

## Concept of Integrating the Łódź and Kielce TEN-T Hubs

Jan RACZYŃSKI<sup>1</sup>, Tomasz BUŻAŁEK<sup>2</sup>, Agata POMYKAŁA<sup>3</sup>

### Summary

The article presents an analysis of the economic and transport connections between the Łódź and Świętokrzyskie regions, in particular between Łódź and Kielce. Shortages in the railway network, which make it impossible to effectively use railway transport for both passenger and freight transport, were identified. An analysis was also performed concerning the use of opportunities arising from the course of the Trans-European Transport Network (TEN-T) through the territory of both regions. A program of necessary infrastructure investment was also proposed.

**Keywords:** transport, regional development, transportation systems

### 1. Introduction

In spite of their geographical proximity, as well as social and economic contacts, there is no efficient transportation network that sufficiently links the Łódź and Świętokrzyskie regions. This is especially true for the railway system. The only railway line, No. 25, linking both provinces has low operation parameters and the interprovincial passenger traffic has been suspended on the line for almost a decade. Both main cities of the regions – Łódź and Kielce – are currently not connected by a direct railway line. However, as a result of the modernisation of the existing lines and the development of new short supplementary sections, it is possible to create a fast railway connection between both cities and to create conditions for the development of a regional railway system around those towns. This connection may constitute an important element in the Polish and European network, providing Kielce with convenient railway connections with central and western Poland, and Łódź with south-eastern Poland, respectively. The connection may constitute both an important element for the routes of long-distance passenger trains and for the easy functioning of freight trains, including to the border crossing with Ukraine in Medyka.

The Railway Institute has developed a complex solution to the problem of transportation connections between both regions, in particular between Łódź and Kielce, with the key elements as follows [1]:

- modernisation of Line No. 25, which is an element of the TEN-T network, according to the project by Regulation No. 1315/2013 of the European Parliament and Council,
- construction of a line section connecting Lines No. 25 and No. 8, shortening the railway connection between Łódź and Kielce to about 140 km, and the travel time below 1 hour 30 minutes,
- construction of connecting line from Line No. 25 to the Central Rail Line (Rail Line No. 4), which will enable direct and fast connections between Łódź and Cracow (travel time of about 2 hours) and between Kielce and Warsaw (travel time of about 1 hour and 30 minutes),
- construction of local multi-modal nodes integrating various means of transportation and enhancing the effectiveness of public transport in Tomaszów Mazowiecki, Opoczno and Końskie.

### 2. Historical outline and current technical condition of Rail Line No. 25

Rail Line No. 25 is one of the oldest rail lines in the territory of the Łódź and Świętokrzyskie regions. Its history and origin have had an important impact on its operation, even to this day. Its main part was built in 1885, as a branch of the Dąbrowa Górnicza – Dęblin line (Iwanogrodzko-Dąbrowska Rail Line) [4]. The main purpose for the con-

<sup>1</sup> M.Sc. Eng.; Railway Research Institute, Senior Specialist, Project Coordination and International Cooperation Unit; e-mail: jracyznski@ikolej.pl.

<sup>2</sup> M.Sc.; City of Łódź Office.

<sup>3</sup> M.Sc. Eng.; Railway Research Institute, Senior Specialist, Project Coordination and International Cooperation Unit; e-mail: apomykala@ikolej.pl.

struction of the line was to include the Old Polish Industrial Region in the developing rail system of the Congress Poland. The rail line from Dąbrowa Górnicza facilitated the transportation of coal from the Dąbrowskie Industrial Region, while the branch towards Łódź provided a connection with the Łódź area for the Świętokrzyskie Metallurgy Plant. The constructed line linked the towns of the Old Polish Industrial Region (Ostrowiec Świętokrzyski, Skarżysko-Kamienna, Stąporków and Końskie) with the Koluński node.

In the Słotwiny – Tomaszów – Opoczno – Końskie section the railway runs almost in a straight-line, because of the more sparse settlements and smooth landscape. In the territory of the former Old Polish Industrial Region, the line is not so straight due to the more varied scenery, its route running along the Kamienna river valley and the necessity to adapt to the network of townships.

Unlike in the case of the Warsaw – Vienna and Łódź Fabryczna lines running via Koluński, the line was built in broad-gauge standard. Along with the construction of the Warsaw – Łowicz – Łódź – Kalisz broad-gauge railway in 1902, the line was extended from the station of Słotwiny along the existing Koluński – Łódź Widzew line, and then down the route of the so-called Ring Railway to the station of Łódź Kaliska. During WWI, the track gauges were changed to standard gauge and it was integrated with the entire national network. Also in that period, in the years 1914–1915, the line was extended from Ostrowiec Świętokrzyski to Sandomierz.

Between the wars, the line became an element serving the Central Industrial Region. During WWII, on the other hand, it was an important element serving the eastern frontline. For military reasons, the Łódź Chojny – Łódź Olechów – Bedoń section was built, the Koluński node was remodelled and the construction of a new Tomaszów Mazowiecki – Radom line was started. When finished in 1949, it took the role of a transit corridor in the transportation of goods.

Construction of the Central Rail Line (Rail Line No. 4), which cut through Line No. 25 in the area of Opoczno, but without the possibility of connection of both lines, has not contributed to a better use of line No. 25. Exits from the constructed main line were made to the Tomaszów – Radom line, under the process of electrification at that time. Later, in the years 1987–1990, the whole route was electrified from the Skarżysko-Kamienna node via Ostrowiec Świętokrzyski – Sandomierz – Stalowa Wola Rozwadów to Przeworsk. However, the line from Tomaszów to Skarżysko-Kamienna (88 km) remained the only section in central Poland that was not electrified, which – in view of the cessation of the electrification process after 1989 made the rational execution of transport more difficult and decreased the significance of the route.

Summing up:

1. The current Line No. 25 was created as a freight route designed to serve the industries of the Old Polish Industrial Region. Nevertheless, their role has diminished strongly, while Kielce became the principal centre of the Świętokrzyskie region; however, the city is not directly served by the line.
2. Because of the purpose of the route, the Końskie – Opoczno – Tomaszów – Słotwiny – Łódź section was transit in nature and its course is not always strictly in line with the structure of the settlement arrangement. At the same time, the line has good geometry parameters for adaptation to higher speeds, especially in the Łódź – Końskie section and has the potential to be an element of the essential national network of connections.
3. The significance of the line in freight transportation has decreased after the construction of the Tomaszów – Radom line, which was later consolidated by the lack of electrification of the Tomaszów – Skarżysko-Kamienna section and lack of connecting curves between Line No. 25 and the Central Rail Line (Line No. 4).
4. After the decreased importance in freight transportation, the line has not properly taken over the function of operating passenger connections due to the peripheral route in relation to Kielce – the main city of the Świętokrzyskie region and the necessity to use diesel traction and gradual deterioration of its technical condition.

### 3. Current condition and use of the line

With regard to technical characteristics today, Line No. 25 is very inconsistent, with different technical parameters on individual sections:

- **Łódź Kaliska – Łódź Chojny**

A double-track, electrified line, modernised to the line speed of 100 km/h. Currently, the line is the most intensely used in the Łódzka Kolej Aglomeracyjna system (Agglomeration Railway of Łódź). It is an important freight line, and until the cross-city tunnel in Łódź is commissioned – also the key line for long-distance passenger trains

- **Łódź Chojny – Gałkówka**

An electrified double-track of average technical condition and the maximum speed of 80 km/h in the Łódź Chojny – Łódź Olechów section and 60 km/h in the Łódź Olechów – Gałkówka section (but with the possibility to increase the speed to at least 120 km/h), essentially a freight line.

- **Gałkówka – Tomaszów Mazowiecki**

A double-track electrified line with the general line speed of 100 km/h (in the Mikołajów – Tomaszów Mazowiecki section for electric multiple units and for die-

sel multiple units the maximum speed is 120 km/h). In the area of the Mikołajów station, an unfavourable layout of tracks occurs, which forces the reduction of speed down to 40 km/h as a result of travelling along the diverging tracks of turnouts. The stations, including the one in Tomaszów Mazowiecki, require the modernisation of platforms, but generally no new platforms need to be constructed. A line of low development and long straight sections. It is currently of high importance in freight traffic, secondary significance in regional traffic and is significant for long-distance passenger traffic as the connection of Łódź and the Central Trunk Railway for the Poznań/Bydgoszcz – Łódź – Cracow trains. It is planned for inclusion in the Łódzka Kolej Aglomeracyjna system due to the large potential of Tomaszów Mazowiecki and Opoczno.

- **Tomaszów Mazowiecki – Opoczno**

A single-track, non-electrified line with the speed of 80 km/h with local speed limits, in deteriorating condition. It has an almost straight-line course (route lengthening 1.03) without major curves. It is of significant importance in freight traffic, including the traffic generated locally (serving the mining, timber and mineral industries). Since December 2012, regional passenger transportation has been assumed on the line. The line is the shortest route linking Łódź with the Central Rail Line, but does not have the possibility to enter that line, which extends the route of long-distance trains by about 15 km over the distance of less than 30 km (because of the necessity to run them along a section of Line No. 22 and via the station of Idzikowice).

- **Opoczno – Końskie**

A single-track, non-electrified line with the maximum speed of 80 km/h with local speed limit reductions, in deteriorating condition. Low route lengthening of the line (1.05), without major curves. It is of significant importance in freight traffic, including the traffic generated locally (serving the timber and mineral industries). Currently no passenger traffic.

- **Końskie – Skarżysko-Kamienna**

A single-track, non-electrified line with the maximum speed of 80 km/h. No permanent speed limit reductions along the section. A less straight line (route lengthening of ca. 1.14), with curves providing for the possibility of modernisation (radius 1100 m). It is of significant importance in freight traffic, including the traffic generated locally (serving the timber, metallurgy and mineral industries). Currently no passenger traffic.

- **Skarżysko-Kamienna – Dębica**

A double-track line in the Skarżysko-Kamienna – Zalesie Gorzyckie section, electrified, under modernisation for the needs of long-distance passenger connections serving Rzeszów.

Therefore, it is clear that the infrastructure of the line is the worst in the middle sections, from To-

maszów Mazowiecki to Skarżysko-Kamienna, with significantly better conditions in the extreme sections. This makes it difficult to rationally use the line, especially for use as a transit line and it practically does not allow passenger routes that would be competitive with regard to the time of travel to be operated.

#### 4. Population and economic potential covered by the impact of Rail Line No. 25

Kielce and Łódź are provincial cities located within a short distance of each other, only ca. 130 km. The Łódź area composes an urban complex with the population of ca. 1.1m, Kielce with its county has the population of ca. 400k, and the counties of Tomaszów, Opoczno and Końskie, which are located in between the two major cities, are populated by ca. 280k residents. Hence, there is a total population of about 1.7m in the Łódź – Kielce axis. The visible disproportion in the size of urban complexes and the differing socio-economic structures over the short distance constitute the potential for networking between the agglomerations.

The current transport infrastructure between Łódź and Kielce can be described as insufficient. The railway line directly linking the two cities is non-existent, and the No. 74 trunk road in the Piotrków Trybunalski – Kielce section offers a low travelling standard – the route is entirely a single-road with a paved shoulder, a curved profile and large slopes, cutting through urbanised areas. The alternative routes are the 713, 726 and 728 county roads, offering an even lower standard. The condition of transport infrastructure is a serious impediment to the development of socio-economic links between the cities.

Some functional connections between Łódź and Kielce are of a traditional character. Łódź, due to the more comprehensive supply of services, has been an important centre for the population of Kielce and the Świętokrzyskie region by providing higher-level benefits – educational, cultural and health services. Łódź has more universities, both public and private, including art colleges. It also provides wider access to specialized health care, related to the operation of specialized establishments, such as the Polish Mother's Memorial Hospital Research Institute. Other positive points are associated with relatively new investment, such as the *Manufaktura* shopping and entertainment centre or the *Atlas Arena* entertainment hall. The number of people travelling to Łódź for tourism is also growing. In addition, the recognition of Łódź as a hub city for the TEN-T network, together with a thorough reconstruction of the Łódź Railway Junction, the construction of motorways and expressways around the city and the planned construction of the

Warsaw – Łódź – Wrocław / Poznań high-speed line, will result in an increase in the transit role of Łódź in travel along domestic and international routes.

Kielce is currently the second most important exhibition centre in Poland. Annually, there are over 40 fairs and exhibitions held there, visited by over 200,000 visitors. Kielce is also the capital city of a tourist region based on natural and cultural attractions, as well as an important industrial centre. In addition, trips to both capitals are generated by the existing business cooperation or family ties, including those resulting from previous migrations.

The Świętokrzyski tourist region covers an area similar to the territory of the province and its availability is both the result of the ability to get to Kielce and to smaller townships. The wildlife attractions are those related to the Świętokrzyskie Mountains, including the highest Łysogóry range under the protection of the Świętokrzyski National Park, as well as the Puszcza Jodłowa woods and Ponidzie. The cultural attractions include: archaeological sites (neolithic mines in Krzemionki Opatowskie and bloomeries), historical buildings of medieval towns (Sandomierz), defensive structures (Chęciny and Ujazd), technical monuments – most often associated with the iron and steel industries but also e.g. railways (narrow-gauge railways). The region is also the home to artificial water reservoirs that are used for recreation, several downhill ski runs, museums (e.g. Kielce Village Museum) and spa towns – Busko-Zdrój and Solec-Zdrój.

Some small and medium-sized towns are located along the axis between Łódź and Kielce: Koluszki, Tomaszów Mazowiecki, Opoczno, Końskie, Stąporków and Skarżysko-Kamienna within the range of Line No. 25. The townships located on the route can be both generators of journeys between one another or to the largest centres in the discussed area. This area is not economically coherent, nevertheless it remains quite well integrated internally, and identifiable sub-areas with a characteristic economic structure disregard the existing administrative boundaries.

Historically, the Łódź agglomeration and Tomaszów Mazowiecki were light-industry centres, while towns such as Końskie, Stąporków and Skarżysko-Kamienna, together with Kielce, composed the Old Polish Industrial Region, the home of metallurgical and machine industries. Today, although the production structure has changed, the original industries are still present there.

Currently, a large part of the industrial activity in this area is based on the local raw material base. Substantial resources of high-quality clays have led to the development in the area of the Tomaszów, Opoczyński and Konecki counties, as well as in Kielce, of a cluster of construction and sanitary ceramics producers, representing the majority of domestic production. A re-

lated activity is the production of construction materials, especially cement, gypsum and gypsum boards, mainly in Kielce and its county, also based on local raw materials. In addition, in the area between Tomaszów and Opoczno, there are the largest domestic deposits of sand used for glass-making, worked by several mining plants, and supplied, among others to the glassworks in Sandomierz, by means of Line No. 25.

In addition to the traditional textile industry, the agglomeration of Łódź is today a major centre of other kinds of services and industrial production and processing, including from the so-called BPO (Business Process Outsourcing) sector, as well as comprehensive storage and logistics facilities. The urban complex of Kielce, on the other hand, is an area where the construction industry has developed – partly based on local production.

## 5. Identified lacks in the railway system – direct connection of Kielce with Końskie

### 5.1. Problem identification

The lack of a direct connection between Łódź and Kielce is a significant gap in the Central Poland railway network. In 2018, there was no direct passenger train between those neighbouring provincial cities, in spite of the short distance between them (130 km in a straight line). In the past, for short periods of time, trains travelled between those cities on circular routes: via Radom (230 km), via Opoczno – Skarżysko-Kamienna (187 km) and via Częstochowa (264 km).

Due to the construction of a new Czarnca – Włoszczowa Północna connecting curve, it may be possible to start the operation of direct connections from Łódź to Kielce with partial use of the CMK line, or via Tomaszów Mazowiecki – Idzikowice – Włoszczowa Północ – Czarnca (estimated distance of ca. 215 km), but this connection is not the shortest one and is also characterised with a certain peripherality in relation to the settlement belt between Łódź and Kielce (omission of the County town of Końskie) and the lack of perspectives for using those trains strictly for regional traffic. Such a connection should be mainly used for inter-regional traffic and the possible travel time from Łódź to Kielce is about 2 hours 10 minutes (shorter than by bus – the travel time from 2 hours 20 minutes to more than 3 hours), however, it should not be treated as the ultimate solution.

### 5.2. Proposed solution

The establishment of a Łódź – Kielce railway connection using the existing Line No. 25 and a new sec-



tion of the line, as proposed in the Study, would offer a journey time significantly shorter than the time of travel offered by the collective road transport. Travel time by train would also be significantly shorter and, above all, more predictable than in the case of road transport. It should be expected that an attractive transport offer would result not only in a modal change (i.e. some of the current passengers switching to trains), but also in a considerable increase in the total number of journeys related to economic activation.

The concept of a new connection between Łódź and Kielce assumes the use of Line No. 25 which would undergo comprehensive modernisation and the construction of a new section between this line and Line No. 8 Warsaw – Kielce – Cracow (Fig. 1). This section would connect the Końskie area (Line No. 25) and the neighbourhood of the Tumlin stop (on Line No. 8). In this way, a rail corridor from Łódź to Kielce would be created, running almost in a straight line (about 140 km). In addition, the following connecting curves are also proposed:

- Słomianka – Opoczno Południe (CMK line) allowing the travel time for the Poznań / Bydgoszcz – Łódź – Cracow trains to be shortened,
- Opoczno – CMK line, in order to create a direct, and shortest, rail connection from Kielce to Warsaw and the new Central Polish Airport (CPK).

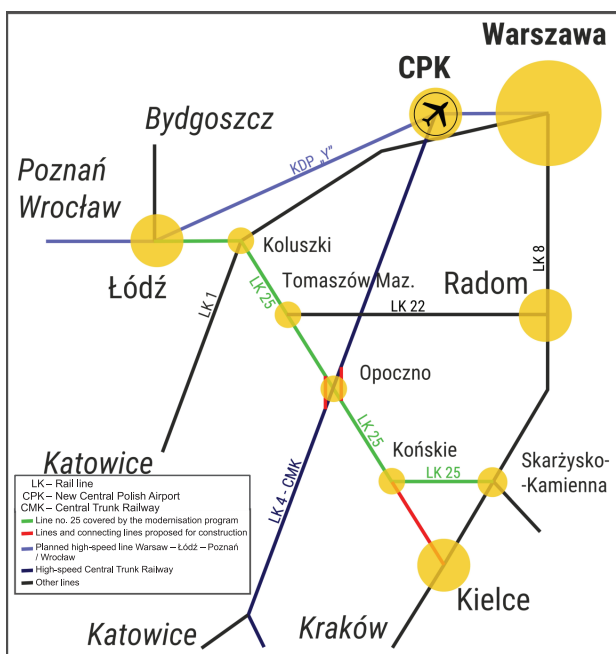


Fig. 1. Location drawing of the proposed new rail line [2, 7, 8]; [own work]

## 6. Project execution proposals

It is proposed that the implementation connected with establishing the new connection between Łódź and Kielce is divided into tasks related to the scope

and character of the work, possibilities that will be created by the modernising actions and the complexity of the investment tasks (Fig. 2, Table 1).

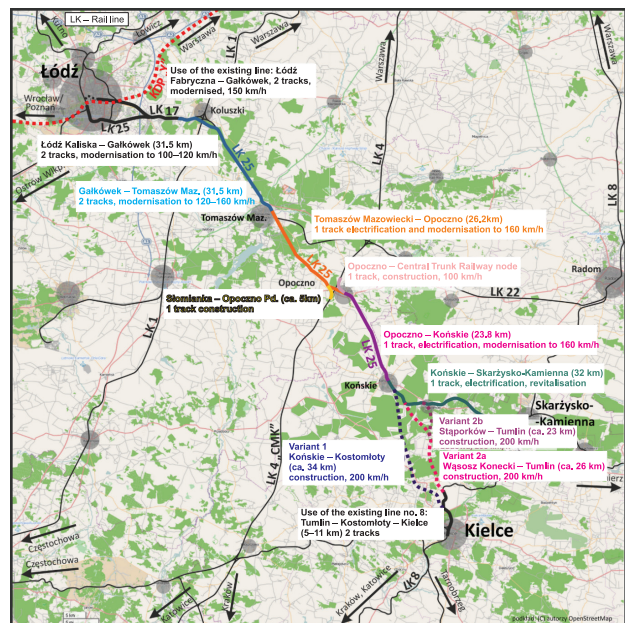


Fig. 2. Łódź – Kielce connection and extent of the proposed investments for individual sections [own work on the background of © OpenStreetMap]

### • Łódź – Gałkówek

This part of the connection between Łódź and Kielce is located in the territory of the Łódź agglomeration, with the freight and passenger traffic separated:

#### 1) Łódź Fabryczna – Gałkówek

At present, passenger train traffic operates in the Łódź Fabryczna – Gałkówek section by Line No. 17, modernised in the period 2006–2016 to the maximum speed of 150 km/h. In 2016, the Łódź Fabryczna station was built as a multi-modal hub for the Łódź agglomeration with the ultimate purpose to serve high-speed trains. In 2015, the Łódź Widzew train station was commissioned after a thorough modernisation. According to the plans, in the next years this line is to be additionally equipped with an ERTMS (ETCS level 2 and GSM-R) traffic control system.

#### 2) Łódź Kaliska – Gałkówek

This section mainly operates freight traffic and the agglomeration movement in the city of Łódź. On part of it, from the station of Łódź Chojny to Gałkówek, the technical condition of the line can be described as average and the maximum speed is 60–80 km/h. It is proposed that this section should be modernised / revitalised in order to increase the speed up to 100/120 km/h and to increase the maximum axle load to 221 kN (22.5 t). In order to eliminate transit trains travelling on diverging tracks of turnouts (speed limit of 40 km/h), it will be necessary to modify the eastern turnout head within the area of the Łódź Olechów station.

Table 1

## Summary of the scope of investments for the Łódź – Kielce / Skarżysko connection

Section	Length [km]	Scope of investment	Remarks
Łódź Fabryczna – Gałkówka	19.2	Not required	Executed under other programs in the period 2006-2016
Łódź Kaliska – Gałkówka	24.2	Modernisation / revitalisation of this section in order to increase its speed up to 100/120 km/h and to increase the maximum axle load to 22.5 t	Executed in the Łódź Kaliska – Łódź Chojny section
Gałkówka – Tomaszów Maz.	31.5	Modernisation, platforms, station layouts	Feasibility study completed in 2013 (under the high-speed line Wrocław / Poznań – Łódź – Warsaw)
Tomaszów Mazowiecki – Opoczno / Opoczno Południe	26.2	Modernisation, electrification, platforms, station layouts. Construction of Słomianka – Opoczno Płd. and Opoczno – CMK line connecting curves	Feasibility study completed in 2013, update for electrification (in progress)
Opoczno – Końskie	23.8	Revitalisation / modernisation and electrification	Feasibility study completed in 2015 together with an environmental decision (without electrification)
Końskie – Kielce	23–34	Construction of a new single-track and electrified line	No feasibility study
Końskie – Skarżysko	37.9	Revitalisation and electrification	No feasibility study

[Own work]

- **Gałkówka – Tomaszów Mazowiecki**

In the Gałkówka – Tomaszów Mazowiecki section (ca. 31.5 km), modernisation of the existing double-track line is desired, as well as its adaptation to the speed of 160 km/h for passenger trains. The modernisation should cover replacement of the surface and the overhead contact line. Locally, especially at the Kuluszki junction, a correction of the geometric layout of the route is advisable. A thorough reconstruction should be performed to the track layout of the Mikołajów station, with a change in the basic direction so that the directions of straight turnouts would incorporate the trains travelling from the direction of Łódź and Gałkówka, and the diverging tracks – those from Kuluszki and Słotwin. The infrastructure of the Mikołajów and Tomaszów Mazowiecki stations should be reconstructed. It is also necessary to make new platforms with a height of 760 mm above the rail head and the accompanying infrastructure at individual stations and passenger stops, taking into account the needs of the Łódź Agglomeration Railway and to improve the service of Tomaszów Mazowiecki.

Due to the growing traffic of passenger trains in the section from Łódź towards Tomaszów Mazowiecki, as well as the resultant bottleneck created when passing from Line No. 25 to Line No. 17 (with the intersection of its No. 1 track), it is advisable to build a collision-free connection of the two lines on the east side of the Gałkówka station (a connecting curve for trains from Tomaszów towards Łódź Fabryczna).

- **Tomaszów Mazowiecki – Opoczno**

The Tomaszów Mazowiecki section (ca. 26.2 km) requires adaptation to the speed of 160 km/h for

passenger trains. The modernisation should cover replacement of the surface and subgrade of the line along the entire section with local changes of the route geometry. The station's equipment, including platforms, would be modernised. This is the subject of a feasibility study carried out in 2013 and a supplementary study currently being carried out, whose main goal is the electrification of the line in this section [12]. The completion of the route modernisation is the construction of two connecting curves:

- 1) Słomianka – Opoczno Południowe (ca. 4 km),
- 2) CMK – Opoczno (ca. 4 km).

With the currently forecast traffic, there is no necessity at the current stage of construction to provide a second track in this section of the line, provided that the functions of the Jeleń and Bratków stations are maintained. It is also advisable to create an additional Słomianka station (at the branch of the connecting curve to the Opoczno Południe station at CMK).

- **Opoczno – Końskie**

Modernisation of the Opoczno – Końskie section (23.8 km) should cover electrification, remodeling the station units and station equipment, complex replacement of the surface with a possible partial strengthening of the subgrade and taking into account the local change in the route geometry, development of a traffic management system and securing passages at the track level (category B). After the modernisation, the line should allow passenger trains to travel at the speed of up to 160 km/h. In order to provide

appropriate passage capacity, it is necessary to reconstruct at least one passing tracks (Petrykozy station). A feasibility study was developed for this section in the past, however, it did not take electrification into account [13].

- **Construction of the Końskie – Kielce section**

Construction of a new line is proposed to incorporate the north of Kielce into Line No. 8, under one of the following alternatives:

- 1) Końskie – Kostomłoty (ca. 34 km), or
- 2) Wąsosz Konecki – Tumlin (ca. 23-26 km), alternatively with a route at the eastern side of Stąporków (with a station to serve the town).

At the first stage, the line may be single-track with the following parameters:

- 1) maximum speed for passenger trains: up to 200 km/h,
- 2) maximum speed for freight trains: 120 km/h.

- **Końskie – Skarżysko-Kamienna**

The line modernisation process should be completed with the electrification and revitalisation of the Końskie – Skarżysko-Kamienna section (ca. 37.9 km). This task will allow diesel traction to be eliminated and will connect the modernised sections from the side of the Łódź and Podkarpackie provinces, constituting a transportation passage included in the TEN-T. Revitalisation of the line should cover replacement of the surface and subgrade, modernisation of the track layout and station infrastructure, modernisation of the traffic management system and change in the category of train travel in order to provide the possibility of travelling at the speed of at least 120 km/h (desired 160 km/h).

- **Investment phase**

Bearing in mind the extensive nature of the entire investment and the necessity to meet the most urgent transportation needs in the shortest possible time, it is advisable to phase the investments. The completion date – taking into account the provisions below:

- necessity to finalise Stage II of the extension of Łódzka Kolej Aglomeracyjna and starting to serve Opoczno within the system,
- achieving full synergy effects from the modernisation of the TEN-T corridor from the Łódź node of TEN-T to east-western Poland (the investments from Skarżysko to the eastern border will be mostly completed by 2023),
- improvement of the link between Kielce and the new airport near Warsaw,
- inclusion of the Świętokrzyskie region into the Warsaw – Łódź – Poznań / Wrocław high-speed line should not be later than 2026 – which is viable, but requires the prompt commencement of work with regards to the feasibility studies that are missing at the current stage.

The investment priorities are as follows:

- 1) electrification of the Tomaszów Mazowiecki – Opoczno section
- 2) construction of a Słomianka – Opoczno Płd. connecting curve (CMK) to shorten the travel time for the Szczecin – Poznań/Bydgoszcz – Łódź – Cracow trains,
- 3) modernisation and electrification of the Opoczno – Skarżysko section,
- 4) construction of the line connecting Kielce with Końskie,
- 5) construction of a connecting curve from the station of Opoczno to the CMK line for the trains from Kielce towards Warsaw,
- 6) complex modernisation of the Tomaszów Mazowiecki – Opoczno section,
- 7) complex modernisation of the Gałkówek - Tomaszów Mazowiecki section,
- 8) modernisation/revitalisation of the Łódź Chojny – Gałkówek section.

It is roughly estimated that the cost of modernisation for the Tomaszów Mazowiecki – Skarżysko-Kamienna section is about PLN 650m, and for construction of a new line about PLN 900m. An appraisal of the modernisation of the remaining sections requires a detailed assessment of their condition.

## 7. Target technical standards for the modernised and new line

- **Line No. 25**

Due to the great importance of Line No. 25 as part of the domestic and trans-European network (TEN-T), and ensuring the full use of the line's transport potential, it is required to standardize the technical parameters along the entire length of the line. This applies to the parameters relevant to both passenger and freight traffic. After modernisation, the parameters should correspond to the line category for combined traffic [11]:

- 1) for passenger traffic:
  - line category P4 according to TSI INF (EU Reg. 1299/14),
  - maximum speed up to 160 km/h with the possibility to locally apply lower speeds in sections with unfavourable landscape conditions;
- 2) for freight traffic:
  - line category F1 according to TSI INF (EU Reg. 1299/14),
  - maximum speed up to 120 km/h with the possibility to locally apply lower speeds in sections with unfavourable landscape conditions,
  - admissible maximum axle load on track of 22.5 t,
  - station track length not shorter than 740 m.



It is proposed to maintain single-track sections of the line, at least during the first stage of modernisation while ensuring the appropriate number of stations for train crossings. An ERTM level 2 traffic control system is required.

- **A new line linking Końskie with Kielce**

For the new line connecting Końskie with Kielce, technical parameters are proposed that are compatible with the existing Line No. 25 with a proposed higher category for passenger traffic, allowing the trains to travel at the speed of at least 200 km/h with the 3 kV of direct current traction supply system:

- 1) for passenger traffic:
  - line category P2 according to TSI INF (EU Reg. 1299/14),
  - maximum speed of at least 200 km/h;
- 2) for freight traffic:
  - line category F1 according to TSI INF (EU Reg. 1299/14),
  - maximum speed up to 120 km/h,
  - admissible maximum axle load on track of 22.5 t,
  - station track length not shorter than 740 m.

On the entire length, the new line should have two-level intersections with roads. For the new line, a single-track layout is proposed with the possibility of extension in the future depending on traffic needs, with the construction of at least one station for train crossing as well as suitable stations connecting this line to Line No. 25 and Line No. 8. An ERTM level 2 traffic control system is required.

## 8. Identified costs and the possibility of phasing the investment

Due to the great importance of the analysed lines and their partial single-track layout, it is necessary to carry out modernisation works and to construct a new line at once in full extent, maintaining high quality of the works and applied technical solutions. A detailed cost estimate requires the development of an appropriate feasibility study. At the current stage, the initial cost estimate can be made using the index-comparison method in relation to other investments, assuming the following data:

- cost of the complex modernisation of 1 km of a single-track line with electrification – about PLN 8m,
- cost of the construction of 1 km of a single-track line with electrification – about PLN 30m.

That would translate into the modernisation cost of the Tomaszów Mazowiecki – Skarżysko Kamienna section of about PLN 650m, and of the construction of a new line about PLN 900m. Preparing a cost estimate

of modernisation for the remaining sections requires a more detailed assessment of their condition and it is estimated that the Gałkówka – Tomaszów Maz. section requires PLN 300m (about PLN 10m per 1 km), while the Łódź Chojny – Gałkówka section with the lower traffic parameters required – below PLN 100m (not more than PLN 5m per 1 km). The estimated value of the whole investment would amount to PLN 1,750m.

Part of these costs would be covered until 2023, under the decision of the Marshal's Office in Łódź on electrification of the Tomaszów Mazowiecki – Opoczno section, from the funds of the Łódź Province's Regional Operating Programme.

## 9. Role of the new connection between Łódź and Kielce in regional and inter-regional transport

### 9.1. Regional and agglomeration traffic

The new railway connection will operate within the historically formed settlement belt. Some relatively large county towns are located between Łódź and Kielce: Tomaszów Mazowiecki (population of 63k), Opoczno (22k) and Końskie (20k) as well as a smaller one – Stąporków (6k). The county towns mentioned above can also be significant multi-modal nodes generating passenger traffic:

- Tomaszów Mazowiecki, as a major road node with the S8 Expressway and a rail node to a smaller extent,
- Opoczno, as a road node with the No. 12 trunk road (S12 Expressway) and a potential major rail node on the CMK high-speed line after inclusion of Line No. 25 in it by means of the connecting curves,
- Końskie, as a node of provincial and county roads.

For this region, it will be possible to establish the courses of inter-regional trains:

- Łódź – Opoczno – Końskie – Kielce,
- Łódź – Końskie – Stąporków – Skarżysko-Kamienna – Starachowice – Ostrowiec Świętokrzyski.

After completion of electrification of the Tomaszów Mazowiecki – Opoczno line, the development plan of Łódzka Kolej Aglomeracyjna incorporates the opening of Łódź – Opoczno agglomeration connections.

### 9.2. Domestic traffic

Modernisation of Line No. 25 and construction of a section connecting it with Line No. 8 near Kielce can be the basis for starting new railway services. In particular, it will be possible to serve the following inter-regional trains:



- Kielce – Łódź – Poznań – Szczecin (high-speed trains),
- Kielce – Łódź – Toruń – Bydgoszcz – Trójmiasto,
- Kielce – Opoczno – CPK - Warsaw (high-speed trains; possibility to link with the Warsaw – Białystok or Warsaw – Olsztyn lines),
- Leszno – Ostrów – Łódź – Skarżysko-Kamienna – Rzeszów – Przemyśl.

The modernised line with a new section will also enable transit and destination freight connections to be opened.

### 9.3. Utilising the investment effects

Modernisation of the existing Line No. 25 and construction of a new section, as well as two connecting curves in the area of Opoczno will allow connections of varied types, relations and categories to be served, providing an economic basis for the operation of the line. The forecast use of the investment in its individual sections is presented in Figure 3.

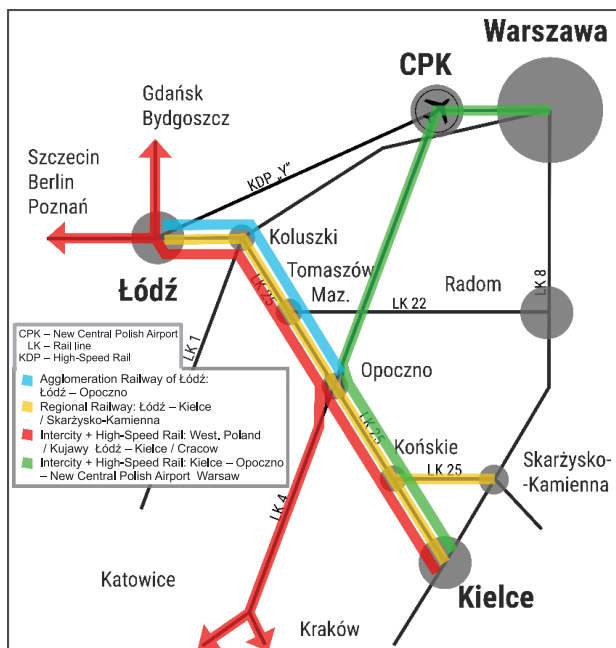


Fig. 3. Drawing of potential utilisation of Line No. 25 and related ones for all types of traffic [own work]

The presented concept assumes the direct inclusion of Kielce into the future high-speed railway system in Poland, by means of:

- Łódź to the Warsaw – Poznań / Wrocław line and further to Szczecin, Zielona Góra and to Berlin,
- Opoczno and Włoszczowa / Żeliszewice node to the Warsaw – Katowice / Cracow CMK line with international trains [2, 7, 8, 12].

## 10. TEN-T network and the target system of high-speed railways

The proposed new section of the line, together with the modernised Line No. 25, will contribute to the better inclusion of Kielce into the TEN-T network, while for Łódź they will result in better connection not only with Kielce, but also with south-eastern Poland. Pursuant to the EU Regulation No. 1315/2013, Line No. 25 in the Łódź – Sandomierz section, as well as the Sandomierz – Stalowa Wola Rozwadów and Stalowa Wola Rozwadów – Przeworsk sections have been included to the TEN-T network. Under the assumptions of this Regulation, the entire course of the line is to be a transportation axis for direct railway connections from that region, from south-eastern Poland and from Ukraine, via the Łódź node (also included in TEN-T) to western Poland (and further to western European countries), as well as to the seaports in Gdańsk and Gdynia. Two out of the eight main TEN-T European corridors run through the Łódź region, with the developing system of inter-modal terminals, among others, with the use of a new railway connection with China [9, 10].

In the Łódź Fabryczna – Opoczno section, Line No. 25 belongs to the basic network of TEN-T, while the remaining section which ends in Przeworsk belongs to the complex network of TEN-T. Line No. 8 from Warsaw via Kielce to Cracow also belongs to the complex network. Construction of a new section connecting Końskie with Kielce would allow for more intense use of the TEN-T impact on the development of both provinces. TEN-T also incorporates the following lines:

- Warsaw – Katowice / Cracow and the international extension from Katowice to Ostrava,
- the planned Warsaw – Łódź – Poznań / Wrocław high-speed line and its international extensions to Berlin and Prague,
- as well as the link between both mentioned lines: Łódź – Opoczno Południe.

The new connection of Kielce and Łódź with high technical parameters will allow the residents of Kielce to use the new Warsaw – Łódź – Poznań / Wrocław high-speed line. The travel time from Kielce to Wrocław and Poznań would be shortened to about 2.5 hours. After the construction of extensions of this line to Berlin and Prague, Kielce would gain the possibility of inclusion into the international network of high-speed railway connections. If the high-speed railway in Poland is further developed, Kielce would benefit from convenient and fast railway connections with Gdańsk and Szczecin. That would considerably enhance the economic and social development of Kielce.

The scheme of TEN-T in the Łódzkie and Świętokrzyskie provinces is presented in Figures 4 and 5.

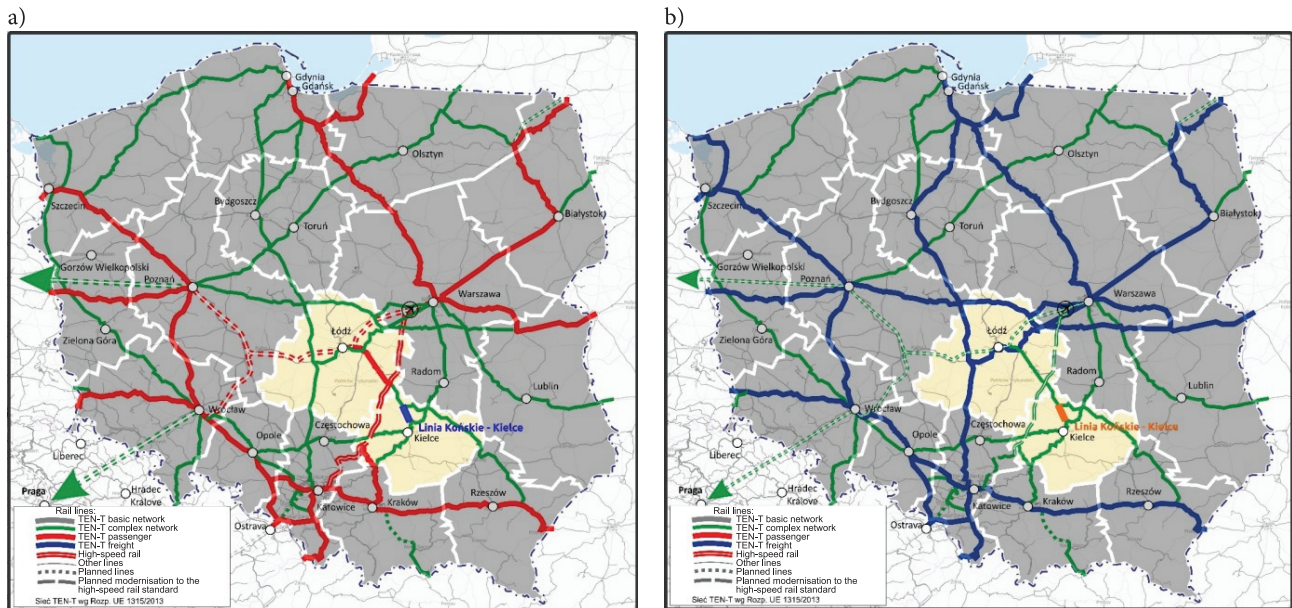


Fig. 4. Map of the TEN-T network in Poland [9, 10]: a) passenger, b) freight [own work on the background of © OpenStreetMap]

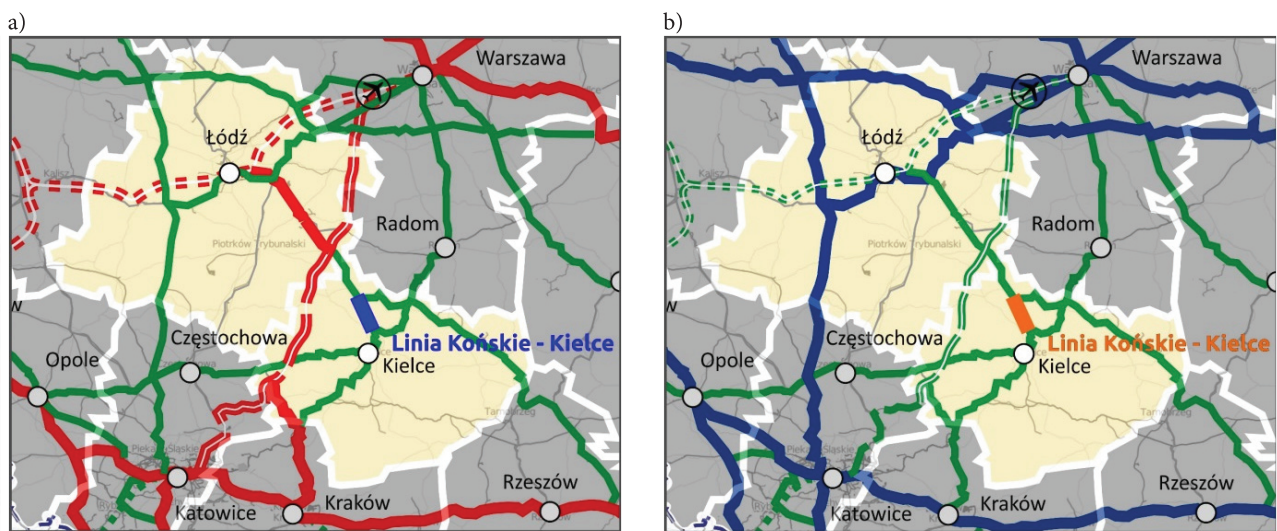


Fig. 5. Map of the TEN-T network in the Łódzkie and Świętokrzyskie Provinces [9, 10]: a) passenger, b) freight [own work on the background of © OpenStreetMap]

### 11. Local multi-modal nodes and their impact areas

Full use of the potential of the proposed connection will be possible when the multi-modal connections are also taken into account. Multi-modal travel will allow the extent of the line impact to be extended outside the traditional range of access to a station, hence to the inclusion of communal townships, bigger village-towns and tourist centres into the service by the line. Some of the multi-modal connections can be executed with the use of a car (own – park&ride, or using a lift – kiss&ride) where transport from as far as dozens of kilometres away is possible – in the case

of access to long-distance connections. Nevertheless, this mainly concerns occasional travel. For everyday travel, this distance will decrease with higher demand for the use of permanent bus connections.

It is assumed that the basic access lines to the connections with the use of the new line should allow access to the three major nodes on the route, i.e. Tomaszów Mazowiecki, Opoczno and Końskie (Fig. 6). Those towns will also offer the biggest number of connections as, in addition to the regional and agglomeration trains, they should also serve some long-distance relations.

In the case of Tomaszów Mazowiecki, transport will also be reasonable to the southbound connections and



those towards the south-east. It is proposed to use the S8 Expressway and provide transport from the townships with no railway connections – Rawa Mazowiecka and Wolbórz and the en-route towns. Because of the large population potential, the connection should be executed from Piotrków Trybunalski or Bełchatów. Moreover, transport towards Łódź should be provided from two major tourist centres – Inowłódz and Spała. For organisational reasons, the same line would provide transport to the node in Opoczno – chiefly serving the south-eastern directions, but potentially also transport to Warsaw and CPK.

towards the south and south-east, the hub would also serve Przysucha and Drzewica.

The possibility of using the connections operating along the Łódź – Kielce axis for multi-modal travel will serve to extend the impact and strengthen the role of railway in this corridor. In addition to the possibility of transport by car, the operation of bus connections can constitute an important factor providing the strength and social impact of the line, especially when taking into account the widely spread settlement development and the relatively modest network of towns and cities.

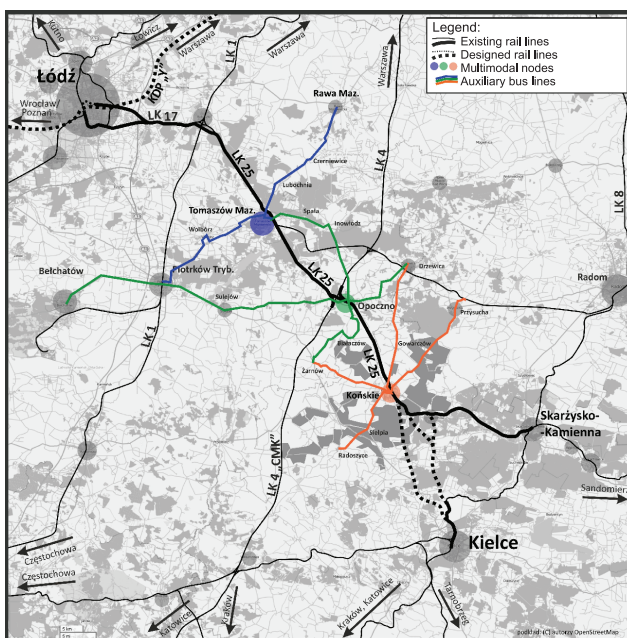


Fig. 6. Map of multi-modal connections in the local nodes: Tomaszów Mazowiecki, Opoczno and Końskie [own work on the background of © OpenStreetMap]

In the case of Opoczno, it is proposed to maintain the long-distance connection enabling transport from Sulejów, Piotrków and Bełchatów. In so far as passengers from Piotrków and Bełchatów are concerned, it will usually not serve everyday commuting, however, it may still be a rational offer for occasional travel to Kielce, Skarżysko-Kamienna, Starachowice, Ostrowiec, Sandomierz or Rzeszów. When travelling to Cracow and Warsaw, the passengers will use the hub in Piotrków. Transport to the connections at each of the levels, including agglomeration ones, should be provided from townships such as Żarnów or Białaczów. Transport from the area of Drzewica and Przysucha towards Łódź should be provided by the railway Line No. 22, while Opoczno can constitute a hub for transport to Warsaw and Cracow.

The Końskie hub should mainly serve local relations, including those covering Żarnów, Gowarczów or the tourist centre in Sielcia Wielka. For transport

## 12. Conclusions

Establishment of a fast railway connection between Kielce and Łódź is of critical significance for the development of both cities and macro regions. Currently, in spite of the natural factors generating increased traffic between the Łódź and Świętokrzyskie regions, the transport system linking them is poorly developed and is not favourable to the development of mutual economic links. The biggest discrepancy between the outlined role of the line and the settlement structure of the served areas is the historically conditioned lack of direct inclusion of the capital of the Świętokrzyskie region into the operation of Line No. 25. The resultant lack of direct connection from Kielce in the north-westerly direction deprives the capital city of the Świętokrzyskie region of good railway connections with Greater Poland, Kuyavia and the region of Łódź.

With the proper quality of the transport connections between both cities, the short distance will be in favour of an intensified commercial exchange and economic cooperation. It will also be the natural driving force to establish functional relationships between the provinces, benefiting from a wider economic basis and a more extensive availability of services.

The new railway connection between Łódź and Kielce can play the leading role in the connections of Greater Poland, Kuyavia and the Łódź region with the Świętokrzyskie region as well as the southern Lublin area and Sub-Carpathia. The Świętokrzyskie region can gain special benefits by obtaining good transportation connections not only with Łódź but also with western Poland and Pomerania. This relates both to passenger and freight transport. Improvement of transport links to the highly developed regions of western Poland and western Europe can create favourable conditions for the development of the entire Świętokrzyskie region.

The new connection would be essentially based on the existing Line No. 25, which is included as an element of the TEN-T network in the EU Regulation



No. 1315/2013 on the trans-European transportation network. In the Gałkówka – Skarżysko section, the line should be revitalised as soon as possible, and ultimately should be modernised. In the Mikołajów – Końskie section, it has convenient technical parameters which make it possible to adapt it to the speed of 160 km/h, by means of modernisation. The Końskie – Skarżysko section with slightly inferior technical parameters, running through a more difficult territory, can be adapted to the speed of 120 km/h.

## Literature

1. Analiza powiązań gospodarczych i transportowych Łodzi i Kielc w kontekście integracji węzłów TEN-T, Instytut Kolejnictwa, Warszawa, kwiecień 2018.
2. Baca B. et.al.: *Warunki realizacji przedsięwzięcia systemowego – Uruchomienie Centralnego Portu Komunikacyjnego wraz z towarzyszącą infrastrukturą biznesową*, Instytut Sobieskiego 2017.
3. Bużalek T., Raczyński J.: *Połączenie Łodzi i Kielc jako element krajowej sieci kolejowej – stan obecny i perspektywy rozwoju*, TTS Technika Transportu Szynowego, 09/2013.
4. Jerczyński M.: *Rys historyczny kształtowania się Łódzkiego Węzła Kolejowego* [w:] *Łódzki Węzeł Kolejowy – stan obecny i perspektywy rozwoju*, Instytut Kolejnictwa, Warszawa, 2016.
5. Kierunki rozwoju kolei dużych prędkości w Polsce, PKP PLK S.A., Warszawa 2011.
6. Kierunkowy program rozwoju kolei dużych prędkości w Polsce do roku 2040, Instytut Kolejnictwa, Warszawa 2010.
7. Pomykała A.: *Realizacja programu przygotowania i uruchomienia przewozów kolejami dużych prędkości*, TTS Technika Transportu Szynowego, 6/2017.
8. Pomykała A.: *Uwarunkowania obsługi Centralnego Portu Komunikacyjnego przez transport kolejowy*, TTS Technika Transportu Szynowego, 9/2017.
9. Rozporządzenie Parlamentu Europejskiego i Rady nr 1315/2013 z dnia 11 grudnia 2013 w sprawie unijnych wytycznych dotyczących rozwoju trans-europejskiej sieci transportowej, Dz.U. L 348 z 20.12.2013.
10. Rozporządzenie Parlamentu Europejskiego i Rady (UE) nr 1316/2013 z dnia 11 grudnia 2013 ustanawiające instrument „Łącząc Europę”, Dz.U. L 348 z dnia 20.12.2013.
11. Rozporządzenie Parlamentu Europejskiego i Rady (UE) nr 1299/2014 z dnia 18 listopada 2014 r. dotyczące technicznych specyfikacji interoperacyjności podsystemu „Infrastruktura” systemu kolei w Unii Europejskiej. Dz.U. L 356, z dnia 17.12.2014.
12. Studium wykonalności dla budowy linii kolejowej dużych prędkości „Warszawa – Łódź – Poznań / Wrocław”, IDOM, Warszawa 2013.
13. Studium wykonalności dla przystosowania Łódzkiego Węzła Kolejowego do obsługi kolei dużych prędkości oraz zapewnienia jego intermodalności z innymi środkami transportu, opracowane przez SENER na zlecenie PKP PLK S.A., 2013.