7. Systems of product identification as the basis for IT systems

7.1. Division and typology of product identification

Identification, marking, coding of products, services, buildings and people are the basis for the IT system support.

When Poland regained independence after World War I, there existed a tremendous variety of typologies for objects, quality, terms (especially for material, technical equipment, uniforms, accommodation, etc.). This created the need to classify the inherited variety and therefore, to create conditions for proper management of the assets and capacities. The areas that needed standardizing were: organization, methods of training, command and control, orders, logistic documents and many other elements of the national economy as well as defense and security. The work concentrated especially on the administrative and organizational terms, the orders and professional terminology and standardization of material and technical equipment. The cooperation with scientific and technical institutions and the industry commenced. During that period, the armed forces (mainly in the area of material procurement) initiated cooperation with Polski Komitet Normalizacyjny (Polish Committee for Standardization) in 1924. They organized many areas important for defense and security: unified terms, orders, symbols, tactical terms, etc. started works on common rules of cooperation in the armed forces as well as national economy including home production of armor and equipment.

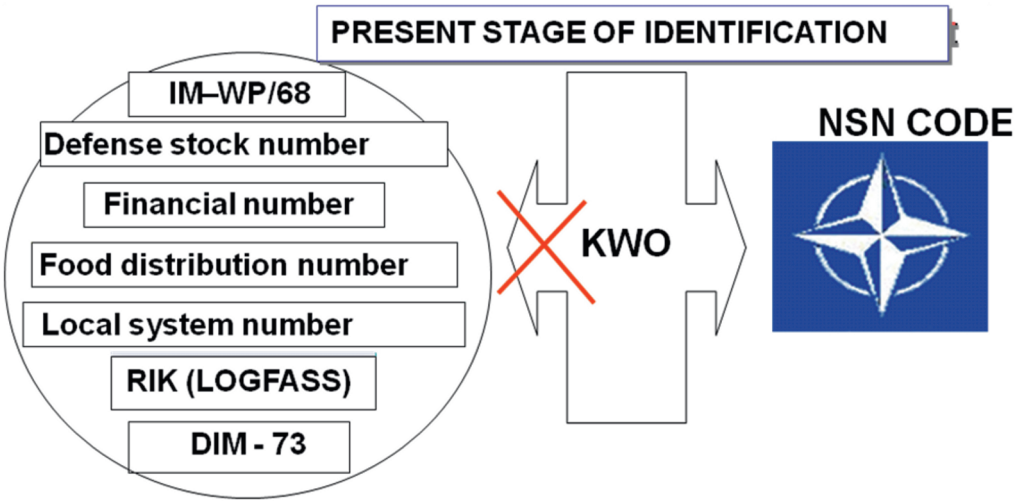
During the mid-war period, the technical advances brought new possibilities for the national economy, including production of special equipment for the defense and security. This influenced the quality of products. The main efforts focused on improvement of the organizational structures and standardization of documents. Considerable effects of the armed forces' work were the newly defined norms with identifiers of a given group of objects, its code, manufacturer's name and the information "for defense purposes". In the mid-war period, the armed forces elaborated standardization documents, so so-called technical criteria besides the military norms (PNW – Polskie Normy Wojskowe) and the industry standards (PN). To sum up, it can be stated that efforts of the army concentrated on organizing, standardizing and improving the management of assets and capacity. In spite of exceptionally difficult socio-economic conditions, the work was successfully completed. Until the break of WW II about 4000 Polish norms (and projects) were defined, including 1400 Polish Military Norms (PNW). The 1950' were the period of work on standardization of procedures for military requirements with national norms for production, usage and storage of the defense goods. Some efforts aimed also at standardization of the basic research methods, technical acceptance, quality requirements, reliability, classification and terminology. Starting production of armor and specialized military equipment (under licenses granted by the USSR and Czechoslovakia) was the priority.

In 1958, following the proposal by the Ministry of National Defense (MON), the Prime Minister authorized Polish Committee for Standardization (PKN) to unify national norms for armor and technical equipment for defense and security. As a consequence, PKN issued the catalogue of bridging tables (TP) which were immediately adapted in the industry and facilitated authorization in companies. The catalogue included 600 entries. The bridging tables included also regulations regarding the valid, updated and developed national requirements of ISO norms.

In the 1960's military standardization included special purpose armor and products for the Polish Army. Mały Indeks Materiałowy (MIN, note: Small Stock Number) with basic entries was issued. In 1965 Duży Index Materiałowy (DIM, note Extended Stock Number), an extended version of Mały Indeks Materiałowy included also the defense products. During that period symbols were used for about 8000 entries. A great number of products purchased by the armed forces (approx. 80% of the national production) was the reason why representatives of the Ministry of National Defense (MON) participated in the development of the universal, national System Wykazu Wyrobów (note: the National System of Defense Products Codification). The universal system of product coding was launched in 1965 and supervised by Główny Urząd Statystyczny (Central Statistical Office of Poland). The outcome of the civil-military cooperation was the method for including special resources into the national system of defense products codification. At that time the NIM and DIM were updated to describe the characteristics of the products for the armed forces and services. The works finished in 1968 with the issue of the updated Indeks Materiałowy – WP68 (note: Stock Number). It did not, however, replace NIM and DIM, but became a basis for further works on planning and procurement for the army. In the 1970's the emphasis was put on the international identification of products for export and for procurement of the armies of the Warsaw Pact and Jednolity Kod Materiałowy (JKM note: Universal Stock Number) was elaborated as the national system of defense products codification.

Till 1994 the codes were issued by Centralne Organy Zaopatrujące (COZ Central Authorities for Procurement). After restructurization and modernization of Polish Armed Forces this task was assigned to units in institutions responsible for procurement, (UiSW) arms and military equipment, (śbim) munitions and materials. Thus, there was no comprehensive standardization. Different military and local systems with different structures and range of information were used, e.g.: DIM-73, IM-WP/68, arms and military equipment list, munitions list, food lists, list in the accountancy department and others created for given branches or type of procurement. They had different hierarchical structure and were composed of 3-15 figures (Fig.22) which effected in the following:

- ♦ Multiplied identification of the same products with different symbols,
- ♦ Different products with the same symbol,
- ♦ No comprehensive database with universal stock number in IT systems.



Source: J. Kuck, *Nowoczesne technologie...*, cit.., p. 136.

Fig. 22. Present stage of identification

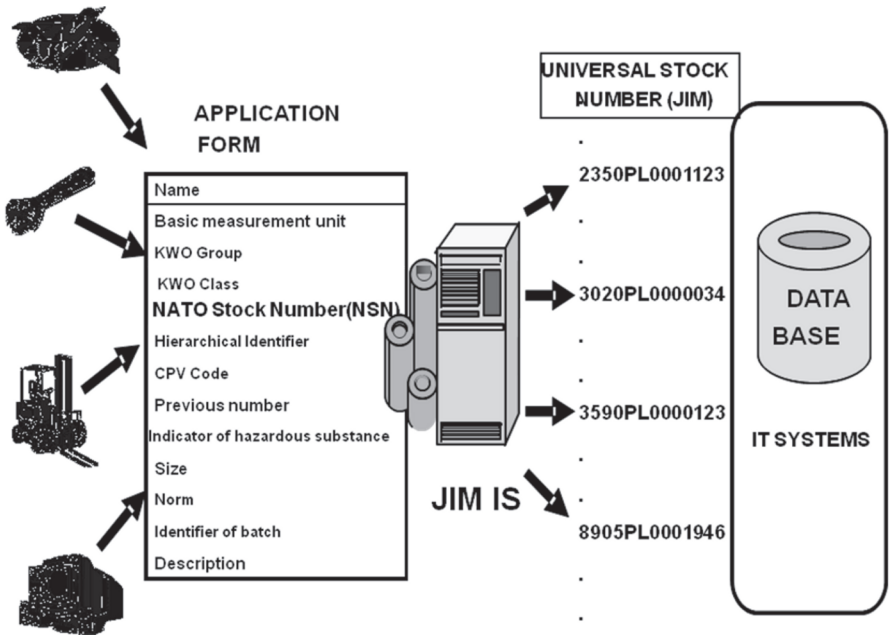
There was also no coordination of systems in the Police, the Border Guards, the Fire Service. Changing of status quo and introducing the universal stock number for all the institutions would facilitate effective performance, e.g.: fighting natural disasters. The solution would be the universl system of identification (Jednolity Indeks Materiałowy, Universal Stock Number) with Klasyfikator Wyrobów Obronnych[130] (KWO, Identifier for Defense Products).

Nowadays, there are various forms of identification in logistics[131]:

- ♦ Bar code,
- ♦ Radio Frequency Identification (RFID),
- ♦ Magnetic stripe,
- ♦ Optical Character Recognition (OCR),
- ♦ Vision systems,
- ♦ Voice solutions.

Identification and automatization systems in organizations, institutions and companies foster fluent and immediate collection of logistic data. Automatic identification is an element of modern management systems (MRP, MRPII, ERP) and helps to control the costs and to optimize processes of procurement, production, storage, distribution and transport. It streamlines also the Electronic Data Interchange (EDI)[132].

7.2. Legal grounds for product identification



Source: J. Kuck, *Nowoczesne technologie...*, cit., p. 136.

Fig. 23. Concept of product identification

130 Rozporządzenie Rady Ministrów z 29 stycznia 1999 r. w sprawie Klasyfikacji Wyrobów Obronnych
131 (KWO), DzU nr 26, poz. 231 ze zm.
132 M. Szymczak, *Automatyczna identyfikacja i kody kreskowe* [w:] E. Gołembska, *Kompendium wiedzy o lo-*
133 *gistyce*, PWN, Poznań 2001, p. 160.
E. Hałas (red.), *Kody kreskowe. Rodzaje. Standardy. Sprzęt. Zastosowania*, Instytut Logistyki i Magazynowania, Poznań 2000, pp. 11–12.
Gestor UiSW i śbim – a military institution in the Polish Armed Forces responsible for the directions of development, modernization and organization of processes of type (group) UiSW use and trainings.

In 2002 the General Board of Logistics – P4 together with UiSW and śbim gestors[133] commenced reorganization of the army assets with the use of IT solutions. Effective management of military assets depends on professional knowledge of the quantity, quality and value of the property. Unifiversal quality-quantity-value identification and material-financial planning based on the integrated IT systems needs **reliable system of identification and classification of all assets approved for use and on stock**. Implementation of this system (Fig.23) would foster proper operation of all systems: planning, inventory, reporting in the Ministry of Defense and eventually in the security services.

A solution that meets expectations would be Universal Stock Number (JIM) built and implemented pursuant to the Decision of MON No 255 MON/P4 of 10 September 2003 on implementation and application of the Universal Stock Number in the Ministry of National Defense and Decision No 69/MON of 19 February 2007 on implementation and the Universal Stock Number.

The basic goal of the system was to provide an efficient solution for universal and clear identification of defense products supported by SAP Platform R/3. Implementation of this system facilitated the collection of information about all assets used and planned to be used. It was assumed that the system would be a national source of information about the defense products available for all organizational units of MON, producers and suppliers and other business institutions.

It was expected that consistent implementation of JIM would considerably accelerate computerization (which will improve management of assets of MON) and implementation of the Integrated Multilevel IT System for Logistics, Finance and HR. This application shortened the circulation of sources information and decisions at all organizational levels. As the end-result it will be possible to provide:

♦ reliable information about all assets of the Ministry of National Defense, their quality, quantity and value in a real time;

♦ updating, complete and more reliable information for evaluation, planning and decision-making processes;

♦ safe electronic interchange of classified and disclosed information and reporting;

♦ tools for monitoring budget spending and unification of material-financial planning process;

♦ single, integrated quantity-quality-value inventory to monitor spending in logistics and finance;

♦ efficiency of logistics support in the transition period from the command and control system in time of peace to the one in time of war; mobilization and operational development of forces and operations abroad;

♦ complete inventory of defense assets and the data base for all IT systems supporting management;

♦ access to information about the created entries and codes for producers and suppliers and other business institutions pursuant to the policy of MON;

♦ interoperability between different terminology systems / standards bodies in a national economy, NATO and EU.

♦ The Central Data Base (CBD) about the assets, logistics resources, introducing bar codes and product tracing system.

After the implementation of JIM it will be also necessary for logistics to implement the coding system of NCS[134] for mutual understanding of NCS and other cataloguing systems of the member states. Complexity of the coding processes and variety of forces and means involved is the reason why at the very beginning of the enterprise two coding systems will be used independently within MON.

134 NCS – *NATO Codification System*

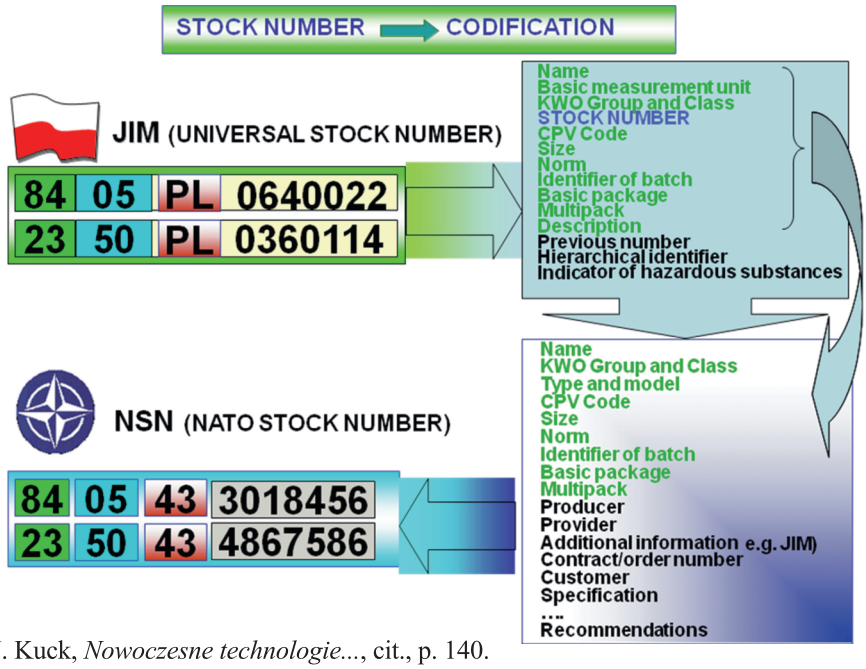
7.3. Characteristics of JIM (Universal Stock Number)

JIM created and developed by Inspektorat Wsparcia (note: the Inspectorate for Support of the Armed Forces) and administered by the IT Depatment will streamline the management of assets in the national system. Identification and classification with JIM will create the basis for quantity-quality-value inventory and necessary stock-record of defense products. After implementing the integrated, multilevel IT system with JIM it will be possible to identify those products which because of their *innovative support position* will be codified according to NCS in the first place.

Political-economic changes and reorganization of Polish Armed Forces created the necessity to adapt the coding system of NATO member-states in the MON in 1989. NATO Codification System (NCS) is a system for production logistics. The legal grounds for introducing it were: Standardization Agreements (STANAG): STANAG 3150 and 3151. These two documents were signed and came into force in NATO member-states on a voluntary basis and under their own responsibility. NCS is the system of identification and codification of defense products common to all NATO members.

Universal Codification System for Defense Products (Jednolity System Kodyfikacji Wyrobów Obronnych, JSKWO) is a comprehensive system of identification based on NATO Codification System.

Entering the NATO structures, Poland speeded the works on codification of defense products in MON and introduction of the Universal Codification System for Defense Products. This system is developed and implemented by the Military Centre for Standardization, Quality Assurance and Codification (Wojskowe Centrum Normalizacji, Jakości i Kodyfikacji, WCNJiK). WCNJiK acts as the **National Codification Bureau (NCB) of Poland**, identified as **NCB 43**). The center adapts procedures and regulations of NATO Codification System (NCS) to Polish conditions. The first stage was developing and introducing of the Classification of the Defense Products (the Regulation of the Council of Ministers of 29 January 1999, J.L.No26, p.231), based on classification of items in *Supply Classification Handbook* (ACodP-2).

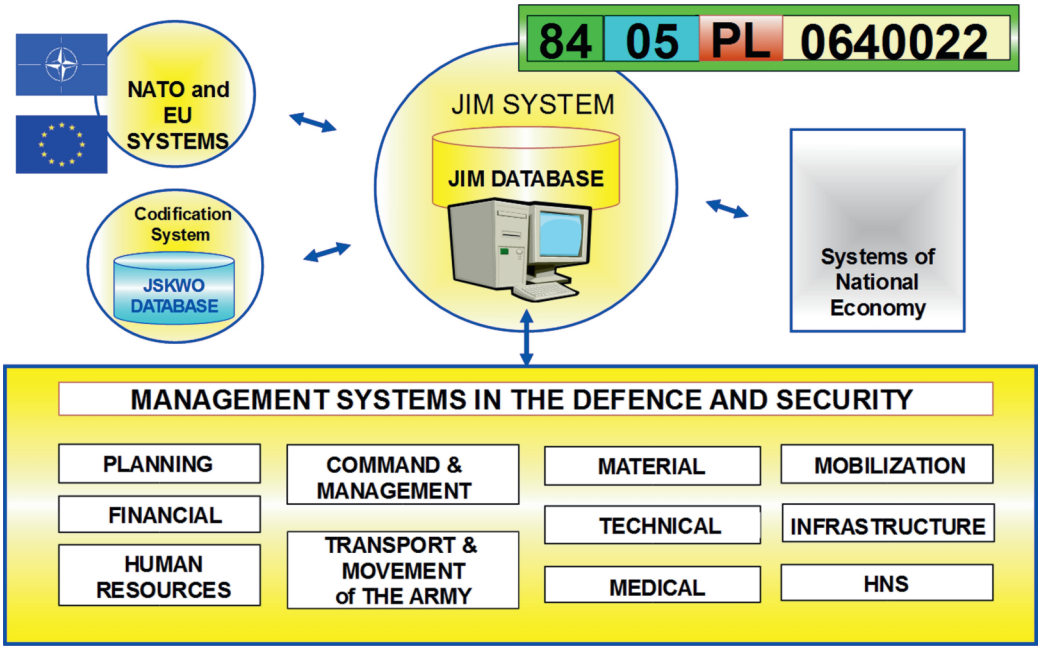


Source: J. Kuck, *Nowoczesne technologie...*, cit., p. 140.

Fig. 24. From Universal Stock Number to NCS

In order to coordinate works on identification and codification for Universal Stock Number system the items were coded according to NSN system (Fig.24).

At present the Universal Stock Number is the only complete source of information about the defense products. JIM Data base organizes, identifies and classifies products and at the same time serves as a platform which integrates all systems of managing the defense products. The internal and external (operating) environment of JIM system is presented in Fig. 25.



Source: A. Skierkowski, J. Kuck, W. Wiszniewski, *Identyfikacja wyrobów obronnych*, „Myśl Wojskowa" nr 2/2006, p. 103.

Fig. 25. Environment of Universal Stock Number System

The external environment of that system is the national industry using the sources of the JIM data base for selling, purchasing items for the army. Moreover, JIM can support the codification for NATO and EU systems.

If JIM system is introduced in other branches of the defense and security services (the Police, the Fire Service, the Border Guard, the Municipal Guard) it enables effective information exchange and sharing for common operations in time of natural disasters. Judging by experience and examples, the efficient performance of the services may save lives of many.

7.4. Organizational-functional structure of Universal Stock Number (JIM)

One of the basic principles for the concept of JIM is the coordinated cooperation of single system users. The users' roles in JIM system are defined by the functional structure of the following elements:

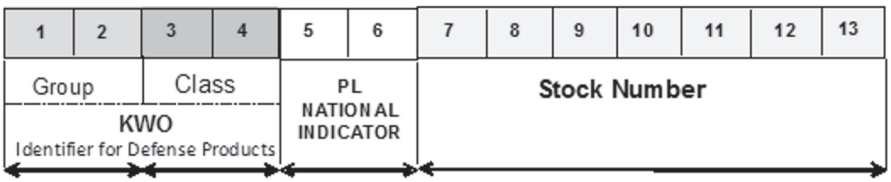
1) **The administrative and management bodies** are:
   a) Inspektorat Wsparcia Sił Zbrojnych (note: the Inspectorate for Support of the Armed Forces) which manages works on identification system and,
   b) Telecommunication and IT Department which administers the IT system for JIM IS.

The task of the administrative and management bodies are:
♦ appointing personnel responsible for IT operations,
♦ issuing single, unique identification number,
♦ managing database,
♦ approving applications,
♦ generating, maintaining and distributing,
♦ removing defined items from the central data base,
♦ staff training.

2) **The executive body** – gestor of UiSW and śbim identifies the needs for issuing JIM and manages data. The tasks are:
♦ Applying for JIM for (UiSW) arms and military equipment, (śbim) munitions and materials,
♦ Modifying data about items in the JIM central database,
♦ Applying for removal of items from JIM central database,
♦ Training JIM system users in the subordinate organizational units.

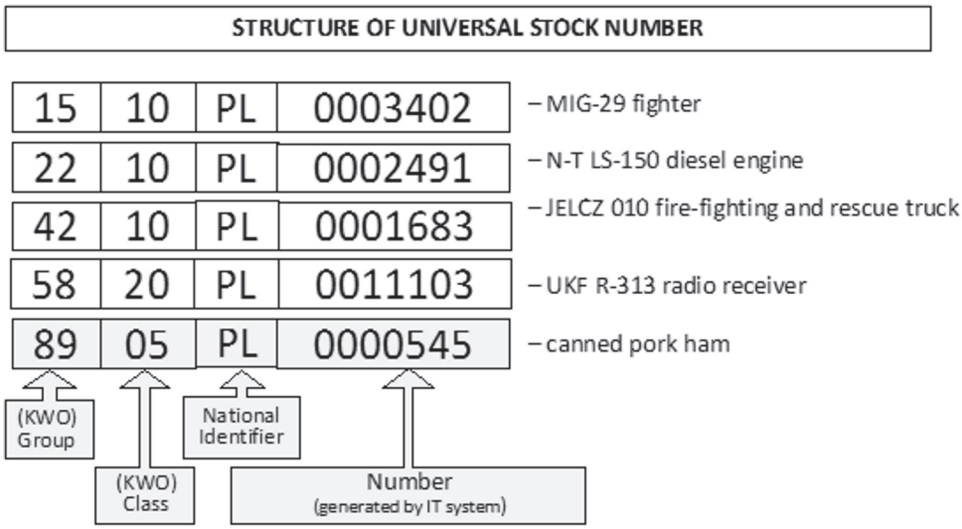
3) **The user (recipient)** – the Ministry of National Defense (MON) and the national industry using JIM pursuant to their legal rights and needs.

For the efficient JIM system it is important to provide the system users with equipment and software and connect them to MIL-WAN network. The JIM system classifies item names by group and class, under the provisions of the Regulation of the Council of Ministers of 29 January 1999 on the Classification of the Defense Products (KWO) and STANAG 3150 and 3151. The JIM system has a hierarchical 13-digit structure (Fig.26).



Source: J. Kuck, *Nowoczesne technologie...*, cit., p. 137.

Fig. 26. Structure of Universal Stock Number



Source: A. Skierkowski, J. Kuck, W. Wiszniewski, *Identyfikacja wyrobów...*, cit.., p. 100.

Fig. 27. Universal Stock Number for single products

Universal Stock Number of a single defense product is a sequence of 13 alphanumeric digits which uniquely identify a given product and differentiate it from all others. The Universal Stock Number for single products is presented in Figure 27.

7.5. Procedures for issuing Universal Stock Number

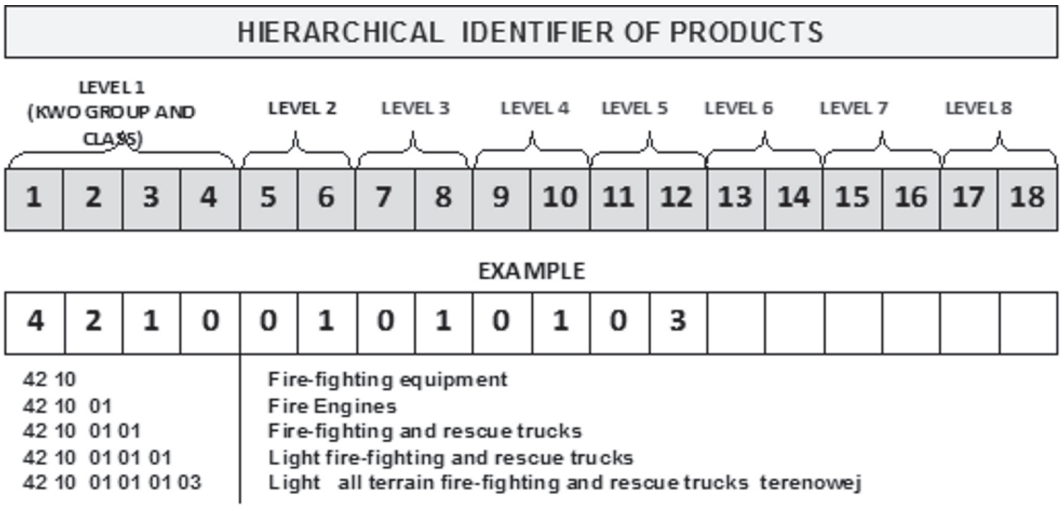
The procedures of issuing the Universal Stock Number are divided into three stages:

Stage I – after the gestor's application for Universal Stock Number is prepared, the product is identified on a structural level (in a vertical pattern) of the hierarchical identifier.

The hierarchical identifier is a method of grouping, formalized by a gestor, in order to:

- ♦ Define norms and payments due,
- ♦ Provide overall lists at different organizational levels of the Ministry of National Defense (MON),
- ♦ Prepare reports and analysis (data aggregation).

In the JIM IT system there are eight hierarchical levels (to 18 characters with 4-2-2-2-2-2-2-2 structure) which identify an item according to other gestor's demands. The exemplary classification is presented in Figure 28.



Source: A. Skierkowski, J. Kuck, W. Wiszniewski, *Identyfikacja wyrobów...*, cit., p. 106.

Fig. 28. Structure of Hierarchical Identifier – an example

The first level of the identifier refers to the group and class of KWO. The next levels include details of a given group of items. The Universal Stock Number works properly if it is assigned to the right node of the hierarchical identifier.

Stage II – identification of the item and preparation of the application for issuing JIM for the item by the executive body, i.e. gestor defines:

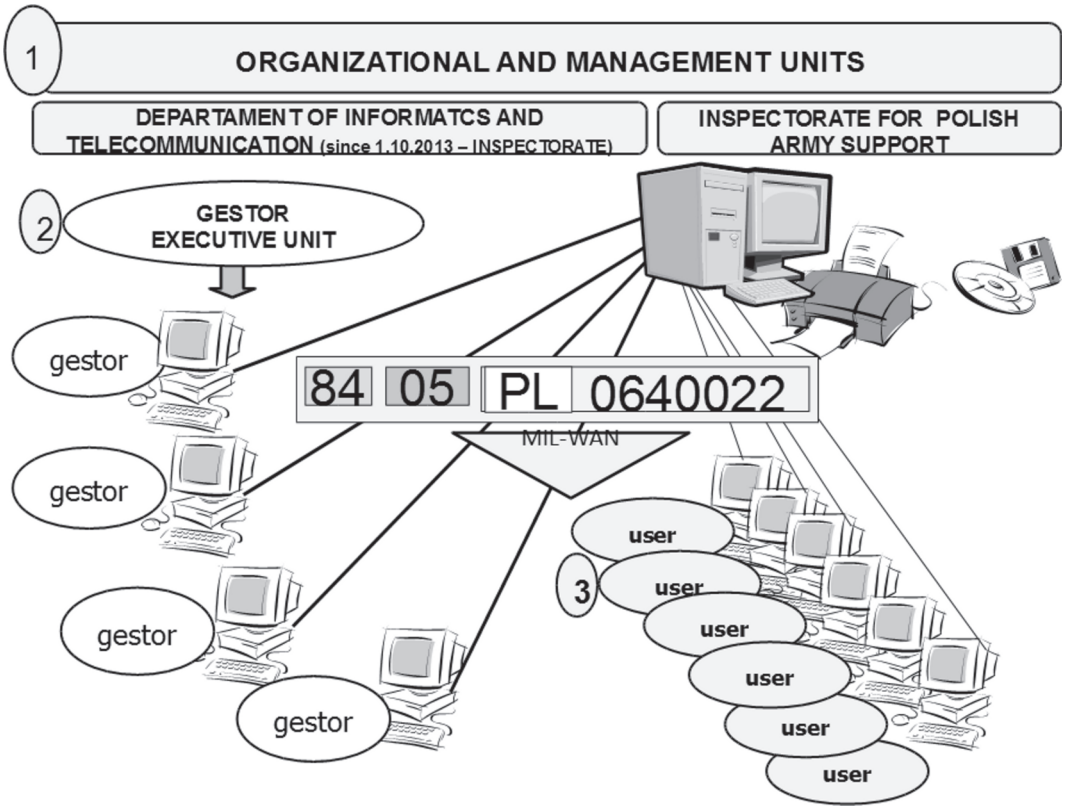
- ♦ item in a given group and class of KWO,
- ♦ name of the item,
- ♦ full name and other features of the item,
- ♦ basic measurement unit,
- ♦ supplier,

- ♦ hierarchical identifier (identifying the nod),
- ♦ classifier for a package,
- ♦ NSN if assigned,
- ♦ additional technical and functional parameters of the item (at the gestor's request):
  - – reference to another identification systems (current symbol/number),
  - – CPV code,
  - – Indicator of risk material,
  - – Exchange,
  - – Standards (international, European, Polish, defense, industry),
  - – Catalogue symbol,
  - – Package.

Stage III – issuing the JIM by the administrative and management body, i.e. Inspektorat Wsparcia Sił Zbrojnych involves:

- ♦ Registering the application,
- ♦ Verifying the description of the item,
- ♦ Issuing the JIM (by IT system),
- ♦ Entering new information to the JIM IS central database.

Activities at all stages are supported by the IT system of JIM. The applications use SAP platform R/3 which allows for distant generation and approval of the application for identification as well as distant access to JIM database. The JIM IT system is presented in Figure 29.



Source: J. Kuck, *Nowoczesne technologie...*, p. 147.

Fig. 29. JIM IT system

The basic and most popular form of distribution is by distant access to JIM database, administered by Telecommunication and IT Department. JIM IS database works according to the following principles:

♦ data about items previously prepared and verified by UiSW and śbim gestor are entered in real time (to extended MIL-Wan network),

♦ the data are verified and controlled by Ispektorat Wsparcia Sił Zbrojnych,

♦ JIM is distributed cyclically or on demand of Inspektorat Wsparcia Sił Zbrojnych.

JIM system provides effective access to information about items in JIM IS database for the authorized users. This solution facilitates:

♦ Traditional (paper)documentation with the content of JIM IS database,

♦ Electronic distribution of JIM IS database,

♦ Distant access to JIM data base in the MIL-WAN network.

7.6. Identification of products with bar codes

Standardization and automatization in every area are the factors which determine cost reduction. In the times of computerization and the attempted reduced performance time, a system of automatic identification becomes a standard. Automatic identification means identifying objects on the basis of information captured in the computer system by specialized electronic instruments (readers) and using the database information about these objects. For worldwide, automatic reading of the standardized symbols, a computer systems and the applications should use the Global System 1 bar codes which are currently the basic data carriers in logistics. GS1 is an international standard for identification of products in retail and wholesale circulation, logistics units, physical positioning, resources and services. It is the inter-branch and international system of unambiguous and automatic identification and electronic data exchange for the industry, trade, services and administration. Global System 1 (previously EAN International) is the world organization which controls this system. GS1 associates 150 countries and more than million companies use its solutions to complete 5 billion transactions a day. Used worldwide, the GS1 standards contribute to unification and standardization of logistics processes. The advantages of GS1 are:

♦ Worldwide, universal identifiers for transactional items,

♦ Worldwide, universal identifiers for entities,

♦ Worldwide, universal application identifiers (application IDs).

Implementation of bar codes streamlines the inventory, eliminates the amount of documents, improves and speeds up the customer service, automatically provides information about shortages in supplies, production and distribution. Bar codes have many advantages, e.g.: shorten time of operations, eliminate mistakes, losses of cargo, traditional documents, provide automatic documentation as well as analysis of inconsistency.

The first bar codes were designed in the 1940's. During that period the research aimed at automation of reading of information on goods with special symbols and signs. **J. Woodland and B. Silver** in the USA conducted the research, the outcome of which was the first bar code (called *bulls eye* for its looks of a shooting target). This code was composed of several concentric bright and dark rings of various thickness. Further studies carried out throughout the 1950's and 1960's resulted in developing a stock identification system, which uses special signs and symbols. Rapid development of hypermarkets (in the1960's) demanding comprehensive

customer service, forced American and Canadian manufacturers and tradesmen to establish an association which came into being in early 1970's. The association then developed some uniform rules for goods identification and created the UPC (*Universal Product Code*).

At the same time, trying to meet the retail market demands, the European countries introduced their own coding system, independent of the US. scheme. Benefits of bar codes for retail goods were appreciated also by other branches of industry. Bar codes were placed on multipacks, the production line elements, in libraries, archives, etc.

A bar code is a graphic representation of information presented as dark bars or stripes (partly narrow, partly wide) printed side-by-side so that they can be read quickly and accurately.

There are over 250 bar codes so there are also many typologies; bar codes can be divided by:

♦ **measurement**[135]:
- one-dimensional (linear, 1D) – information is coded in one line (generally as stripes/bars),
- multi-row barcodes also called 2D-Barcodes (two-dimensional barcodes) the characters are arranged row by row and continued in the following row,
- matrix two dimensional code is a way of representing information on a given surface with different designs, not bars,
- complex with one dimensional and two dimensional elements,
- three dimensional *Bumpy Bar Code* is any one dimension code. The difference, however, is in the depth of the embossed symbols which matters, instead of colors.

♦ **width of bars**:
- two-width,
- many-width (modular).

♦ **the type of characters coded**[136]:
- numeric only digits are coded in a decimal system,
- alphanumeric uses digits, special characters from other alphabet, and "full ASCII" mode.

♦ **continuity of the code (not applicable to matrix codes)**:
- continuous – with no inter-character space,
- discrete - individual characters are separated by inter-character spacing.

♦ **number of coded characters**:
- with strictly defined number of characters (fixed length),
- with varied number of characters (changeable length).

♦ **data verification method**:
- self-checking (all m z n type codes) – with built-in procedures of detecting errors, e.g. single characters are coded in a way to differ completely so that if misinterpreted the whole code is automatically faulty.
- with a check character (e.g. a digit),
- self-checking with additional check character.

Bar code can be read with different types of portable and stationary readers. Most popular are CCD and laser scanners which have proved to be reliable and easy to use units. They are generally compatible with stationary computers, tills and portable and network terminals.

135 J. Długosz, *Nowoczesne technologie...*, cit., pp. 80–81.
136 *Ibidem*, p.81.

A bar code reader consists of a light source and a light sensor. Bright surfaces reflect the light and the dark ones absorb it. The reader analyzes a bar code data and processes it into the coded information.

An indispensable element of every bar code system is the software. Only with a proper computer system, the bar code technology is really effective.

Source: http://www.megatanio24.pl/index.php?p1073,motorola-mc9500-k [15.01.2013].

Fig. 30. Barcodes readers

There are several bar code systems: **EAN/UPC (Fig.31), Codabar, ITF, Code 39, Code 128**. They differ in the arrangement of bars and possibilities of coding (digits, letters, number of characters) and are used in many areas: trade, industry, medicine, transport, etc. EAN/UPC system has been used in trading for 20 years and this code is still applied to streamline the retail and wholesale circulation.

Source: home.pl/kartyplastikowe/pliki/kody.htm [15.01.2013].

Fig. 31. Bar Codes: EAN -8, EAN -13, EAN-128

The type of code applied depends on the purpose and standards. One of the most popular applications is bar coding to identify goods in the retail and wholesale environment. The type and range of code is selected according to the rules for number, structure and quality parameters (accuracy, contrast of printing, location). These determine legibility of the code. One of the solutions in EAN (European Article Numbering)[137], which identifies items in retail and wholesale. This system is supervised, developed and distributed by EAN International (Global System 1). The objective was to introduce a single global, inter-branch system for identification and automatic transfer of data of products and services which would be based on the international trade standards. Since 1990, GS1 Polska (ILIM-Poznań) has been part of a system in EAN International. The EAN is a numeric only bar code system used for marking the retail goods. The EAN symbol has two basic formats, the 8 and 13 digit variants. They only identify products and information about the name or price which are issued from the database. Bar codes identify the products reliably and fast. System EAN offers also EAN-128 code (based on Code128) in which numbers are allocated to every individual retail product, not just by the product brand but by variation (production date, expiry date, address, serial number etc.). It is used for the dispatched goods as it is an international system and ensures that a given number is unique worldwide. The organization Global System 1 supervises issuance of numbers by national organizations. A manufacturer must register in a system in the national organization or its representative to mark his products with EAN code. There are two options of the code: the basic 13 –digit (EAN-13) and shortened 8- digit code (EAN-8) for small packages.

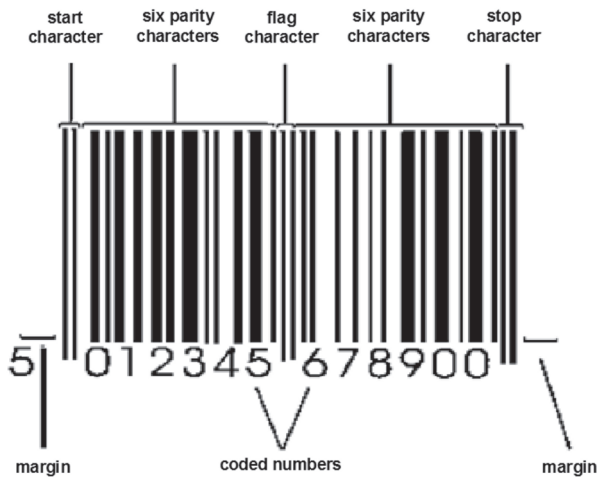
EAN-13 encodes 13 characters:

♦ the first two or three are a country code which identify the country in which the

♦ manufacturer is registered (not necessarily where the product is actually made). Joining EAN International, Poland was granted number 590, so the goods produced by manufacturers registered in Poland will be marked with the prefix 590,

♦ the country code is followed by 9 or 10 data digits (depending on the length of the country code) and a single digit checksum. Each country has a numbering authority which assigns manufacturer codes to companies within its jurisdiction,

♦ 2-digit and 5-digit supplemental barcodes may be added by the manufacturer and it is the number for the product line with the same name, price, weight, capacity, color, size, ingredients, etc. If another line differs in any of these features a new number is given. (If the price changes for the same product, it is not necessary to change the code for each item of a line as the price is entered in the shop and refers to a given number; there it can be easily changed).



Source: http://www.kartyplastikowe.cardco.home.pl/kartyplastikowe/pliki/kody.htm [dostęp: 15.01.2013]

Fig. 32. Structure of EAN-13 Code

137 *Ibidem*, p.78.

EAN-13 specification. Each EAN bar code character is composed of two bars and two spaces. The wide elements are multiples of the narrow elements. Wide elements are composed of one, two, three, or four narrow elements. An EAN 13 code consists of a start character, a flag character, the left side data field, the left bar character, the right side data field, the check digit and the stop character. The start character provides the bar code reader with the starting instructions. The left side data field consists of six odd and even parity characters. The odd parity characters consist of three or five bars while the even parity characters contain two or four bars. The flag character, a suppressed number system is implied by the sequence of odd and even parity characters. The left side odd parity characters are comprised of three or five bars. The even parity characters are comprised of two or four bars. The left bar is a special character used to separate the left side data field from the right side data field. The right side data field consists of six even parity characters. Unique bar patterns are used to distinguish the characters used in the right side from those used in the left side. The stop character marks the end of the symbol. The product code should identify a specific, unique item. If there are any changes the new code should be assigned. This rule applies to all manufacturers and implies keeping registers of the product numbers within companies.

EAN-8 specification. EAN-8, a shortened version of EAN-13, encodes 8 numeric digits consisting of two country code digits, five data digits and one check digit. Each bar code character comprises two bars and two spaces. The wide elements are integer multiples of the narrow elements, which means that one, two, three, or four narrow elements, taken together, create one wide element. There are a total of seven elements in each character.

EAN -8 code includes the start character, the left side data field, the center bar character, the right side data field, the check digit, the stop character, and the area surrounding the symbol (quiet zones). The start character (left guard bar) is used at the beginning of the symbol to provide the bar code reader with the starting instructions. The left side data field consists of four odd parity characters. Odd parity characters comprise three or five bars. The right side data field consists of four even parity characters. The check digit is the last character in the right side data field, and is used to check for an error in scanning or data entry[138].

The product code is assigned by the national organization and EAN-8 code is assigned only in well-grounded cases when EAN-13 code cannot be placed on the package. For example, publications are coded with EAN-13 symbol. A publisher registers a book in EAN system and then codes it with ISBN number. If the book does not have the ISBN number it is coded like any other product. The structure of EAN-13 code with ISBN number is as follows:

Prefix is the number 978 assigned for books by EAN International. ISBN (International Standard Book Number) is a unique number identifying the book and is granted by Krajowe Biuro ISBN headquartered in the National Library. The check digit verifies proper coding. It is counted according to a special algorithm of the digits in the code. It is also possible to adapt two- or five-digit "Add-on" to a bar code to include supplementary information, e.g.: marking the publishing format. The basic elements of the code are:

♦ Color of the background reflecting the light emitted by the reader,

♦ Patterns of bars with spaces between them, representing graphically the coded numbers,

♦ Coded number written in Arabic numbers – readable only for humans, a scanner does not recognize it.,

♦ Light margin indicator ">" on the right is not obligatory, yet it is necessary to mark the margin. The left margin is marked by the first digit,

♦ Light margin – a zone with defined space (the left margin is wider than the right one) in the color of the background without any graphic elements.

138 http://www.nationalbarcode.com/articles/ean8.htm [15.05.2014].

EAN codes can be of various size, however the smaller the code, the smaller acceptable deviation of the bar width and so the more accurate printing is needed. The code size is determined by magnification factors, SC symbol. The nominal value with the magnifying factor 1 (100%) is marked with the symbol SC2. The allowable limits are 80% to 200%. For each magnification there is a recommended (or nominal) height of the bars. Codes in size SC0 and SC1 should not be reduced in height. These figures are recommended to ensure symbol readability. Therefore any reduction in height (truncation) should only be applied if really indispensable.

While printing the bar codes it is the contrast between bars and the spaces (background) which is important. The bars should maximally absorb and a background reflect the red light (emitted by the scanner). A perfect match is the white background with black bars, yet another combination may prove effective. The width of the code is not the space from the first to the last bar but includes also margins in the color of the background. Generally they are marked by the beginning of the first left digit and the end of the last right sign. For the nominal value SC2 it is 4 mm on the left and 3 mm on the right. In this zone there should be no graphic elements. The space of 1 mm should also be kept at the top and bottom of the code. It is advisable to create a margin by 1 mm wider than required. A check digit detects errors in reading. It is counted according to a special algorithm for a given type of code.

A bar code, especially EAN-13, can be printed with a polygraph method directly on the packages. In the industry, warehouses or shops, most popular are professional thermal transfer printers that print on adhesive labels to mark ready products and goods. To streamline barcoding, pursuant to the agreement with suppliers of the 1st January, 2010, all market chains and retail outlets have been allowed to use codes of DataBar family (Fig.33): GS1DataBar Omnidirectional and GS1 DataBar Expanded Stacked.

Source: http://www.gs1pl.org/gs1-databar/rodzaje-kodow-gs1-databar [15.01.2013].

Fig. 33. GS1DataBar Family

This solution can be used interchangeably with the bar codes EAN-13, EAN-8, UPC-A and UPC-E. The smaller GS1 DataBar code includes only the product number – GTIN (Global Trade Item Number): 13 and 12-digit American number. These entities and companies whose equipment and software can process more information may apply two additional codes: GS1 DataBar Expanded and GS1 DataBar Expanded Stacked which code GTIN number and additional information in a form of one symbol, e.g. expiry date or net weight[139].

It is assumed that by 2014 GS1symbols and additional coding with GS1 system will have been introduced to the open supply chains. The analysis conducted so far by Global System 1 shows that most scanners produced during the past four years can read GS1DataBar Omnidirectional and GS1 DataBar Omnidirectional Stacked. Moreover, scanners produced seven years ago can be up-graded to read DataBar codes[140].

The new symbols in GS1 standards is Data Matrix of 2dimensional character that can be read by scanners or machine vision. DataBar Matrix can be used in[141]:

♦ direct coding of parts, e.g.: microcomputer coding on metal motor and aviation parts,

♦ medical instruments and implants,

♦ laser cutting and chemical etching of parts on low contrast surface or lightly coded elements on dark surface (e.g. electronic parts, medical instruments, implants),

♦ ink print with high speed on parts and elements where dot coding cannot be read by linear scanners,

♦ small elements which need square-shaped code and cannot be coded with smaller GS1 symbols and composite components (Fig 34).

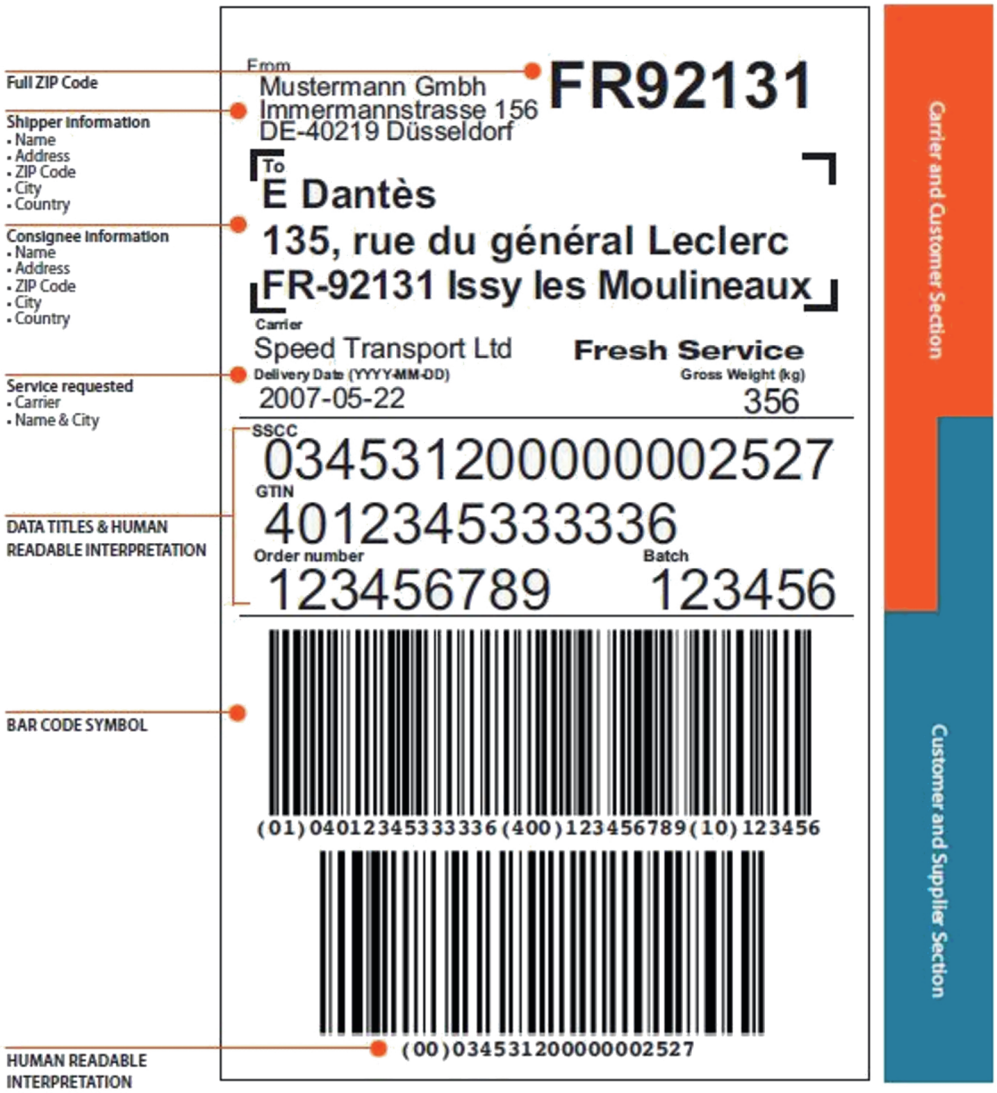
Source: http://www.gs1pl.org/gs1-datamatrix [15.01.2013].

Fig. 34. GS1 Code Family

139 http://www.gs1pl.org/gs1-databar [15.01.2013].
140 *Ibidem*.
141 *Ibidem*.

QR code is 2-dimensional and developed by Japanese motor industry. The pioneer was Denso Wave company which used QR code to trace a vehicle during the production process. QR code is used to[142]:

- ♦ code parts directly,
- ♦ replace general information with a globally unique reference number,
- ♦ trace goods using changeable data, e.g. series number, country of origin,
- ♦ manage dates, expiry dates,
- ♦ code data on a small printing surface,
- ♦ organize promotion and marketing by reading data from smartphones.



Source: http://www.gs1.eu/?page=&tudasbazis=60&lister=26 [15.05.2014].

Fig. 35. Logistic label

142 *Ibidem*.

The GS1 Composite Symbology combines a linear component, which encodes the item's primary data and an adjacent 2D composite component, which encodes supplementary data to the linear component. There are three types of composite components: A, B, and C which differ with coding patterns. The coding model was designed to optimize selection of the right code. The linear component is GS1-128, EAN-8, EAN-13, UPC-A, UPC-E or any barcode in the GS1 DataBar family. The supplementary, 2D composite component is one of the following:

♦ Composite Code A barcode, which is derived from the MicroPDF417 specification, for EAN-8, EAN-13, UPC-A, UPC-E, GS1 DataBar barcodes (can encode approximately 56 characters), or

♦ Composite Code B barcode, which is derived from the MicroPDF417 specification, with new procedures (can encode approximately 338 characters), or

♦ Composite Code C barcode, which is derived from the PDF417 specification with new procedures (can encode approximately 2361 characters).

Based upon the GS1 General Specifications, the GS1Logistic Label (Fig. 35) is a global standard for all participants in the supply chain. It allows for logistic traceability of the logistic units. The GS1 logistic label contains all information necessary for use while transporting goods from the pick-up location to the delivery point. There could be three label sections on a GS1 Logistic Label, holding certain pieces of information. These sections are: supplier, customer and carrier. Each section may have three blocks. Each block has a certain function. The lowest block contains the bar coded information with GS1-128 code, the middle block contains human readable information reflecting bar coded data (as a backup) and free text and the top block is used for logos, addresses etc[143].

7.7. The origin and functions of Radio Frequency Identification (RFID) technology

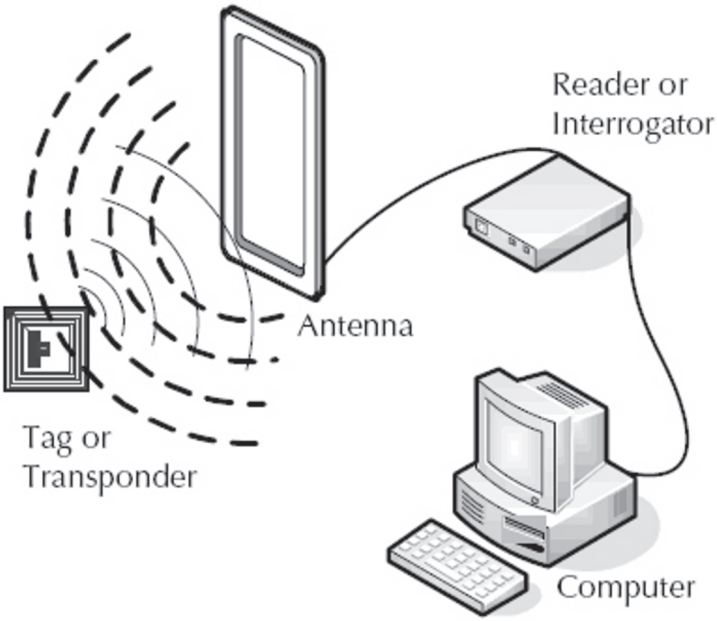
In spite of many advantages, bar codes show also numerous drawbacks, e.g. it is not possible to rewrite the information, the data are not durable and can be read only with a scanner/reader. The recent research and experience gained from the business market focus on the Radio Frequency Identification (RFID) technology as a platform to build and integrate the logistics system for tracing supply chains of resources, materials and finished products. At present, the products of RFID family allow to collect and manage data received from RFID sensors. These data are controlled and managed at the all stages of the supply chain: packing, repacking, storage, dispatch, receiving, tracking and control. ERP and SCM solutions available throughout the market, can use repository of the business knowledge to automate processes of inventory and delivery of products with the use of RFID technology.

The beginning of wireless identification dates back to the 1940's when the systems based on metal detectors appeared. The first shopguard systems using anti- theft security tags with a resonance circuit or a magnetic-acoustic piece of metal have been in use since the1960's. The first radio frequency identification was developed in the 1970's. The RFID is actually the system to control the product flow, based on distance reading and coding data with special electronic systems attached to the identified materials or goods.

Nowadays, the RFID technology is known and applied in different areas, yet at the beginning the use was limited because of high price of equipment. Advances in microelectronics and information technology as well as mass production of microchips reduced the costs. Thus, the RFID solutions started to be used for tracking goods in shops, to record work time, to control authorized access to rooms or for distance record of tolls. Such possibilities of the RFID contributed significantly to better flow of goods in companies.

143 http://www.gs1.eu/?page=&tudasbazis=60&lister=26 [15.05.2014].

There are two types of RFID tags (Fig. 36): passive and active (battery powered). A battery powered RFID tag is embedded with a small battery that powers the relay of information. The passive one can be 0.4X0.4 mm² so practically invisible. Tags can be of different shape, e.g.: badge, token or chip and usually made of thin paper or stick-on plastic.



Source: http://www.epc-rfid.info/rfid[15.05.2014].

Fig. 36. Concept of Radio Frequency Identification (RFID) system

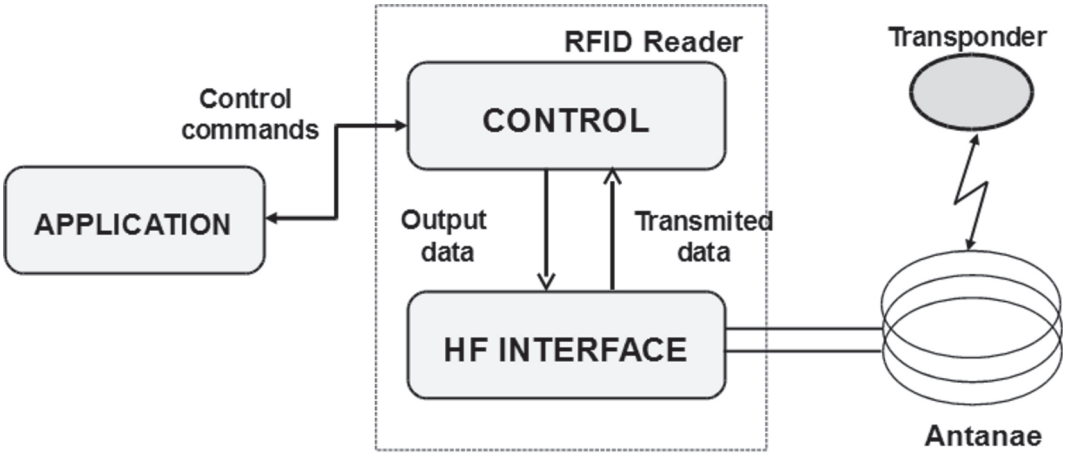
The Radio Frequency Identification (RFID) technology can replace traditional tags with a barcode as it has the following advantages[144]:

- ♦ a tag does not need to be within direct line-of-sight of the reader to be tracked,
- ♦ due to the free radio wave signal permeability the RFID label can be placed within an identified object,
- ♦ the antennae can read several labels within one cycle,
- ♦ the write on the label (depending on type) is not disposable and can be updated many times,
- ♦ high memory capacity (bigger than that of barcodes),
- ♦ the RFID labels (depending on type) do not need battery supply,
- ♦ the RFID labels work in a difficult environment, e.g. dirt, humidity, high and low temperatures, chemicals,
- ♦ faster, more efficient and flexible reading rate,
- ♦ enhanced security - every identifier is assigned the serial number which cannot be changed,
- ♦ compatible with different applications, e.g.: control of access, registering work time, traffic/ticket controlling systems, (sports centers, parking lots), production, storing, distributing and animal identification,

144 R. Hoffman, *Systemy identyfikacji wyrobów – infrastruktura informatyczna, uwzględniająca technologie*
145 *RFID w systemach logistycznych [w:] Perspektywy informatyzacji logistyki Wojska Polskiego*, Logis. Wewn. 4/2006, SG WP, Warszawa 2006, p. 103.
A. Kawa. *Elektroniczne metki w łańcuchach dostaw*, Magazyn, *Logistyka. Nowe inwestycje*, http://ceo.cxo.pl/artykuly/ 54954_2/Elektroniczne.metki.w.lancuchach.dostaw.html [dostęp: 10.10.2013] and „RFID - sposób na skuteczną kontrolę przepływu towarów w twojej firmie", E-letter, Wydawnictwa Wiedza i Praktyka, [01.02.2007].

♦ labels can be placed at any location, safe or hidden for their longer durability,
♦ reduces errors and workload[145].

Radio-Frequency Identification (RFID) is the use of radio waves to read and capture information stored on a tag attached to an object (Fig.37). To read the information encoded on a tag, a reader (two-way radio transmitter-receiver) emits a radio wave signal to the tag using an antenna. The tag responds with the information written in its memory bank. A passive RFID tag will use the interrogator's radio wave energy to relay its stored information back to the reader. The 125 kHz frequency is mostly used as it enables reading from the distance of 50 cm. More complex systems enables reading/writing within 1to several meters use 13.56 MHz frequency. The frequencies from 868 – 956 MHz, 2.4 MHz and 5.8 Mhz enables device working within 3-6 m.



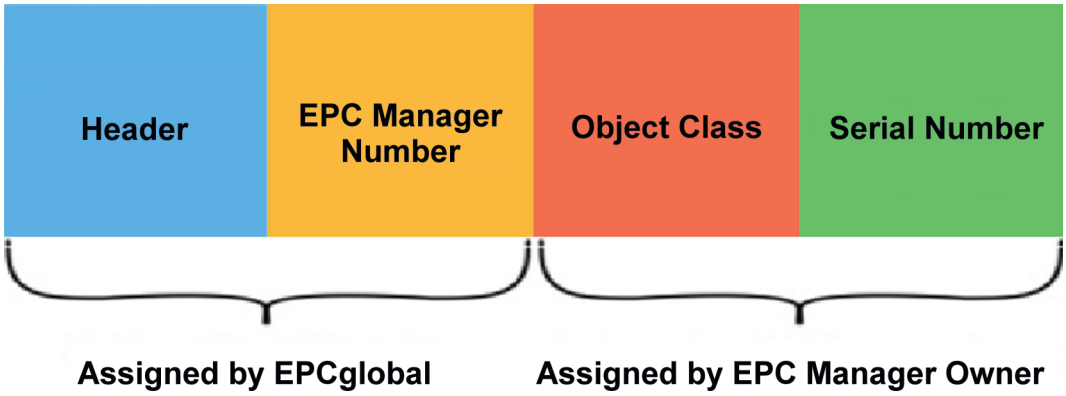
Source: K. Finkenzeller, *RFID Handbook: Fundamentals and Applications in Contactless Smart Cards and Identification*, John Wiley & Sons, 2nd ed., March 2003.

Fig. 37. Data flow in RFID system

An Electronic Product Code (EPC) is a universal latest generation identifier that gives a unique identity number to a specific physical object and all categories of physical objects in the world, for all time. EPCglobal, manages the application and standardization of EPC use. To ensure the best practices of EPC usage, EPCglobal devised the EPCglobal Architecture Framework (EPCAF), a collection of hardware, software, and data standards[146]. Much like a Global Trade Item Number (GTIN) or Vehicle Identification Number (VIN), GS1, EAN, UCC System Keys, UID the EPC is a part of the EPCglobal Network™ which manages the subscribers data base. Designed to be stored on an RFID tag The Electronic Product Code (EPC) is a successor of printed bar codes. It is used to track all kinds of objects in the supply chain including: trade items, fixed assets, documents, or reusable transport items.

Compared to a printed barcode EPC provides automatic, wireless communication in a real time. The EPC can distinguish two identical products and provide a specific product's manufacture date, origin or batch number[147].

146 EPCglobal Network 1.0 from August 2003 includes specifications on implementation of transponders, readers in many software components.
147 http://www.epc-rfid.info/



Source: http://www.epc-rfid.info/ [15.05.2014].

Fig. 38. Basic Format of EPC

♦ Header - Identifies the length, type, structure, version, and generation of the EPC,

♦ EPC Manager Number – Entity responsible for maintaining the subsequent partitions,

♦ Object Class – Identifies a class of objects,

♦ Serial Number – Identifies the instance.

EPC is "an electronic structure of EPC product code" that automatically identifies items in a supply chain in any company and industry all over the world. RFID structure of EPC codes is made up of (Fig.39)[148]:

♦ EPC – unique global identifier of the physical object on the electronic carrier,

♦ RFID transponder and reader – captures data to correlate goods and information flows,

♦ Middleware software – interface for IT systems and EPC global network to filter input data from readers and reduce network traffic,

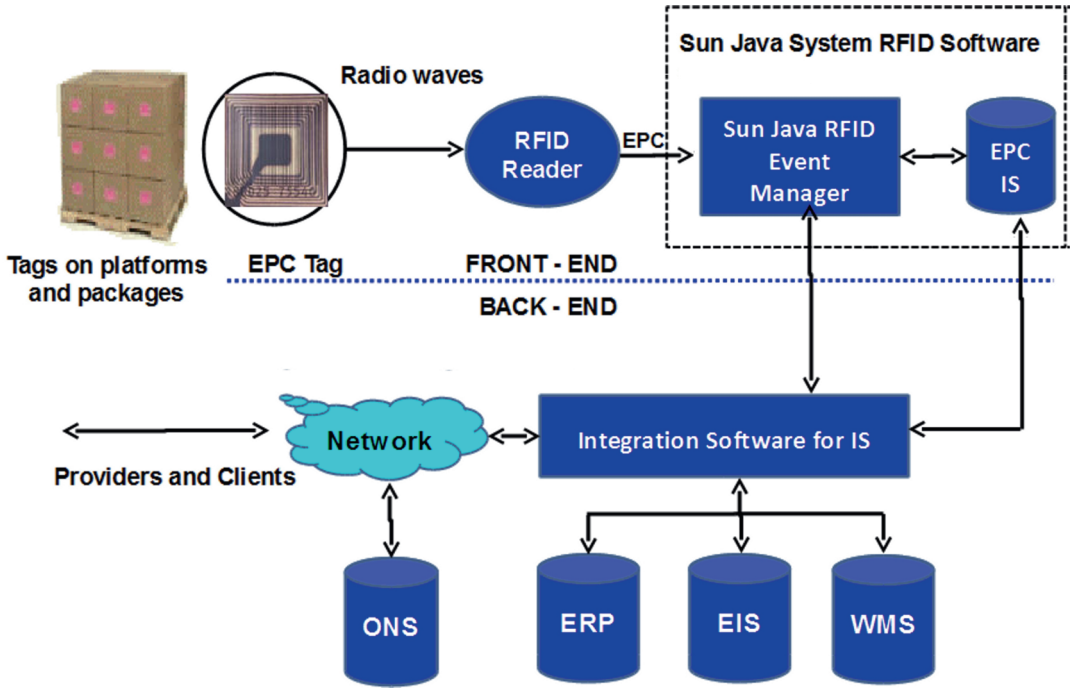
♦ Object Naming Service[149] (ONS) – is a network catalogue of information about EPC. It is compose of two levels: RootONS is a catalogue of manufacturers offering products in the EPCglobal network. The second level is LocalONS – a catalogue of single products of a given manufacturer,

♦ EPC Information Service (EPC IS), e.g. Sun Java System RFID Information Server – a service for the information exchange between business partners, based on EPC codes. It uses Physical Markup Language (PLM)[150].

148 T. Staake, F. Thiesse, E. Fleish, *Extending the EPC Network – The Potential of RFID in Anti-Counterfeiting*, 2005 ACM Symposium on Applied Computing, 13–17 March 2005, New Mexico, USA.

149 ONS is similar to DNS; EPCglobal Object Name Service (ONS) 1.0. Technical report, EPCGlobal Inc, April 2004.

150 PML, developed by Auto-ID Laboratory (http://www.autoidlabs.org), a standardized XML dictionary XML to describe phisical objects, systems, processes and object's environment.



Source: M. Sokołowski, A. Zagrodziński, *Infrastruktura informatyczna uwzględniająca technologię RFID w systemach logistycznych*, SGWP, Warszawa 2005, p. 107.

Fig. 39. Infrastructure of EPC network

The reference architecture of radio identification network generally consists of (Fig.39):

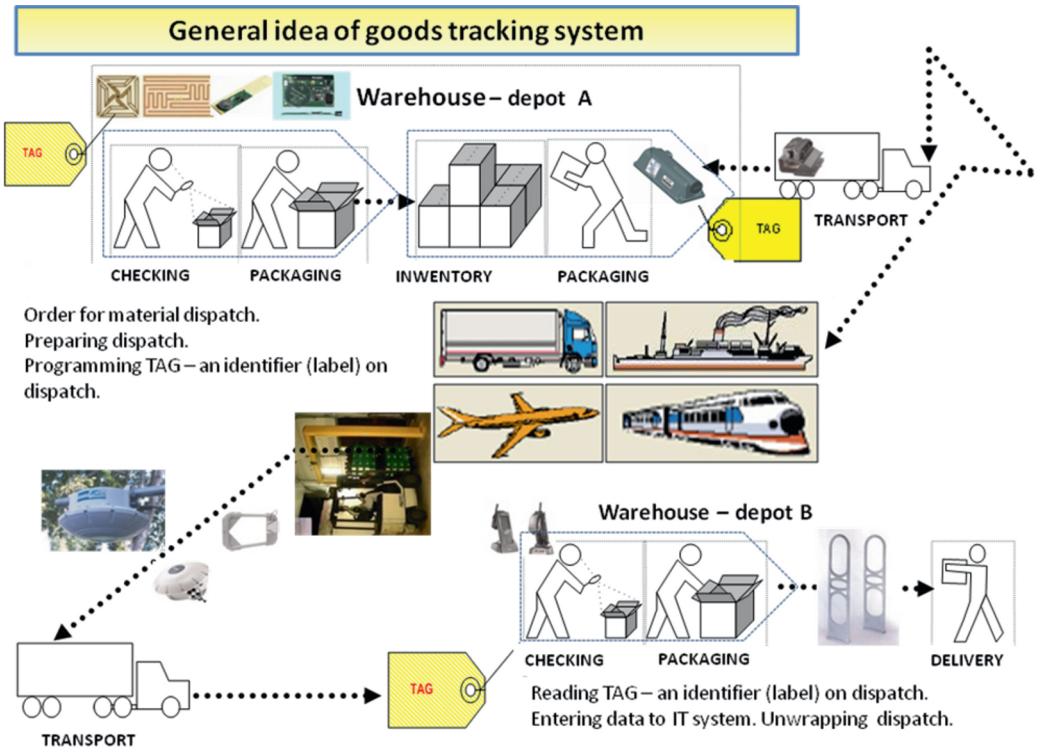
♦ Sensors – RFID transponders (EPC tag) and RFID Reader with an antenna,

♦ Identifier data base and middleware software: Java System RFID Event Manager and Java System RFID Information Server,

♦ Integrating software *Enterprise Application Integration* for RFID system and the management systems: *Warehouse Management System, Supply Chain Execution*, *Enterprise Resource Planning*.

If needed to transfer printed barcodes on RFID identifiers, a reader-transponder should be used[151]. Transponder includes a unique number, secret key and cryptographic unit. The key is stored in a database and is connected with a single tag. The EPC network information service stores the cryptographic unit. The authentication process can be as follows. A transponder passes its identifier to Cryptographic Unit that generates the massage. This message is sent to the transponder which codes it with its key and sends back as encoded information to Cryptographic Unit. The unit matches the right key and verifies the transponder answer. This authentication process is transparent for a reader.

151 T. Staake, F. Thiesse, E. Fleish, *Extending the EPC Network...*, cit.



Source: the author's own elaboration.

Fig. 40. General idea of product tracking system

The increasing complexity and speed of business operations requires immediate access to data to gain the demanded competitive advantage. Automation of the identification process (Fig.40) streamlines management at all stages: packing, repacking, storage, dispatch and receiving in product tracing and the surveillance processes worldwide. The presented types of identification may be implemented in various areas and often perform in a complementary mode.

♦♦♦