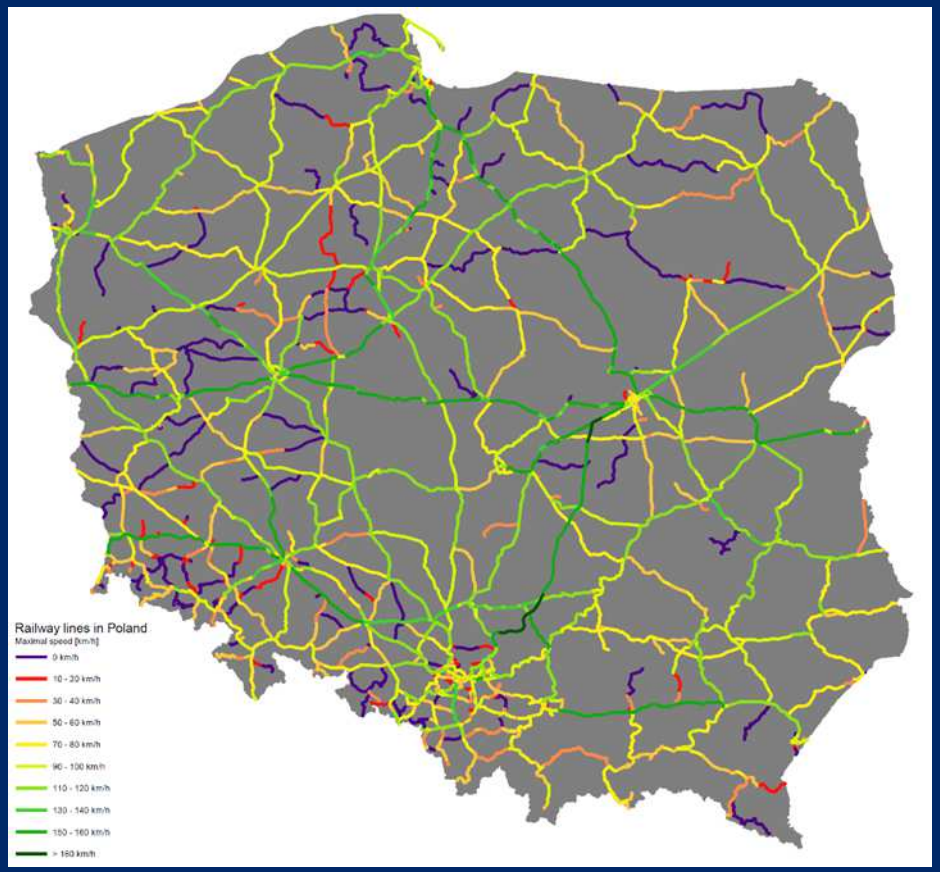
Evolution of maximum speeds in Poland



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
V=200	0,0	0,0	0,0	0,0	0,0	0,0	0,6	0,7	0,7	1,0
V=160	5,4	5,6	6,0	6,6	7,1	7,5	8,9	9,7	11,1	10,4
120<=V<160	14,4	14,2	14,2	15,3	16,4	18,0	19,5	21,9	23,8	26,4
80<=V<120	37,7	36,3	36,0	35,9	35,9	37,1	35,7	33,9	33,8	32,7
40<=V<80	33,3	35,4	35,8	34,5	33,2	30,4	28,5	27,4	25,3	24,3
V<40	9,1	8,5	8,0	7,7	7,4	7,0	6,8	6,4	5,3	5,2

- The structure of maximum speeds on the Polish railway network has been significantly changed recently:
  - In December 2010 only 20.2% of main tracks were cleared for operation at the speed of 120 km/h or more.
  - In 7 years, till December 2017, the share of main tracks with the maximum speed of 120 km/h or more has been increased to 37.8%.

Maximum speeds in Poland (2017)



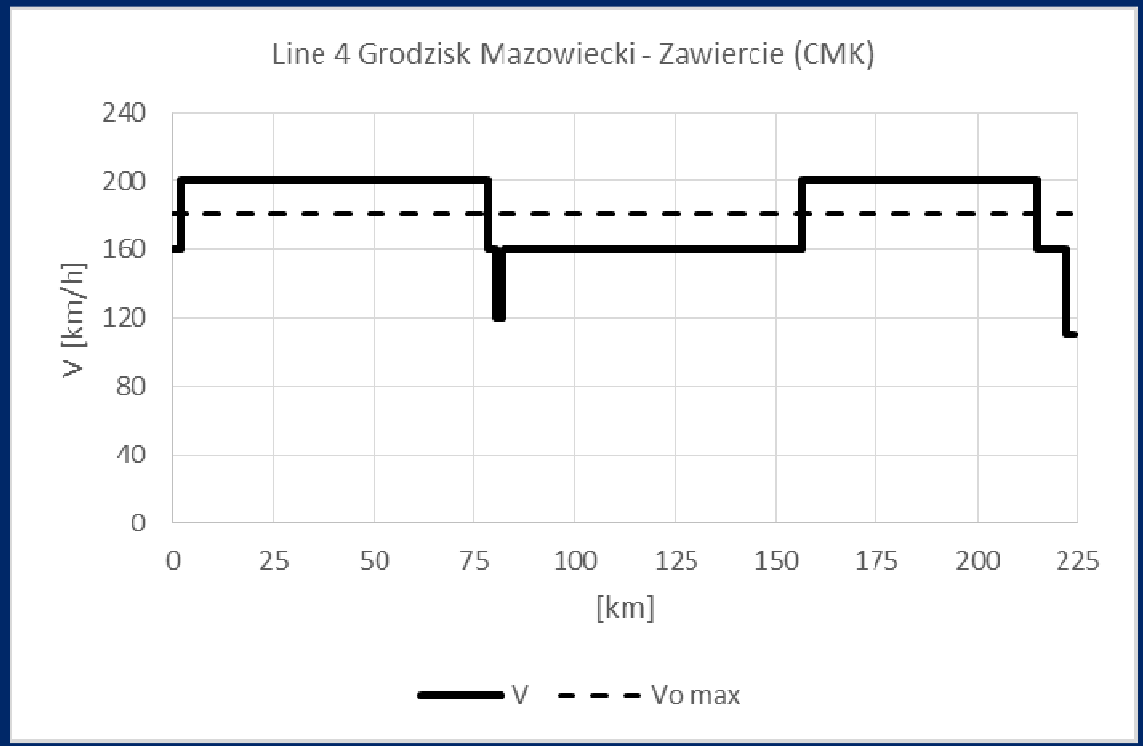
- The structure of maximum speeds on the Polish railway network has been significantly changed recently:
  - the percentage of main tracks with the maximum train speed lower than 80 km/h significantly reduced
  - from 43.8% in 2010
  - to 29.5% in 2017.

Utilisation of maximum line speed in Poland

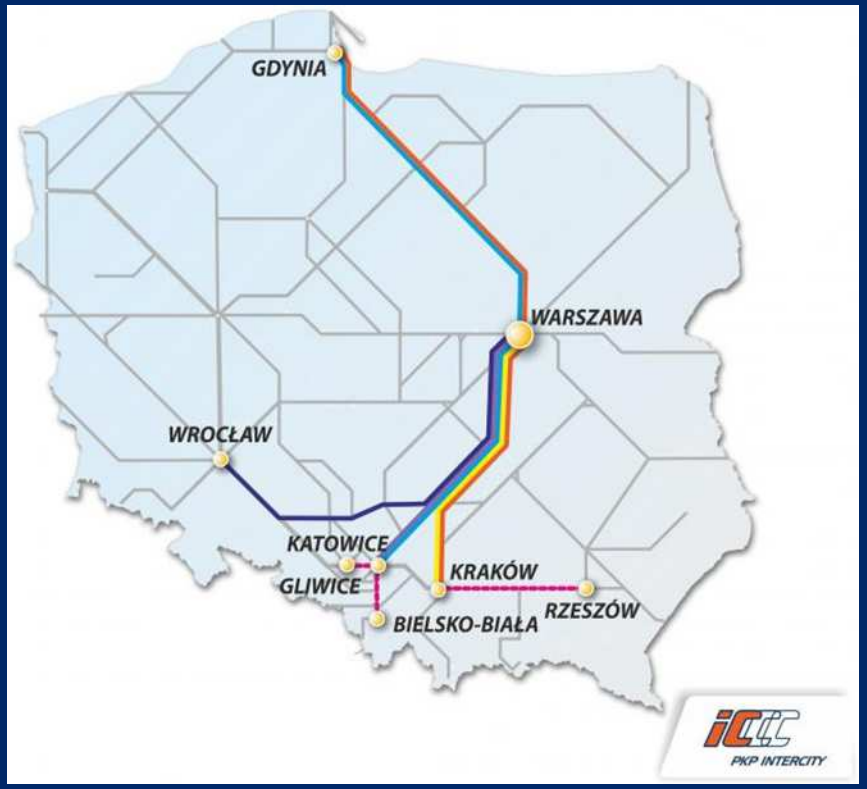
- The analysis covers the utilisation of the maximum line speed by the long-distance trains in Poland in the 2018/2019 timetable.
- Database covering:
  - 46 start-to-stop runs of Express Intercity Premium (EIP) trains
  - 448 runs of long distance EIC, IC, TLK trains.
- Practically all electrified railway lines in Poland, served with long-distance trains have been included

Examples from the Polish railway network

- The official data of PKP PLK were used to calculate exact distances and mean maximum speeds for all sections.
- The differentiation of the maximum speed along the line is taken into account with the harmonic weighted mean $V_{0\,max}$

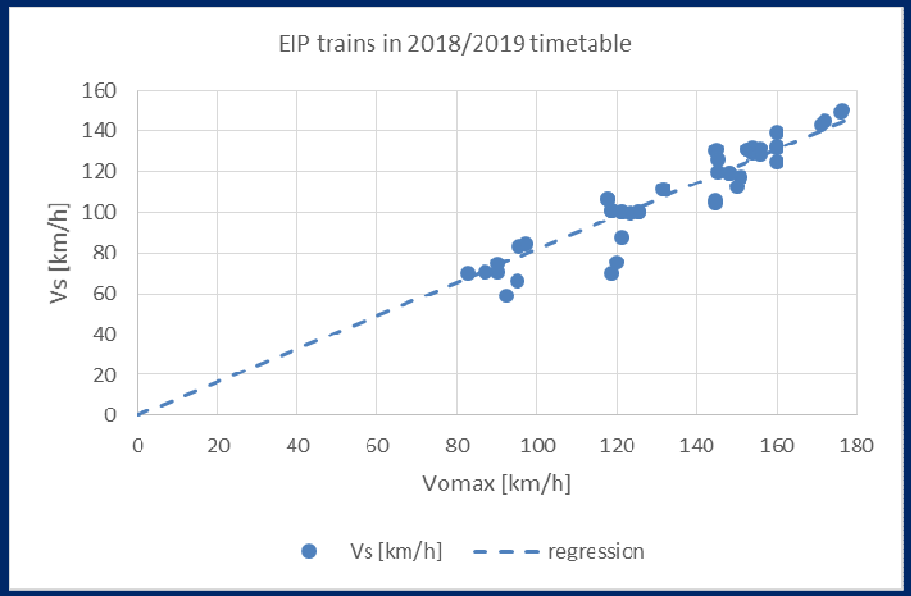


EIP train service in Poland



- Start of new services operated with ED250 trains from 14 December 2014
- Main routes served (2014/2015):
  - Warsaw – Cracow (293 km in 2 h 25 min)
  - Warsaw – Katowice (298 km in 2 h 30 min)
  - Warsaw – Wroclaw (422 km in 3 h 41 min)
  - Warsaw – Gdansk – Gdynia (349 km in 3 h 20 min)

Results – EIP trains – 2018/2019 timetable

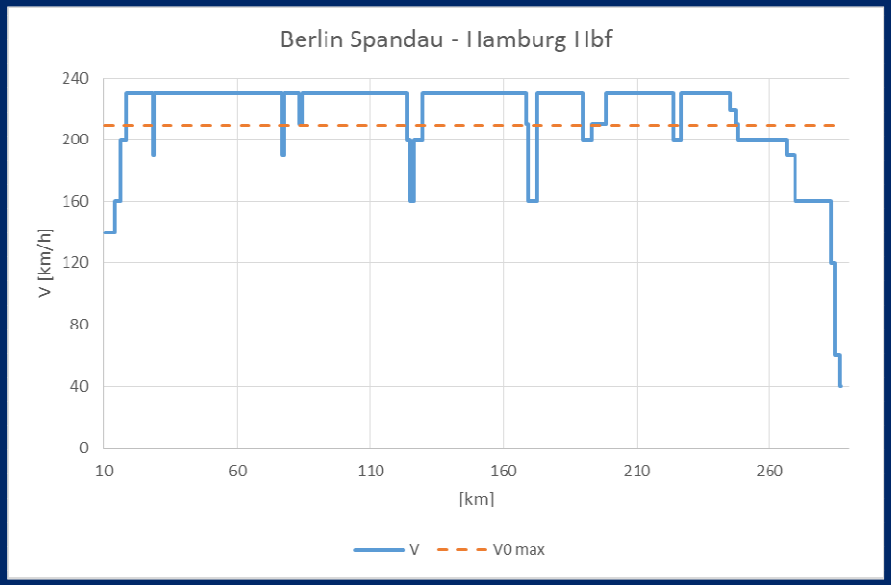


- 46 runs of EIP trains
- Good correlation of start-to-stop averages with average maximum speeds (r = 0.942).
- Favourable utilisation of maximum line speed:
  - Warszawa Wschodnia – Ilawa Glowna (I_s=0.900)

- $V_s = 0.818 \cdot V_{0\,max}$

International good practice: Berlin – Hamburg case

- The distance of 276.3 (Berlin-Spandau – Hamburg Hbf)
  - The speed of 230 km/h at the length of 194 km
  - The speed of 200-220 km/h at the total length of 50 km



- Maximum speed V_{max} = 230 km/h
- Av. max. speed $V_{0\,max}$ = 210 km/h
- Start-to-stop speed V_s = 180 km/h
- Speed utilisation ratio I_s = 0.858

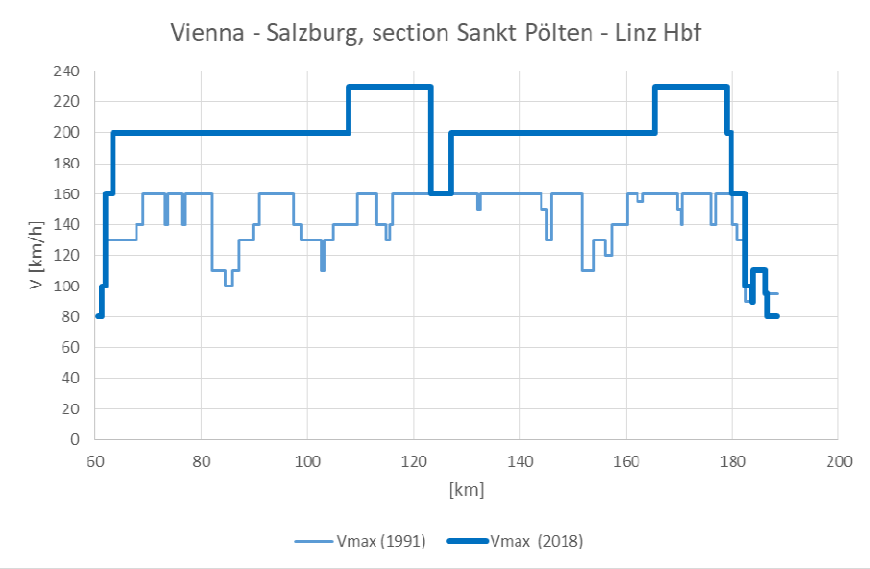
International good practice: Moscow – St. Petersburg case

- The distance of 650 km
  - The line constructed in 1851, comprehensively modernised
  - The speed of 200-250 km/h at the total length of 572 km (approx. 88%)
  - The journey time for the fastest train reduced to 3 h 30 min

- Maximum speed V_{max} = 250 km/h
- Start-to-stop speed V_s = 185 km/h
- Speed utilisation ratio I_s = 0.9 (approx.)

International good practice: Vienna – Salzburg case

- The distance of 123 km (Sankt Pölten - Linz)
  - The modernised, to large extent quadrupled railway line
  - The speed of 200-230 km/h (lower speeds at St. Pölten and Linz nodes)
    - Maximum speed V_{max} = 230 km/h
    - Av. max. speed $V_{0\,max}$ = 191 km/h
    - Start-to-stop speed V_s = 168 km/h
    - Speed utilisation ratio I_s= 0.878



Conclusions

- Confirmed very good correlation between the average maximum line speed and the train commercial (start-to-stop) speed.
- The method for evaluation of actual utilisation of the maximum line speed has been developed.
- The proposed methodology has been verified for the comprehensive data base including the runs of long-distance trains in Poland
- Typical values of speed utilisation ratio *Is* for the long-distance passenger services in Poland are:
  - 0.8 for traditional train compositions
  - 0.82-0.83 for the EIP trains operated with ED250 Pendolino EMU.
- These values are in line with respective data from other EU countries

Conclusions

- The highest values of the speed utilisation ratio I_s are observed for the longest sections passed without intermediate stops.
  - the influence of acceleration and braking relatively minor.
  - *Is* values at the level of 0.9 have been identified for some runs of EIP trains, operated with ED250 trainsets, for example between Warszawa Wschodnia and Ilawa Glowna stations (distance 204.7 km).
- The utilisation of maximum speed is negatively influenced by significant differentiation of the speed profile (frequent and large changes of speed along the line).
- The most effective utilisation of line capabilities is in the case of Electric Motor Units (EMUs) with distributed power and high power-to-weight ratio.

Thank you for your attention