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Symbols and Codes Used in the Cartographic Documentation of Railway Areas

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Summary

The cartographic documents covering railway areas require additional specific cartographic symbols and codes because of the diversity of the existing railway infrastructure elements. Cartographic symbols represent objects featured in maps and schematic plans, according to their attribute characteristics and the scale of a given map. A cartographic code is a designation assigned to cartographic symbols featured in maps in scale ranges of 1:500 to 1:5000. The main purpose of the conducted study was to determine the extent of uniformity of cartographic symbols and codes used in railway areas in the light of the relevant applicable legal regulations, technical standards, industry-specific manuals, and the perception of space as presented in the cartographic documentation of railway areas. The condition of cartographic symbols and codes has been analysed, taking the characteristics of the target audience of cartographic documents as well as the intended use and content of such documents into consideration. The paper describes the patterns behind the processes of coding real elements of railway infrastructure in cartographic documents, and offers tables including findings of comparative analyses of cartographic symbols and codes according to the following requirements:

- GK-1 of the technical standard "Organisation and performance of measurements in railway land surveying",
- Regulation of the Minister of Administration and Digitization of 2 November 2015 on the topographic objects database and the principal map,
- Ig-10 (D-27) instruction on developing and updating schematic plans.

The conducted studies have revealed a lack of consistency and discrepancies among the cartographic symbols and codes used and adopted in railway areas. These symbols should be consistent and harmonised with other symbols and elements of cartographic documents in order to function as a harmonious whole. It has also been found that there are no definitions for characteristic cartographic symbols and codes found across railway infrastructure elements. The paper offers new original cartographic symbols and codes for those elements which have not been defined so far. New definitions cover: animal protection device and stabilised fixed points of reference for observing the areas susceptible to creep of rails in a continuous welded track. The findings of the conducted studies contribute to the subjects raised in the contemporary domain of civil engineering and railway transport. The article contains author's insights and conclusions. The paper has been developed as part of AGH's statutory research no. 11.11.150.005.

Keywords: cartographic symbol; cartographic code; graphic symbol; map; railway area, railway surveying

1. Introduction

The cartographic documents of railway areas should provide correct information in order to remain effective and serve the intended purpose as expected. Maps, schematic plans and railway area line profiles are an illustration of the reality. A significant issue here is the uniformity of the adopted cartographic symbols and codes. The cartographic documents of railway areas are a specific group of documents, requiring additional and distinct cartographic symbols and codes because of the diversity of the existing railway infrastructure elements. Their content transmits information describing the present reality. Art. 19, section 2 of the act of 17 May 1989 – Geodetic and Cartographic Law – [21] suggests that carrying out special-purpose land surveying and cartographic works for the needs of particular departments should

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be determined by the relevant ministers and heads of central units with the Surveyor General of Poland. This suggests a harmonisation of databases, which is to mean legal, technical, and organisational activities pursued to make these databases internally consistent and suitable to be used jointly and as a whole.

Railway surveying (railway land surveying) is governed by different standards, technical conditions, and instructions regarding the organisation and performance of measurements and drawing up land survey documentation on their basis. Cartographic documents describing railway areas, including: maps, schematic plans, longitudinal or pocket-version profiles, come with a variety of qualities characteristic of the land survey documents developed for such works.

A map can be misleading or useless if its audience – those who are to read it – are unable to read the graphic symbols featured and figure out their meaning. At the same time, the message conveyed by graphic symbols needs to be understandable intuitively and uniform with the provisions of the Geodetic and Cartographic Law act of 17 May 1989 [21], with the Regulation of the Minister of Administration and Digitization of 2 November 2015 on the topographic objects database and the principal map (hereinafter referred to as MAiC, after the Polish initials) [16], and with industry-specific instructions (internal regulations of PKP S.A. and PKP PLK S.A.), especially with the GK-1 technical standard [5], and with Ig-10 (D-27) instruction on developing and updating schematic plans [8]. Audiences well familiarised with maps take advantage of graphic symbols based on associations because the descriptions featured in maps are also their content. The size of object descriptions plays a significant part as well. Therefore, the textual layer of a description should be based on a clear visual relationship between the text and the object described, and indicate the location, e.g. near the object (railway turnout number, description of kilometre and hectometre marker posts) or on the object.

The purpose of the conducted study was to determine the extent of uniformity of symbols and codes featured in cartographic documentation in the light of the relevant applicable legal regulations, technical standards, industry-specific manuals, and the perception of space as presented in the cartographic documentation of railway areas. The discrepancies found in the applicable legal regulations have been addressed as well. The paper names the patterns behind the processes of coding real elements of railway infrastructure in cartographic documents, and present tables including the findings of comparative analyses of cartographic symbols and codes according to the following requirements:

- GK-1 of the "Organisation and performance of measurements in railway land surveying" technical standard [5],
- Regulation of the Minister of Administration and Digitization of 2 November 2015 on the topographic objects database and the principal map [16],
- Ig-10 (D-27) instruction on developing and updating schematic plans [8].

The article offers original observations and conclusions. The paper has been developed as part of AGH's statutory research no. 11.11.150.005.

2. Overview of selected published sources dealing with the subject of the study

Kuna and Rzuciło argue in [14] that, as the modern technologies of data transmission and collection develop, the amount of information that reaches us is increasing at a rapid rate. Much of this data is of a spatial nature, which means that it is possible to identify information on the surface of the Earth. The act on spatial information [23] defines spatial data as data referring directly or indirectly to a given location or geographic area. In [1], Bielecka stresses that spatial data includes the geometrical properties of a given object, its position in the adopted frame of reference, and the spatial relationships that may occur between such an object and other objects present in that space. Fiedukowicz et al. claim in [4] that the utility of cartographic maps as an effective means of communication of information depends on the selection of source data, image clarity, aesthetics, and the logic of the system of conventional symbols. They highlight the significance of applying rules concerning the nomenclature, the generalisation, and the symbolisation of the presented data at the stage of map development. They conclude that only a consistent structure of components may serve as grounds for further analysis. In [19], Stachoň et al. focus on the impact of the graphic design of cartographic symbols on their perception. Map symbols include both spatial and semantic information at the same time.

Designing symbols is a truly complex task and they should be understandable and differentiable. It is also necessary to minimise their size on maps in order to reduce the total amount of graphics featured in maps [20]. In [20], Staněk et al. claim that how quickly we understand information and the full view of a given situation are strictly correlated. A proper visual representation is more than helpful. The symbols in use should be simple in their appearance, closely linked to the significance of the message conveyed, and able to express the intended meaning. The authors refer to redundancy in the designed symbols. The ability of a mapped area to convey information is poor if such redundancy is excessive. Excessive redundancy, in turn, either reduces the communication-related properties of many attributes related to the function or increases the graphic overload, which makes the map illegible. A map's 'effectiveness' or utility does not exactly equal its quality. The problem with the quality of maps requires the quality of available data being taken into account, which goes beyond the purely cartographic part of the processing of maps [20]. Given the complexity of a map, a simple change in the design of one map symbol has a profound impact on the psychological effect of this map [20]. The uncertainty of studies on visualisations has been dealt with by the authors of [13], focusing on the issue of understanding and the application of maps with respect to perception.

Grzechnik argues in [6] that the legal status of railway lands needs to be regulated to a greater extent, which requires a relevant land survey documentation. His suggestion is that appropriate services should assess this status and develop a programme to sort it out. He also stresses that linear investment projects are preceded by, among others, advance works including:

- a plan of the route (railway line) on an appropriate map,
- a map for design purposes,
- a map with a real estate subdivision project (a subdivision map),
- changes in the existing land development infrastructure (also on the map),
- an environmental impact report (with appropriate maps),
- a construction design (on a map).

Apart from the concept of the route of the linear investment project [6], which can be topographic map, other documents require valid large-scale maps, and the basis for their development is a registry of land and buildings.

Railway land surveying is also featured in the standards of the act of 17 May 1989 – Geodetic and Cartographic Law [21], in keeping with the characteristics of a restricted railway area [24]. In [24], Wardziak argues that the specificity of a restricted railway area (linear arrangement, equipment to control and manage railway traffic, and an exceptionally dense service infrastructure) means that carrying out works and locating new networks demands a particular care for the quality of land surveying documents. This imposes much stricter requirements compared to the "civil" domain of land surveying. He claims that the data collected in documentation centres is reference and base information for infrastructural projects whose planning and implementation depend much on the quality of, accessibility to, and 'updatability' of this data. At the same time, [24] points to the digitisation of the resource, which should make it possible to develop an object-oriented railway map according to the applicable regulations and the GK-1 railway standard, keep land survey records of service infrastructure, and manage the enquirers of the Railway Centres of Geodetic and Cartographic Documentation [in Polish: *Kolejowe Ośrodki Dokumentacji Geodezyjnych i Kartograficznych*, hereinafter referred to as KODGiK] with the use of IT tools. Another matter stressed is the introduction of a KODGiK system, referred to as the Special-Purpose Map of Railway Objects [in Polish: *Specjalistyczna Mapa Obiektów Kolejowych*, hereinafter referred to as SMOK], where the adopted software takes advantage of symbol libraries, which makes the featured objects the same for every area and user [24]. At the same time, according to [24], the solution features a dedicated model of Railway Land Surveying Object Database [in Polish: *Baza Danych Obiektów Geodezji Kolejowej*, hereinafter referred to as BDOGK], developed using the GK-1 technical standard [5] applied across the railway infrastructure.

In [15], Postaremczak raises the issue of object symbolisation featured in a promotional map by referring to the example of the urban space of the city of Poznan [in Polish: *Poznań*]. He finds that the main role of a cartographic concept is about presenting the content of a map in a way to make it a uniform whole and that all of the elements it intends to illustrate are clear and legible. Each element of a map needs to be analysed with a view to being combined with other components in terms of its likely effect on the audience of the map. The author of a map needs then to be fully aware of the intended purpose of the map [15]. He also stresses that defining the purpose and the audience is a factor determining the whole process of symbolisation because it will be subject to the former. The most important carrier of the message of a map is the system of cartographic symbols, often referred to as the language of a map. The system of cartographic symbols is an expression of a map's concept.

The conducted literature research has shown that there are no publications on the condition of uniformity of the symbols and codes of cartographic documents used across railway areas. The presented findings fill the gap in this area, contributing therefore to the improvement in the quality of cartographic documents.

The paper is a continuation of articles entitled "Opracowanie map do celów projektowych w aspekcie realizacji inwestycji" ["The preparation of maps to project aims in aspect of realization of investment"] [10] and "O geodezyjnej inwentaryzacji powykonawczej obiektu budowlanego" ["About as-built survey of a structure"] [3], offering more detailed insights and the addition of findings concerning the uniformity of cartographic symbols and codes in the light of the applicable regulations.

One of the papers [10] offers a suggestion concerning the adoption of "standardised graphic symbols required under internal (industry-specific) instructions" and that "it is necessary to aim at standardising the applicable regulations and their correct interpretation", which implied "developing a new instruction or updating instruction D-19 on the organisation and performance of measurements in railway land surveying [2], so that it becomes consistent with other instructions and technical conditions adopted in Poland and legal regulations of the European Union". New regulations resulting from the GK-1 technical standard [5], Ig-10 (D-27) instruction [8], and MAiC regulation [16] were developed, subject further to examination in the scope of correspondence of symbols and codes featured in cartographic documents of railway areas as covered in this publication. At the same time, [3] emphasises the lack of a uniform terminology in the applicable legal acts, an example of which is a technical report and as-built survey map (post-completion survey map).

3. Planimetric and contour map of a restricted area

The GK-1 technical standard "On the organisation and performance of measurements in railway land surveying" [5] involves land survey works carried out in a railway area, whose nature and method of performance differs from standard measurements performed in urban surveying. Visual cartographic variables in railway areas depend on the shape of a given object (Table 1). The crucial part of a proper survey document is the right interpretation of the sphere of works – the "railway area". In the light of the act of 28 March 2003 on railway transportation [22], a railway area is a piece of land demarcated by the borders of parcels, with a railway running through it, featuring buildings, built features, and equipment used to manage, maintain, use, and operate railway lines, and transport people and goods. According to Art. 4, section 2 of the act of 17 May 1989 – Geodetic and Cartographic Law [21], in the case of restricted areas there are separate maps including also a representation of the network of buried service infrastructure developed instead of a principal map (basic map).

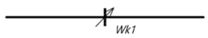
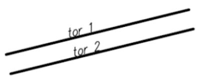
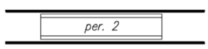
Therefore, developing and updating such maps and setting the borders of restricted areas is the responsibility of the relevant ministers and heads of central units. The relevant ministers and heads of central units notify the Surveyor General of Poland of the establishment of a restricted area and indicate the clause of confidentiality of information concerning the objects found in such an area, as covered in [11] and [12].

Restricted railway areas need to have planimetric and contour maps including a underground utilities and of the borders of parcels. Depending on the location, maps are developed [5]:

1. In the scale of 1:500 for railway station areas,

Table 1

Visual cartographic variables depending on the object shape

Object type	Real object	Visual (graphic) cartographic variable
Point		 Derailer (GK-1 code: WYK)
Linear		 Standard main track centre lines (GK-1 code: TNG)
Surface (delineation)		 One-side platform (GK-1 code: PRR)
Explanatory		The textual description *per. 2* is a label describing the object

Own elaboration (column 1, 2); own elaboration based on [5] (column 3).

2. In the scale of 1:500 or 1:1000 for railway routes,
3. New numerical surveys need to be developed with editing for the scale of 1:500.

A planimetric and contour map is a separate cartographic document, developed for restricted areas, with its content featuring elements of the principal map and railway infrastructure [5]. According to the act of 17 May 1989 – Geodetic and Cartographic Law [21], a principal map is a large-scale cartographic document including information about the spatial arrangement of: survey control points, record parcels, buildings, classification land, classification contours, utilities networks, buildings and construction equipment, and other topographic objects, as well as selected descriptive information concerning these objects.

According to recommendations under GK-1 [5], the content of a planimetric and contour map of restricted areas for general details is based on the provisions of the Minister of Internal Affairs and Administration's regulation of 9 November 2011 on the technical standards of the performance of topographic land surveys, and compiling and inputting the results of these measurements to the National Geodetic and Cartographic Resource (hereinafter referred to as MSWiA, after the Polish initials) [17], while in the content of railway technical equipment (underground utilities, buildings and built features, descriptions and labels) need to feature the catalogue of railway industry-specific symbols, provided as an appendix to the GK-1 standard [5].

An instance of the secondary legislation to the act of 17 May 1989 – Geodetic and Cartographic Law [21] is the Minister of Administration and Digitization's regulation of 2 November 2015 on the topographic objects database and the principal map [16], defining the procedure and the technical standards of developing the principal map in the following scales: 1:500, 1:1000, 1:2000, 1:5000. At the same time, appendix 7 to regulation [16] provides a list of cartographic symbols and codes for objects being the content of the principal map. The geometry of particular objects (line thickness, text size) depends on the scale of a given map, also including symbols intended for railway areas. The conducted studies concern cartographic documents developed in two scales: 1:500 and 1:1000, showing certain discrepancies. The differences in terms of uniformity can be seen mainly among point and linear objects (Table 2).

Base maps for design purposes (BMDPs) [in Polish: *MDCP*] are developed on the basis of data acquired from a Railway Centre of Geodetic and Cartographic Documentation, including planimetric and contour maps with underground utilities and direct topographic surveys and data obtained from a Poviat Centre of Geodetic and Cartographic Documentation [in Polish: *Powiatowy Ośrodek Dokumentacji Geodezyjnej i Kartograficznej*]. The content of a BMDP covering technical railway equipment is represented by industry-specific symbols included in appendix no. 5 to GK-1 [5]. A suggestion of the GK-1 standard [5] is to mark other objects presented in the documentation developed as a result of topographic land surveys using cartographic symbols, according to the Minister of Administration and Digitization's regulation of 12 February 2013 on the land survey records of service infrastructure, the topographic objects database, and the principal map [18], making reference to a regulation that is no longer valid. BMDPs may feature legends explaining the objects featured in their content and which are not described by symbols in [5] and [18].

4. Schematic plans

Schematic plans (schematics) illustrate the arrangement (layout) of railway situational details (detail point) and technical equipment using conventional symbols (markers, cartographic symbols, conventional symbols, industry-specific symbols, graphic symbols) included in appendix no. 8 to Ig-10 (D-27) [8]. Ig-10 (D-27) [8] suggests developing schematic plans on the basis of data taken from direct surveys, planimetric and contour maps, and longitudinal profiles of railway lines. Documents are developed based on the MAiC regulation [16], the MSWiA regulation [17], and GK-1 [5]. These differ and contradict each other in terms of the adopted cartographic symbols and codes (Table 2).

Schematic plans are developed in two scales:
1. Longitudinal scale (for track lengths) – 1:2000,
2. Horizontal scale (for track spacing) – 1:500,

In addition, a schematic plan in the following scales:
1. Longitudinal scale (for track lengths) – 1:4000,
2. Horizontal scale (for track spacing) – 1:1000,

can be applied upon prior approval of the Office for Railway Real Estate and Geodesy [in Polish: *Biuro Nieruchomości i Geodezji Kolejowej*] and of a locally competent Railway Track Development and Construction Unit [in Polish: *Zakład Linii Kolejowych*].

At the same time, the reference to appendix no. 8 of Ig-10 (D-27) [8], including a list of conventional symbols, does not offer their scales for the development of schematic plans in the correct scale range, nor does it feature the required codes. Ig-10 (D-27) [8] also makes it possible to develop schematic plans in a new – digital – version (apart from the basic analogue version), to be kept at the Module of Information System Documentation for Railway Lines [in Polish: *Moduł Dokumentacja Systemu Informacji dla Linii Kolejowych*], but it does not feature cartographic codes, and the codes provided under the MAiC regulation [16] and GK-1 [5] do not correspond to each other (Table 2).

Table 2

A comparative analysis of the cartographic symbols and codes provided in the GK-1 technical standard [5], the MAiC regulation [16], and the Ig-10 (D-27) technical instruction [8]

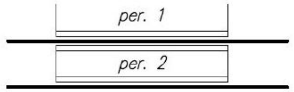
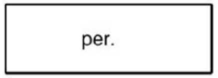
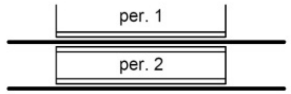
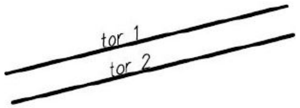
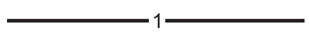
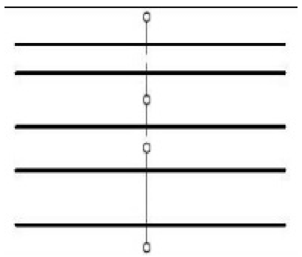
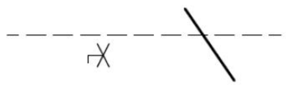
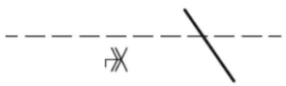
Symbol type	GK-1 [5]	GK-1 code	Line thickness / scale GK-1	MAiC reg. [16]	MAiC code	Line thickness / scale MAiC	Ig-10 (D-27) [8]	Code Ig-10 (D-27)	Line thickness / scale (Ig-10) (D-27)
1	2	3	4	5	6	7	8	9	10
platform	one-side platform  per. 1 per. 2 double-sided platform	PRR	0.18 / scale 1:500 0.18 / scale 1:1000	 per.	BUIB03_01	0.18 / scale 1:500 0.18 / scale 1:1000	one-side platform  per. 1 per. 2 double-sided platform	none	0.18 / none
railway track	 tor 1 tor 2 standard main track centre lines	TNG	0.5 /scale 1:500 0.5 / scale 1:1000		KTTR01	0.35 / scale 1:500 0.25 / scale 1:1000	 1 main track centre line on standard gauge and narrow gauge lines	none	0.5 / none
electric traction pole		STK	0.18 / scale 1:500 0.18 / scale 1:1000		SUSM07	0.18 / scale 1:500 0.18 / scale 1:1000	none	none	none / none
crossbuck on a single-track line	 notice: the base of the symbol attached with the left end of the line	KA1	0.18 / scale 1:500 0.18 / scale 1:1000	none	none	none / none	 notice: the base of the symbol attached in the middle of the line	none	0.18 / none
crossbuck on a multiple track line	 notice: the base of the symbol attached with the left end of the line	KA2	0.18 / scale 1:500 0.18 / scale 1:1000	none	none	none / none	 notice: the base of the symbol attached in the middle of the line	none	0.18 / none

Table 2 Cont.

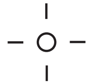
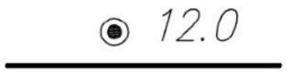
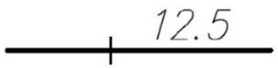
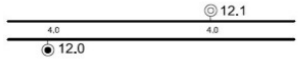
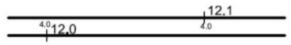
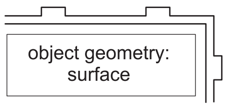
1	2	3	4	5	6	7	8	9	10
wind turbine	none	none	none / none	 notice: the base of the symbol attached with the left end of the line	SUSM10_01	0.18 / scale 1:500 0.18 / scale 1:1000	none	none	none / none
lamp post	none*	none*	none*/ none*		SUSM01	0.18 / scale 1:500 0.18 / scale 1:1000		none	0.18 / none
hydrant	none*	none*	none* / none*		SUUS02	0.18 / scale 1:500 0.18 / scale 1:1000		none	none / none
kilometre and hectometre marker post	 stabilised kilometre  stabilised hectometre  non-stabilised kilometre and hectometre	KMS HMS KHN	0.18 / scale 1:500 0.18 / scale 1:1000 0.18 / scale 1:500 0.18 / scale 1:1000 0.25 / scale 1:500 0.25 / scale 1:1000	none	none	none / none	 stabilised (single-track line)  stabilised (dual-track line with specification of the space between parallel tracks)  non-stabilised (single-track line)  non-stabilised (dual-track line with specification of the space between parallel tracks)	none	0.18 / none
fixed fencing	none*	none*	none* / none*	object geometry: line	KTOK05_01	0.35 / scale 1:500 0.25 / scale 1:1000		none	0.35 / none
fixed fencing	none*	none*	none* / none*	 object geometry: surface	KTOK05_02	0.18 / scale 1:500 0.18 / scale 1:1000		none	0.35 / none

Table 2 Cont.

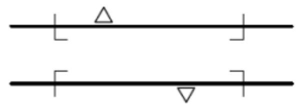
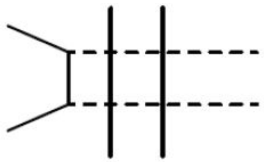
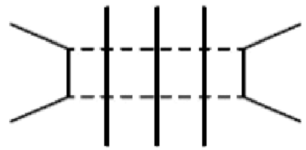
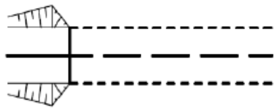
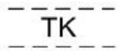
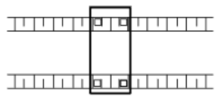
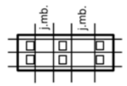
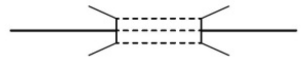
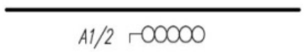
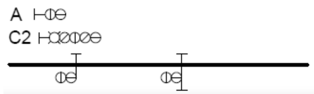
1	2	3	4	5	6	7	8	9	10
insulated track	 insulated track sections	SIZ	0.18 / scale 1:500 none / scale 1:1000	none	none	none / none	 insulated track section	none	none / none
passage under the tracks		PID	0.25 / scale 1:500 0.25 / scale 1:1000	none	none	none / none		none	0.18 / none
track below a civil engineering structure	 tunnel, overpass, viaduct	TOI	Thickness of the middle line corresponds to the thickness of track symbol. External line thickness – none / scale 1:500 External line thickness – none / scale 1:1000	 railway tunnel  overpass  viaduct	SUBP07 BUBI01 BUBI04	0.18 / scale 1:500 0.18 / scale 1:1000 0.35 / scale 1:500 0.25 / scale 1:1000 0.35 / scale 1:500 0.25 / scale 1:1000	 railway tunnel (railway line in a tunnel)	none	0.18 / none
light semaphore	 notice: the base of the symbol attached with the left end of the line	SMx	0.18 / scale 1:500 0.18 / scale 1:1000	none	none	none / none	 notice: the base of the symbol attached in the middle of the line	none	0.18 / none

Table 2 Cont.

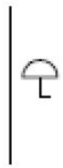
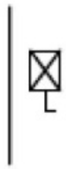
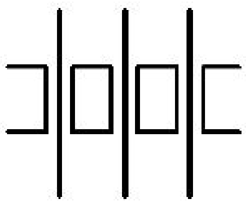
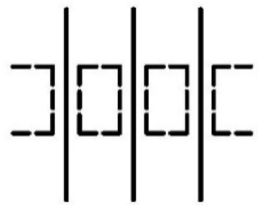
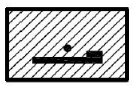
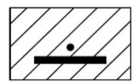
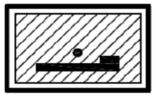
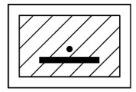
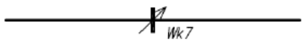
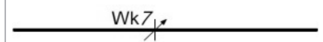
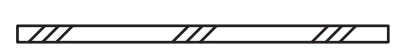
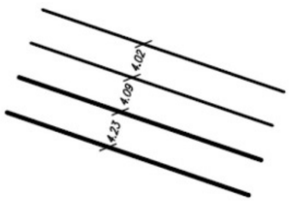
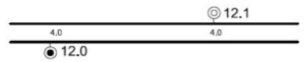
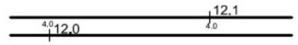
1	2	3	4	5	6	7	8	9	10
fouling point		UKR	0.18 / scale 1:500 0.18 / scale 1:1000	none	none	none / none		none	1.8 / none note: recom-mended 0.18
limit of shunt indicator	 notice: the base of the symbol attached with the left end of the line	WSR	0.18 / scale 1:500 0.18 / scale 1:1000	none	none	none / none	 notice: the base of the symbol attached in the middle of the line	none	0.18 / none
W-1 indicator	 notice: the base of the symbol attached with the left end of the line	WSB	0.18 / scale 1:500 0.18 / scale 1:1000	none	none	none / none	 notice: the base of the symbol attached in the middle of the line	none	0.18 / none
crossing the tracks in the level of rails		PIT	0.25 / scale 1:500 0.25 / (scale 1:1000	none	none	none / none		none	0.18 / none
mechanical interlocking station	 single-storey interlocking station	NAM	0.5 / scale 1:500 0.5 / scale 1:1000	none	none	none / none	 single-storey interlocking station	none	0.5 / none

Table 2 Cont.

1	2	3	4	5	6	7	8	9	10
mechanical interlocking station	 multi-storey interlocking station	NAM	0.18 int. / scale 1:500 0.5 ext. / scale 1:500 0.18 int. / scale 1:1000 0.5 ext. / scale 1:000	none	none	none / none	 multi-storey interlocking station	none	0.5 / none
derailer	 single  dual	WYK	0.18 / scale 1:500 0.18 / scale 1:1000	none	none	none / none	 single	none	0.5 / none
retaining wall	none*	none*	none* / none*	 object geometry: line  object geometry: surface	BUUD02_01 BUUD02_02	0.18 / scale 1:500 0.18 / scale 1:1000 0.18 / scale 1:500 0.18 / scale 1:1000		none	0.18 / none
space between parallel tracks, intertrack space (centre-to-centre spacing)		POD	0.18 / scale 1:500 none / scale 1:1000	none	none	none / none	 Width of the space between parallel tracks on the line with stabilised kilo- and hectometre markers  Width of the space between parallel tracks on the line with non-stabilised kilo- and hectometre markers	none	0.18 / none

Own elaboration based on [5, 8, 16]; where:

None – no symbols, no codes, no line thickness or scale value in MAiC [16], GK-1 [5] or Ig-10 (D-27) [8] respectively,

none* – apply symbols like in MAiC.

It is possible to develop plans based on data taken from planimetric and contour maps, whose content depends on, among others, the cartographic symbols and their scales adopted for maps in an appropriate scale range. A distinctive feature of schematic plans is their content, whose quality is significantly limited.

Figure 1 illustrates the inconsistency in the application of symbols representing elements of a railway crossing barrier. In terms of the cartographic symbol featured in Fig. 1a and 1c, developed on a print in a cartographic display room, the barrier is represented by a symbol of a railway crossing barrier. In Fig. 1b, in turn, it is represented by the wrong cartographic symbol because the symbol used denotes a catenary pole.

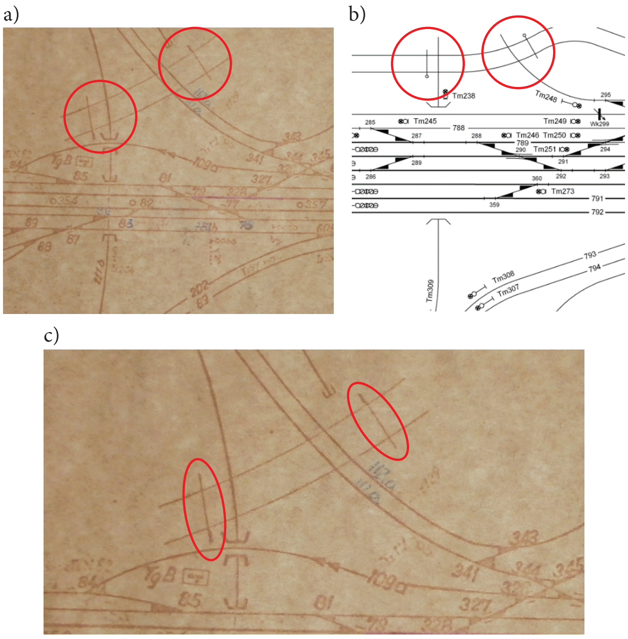


Fig. 1. Differences in the application of cartographic symbols of a schematic plan: a) a print in the display room of a land survey department [photography of authors], b) a computer-designed work; own elaboration based on [25], c) a zoomed version of the symbol of a railway crossing barrier [photography of authors]

5. Railway infrastructure elements as cartographic symbols

Many real railway infrastructure elements are represented in maps and schematic plans by means of “coding”. Both maps and schematic plans present the reality using a system of conventional symbols. The real, existing elements of railway infrastructure and other objects found in railway areas are converted into conceptual models and then featured in a map or schematic plan represented by a cartographic symbol.

The process of coding of infrastructural elements should maintain a logical order between the actual state, the conceptual state, and the graphic symbol used, to support the effect of the content of cartographic documents within the framework of the construction of transport infrastructure (Fig. 2 and 3). The outlines of the processes of coding the real elements of railway infrastructure in cartographic documents have been defined using the example of a regular electric turnout Rz S60 – 1:9 – 300 with textual information on the number of the turnout and its entry angle, and of an island platform with explanatory information *per. 2* acting as a label describing the object.

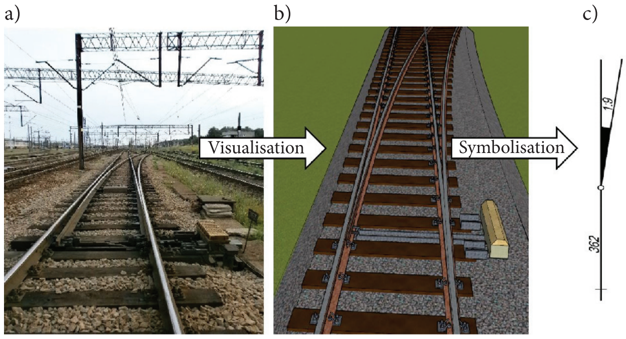


Fig. 2. The process of coding of a regular electric turnout Rz S60 – 1:9 – 300: a) real object [photography of authors], b) visualised model (concept) [drawing of authors], c) cartographic symbol, GK-1 code: RZE; own elaboration based on [5]

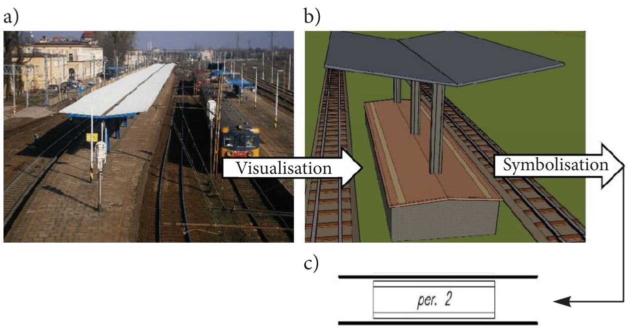


Fig. 3. The process of coding of the marking of an island platform: a) real object [photography of authors], b) visualised model (concept) [drawing of authors], c) cartographic symbol, GK-1 code: PRR; own elaboration based on [5]

In [14], it is stressed that the process of symbolisation involves the deprivation of an object of its individual qualities, but the advantage of this process is the option to offer a large amount of information on a relatively small surface.

A cartographic symbol is a graphic symbol representing the objects making up the content of the principal map, according to their attributes and map scale [16]. A cartographic code, in turn, is a designation assigned to cartographic symbols featured in maps in scale ranges of 1:500 to 1:5000 [16]. An important aspect of cartographic documents covering railway areas in the process of information exchange is their perception, meaning their audience’s ability to perceive, organise, and interpret the experienced sensory input in order to understand the mapped environment through the reception of the transmitted cartographic message. Kuna and Rzuciło argue in [14] that the effectiveness of the message transmitted by spatial information depends on three crucial aspects:

1. The subject of the map (the nature of the presented information).
2. The systematic correctness of the map (the type of the adopted methods of presentation).
3. The audience's ability to read the map.

The content of the cartographic documents covering railway areas is demanding, given the specificity of the content of the details of railway infrastructure elements, which requires specific knowledge of the audience of such documents.

Railway turnouts are a good example. The application of cartographic symbols and codes for turnouts depends on their type and sort, and on the type of the drive solution adopted: manual, mechanical or electric. Each of the said drive solutions can be differentiated from one another thanks to different elements of texture (pattern) filling between the main track direction and the branch-off track direction:

1. Manually set regular turnout – the texture filling element is diagonal lines running upwards from left to right. The cartographic symbol is interpreted as a manually operated turnout, where the coupling rod is set using a lever found next to the rail switch ("sphere").
2. Mechanically set regular turnout – the texture filling element is a diagonal grid. The cartographic symbol informs that the turnout features a mechanical (transmission) driving mechanism. Activated using a lever and a wire line shaft.
3. Electrically set regular turnout – the filling element is a black background. Interpreted as turnouts featuring an electric driving mechanism, activated by an electric motor switched on in the interlocking station (Fig. 2).

The information communicated by the content of maps and schematic plans should be clear, real, and legible.

6. Definition of new cartographic symbols in the development of railway infrastructure elements

The development of railway infrastructure breeds new elements thereof, which so far have not been featured in cartographic documents. The conducted studies have shown that the following have not been included in the existing documentation thus far:

- stabilised fixed points of reference for observing the areas susceptible to creep of rails in a continuous welded track – other than those placed on catenary poles (Fig. 4),
- animal protection devices (Fig. 5),

which play a significant part in the contemporary domain of civil engineering and rail-based transportation.

a) b) c)

Fig. 4. Stabilised fixed points of reference for observing the areas susceptible to creep of rails in a continuous welded track: a) fixed to a concrete post – rear view [photography of authors], b) fixed to a concrete post – front view. Markings according to Id-1 (D-1) [photography of authors], c) base point – a notch in the external surface of the railhead [photography of authors]

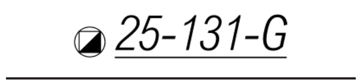
Fig. 5. Animal protection device [photography of authors]

A definition of cartographic symbols and codes for stabilised points of reference for observing the areas susceptible to creep of rails in a continuous welded track (Table 3) and for animal protection devices (Table 4) has been provided.

It is necessary to fix the number of the cartographic symbol for a stabilised fixed point of reference for observing the areas susceptible to creep of rails in a continuous welded track next to this symbol – with an underline (descriptive attribute), presented in Table 3 as 25-131-G (twenty fifth stabilised fixed point of reference for observing the areas susceptible to creep of rails in a continuous welded track, located on railway line no. 131 Chorzów Batory – Tczew, section G, i.e. Kalety – Kalina, from km 47.966÷67.099. The num-

Table 3

The cartographic symbol and code of a stabilised fixed point of reference for observing the areas susceptible to creep of rails in a continuous welded track

Stabilised fixed point of reference for observing the areas susceptible to creep of rails in a continuous welded track		**SPO**	
GEOMETRY: point			
DESCRIPTIVE ATTRIBUTES	NAME	PERMISSIBLE VALUES	
The number of the stabilised fixed point of reference for observing the areas susceptible to creep of rails in a continuous welded track	XXY	An alphanumeric sequence	
GRAPHIC REPRESENTATION	COMMENTS		
	The cartographic symbol is placed on a stabilised: post/pole, rebar, vertical rail, platform wall or on the piers of civil engineering structures. Does not apply to symbols placed on a catenary pole. Description of the point number parallel to the track.		
ELEMENTS OF GRAPHIC REPRESENTATION		SCALE RANGES	
ELEMENT	ELEMENTU DESCRIPTION	1:500	1:1000
	external line thickness internal line thickness a diameter	0.18 0.5 3.0	0.18 0.5 3.0
25-131-G	underlined text	1.8	1.8

[Own elaboration]

Table 4

Cartographic symbol and code of animal protection device

Animal protection device		**UOZ**	
GEOMETRY: point			
GRAPHIC REPRESENTATION	COMMENTS		
	The cartographic symbol placed parallel to the railway track. The object is found in the central part of the circle.		
ELEMENTS OF GRAPHIC REPRESENTATION		SCALE RANGES	
ELEMENT	ELEMENTU DESCRIPTION	1:500	1:1000
	line thickness a square side	0.5 3.0	0.5 3.0

[Own elaboration]

bering has been adapted to the "Register of lines" Id-12 (D-29) [7], according to the division into sections of lines managed by PKP PLK S.A. The numbering of stabilised points of reference on a given section needs to follow an increasing order with respect to the increasing chainage. The cartographic symbol of a point of reference for a continuous welded track includes points assigned to a stabilised: post/pole, rebar, vertical rail, platform wall or on the piers of civil engineering structures. The assigned cartographic code is SPO. Does not apply to symbols placed on a catenary pole. The description of the symbol is given in Table 3.

The cartographic code assigned to animal protection device is UOZ. The description of the symbol is given in Table 4. The cartographic symbol placed parallel to the railway track.

7. Conclusions

The current legal regulations governing the application of cartographic symbols and codes do not improve or accelerate the production cycle and the quality of the relevant works. They actually inhibit and limit the procedures involving land surveying activities performed as part of railway projects. This situation is well reflected in the safe maintenance of the infrastructure of railway areas during e.g. renovation works and the planning of such works (including measures taken to keep the infrastructure in good working order). The documentation drawn up by land surveyors, apart from the regulations provided in the act of 17 May 1989 – Geodetic and Cartographic Law [21] and secondary legislation, should be consistent and uniform across the technical standards and industry-specific instructions developed and published by PKP S.A. and PKP PLK S.A., especially when it comes to particular work types. At the same time, the content of instructions:

- Ig-10 (D-27) [8] stating that: "The internal regulation complies with the requirements defined in the act of 28 March 2003 on railway transport (uniform text in the Journal of Laws of 2015, item 1297 as amended) in the scope of assurance of railway traffic safety",
- Ir-3 [9] stating that: "The internal regulation complies with the requirements defined in the act of 28 March 2003 on railway transport (Journal of Laws of 2017, item 2117 as amended) in the scope of assurance of railway traffic safety" appears to be controversial.

The outcomes of land surveying works and the resulting documentation with cartographic input are the basis to provide information, analyse, design, and obtain administrative decisions and manage railway traffic in a safe manner. Any discrepancies, differences or other inconsistencies found in cartographic symbols and codes should be eliminated, which should translate into improved quality of the obtained information. Discrepancies in the domain of cartographic symbols and codes make it difficult to interpret the content of the available cartographic documents. The developed industry-specific instructions, standards, and technical conditions should be uniform and apply across the whole structure of the PKP group, which is, however, not the case.

The audience of cartographic documents covering railway areas should have their content at their disposal, and this content should be consistent, visually friendly, and effective in transmitting the intended message. But this is possible only when the featured cartographic symbols are uniform, thus guaranteeing that the message behind the cartographic information featured in the documents 'gets through' as intended. In [15], Postaremczak finds that cartographic symbols need not only be consistent in terms of their internal content, but also to harmonise with the remaining symbols and other elements of a map so that they offer a harmonious whole.

The provision of item 8, chapter 1 of GK-1 [5], according to which "the Contractor of land surveying works performed in a railway area is fully responsible for their quality" is debatable because the existing relevant regulations are not uniform or consistent.

The problem with cartographic marking also concerns the documents covering areas of narrow-gauge line railways, underground lines, and tram lines. There is currently a shortage of legal regulations addressing cartographic symbols and codes, which leads to a situation that the developed maps come to being on the basis of provisions applied in the sphere of railway areas.

The provision of the Ig-10 (D-27) instruction [8], §1, i.e. "This instruction determines a uniform manner of: 1) developing outlines; 2) updating outlines; 3) accountability of divisions/units for the development and updates of outlines" is inconsistent with its other provisions and against the requirements of GK-1 [5] and the MAiC regulation [16].

To improve the practice of application of cartographic symbols and codes in railway areas, it is necessary to adopt a "general-to-specific" rule, which will guarantee that cartographic documents are drawn up in line with the order adopted in the land surveying profession. But this may happen if the applied these symbols will not be divergent but consistent, especially when the content of railway cartographic documents is highly detailed and requires the application of industry-specific symbols provided by the internal regulations of PKP S.A.

Inconsistencies and differences in the procedure of developing schematic plans may lead to consequences, especially in the field of use and operation (the plans are appended to the sets of technical rules applied at interlocking signal towers) as well as maintenance and keeping station buildings, systems, and technical equipment in good condition (including in the area of winter maintenance). They can also affect the design of train timetables [in Polish: *Konstrukcja Rozkładu Jazdy*; the SKRJ system], the supervision of train traffic control (SEPE), and the development of microsimulation models of railway traffic.

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