GS1 in Europe

European Guideline for the Identification of Railway Assets using GS1 Standards

RFID in RAIL

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1 Identification needs for rail assets

1.1 Background

The use of Radio Frequency Identification (RFID) is increasing meaning that more objects are being identified with the technology. To ensure that objects are identified uniquely there is a need to commit to a numbering scheme. Failure to do so means that the identification chosen can collide with other identification systems leading to inaccurate data and severe consequences depending on the application using the data.

In Europe, there have been a number of RFID pilots in rail. Some of the projects have been running for a number of years and it has become clear that to maximize the benefits of RFID and allow open access to the technology, common standards had to be agreed. As rail assets, meaning vehicles and their component parts, cross country borders the standard had to be European. Failure to use a cross border standard would mean that infrastructure managers would have to allow for different types of readers to be put on the trackside, and vehicles passing different countries would have to have different tags to suit each country etc.

This guideline has been developed by GS1 in Europe with the help of key rail actors in Europe including railway infrastructure managers, train operators, components manufacturers, rail industry bodies and solution providers involved in RFID in Rail implementations. The guideline details how to identify rail assets within the framework of the GS1 System.

Rail assets include goods wagons, passenger cars and locomotives as well as parts for maintenance, repair and overhaul (MRO).

1.2 Need for a European standard for vehicle identification

As vehicles cross national borders cargo owners would like to know how their goods are progressing across the continent. For maintenance purposes, infrastructure owners would like to get information about the rolling stock so as to enable maintenance and inform the owner and/or operator of the vehicle if there are problems. This might be the case if a vehicle is taken out of service or if there are delays. Last but not least, train operators would like to know where their vehicles are, their train formations and to update their maintenance records even when maintenance has been done by a third party.

It is therefore not surprising that the use of RFID in Europe is increasing as the technology is seen as a cost effective way to satisfy these requirements. However, RFID implementations have been done in silos within national borders with a mixture of global and proprietary standards. RFID projects and pilots have in some cases been initiated by one party (cargo owner or infrastructure manager or train operator) while in other cases in cooperation.

The lack of a European standard will make it impossible or expensive to meet the requirements of the different actors. In some countries, such as Sweden, 70% of goods wagons are foreign and therefore national solutions would only meet the needs of a very small percentage of the goods wagons. On the other hand, there are many rail vehicles, especially passenger and maintenance wagons / vehicles that are local and / or are controlled by one party. These types of vehicles will also benefit from an open standard and a common identification approach as there may be a need to share information with other systems and parties.

Existing numbering schemes like the European Vehicle Number (EVN) offer a unique way to identify rail vehicles across Europe. However, the number is only unique within the context of rail registers and as RFID increases and more objects such as containers, trailers and goods are identified using RFID, the EVN on its own is not enough to identify what was actually captured. However, it is a very important attribute in the identification of vehicles as it contains technical information about the vehicles which makes it possible to perform certain activities without access to a database.

1.3 Need for an intermodal standard for identification

For rail vehicles, there is a European identification numbering system which enables the unique identification of authorized vehicles. However, this numbering system is rail specific meaning that the identification numbers are only unique within rail registers. In practice this means that if another object such as a train component, container or trailer has a similar identification format carried in an RFID tag, data on these other objects may be captured in error. The GS1 System helps solve this issue. *(Illustrations 1 & 2)*

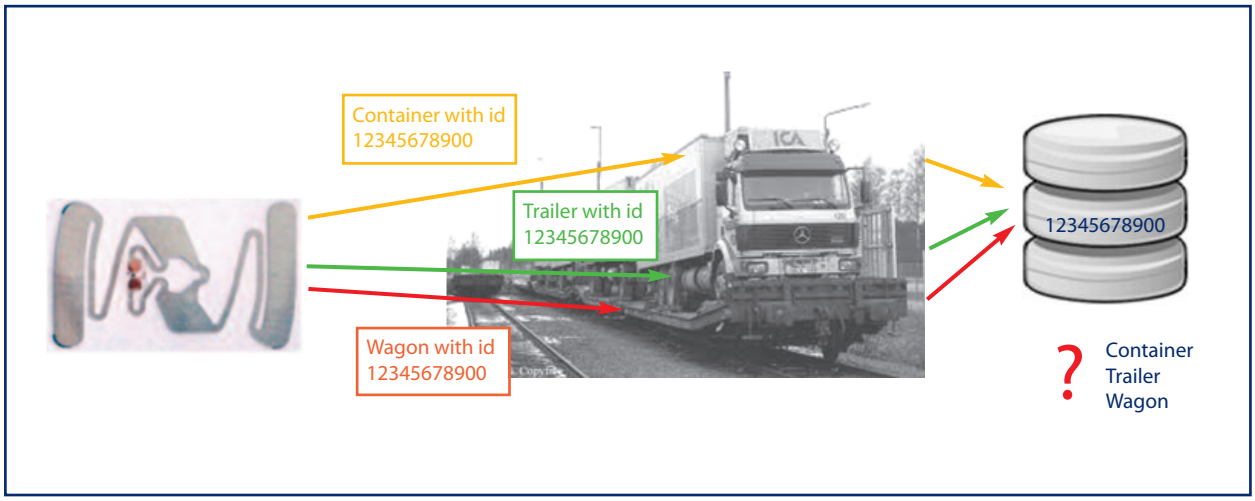


Illustration 1: *RFID Tag with an individual, owner specific identification stored in the data base (leads to different objects with the same identification)*

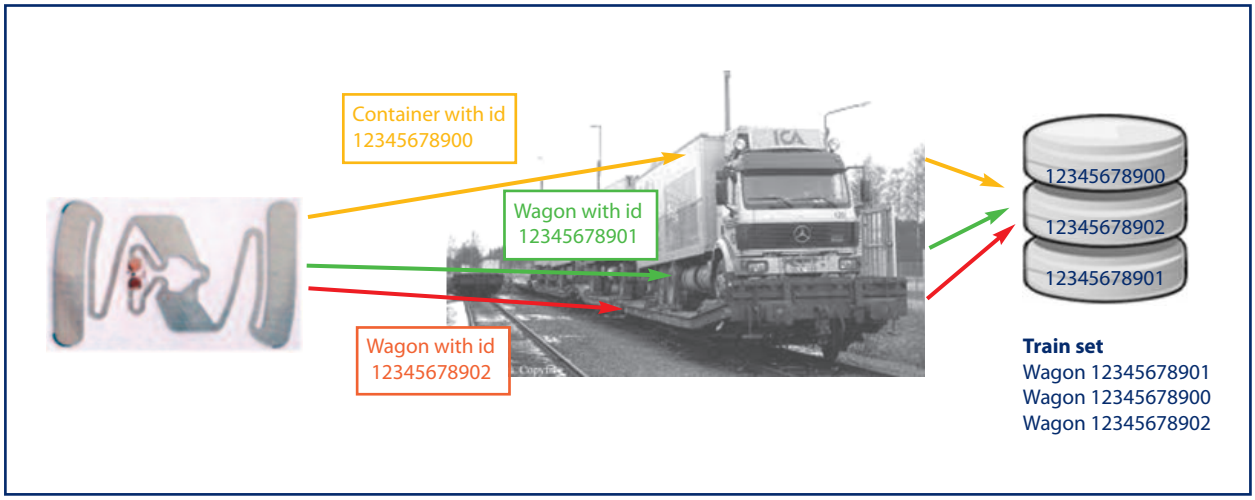


Illustration 2: *RFID Tag with an individual, owner specific identification stored in the data base (leads to misinterpretation of which object has been observed)*

1.4 Need for a standard to identify MRO parts

MRO stands for « Maintenance, Repair and Overhaul ». This definition applies to the Railway industry. It involves fixing any sort of mechanical or electrical device should it become out of order or broken (known as repair, unscheduled or casualty maintenance). It also includes performing routine actions which keep the device in working order (known as scheduled maintenance) or prevents trouble from arising (preventive maintenance). MRO may be therefore defined as all actions which have the objective of retaining or restoring an item in or to a state in which it can perform its required function. The actions include the combination of all technical and corresponding administrative, managerial, and supervision actions.

Today, several railway companies in Europe are evaluating the use of Automatic Identification and Data Capture (AIDC) technologies such as bar codes and RFID to enable automatic data capture of their MRO processes. A lack of agreement between all the parties involved has been identified especially on the subject of identification technologies. There is a big need for a standardisation body such as GS1 to become active in this area. A group consisting of infrastructure managers, train operators, solution providers and GS1 member organisations was therefore formed to develop a solution.

The group has identified the need to track MRO parts that are already-in-circulation as well as the new parts that are being produced by manufacturers. Examples of these MRO parts are:

- Wheelsets
- Bogies
- Pantographs
- Safety Equipment

The MRO parts need to be read at various reading distances (short distances in storage conditions and longer distances on rolling stock). Readability will be affected by various conditions, like weather conditions; which will influence the tracking process of the parts.

1.5 GS1 / EPCglobal Standard

GS1/EPCglobals standard defines data format, capture and query interfaces for RFID. This guideline details how to identify rail assets using GS1 Identification Keys and EPC Gen 2 UHF (ISO 18000-63) tags within the framework of the GS1 System. For detailed information on how to put the information in the tag please refer to the GS1 EPC Tag Data Standard (TDS) http://www.gs1.org/gsmp/kc/epcglobal/tds/.

2 Why choose the GS1 System of Standards?

GS1 is an international not-for-profit association with Member Organisations in over 111 countries. GS1 is dedicated to the design and implementation of global standards and solutions to improve the efficiency and visibility of supply and demand chains globally and across sectors. The GS1 System of standards is the most widely used supply chain standards system in the world.

2.1 GS1 as a partner within the rail industry

Automatic identification and visibility systems based on global standards:

- Make implementation faster and more effective.
- Help users focus on the business requirements instead of developing their own standards for identification and data communication.
- Make it easier to buy hardware, software and equipment reducing the costs of implementation, integration and maintenance.
- Facilitate collaboration between trading partners making it quicker and easier to identify objects and share information (like which vehicle passed which point at what time).
- Make it possible to build a scalable solution / system as they are interoperable with other systems and can easily connect to off-the-shelf systems and applications.
- Increase the longevity of the system as components that are standards-based can be sourced from different suppliers.

GS1 creates and manages exactly these types of proper and well designed systems of standards. For over 35 years it has provided "community management" for the adoption of barcoding/RFID, EDI and data synchronisation solutions in many sectors. GS1's financial model is completely based on cost recovery.
It has strong links with standards organization such as ISO and cooperates with NATO, WCO, UPU, and the FDA to name a few. The GS1 System of standards is well known and widely used in the Transport and Logistics sector.
In Europe, GS1 has offices in every country meaning that users can get support from their local offices. GS1 Standards are built and maintained by experienced staff from different companies across the world and different sectors. The rail industry is welcome to join relevant groups so as to ensure that future standards meet rail requirements.

2.2 The GS1 numbering system

GS1 Identification Keys are the foundation of the GS1 system and ensure the global and cross sector unique identification of products, locations, assets, etc.

2.2.1 GS1 Company Prefix

The GS1 Company Prefix (GCP) provides a way for GS1 users to uniquely and globally identify things like vehicles, containers, consignments, logistic units, locations, components, etc. The GS1 System has a number of identifiers that are used for the different purposes. The GCP is of variable length and the basis to create any of the GS1 Identification Keys. GCPs are allocated to companies/organizations that need to identify their business objects, in the case of rail applications: vehicle owners, transport agencies, infrastructure managers, etc. GCPs are allocated by GS1 Member Organisations in each country (GS1 is an issuing agency under ISO 15459). This document covers two of the GS1 Identification Keys – the Global Individual Asset Identifier (GIAI) and the Global Trade Item Number (GTIN).

2.2.2 GS1 identification keys and their attributes

- GS1 identification keys work in any business sector. Having a unique identifier for an asset allows businesses to identify, track and manage their assets.
- The GS1 key itself is non-significant and has no meaning. This allows the asset to be looked-up in a database and its associated information retrieved at any point or location.

- Allocation of numbers is simple and their uniqueness guaranteed as it is based on the GS1 System using a GS1 Company Prefix, the asset or article reference and a serial number.
- The GIAI and GTIN are both GS1 Identification Keys that identify each individual asset/item uniquely thus ensuring that it is always identified correctly anywhere. (In the case of GTIN, a compound identification key called Serialized GTIN; is created by adding a serial number. See appendix 2 for details.)
- Each asset is allocated a unique serialised item number or individual asset number to ensure that it can be identified separately.

2.3 GS1 system increases security when capturing data

Illustration 3: *The GS1 System has different identification keys for different purposes. The GS1 Company Prefix (GCP) forms a core part of the GS1 Keys to provide a way for GS1 users to uniquely and globally identify different things.*

Train passing read point A on 16 July 2012 at 8.38 CET ***(Readpoint identified with Global Location Number – GLN)***		
GS1 ID	EPC Pure Identity	What is identified
GIAI	urn:epc:id:giai:735005385.2 9074123457	Locomotive with EVN 9074123457 (Vehicle Keeper Marking excluded as GCP is used)
GIAI	urn:epc:id:giai:7332743.1234565	Container with number 1234565 Including BIC number (owner/operator code excluded as GCP is used)
GIAI	urn:epc:id:giai:7332743.1037412345 010	Goods wagon with EVN 037412345 001 (Vehicle Keeper Marking excluded as GCP is used)
serialized GTIN	urn:epc:id:sgtin:730001. 0730001000001.987	Component type identified by the manufacturer with serial number 987
Comment 1:	EPC Pure identify is the EPC syntax for encoding GS1 Identification Keys. The full description is available in the EPC Tag Data Standard (TDS).	
Comment 2:	GS1 Company Prefix varies in length, The partition value allows for systems to know the length of the GS1 Company Prefix.	
Comment 3:	Trackside readers could be programmed to ignore all other Ids except GIAIs. However the system behind the trackside reader must still be able to distinguish vehicle (rail wagon) GIAIs from other GIAIs that might be read when passing by the reader.	
Comment 4.	In Illustration 2 on previous page the serialized GTIN includes a check digit, since it is written in plain text syntax. However in the EPC Pure Identity representation shown in the table, check digits are omitted.	
Comment 5.	Serialized GTIN is a compound GS1 Identification Key where GTIN + serial number is recommended for identification of trade item instances.	

3 Guideline for vehicle identification

For the identification of rail assets in Europe, the Global Individual Asset Identifier (GIAI) is recommended. Furthermore it is recommended to use GIAI-96 encoding and not the GIAI-202 encoding.

3.1 Including the European Vehicle Number (EVN)

GS1 advocates the use of non significant numbers as they make it easier to manage and offer the best use of number capacity.

However from the pilots and implementations that have been conducted in the railway sector, the benefits for the operators offered by the inclusion of the European Vehicle Number (EVN) outweigh the disadvantages. The recommendation of the workgroup is therefore to have the 12 digit EVN as part of the Individual Asset Reference. The Vehicle Keeper Marking (alphabetic) shall not be encoded in the data carrier.

The involved parties (train operator as well as system developers) shall be aware that GIAIs from other implementations with a different application objective may be attached to or be on the vehicle not using any significance.

3.2 Side / end indicator and tag location

Furthermore, two tags are required for each vehicle according to "TSI CR WAG:2006"*, Chapter 4.2.5.2.2. In case later revisions of TSI do not include information about tag location, this recommendation is still valid. Experience has shown that it is important to identify which of the tag was read as this shows actual orientation of the vehicle which in turn provides other benefits such as:

- Safety benefits by enabling actual parameters from Wayside Train Monitoring System (WTMS) to be matched with correct wheel / axle.
- Logistical benefits especially for wagons where loading and unloading can only be done from one side thus making it possible to prepare for these activities before train arrival.
- It is noted that the use of 2 different GIAI tags on the same vehicle does not comply fully with GS1 standards. This approach was adopted because of the lack of a fully compliant solution and the fact that its use is limited to the European rail industry.

3.3 Filter Value

Implementers should be aware that a tag filter value may be allocated by GS1 to minimise the possibility of interference from other tags. If a filter value is agreed then it will be important for all vehicle tags to use the agreed filter value. Implementers should therefore check for the latest information about the filter value from GS1 before rolling out large numbers of tags. In the meantime this guideline will minimise readability issues at high speeds.

3.4 Structure of the Global Individual Asset identifier encoding the EVN

Company Prefix	Individual Asset Reference	
	Vehicle end/side Indicator	EVN
735999271	**1, 2 or 3****	**917400000019**
Entity responsible for maintaining the individual asset reference (vehicle owner, train operator, transport agency etc)	To determine side indicator, please see below.	12 digit European Vehicle Number (EVN)

Determining the vehicle end/side indicator:

For vehicles to which TSI CR WAG:2006 and EN 13775-1:2003 apply**:
According to these standards:
- the tag with side indicator "1" is to be mounted on the left hand side of the vehicle, towards end 1 (non-handbrake end if the wagon has a handbrake);
- the tag with side indicator "2" is to be mounted on the right hand side of the vehicle, towards end 2 (handbrake end if the wagon has a handbrake).

For vehicles to which TSI CR WAG:2006 and EN 13775-1:2003 do not apply:
For vehicles with defined ends 1 and 2:
- the tag with **side indicator 1** is to be mounted on the side that places it towards **end 1**
- the tag with **side indicator 2** is to be mounted on the side that places it towards **end 2**

For vehicles with undefined ends, but with a side A or B:
- the tag with **side indicator 1** should go on the **B side**
- the tag with **side indicator 2** should go on the **A side**

If it is not possible to distinguish between the ends of the vehicle then it is arbitrary which side is 1 and which is 2.

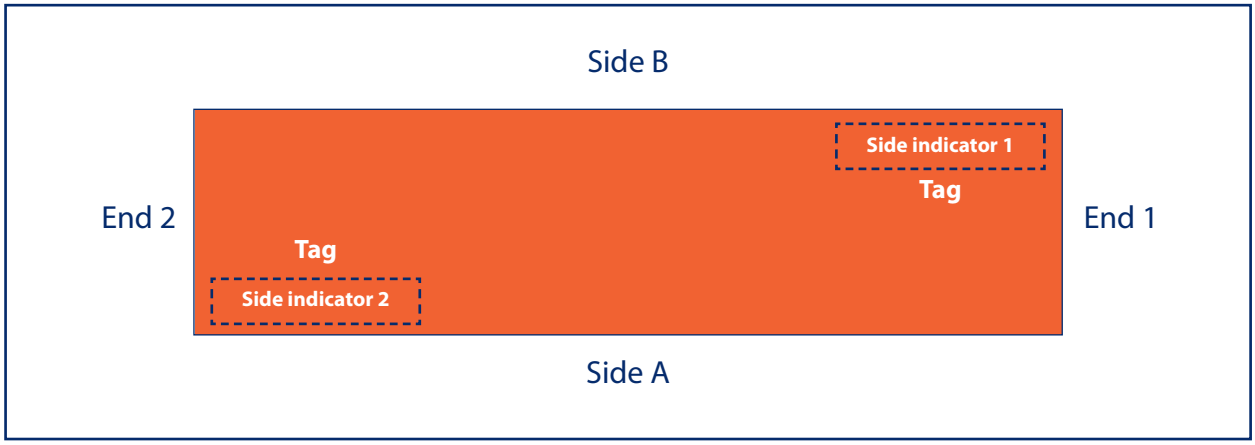
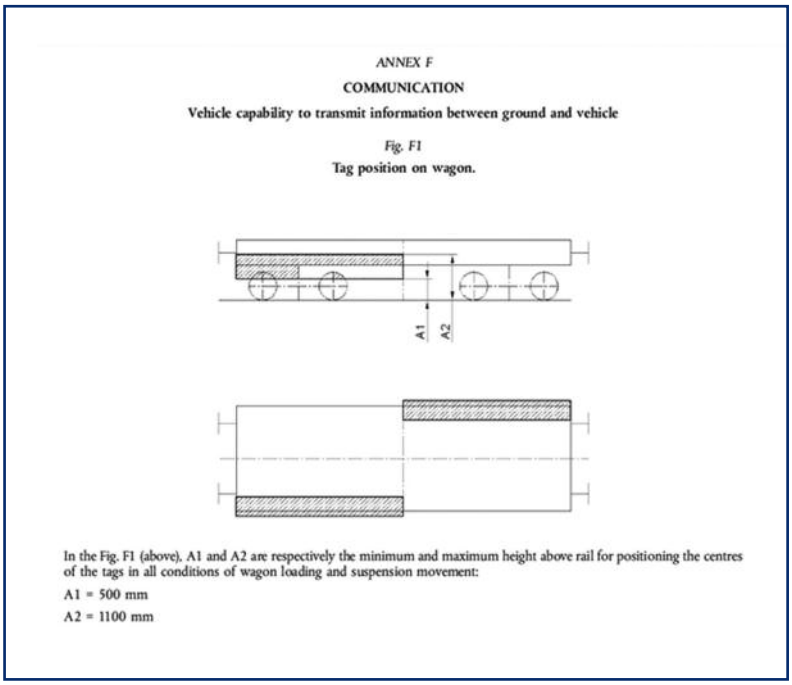


Illustration 4: *Vehicle end/side Indicator*

** Footnote: Side indicator 3 has been used in legacy markings for the tag at vehicle end 1 (respective A) mounted on left hand side of the vehicle". This is not to be used on future implementations.



ANNEX F

COMMUNICATION

Vehicle capability to transmit information between ground and vehicle

Fig. F1

Tag position on wagon.

In the Fig. F1 (above), A1 and A2 are respectively the minimum and maximum height above rail for positioning the centres of the tags in all conditions of wagon loading and suspension movement:

A1 = 500 mm

A2 = 1100 mm

Illustration 5: *Tag location according to TSI CR WAG:2006*.*

In case later revisions of TSI do not include information about tag location, this recommendation is still valid.

3.5 Benefits of including the European Vehicle Number (EVN) in the Global Individual Asset Identifier (GIAI)

1. No access to database or no internet connection:
It is envisaged that RFID will be used by many different parties. In the near future, it is practical to assume that not all parties will have access to information regarding the identified vehicles to take full advantage of RFID. If the EVN is included in the identifier, parties without access to the database are still able to take advantage of RFID. For instance, if a vehicle has to be taken off route for emergency maintenance, the service yard could read the RFID tag and get technical information (as identified in the EVN) without having to access external databases.

2. Double checking the tag:
As there is a European requirement for all vehicles to have a visible EVN displayed on the vehicle, it is possible to double check that the tag is encoded correctly by comparing the numbers in the tag with the EVN on the vehicle during application.

3. Easy to get information from the National Vehicle Register (NVR)
As the EVN is the key to the NVR, encoding the EVN in the code offers a quick access key to the NVR in case access to database or internet connection exists.
The main disadvantage with this approach is that if the identification of the vehicle (e.g. EVN) changes, then the tag has to be changed or re-encoded. The number on the vehicle side will have to be repainted, too, so the current renaming process is not effortless either.

Another disadvantage is that a trackside reader may encounter and read a non-significant GIAI encoded in a way that a system incorrectly believes it is encoded containing an EVN.

* Technical Specification for Interoperability relating to the subsystem Rolling Stock – Freight Wagons, Brussels 06.12.2006.

4 Guideline for MRO identification

4.1 Responsibility of tagging

The responsibility for the identification of the parts depends on the lifecycle of the part. Each part should only have one identifier:

- For new parts, the manufacturer/supplier of the part should be responsible for allocating an identifier to the part. In this case a serialised Global Trade Item Number is recommended.
- For new parts that are not tagged by the manufacturer/supplier or for existing parts that are already in circulation and/or used by train operators, the allocation of the identifier to the part should be done by the current owner of the part using a GIAI.
- If a part, identified with a serialised GTIN, is modified by the train operator it is at the discretion of the train operator to let the part keep its serialised GTIN or to assign a new GIAI.

System developers should allow for MRO parts to be tagged with either a serialised GTIN or a GIAI.

4.2 Structure of the Serialised Global Trade Item Number encoding MRO parts

Global Trade Item Number	Serial Number
400012345678	**812**
Manufacturers GCP and item reference (no check digit)	Serialised part of the identification created and managed by the manufacturer. This can be alpha numeric unless SGIN-96 encoding is used. The serial number must not start with 0 when using the SGTIN-96 encoding.

4.3 Structure of the Global Individual Asset Identifier encoding MRO parts

GS1 Company Prefix	Individual Asset Reference	
	MRO Indicator	Asset Reference
7613299	**4**	**0000123456789012**
Asset owners GCP	Rail application encoding digit: 4 = MRO part 1-3 = reserved for vehicle end/side indicator 5-9 = open 0 = not allowed	Serialised part of the identification created and managed by the asset owner. This can be alpha numeric unless GIAI-96 is used.

4.4 Marking

There should be a redundancy of information on each tag, which on one hand delivers a fall-back (back-up) scenario in case of damage of the tag and on the other hand guarantees functionality in a wide range of different environmental conditions:

- EPC Tag
- GS1 DataMatrix (or GS1-128)
- Plain text (human readable)

This redundancy makes it possible to take advantage of each identification technology by having a consistent and homogeneous identification concept at the same time, manageable with only one type of reading device (combined RFID- and barcode reader):

- RFID chip for identification in extremely dirty environments, critical to optical identification methods like barcodes.
- GS1 DataMatrix-symbols as space saving method for optical identification in conditions critical to radio communication – strong electromagnetic fields, exposure to high voltage currents, high temperature that would damage EPC Tags etc.
- Plain text as fall-back and in situations, where no AutoID-device is available.

For details on marking see Appendix 3 – Examples on Encoding and Marking, MRO Identification.

Appendix 1 – *Global Individual Asset identifier (GIAI)*

The Global Individual Asset Identifier (GIAI) is a unique identification key that can be used globally to identify the asset. Detailed information regarding the asset will be recorded in a database and the GIAI is the key that provides the link to that information. It may be carried in a GS1 DataBar Expanded, GS1 DataBar Expanded stacked or in a GS1-128 bar code, in a GS1 DataMatrix symbol, or in an EPC Tag and used in a database or electronic message.

GIAI – Individual Asset Reference

- Each asset is allocated a unique individual asset number to ensure that it can be identified separately.

Representation of the GIAI

Extract of the General Specifications, chapter 3

Format of the Element String						
Application Identifier	Global Individual Asset Identifier (GIAI)					
	GS1 Company Prefix →			Individual Asset Reference →		
8 0 0 4	N_1 ...	N_l		X_{i+1} ...	variable length	$X_{j\ (j<=30)}$

See Appendix 3 – Examples on Encoding and Marking for an example!

In a GS1 RFID tag there are two possibilities for encoding GIAI; GIAI-96 or GIAI-202.
The GIAI-202 fully supports the GS1 General Specifications (GCP plus alpha-numeric asset reference, in total 30 characters), the GIAI-96 limits the size of the asset reference to a reduced length and to numeric digits (without leading zeroes) depending on the length of the GCP. The reference must be numeric when using a GIAI-96 tag and not longer than*:

GCP: 6 digits max individual asset reference 18 digits
GCP: 7 digits max individual asset reference 17 digits
GCP: 8 digits max individual asset reference 16 digits
GCP: 9 digits max individual asset reference 15 digits
GCP: 10 digits max individual asset reference 14 digits
GCP: 11 digits max individual asset reference 13 digits

The general recommendation for GS1 Identification Keys is to not include any significance in the keys, but rather use the key to link the physical object carrying the key to data stored in a database. This procedure is described in the GS1 General Specifications.

* For clarification in regards to the GIAI partition table in Tag Data Standard TDS 1.6: The longest serial number in GIAI-96 for GCP 9 digits is (52 bits available) 4,503,599,627,370,495 which is a 16 digit long number. As this guideline mandates the first digit of the number must be allocable from 1 to 9, thus the longest number we can present is only 999,999,999,999,999 which is 15 digits long. This explains the deviation from the mathematical individual asset reference lengths indicated in the TDS 1.6.

In the rail context (vehicle and MRO) using non-significant GIAIs will have the following consequences:

- No significance in the first digit of the Individual Asset Reference. This means that the indicator digit (the first digit of the individual asset reference) can not be used to determine if the GIAI identifies a, component/part or something else that may appear appear within reading distance.
- The side indicator will not be present in the Individual Asset Reference. This affects implementations when the GIAI reads will interact with hot box detection systems and other systems, that rely on the side information in automatic railside readpoints.
- A mapping table (with look-up functionality) will be necessary to determine (extract) the EVN or the MRO part identification based on the data capture process. All parties using data based on capturing GIAIs from RFID tags or barcodes will need to have access to master data regarding the GIAIs. For instance, if an RFID tag has been attached by a train operator, he must inform the rail infrastructure managers of all the countries that would like to take advantage of RFID, all the maintenance companies and all other parties interested in reading the tags. Failure to do so will mean that for instance if the vehicle goes in for repair and the maintenance company normally uses RFID to identify vehicles that they repair, update their records and send the information to relevant parties, they will not be able to utilize the RFID on that vehicle as they will not have any useful data unless they can connect to the train operator's system.

If a company / organization decides to choose this approach, they must ensure that that it is possible for other authorised parties to quickly and automatically get access to more information about the vehicle. They should therefore map the GIAI to the EVN and provide the information to other actors.

In summary, using non–significant GIAIs for vehicles adds additional requirements for applications to provide the vehicle tracking functionality required by the rail industry.

Appendix 2 – *The Global Trade Item Number (GTIN)*

Extract from the General GS1 Specifications, chapter 2:

	GTIN-12 / GTIN-13 Data Structure												
	GS1 Company Prefix →							← Item Reference					Check Digit
(GTIN-13)	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}
(GTIN-12)	0	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}

A trade item is any item (product or service) upon which there is a need to retrieve pre-defined information and that may be priced, or ordered, or invoiced at any point in any supply chain. This definition covers services and products, from raw materials through to end user products, all of which may have pre-defined characteristics.

Each trade item that is different from another in design and/or content is allocated a unique identification number, which remains the same as long as it is traded. The same identification number is given to all trade items sharing key characteristics. Such numbers must be treated in their entirety throughout the supply chain.

This identification key is called GTIN (Global Trade Item Number). The serialised identification of trade items enables total connectivity of information and communication systems.

The Serialised Global Trade Item Number (SGTIN)

The Serialised Global Trade Item Number (SGTIN) is a common term for the mandatory association of GTIN and a serial number. SGTIN is a compound identification key to every individual item and can be used globally. Detailed information regarding the product will be recorded in a database and the SGTIN is the key that provides the link to that information. It may be carried in a GS1 DataBar Expanded, GS1 DataBar Expanded stacked or in a GS1-128 bar code, in a GS1 DataMatrix symbol, or in an EPC Tag and used in a database or electronic message.

A serial number is assigned to an entity for its lifetime. When combined with a GTIN, a serial number uniquely identifies an individual item. The serial number field is alphanumeric. The manufacturer determines the serial number. Serial number is an attribute of a trade item; it must be processed together with the GTIN of the trade item to which it relates.

Representation of the GTIN and Serial number

Extract of the General Specifications, chapter 3

	Format of the Element String														
	Application Identifier	Global Trade Item Number (GTIN)													
		GS1 Company Prefix →								← Item reference					Check Digit
(GTIN-12)	0 1	0	0	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}
(GTIN-13)	0 1	0	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}
(GTIN-14)	0 1	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}	N_{14}

Format of the Element String		
Application Identifier	Serial Number	
2 1	X_1 → variable length →	X_{20}

See Appendix 3 – Examples on Encoding and Marking for an example!

In a GS1 RFID tag there are two possibilities for encoding SGTIN: SGTIN-96 or SGTIN-198.
The SGTIN-198 fully supports the GS1 General Specifications (GTIN and a serial number that can be up to 20 alpha-numeric characters). When using SGTIN 96-bit tag there is a limit to the length of the serial number and it consists of digits only which have no leading zeros.

Appendix 3 – *Examples on Encoding & Marking*

Vehicle Identification

Vehicle Identification structure	
Part 1 : GCP	GCP is of variable length
Part 2: Rail application encoding digit: (Vehicle end/side Indicator)	0 = not allowed 1-3 = vehicle end/side indicator **1 and 2** = For vehicles to which TSI CR WAG:2006 and EN 13775-1:2003 apply: According to these standards: ■ the tag with **side indicator 1** is to be mounted on the **left hand side** of the vehicle, towards **end 1** ■ the tag with **side indicator 2** is to be mounted on the **right hand side** of the vehicle, towards **end 2** For vehicles to which TSI CR WAG:2006 and EN 13775-1:2003 do not apply: *For vehicles with defined ends 1 and 2:* ■ the tag with **side indicator 1** is to be mounted on the side that places it towards **end 1** ■ the tag with **side indicator 2** is to be mounted on the side that places it towards **end 2** *For vehicles with undefined ends, but with a side A or B:* ■ the tag with **side indicator 1** should go on the **B side** ■ the tag with **side indicator 2** should go on the **A side** If it is not possible to distinguish between the ends of the vehicle then it is arbitrary which side is 1 and which is 2. 3 = Footnote: Side indicator 3 has been used in legacy markings for the tag at vehicle **end 1 (respective A)** mounted on **left hand side** of the vehicle". This is not to be used on future implementations. 4 = MRO parts 5-9 open
Part 3: Serial number	Serial number content has to be numeric
Example	
GIAI-96 example	GCP: 735999271 End / side indicator digit: 1 EVN: 123456789012 EPC Pure Identity: urn:epc:id:giai:735999271.1123456789012 EPC Tag URI: urn:epc:tag:giai-96:0.735999271.1123456789012

MRO Identification

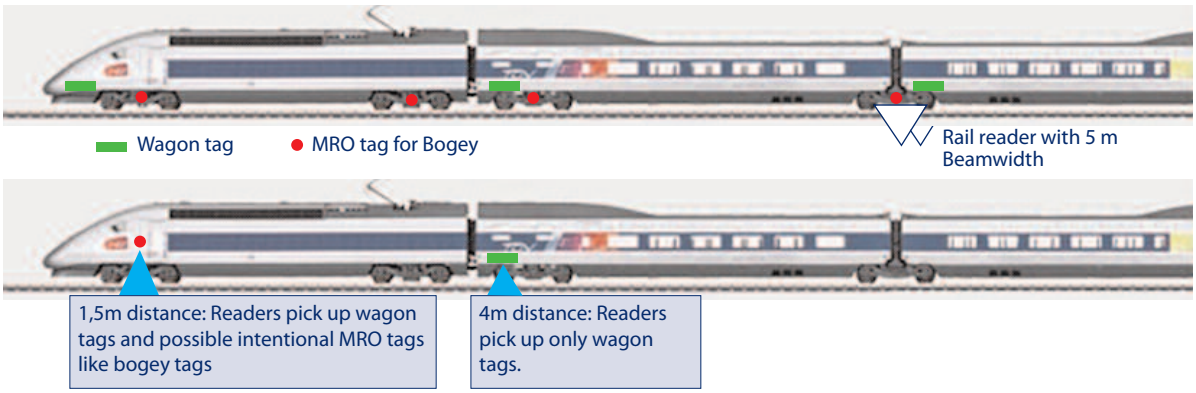
MRO Identification structure	
Part 1: GCP	GCP is of variable length
Part 2: Rail application encoding digit	0 = not allowed 1 – 2 = reserved for Vehicle marking. 3 = legacy (no longer to be used) 4 = MRO parts 5–9 open
Part 3: Serial number	Serial number content is to be alpha numeric for –202 and is numeric for –96
Examples	
GIAI-96 example	GCP: 735999271 Rail application encoding digit: 4 MRO Part serial number: 123456789012 MRO GIAI in GS1 human readable format with AI: (8004)735999271**4123456789012** EPC Pure Identity: urn:epc:id:giai:735999271.4123456789012 EPC Tag URI: urn:epc:tag:giai-96:0.735999271.4123456789012
SGTIN-96 example	For components, the brand owner may decide to tag the products during production. In this case they will use a serialised Global Trade Item Number. See section 4.1 for more information. GCP: 730001 Item reference: 000001 Check digit: 8 Serial number : 987 MRO SGTIN in GS1 human readable format with AI: (01)07300010000018(21)987 EPC Pure Identity: urn:epc:id:sgtin:730001.0000001.987
GIAI-96, zero padded example	Users that have limited space to represent the 2D symbol might want to specify a fixed length for the serial code, so that the 2D symbol always has the maximum size. This prevents surprises as the maximum size is used from the start. This can be achieved by zero padding the actual MRO part serial number. Example, fixed GIAI serial length of 17 digits sought. Note, MRO serial 16 + Rail application encoding digit 1 = 17 GCP: 7613299 Rail application encoding digit: 4 MRO Part serial number: 0000123456789012 (must be numeric for GIAI-96 encoding) MRO GIAI in GS1 human readable format with AI: (8004)7613299**40000123456789012** EPC Pure Identity: urn:epc:id:giai:7613299.40000123456789012 EPC Tag URI: urn:epc:tag:giai-96:0.7613299.40000123456789012
GIAI-202 example	GCP: 735999271 Rail application encoding digit: 4 MRO Part serial number: AB3456789FR2 MRO GIAI in GS1 human readable format with AI: (8004)735999271**4AB3456789FR2** EPC Pure Identity: urn:epc:id:giai:735999271.4AB3456789FR2 EPC Tag URI: urn:epc:tag:giai-202:0.735999271.4AB3456789FR2
2D Symbol GS1 Data Matrix and 1D Symbol GS1 128 examples	GS1 DataMatrix recommended with rail specific data content. Notably the size of the code changes according to the data length, which calls for careful consideration of the sizing of the number and resulting 2D codes on the tag surface. Here, especially with cross use of 2D symbols and EPC Tags, one must understand the technical difference of the structure. A GIAI encoded in an EPC Tag can always

2D Symbol GS1 Data Matrix and 1D Symbol GS1 128 examples	be split into its meaningful parts and thus be mapped to a 2D symbol without additional information. A GIAI encoded in a 2D symbol cannot. Specifically, the length of the GCP is not deductible by decoding a 2D symbol (it is impossible to split the GCP from the serial number without a look-up table or online connectivity to a database like www.gepir.org). To facilitate situations when RFID and barcode technologies need to be interoperable, please refer to the RFID Bar Code Interoperability GS1 Guideline, which can be obtained from all GS1 Member Organizations. In cases when implementing companies bilaterally agree to encode additional information in the barcode symbology GCP length can be exchanged in advance, or it can be agreed bilaterally to include AI (90) with GCP length, please refer to GS1 General Specification, chapter 3.  Example: (8004)7613299412907 GCP: 7613299 Rail application encoding digit: 4 MRO Serial: 12907  Example: (8004)735999271412345678901234 56 GCP: 735999271 Rail application encoding digit: 4 MRO Serial: 1234567890123456  Example: (8004)7359992714AB3456789FR2 GCP: 735999271 Rail application encoding digit: 4 MRO Serial: AB3456789FR2 Although it is not recommended, the coding is also applicable for a 1D symbol (GS1-128 symbology).  A GS1 Barcode is accompanied by the Human Readable Interpretation (see below).
Human readable text example	GS1 human readable format with GS1 Application Identifier recommended in the rail specific presentation format. The serial number will be highlighted. Example: (8004)735999271**41234567890123456**

Appendix 4 – *IT system considerations and implementation advice*

- If tags are ordered with prewritten identification, the serial numbers most likely will be consecutive numbers, thus possible old part numbers must be connected to the new ID on system level. The consequences of this are described briefly in appendix 1.
- The individual users of the RFID information need to consider the usage of the encodings in their IT systems. We must assume variable GCP length, which brings certain considerations with it.
- As this is a guideline and not a mandatory standard, and since one cannot control the tags on cargo, it is recommended that IT systems are set up to cope with other encodings that rail side readers might pick up. One way of achieving this is that organisations allocating GIAIs to rail vehicles agree to inform each other on which GCP they are using for these GIAIs.
- The content and the usage of the user memory are out of scope of this guideline.
- Consideration of reading speed of the wagon tags:
  - When both the vehicle and the MROs are identified with a GIAI, it is currently not possible to select / separate tags before interrogation meaning that a number of GIAIs may appear to the trackside reader.
  - The number of tags that appear depends on different factors including speed of the vehicle (the slower the vehicle the higher the number of tags that appear), the distance between the tags and the trackside reader, the quality of the tags etc*.
  - MRO tags that are in less than 5 m vicinity of wagon tags should have a read distance of less than 2 m in order not to disturb railside reading unintentionally. Implementers should be aware that a tag filter value may be allocated by GS1 to minimise the possibility of interference from other tags. If a filter value is agreed then it will be important for all vehicle tags to use the agreed filter value. Implementers should therefore check for the latest information about the filter value from GS1 before rolling out large numbers of tags. In the meantime this guideline will minimise readability issues at high speeds.

  Example picture of a problematic setup: MRO Tags on the bogeys of a high speed passenger train. At 200 km/h multiple tags are visible in the 5m beam of the rail side reader for 90ms. Singulation of the wagon tag within this brief interrogation "window" represents a challenge, the difficulty of which could be mitigated by employing a standardized Filter value to ensure that the interrogator considers only wagon tags and ignores all non-wagon tags. This would have the effect of maximizing available air time between the interrogator and wagon tags. At present, this Filter value is still under development.



* Current empiric tests have shown that trackside reader systems can cope with 3 visible tags on a 5 m segment of trains up to 160 km/h and with only 1 visible GIAI-96 tag on a 5 m segment of train at speeds of 200 km/h.

Appendix 5 – *Frequently asked questions*

Do I have to use a GIAI? Why can I not use an internal number instead?
Because more and more objects are identified with RFID, the use of internal numbers increases the risks of numbers clashing and therefore capturing the wrong information. It also means that other parties wanting to take advantage of RFID e.g. for safety and maintenance reasons are not able to do so.

I want to use a GIAI. Why should I encode the EVN in the GIAI?
Encoding the EVN enables other parties to take advantage of the RFID even if they do not have access to your database, though they have to take the risk of incorrect interpretation.

Should I use GIAI-96 or GIAI-202?
Two coding schemes for the GIAI are specified, a 96-bit encoding (GIAI-96) and a 202-bit encoding (GIAI-202). The GIAI-202 encoding allows for the full range of serial numbers up to 24 alphanumeric characters as specified in GS1 general specifications. The GIAI-96 encoding allows for numeric-only serial numbers, without leading zeros, whose value is up to a limit that varies with the length of the GS1 Company Prefix.
Currently for vehicle identification applications in Europe, only numeric digits are used and there is therefore no need to use GIAI-202. In addition GIAI-96 allows for shorter read times than GIAI-202 which is beneficial when reading at high speed. However, for MRO, users can choose to use either GIAI-96 or GIAI-202 depending on their needs.

Do I have to pad GIAI-96 with zeroes for unallocated bits?
Just because the maximum number of digits allowed in a GIAI-96 is 25 does not mean that all the digits have to be used. This means that there is no need for zero padding to fill up unallocated bits. All serial numbers from 1 through to the maximum value (without leading zeros) may be used with 96-bit tags.

I want to identify my vehicles using GIAI, where do I get a company prefix?
You can get a company prefix from your local GS1 member organization. A list of organisations and contact details is available in appendix 5.

Whose company prefix is used to create the GIAI?
The GS1 Company Prefix is allocated by GS1 Member Organisations to the company that allocates the GIAI, in this case the company identifying the vehicles or components. In the rail industry the party allocating the GIAI will vary from country to country. Examples of parties that could allocate the GIAI include:

- Vehicle keepers / owners.

- Operators:
  An operator may use its prefix to identify relevant vehicles. This makes it possible for the operator to for example meet the business needs of customers wishing to use RFID.

- The National Safety Authority / party responsible for allocating the EVN;
  As the National Safety Authority is responsible for vehicle registration, this would make it possible for the authority to register the GIAI used in the RFID tag when allocating the EVN. This will in the future make it possible for infrastructure managers to exchange / share information with each other regarding RFID reading along the tracks.

Also, safety is a key driver for many of the infrastructure managers that are implementing RFID.

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