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Identification of Components and Parts in the Rail Industry - Application Standard

Rules on the use of the GS1 keys and attributes for the identification and marking of components and parts in the rail industry

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1 Introduction

This document explains how to use the GS1 identification keys and attributes for the identification of parts and components in the rail industry. Contributors have expressed their commitment to implement the approaches described in this standard to ensure interoperability among rail stakeholders and other related sectors.

In the rail sector interoperability means the ability of a rail system to allow the safe and uninterrupted movement of trains while accomplishing the required performance level. This helps to ensure that rolling stock of operator A can operate on infrastructure of infrastructure managers B, C, D, etc., because the parts where the systems meet (wheelsets, rails, ETCS-components, pantographs, switches, toilet drains, etc.) are guaranteed to be compatible due to international norms. These norms also include configuration management requirements, since these help to ensure that only compatible parts are used on interoperable sections of rolling stock / infrastructure.

The standard consists of two main parts:

- The principles, covered in *Part I*, explain the main business needs and challenges and the way these will be addressed. The principles are not rules but help to explain the logic behind the rules.
- The rules, covered in *Part II*, specify how the identification keys, data attributes and data capture standards must be applied.

This standard will periodically be updated, reflecting the learnings of initial implementations. Please see the page on the website *http://www.gs1.org/rail* for more information about GS1's projects and developments in rail.

1.1 Target audience

This standard is intended to be used by all parties involved in rail manufacturing, maintenance, repair, and overhaul processes. These include:

- Manufacturers (system integrators, system manufacturers, component supplier),
- Operators (rail network operators, rail operators),
- Service providers (MRO workshops, project contractors, logistics service providers, and
- Regulators.

1.2 Scope of the standard

Today's rail manufacturing industry and supply chain is becoming ever more open and competitive, with traditional national players being privatised, competing with new entrants and sourcing their materials from all over the world.

At the same time the rail industry is being challenged by its customers to improve reliability and quality, and by regulatory bodies to implement measures aimed at further improving safety.

As a result manufacturing, maintenance, repair and overhaul (in short Manufacturing & MRO) processes have become far more international and complex than before. This drives the need for greater interoperability among rail manufacturing & MRO process stakeholders and among their systems and supply chains.

In order to meet these challenges, the entire rail industry must improve its manufacturing & MRO processes and in particular develop capabilities for reliable life cycle tracking of components and parts (referred to as MRO-objects in this standard) across companies, supply chains and over life cycles of up to 60 years.

A key enabler will be the ability to unambiguously identify MRO-objects across the systems and processes of all stakeholders. Depending on the operational and safety characteristics as well as legal requirements MRO-objects will need to be identified on class-level, lot-level and more and more frequently up to serial-level.

This standard defines the rules, roles and responsibilities regarding the allocation of GS1 identification keys and regarding the marking of MRO-objects using barcodes, EPC/RFID tags and plain text.

1.3 Conventions applied in the standard

1.3.1 References

References to documents, websites etc. are indicated as follows [REFERENCE, paragraph number (optional)]. The list of references with full details is included in section 2.

1.3.2 Rules and recommendations

Rules and recommendations are numbered per section. For example, clause **[4-3]** is the 3rd clause in section 4.

Within this specification, the terms SHALL, SHALL NOT, SHOULD, SHOULD NOT, MAY, NEED NOT, CAN, and CANNOT are to be interpreted as specified in section 7 of the ISO/IEC Directives, Part 2, edition 7.0 [ISODir2]. When used in this way, these terms will always be shown in ALL CAPS; when these words appear in ordinary typeface they are intended to have their ordinary English meaning.

1.3.3 Format of element strings

The following conventions are applied to indicate the format of GS1 Application Identifiers and data fields.

To indicate the allowed characters:

- N numeric digit
- X any character, see [GenSpecs, figure 7.11 – 1] for the allowed characters.

To indicate the length:

- Nn exact number of digits
- N..n maximum number of digits
- Xn exact number of characters
- X..n maximum number of characters

Examples:

- X3 exactly 3 characters
- N..18 up to 18 numeric digits

To indicate digit / character position:

- X_n
- N_n

Examples:

- N_3 numeric digit on position 3
- X_{16} any character on position 16

2 (Moved to section 11 References)

This section (References) has been moved to section *11*

3 Terms and definitions

For the purposes of this document the following terms and definitions apply.

3.1 General concepts

MRO-object

An MRO-object is an umbrella term used to refer to and describe the entities that need to be managed, handled or in any other way used within the context of Manufacturing and MRO processes in Rail.

Commonly used synonyms of MRO-object are article, part, component, item, Line-Replaceable Unit (LRU) and Shop-Replaceable Unit (SRU). For the purpose of this document the term MRO-object encompasses all these synonyms.

Single MRO-object

An MRO-object which in view of the describing party (for instance rail operator) cannot be further broken down into new (sub-) objects.

Examples: isolator, bolt for rail fastening materials.

Composed MRO-object

An MRO-object which in view of the describing party (for instance rail operator) can be further broken down into new (sub-) objects. A composed MRO-object may be configurable or fully pre-defined.

Example: traction motor for electrical locomotive.

Software

A type of MRO-object that is a collection of computing programs developed for the purpose of being incorporated into a composed or single MRO-object.

Examples: firmware in an ETCS beacon, software in a door control system.

Kit

A kit is a non-homogeneous combination of MRO-objects and installation tools and materials, intended for one specific purpose, and stored, moved, priced, ordered or invoiced as a trade unit.

Synonyms: Set, Pre-defined assortment

Grouping

A grouping is a homogeneous combination of MRO-objects that is stored, moved, priced, ordered or invoiced as a trade unit.

Synonym: trade item grouping (of identical trade items)

Module

A module is a composed MRO-object that is designed to allow for different configurations. The included MRO-objects, and how they are designed to interact with each other, establish the complete configurable device (module).

Object class

An object class designates MRO-objects (including software) which are:

- identical in form, fit and function (FFF),
- can be used interchangeably,
- may be stored, moved, priced, ordered or invoiced individually,
- and form a part of or are used to operate rolling stock and/or rail infrastructure.

Trade item

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. [GenSpecs]

3.2 Physical objects

Instance

An instance designates an individual manufactured MRO-object belonging to an object class. The instance has all the attributes of the object class and may have additional attributes also.

Synonym: Item, Product unit

Instance group

An instance group designates a collection of instances belonging to the same class with the same (production) characteristics.

For example, instances produced as part of the same production run or batch, with the same raw / base materials, by the same manufacturer, in the same plant, ...

An instance group is created by attribution of an attribute to an object class and therefore represents a subset of an object class.

Synonym: Batch / Lot

Configuration

A configuration is a defined occurrence of a module. It consists of a combination of multiple instances interacting with each other and thereby fulfilling a defined form, fit and function (FFF).

Primary packaging

Primary packaging is the material that first envelops the product and holds it. This usually is the smallest unit of distribution or use and is the package which is in direct contact with the contents.

Secondary packaging

Secondary packaging is outside the primary packaging and may be used to prevent pilferage or to group primary packages together.

Tertiary packaging

Tertiary packaging is used for bulk handling, warehouse storage and transport shipping. The most common form is a palletised unit load that packs tightly into containers.

3.3 Maintenance, repair and overhaul

MRO strategy

The way a company is managing an MRO-object from a maintenance, repair and overhaul perspective. For example, repairable, rotable, consumable.

The MRO strategy for a particular MRO-object may vary by party, and it may change over time. For example, an object that is treated as repairable at first may be treated as consumable at the end of its lifecycle.

Consumable

A type of MRO-object that is not re-fabricated and that is discarded after replacement.

Examples: isolators for power switches, rail fastening components.

Repairable

A type of MRO-object that can be re-fabricated and does not follow a usage-based maintenance strategy and does not need to have an individual track record.

Examples: compressors, electrical relays.

Rotable

A type of MRO-object that can be re-fabricated, follows a usage-based maintenance strategy and needs to have an individual track record.

Examples: wheel sets, rolling stock bogies.

Refurbishment

Refurbishment is the rebuilding of a product to specifications of the original manufactured product using a combination of reused, repaired and new parts. It requires the repair or replacement of worn out or obsolete components and modules. (Wikipedia)

Synonym: Remanufacturing—(APICS), re-fabrication

3.4 Identification

Unique identification

Depending on the scope / context the term unique identification may be used to refer to a globally unique identification key for an object class, an instance group, or an instance.

- When referring to the object class key, the term class-level ID is used.
- When referring to the instance group key the term lot-level ID is used.
- When referring to the instance key, the term serialised ID is used.

Automatic Identification and Data Capture (AIDC)

A technology used to automatically capture data. AIDC technologies include barcodes, smart cards, biometrics and RFID. [GenSpecs]

GS1 identification key

A unique identifier for a class of objects (e.g. a trade item) or an instance of an object (e.g. a logistic unit). [GenSpecs]

GS1 ID key issuance and allocation

Issuance is the generation of a GS1 Identification Key based on the format and syntax for that key and on the issuance policy of the managing entity.

Allocation is the association of the issued GS1 Identification Key with an object of the type supported by the GS1 Identification Key in accordance with the GS1 rules.

Different entities may be involved in each process. For example, a computer program could be used to do the issuance and a human could be used to do the allocation. A classic example of this is one where the IT department prepares a spreadsheet of available GTINs (see definition below) for use by the Product Development department. Each GTIN in the spreadsheet is issued, but until Product Development actually has a product for it, it is not considered to be allocated. [GS1 Architecture]

Global Trade Item Number® (GTIN®)

The GS1 identification key used to identify trade items. The key comprises a GS1 Company Prefix, an item reference and check digit. [GenSpecs]

Global Individual Asset Identifier (GIAI)

The GS1 identification key used to identify an individual asset. The key comprises a GS1 Company Prefix and individual asset reference. [GenSpecs]

GS1 Prefix

A unique string of two or more digits issued by GS1 Global Office and allocated to GS1 Member Organisations to issue GS1 Company Prefixes or allocated to other specific areas. [GenSpecs]

GS1 Company Prefix

A unique string of four to twelve digits used to issue GS1 identification keys. The first digits are a valid GS1 Prefix and the length must be at least one longer than the length of the GS1 Prefix. The GS1 Company Prefix is issued by a GS1 Member Organisation. As the GS1 Company Prefix varies in length, the issuance of a GS1 Company Prefix excludes all longer strings that start with the same digits from being issued as GS1 Company Prefixes. [GenSpecs]

U.P.C. Company Prefix

A GS1 Company Prefix starting with a zero (‘0’) becomes a U.P.C. Company Prefix by removing the leading zero. A U.P.C. Company Prefix is used to issue GTIN-12. [GenSpecs]

GS1 Application Identifier

The field of two or more digits at the beginning of an element string that uniquely defines its format and meaning.

Supplemental identification attributes with regulatory significance

Approval of an MRO object by the respective national regulatory body with oversight of rail operations, is based on form, fit and function (FFF), as described by a GTIN and sub-GTIN key attributes. The degree of variations which an MRO object undergoes over its life cycle may have a different impact on documentation requirements, subject to locally applicable regulations.

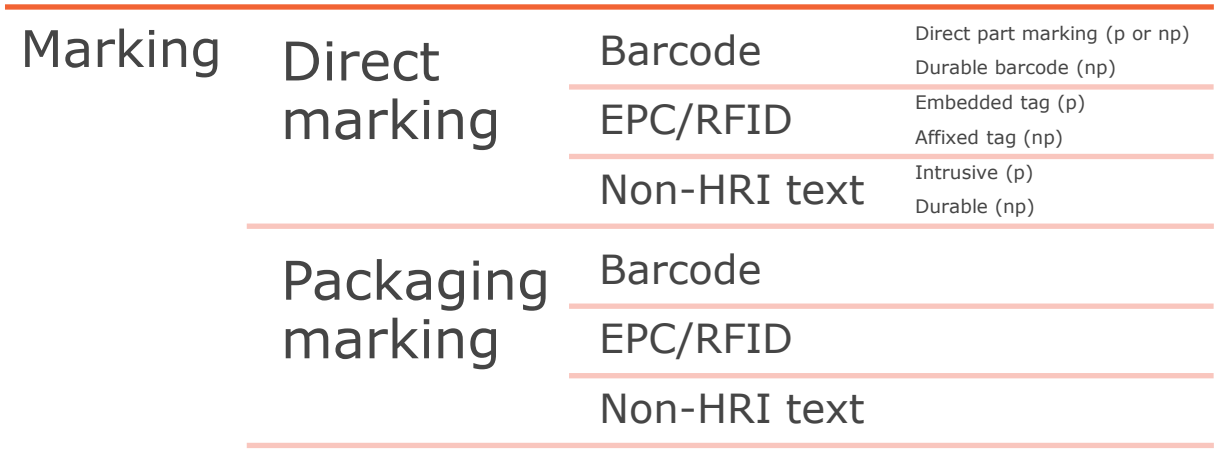
To keep track of the evolution of an MRO object, **functional status** and **revision status** can be used to provide finer granularity, within a given GTIN. Please refer to section 5.2 for an explanation of these.

Changes to an MRO object occur primarily during the maintenance phase; in this context, maintenance encompasses a wide range of activities to prevent malfunctions, failures, and hazards. These activities include, but are not limited to:

- **Maintaining**: Measures aimed at maintaining the target condition of technical systems.
- **Repairing**: Actions taken to restore an MRO object, which has failed, to a state in which it can continue to perform its required function.
- **Improving/Upgrading/Re-fitting**: Actions taken to restore an MRO object by replacing or renewing major components, often to extend their operational life. This may involve the replacement of outdated parts with newer or more efficient ones, sometimes with improvements beyond the original specifications.
- **Refurbishment**: Activity carried out to restore the performance of an item to a level comparable to when it was new, without necessarily upgrading it.

3.5 Marking

Figure 3-1 Illustration of main concepts



(p=permanent marking, np = non-permanent marking)

Marking

noun: A means of physically affixing machine-readable data and/or human readable data to a physical object. (synonym: physical data carrier)

verb: The act of physically affixing machine-readable data and/ or human readable data to a physical object.

Packaging marking

Packaging marking is marking applied on the packaging of the instance.

Direct marking

Direct marking is marking applied on the unpackaged instance.

Direct part marking (DPM)

Direct part marking refers to the process of marking a symbol on an item using an intrusive or non-intrusive method. [GenSpecs]

Permanent marking

Permanent marking (for instance engraving or a marking via an elevated contour of an object) is a type of direct marking connected to an instance in such a way that it cannot be removed without altering the MRO-object itself and / or would normally be expected to outlive the MRO-object.

Non-permanent marking

Non-permanent marking is a type of direct marking that can be applied or removed from an MRO-object without altering the object itself (bolted, glued, banded, etc.). This type of marking may be re-applied several times during the lifetime of an MRO-object and is not expected to outlive the MRO-object.

Human readable interpretation (HRI)

Characters, such as letters and numbers, which can be read by persons and are encoded in GS1 AIDC data carriers confined to a GS1 standard structure and format. The human readable interpretation is the encoded data. Start, stop, shift and function characters, as well as the symbol check character, are not shown in the human readable interpretation. [GenSpecs, Glossary]

Non-HRI text

Characters such as letters and numbers that can be read by persons and may or may not be encoded in GS1 AIDC data carriers and are not confined to a structure and format based on GS1 standards (e.g., a date code expressed in a national format that could be used to encode a date field in a GS1 AIDC data carrier, brand owner name, consumer declarations). [GenSpecs, Glossary]

Data titles

Data titles are the abbreviated descriptions of element strings which are used to support manual interpretation of barcodes. [GenSpecs]

3.6 Data management

Standard Bill of Material

A standard bill-of-material (BOM) defines the MRO-objects that are part of a composed MRO-object, including a hierarchical breakdown from top level to lowest level MRO-objects. The standard BOM is defined in terms of contained MRO-object classes.

Note:

The required detail included in a standard BOM will depend on the role of the party. A manufacturer will have the full detail of all components, the operator may only require full detail of components that are of relevance to them (e.g. safety critical).

Instance Bill of Material

An instance bill-of-material (BOM) defines the instances that are part of a composed MRO object, including a hierarchical breakdown from top level to lowest level instances. The instance BOM is defined in terms of contained instances.

Note:

The required detail included in an instance BOM will depend on the role of the party. A manufacturer will have the full detail of all components, the operator may only require full detail of components that are of relevance to them (e.g. safety critical).

History (of an instance or object class)

Defines all changes made to an object class specification and / or the attributes of an instance as well as maintenance activities carried out at instance level throughout its lifetime.

See version history, maintenance history, usage history, testing history.

Version history

Defines all changes made to an object class specification.

Maintenance history

Record of the maintenance activities that were carried on an instance throughout its lifetime.

Usage history

Record of the operation (e.g. number of operating hours) of an instance throughout its lifetime.

Testing history

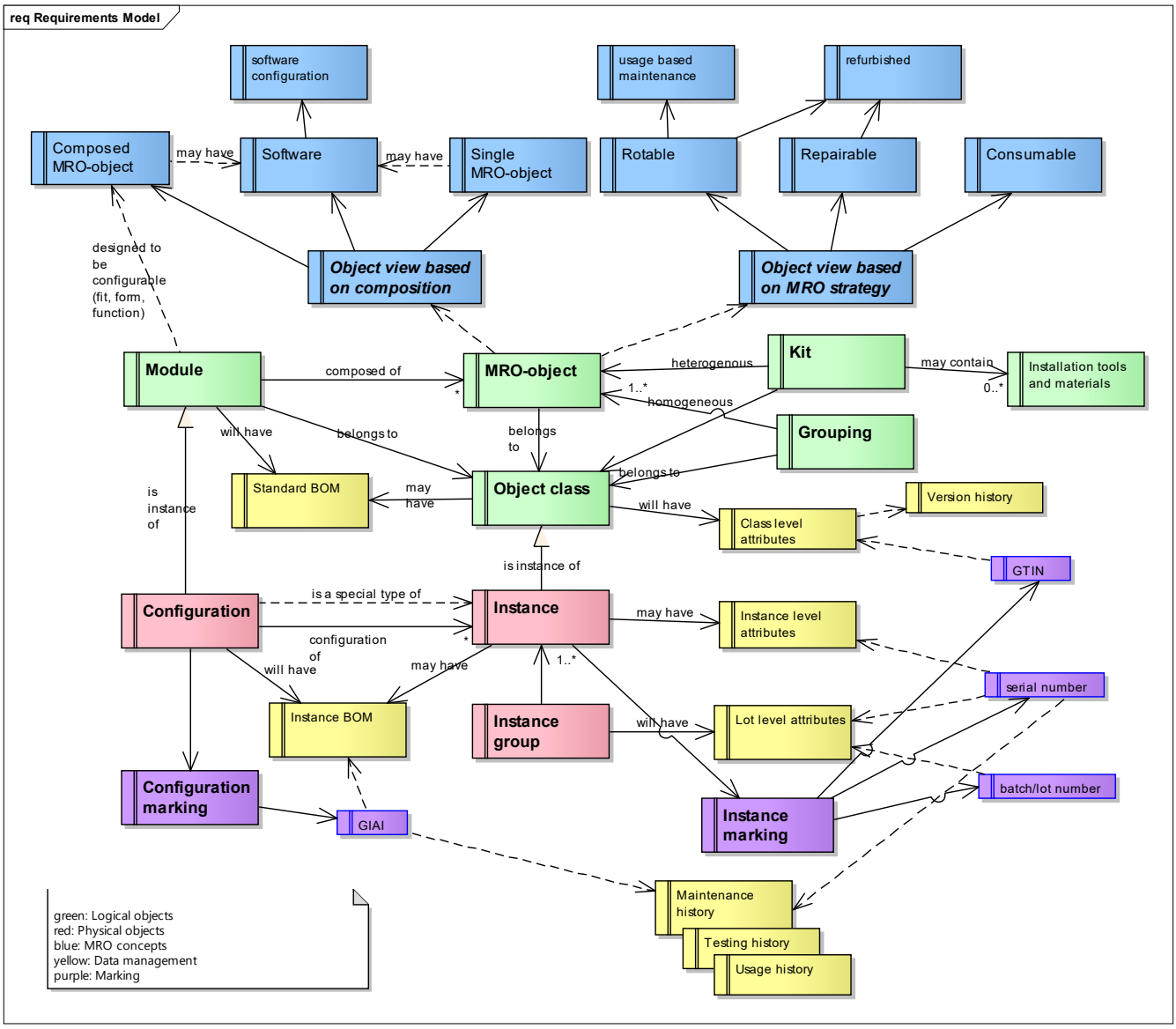
Record of the tests performed on an instance throughout its lifetime.

3.7 List of abbreviations

Abbreviation	Full term
AI	GS1 Application Identifier
AIDC	Automatic Identification and Data Capture
BOM	Bill Of Material
DPM	Direct Part Marking
EPC	Electronic Product Code
ETCS	European Train Control System
FFF	Form, fit and function
GCP	GS1 Company Prefix
GIAI	Global Individual Asset Identifier
GLN	Global Location Number
GTIN	Global Trade Item Number
HRI	Human Readable Interpretation
MB	Memory Bank (of EPC/RFID tag)
MRO	Maintenance, repair and overhaul
RFID	Radio Frequency identification
SKU	Stock Keeping Unit
TDS	GS1 EPC Tag Data Standard

3.8 Conceptual diagram (informative)

Figure 3-2 Conceptual diagram



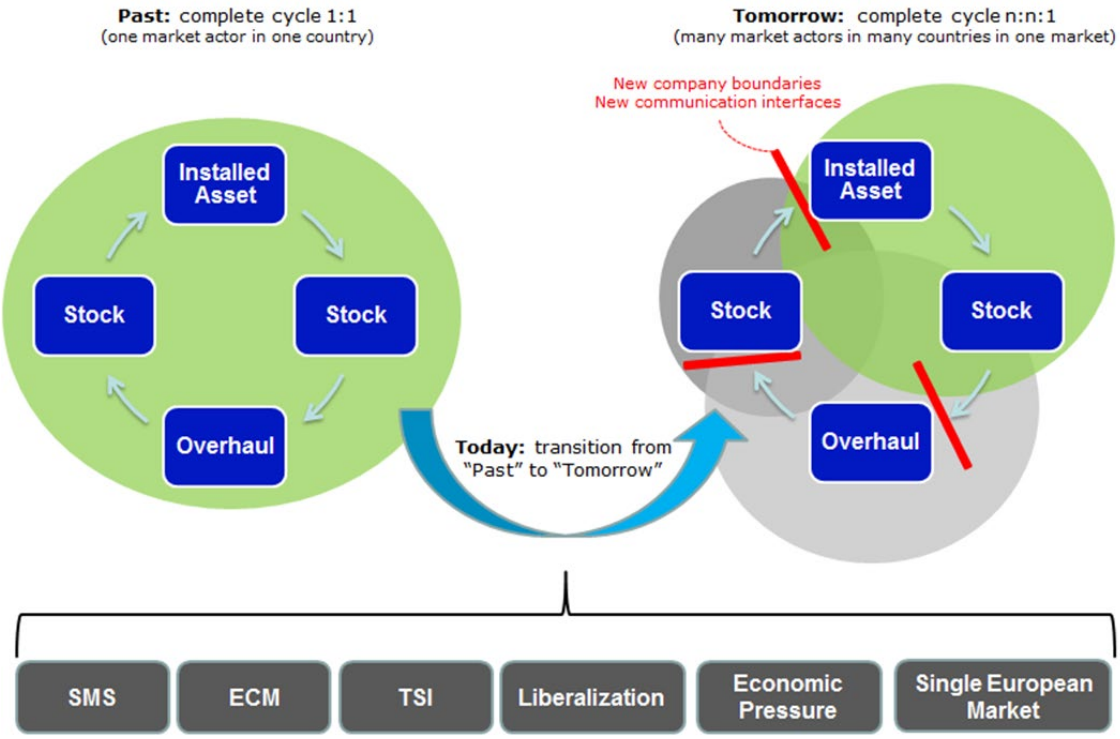
PART I - GENERAL PRINCIPLES

4 Lifecycle identification of MRO-objects

4.1 Value chain

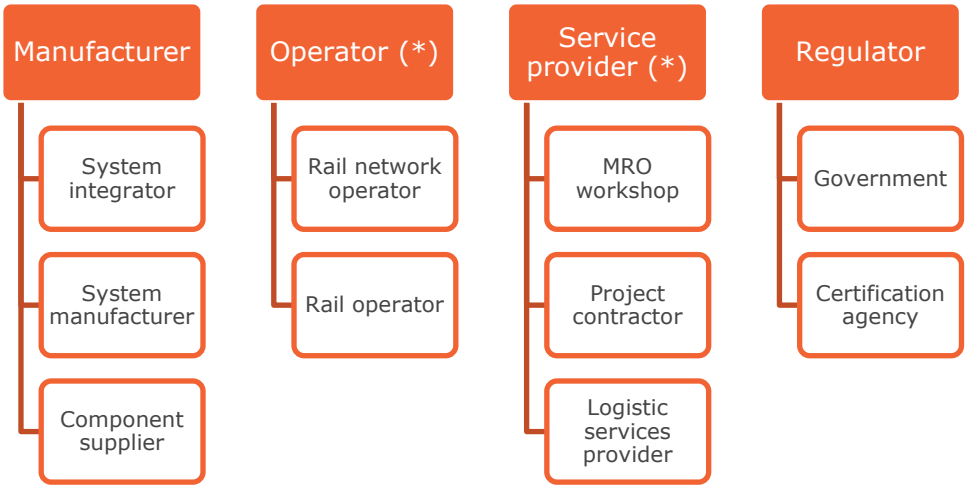
Today's rail manufacturing and MRO industry has become global, with a relatively small number of system suppliers relying on an ever more fragmented international supply chain with a network of specialised suppliers for key components and assemblies.

Figure 4-1 Transition of the rail manufacturing and MRO industry



4.2 Business processes

Figure 4-2 Process roles



(*) Note that the diagram depicts the value chain and that the roles do not exactly mirror the ECM (entity in charge of maintenance) responsibilities.

Table 4-1 Roles and responsibilities

role	Responsibility in process
Manufacturer	
System integrator	Creates a complete, operational asset like a train, locomotive or section of complete rail track
System manufacturer	Produces complex composed MRO-objects out of a number of different MRO-objects
Component supplier	Manufactures MRO-objects without, in principle, integrating major value added MRO-objects from other sources
Operator	
Rail network operator	Manages and maintains the rail infrastructure 1169/2010 : Infrastructure manager
Rail operator	Runs, manages and maintains rolling stock operations 1158/2010 : Railway undertaking
Service provider	
MRO workshop	Repairs and refurbishes MRO-objects
Project contractor	Carries out the project management of the rail network operator's rail infrastructure works, which need to comply with identification and marking standards.
Logistics service provider	Management of inventory, transport and procurement of MRO-objects
Regulator	
Government	Authority/overseer. For example, Office of Rail & Road (ORR) in the UK.
Certification agency	Organisation responsible for safety & standards. For example, Rail Safety & Standards Board (RSSB) in the UK.

4.3 Need for traceability

Identification and traceability requirements are driven by safety aspects and by the economic or operational relevance of an MRO-object (e.g. impacting vehicle downtimes).

Regulatory requirements

According to recent European legislation (see section *11*) **rail and rail network operators** must develop and maintain management systems which guarantee a safe and stable operation as well as the interoperability of the assets used.

This entails that all MRO-objects will undergo a risk analysis reflecting their potential impact on safety. Moreover, a configuration management is compulsory, as required by regulations 445/2011. 1169/2010 and 1158/2010.

For some MRO-objects there exist legal requirements for traceability, but even in the absence of such legal requirements a risk analysis of an MRO-object often results in the requirement that either objects be clearly identified or even tracked on batch or individual instance level, as well as their history recorded over the complete lifetime.

Maintenance strategies

One of the main defining elements of the rail industry is the fact that a substantial number of MRO-objects (in rolling stock as well as in rail infrastructure) is procured for a long-use life cycle of up to 60 years. Such MRO-objects need to be maintained, refurbished or replaced on a regular or on an ad-hoc basis.

The maintenance organisations responsible for the objects needing maintenance will act based upon a wide variety of triggers that will signal that objects require planned or emergency or ad-hoc maintenance.

Figure 4-3 Types of maintenance strategies

Scheduled maintenance	Predetermined maintenance (preventive maintenance without observation)
	Condition based maintenance (preventive maintenance with observation)
	Deferred corrective maintenance
Unscheduled maintenance	Opportunistic maintenance (not immediately after failure)
	Immediate corrective maintenance

[based on DIN EN 13306:2015-09]

4.4 Configuration management

Another key aspect is the need for configuration management. Composite MRO-objects will be manufactured and maintained using a bill-of-material (BOM). Composite MRO-objects may contain other composite MRO-objects (produced by other manufacturers), which means that it must be possible to link BOMs.

Three types of BOMs that may be applied, each with specific characteristics, are:

1. Design BOM: A standard BOM used in conjunction with the technical design, used as a basis for the manufacturing process. It will define the MRO-objects in terms of their type and position, but will not contain any serialised IDs or lot level IDs.
2. Manufacturing BOM: An instance BOM that is created during the manufacturing process and defines the MRO-object 'as built'. It will contain a mixture of serialised and non-serialised IDs of the contained instances. Composite MRO-objects sourced from another party should have a serialised ID allowing to link to the manufacturing BOM of the supplier. This linking of instance BOMs is an essential aspect.
3. Installation BOM: An instance BOM that is used by the operator and the manufacturer's after sales service organisation and used for the maintenance process. Like the manufacturing BOM this is an instance BOM, but unlike the manufacturing BOM the installation BOM will only contain instances that can be physically identified (serialised MRO-objects).

Example

Figure 4-4 Locomotive

A locomotive will consist of several subsystems. Each subsystem will consist of several physical components.

The system integrator will have a design BOM of the locomotive, and will create a manufacturing BOM for each manufactured locomotive.

The sub system manufacturer of the brake system will have a design BOM and a manufacturing BOM for the sub system, consisting of several components that need to be integrated by the system integrator.

Based on the data from the suppliers the system integrator will create an installation BOM. In that BOM the brake system as a 'whole' will not be present, but primarily the serialised physical components that make up the system.

5 Identification and marking principles

5.1 Identification levels

A critical question is at what level physical MRO-objects will be identified. Due to the wide variety of MRO-objects in rolling stock and infrastructure management, and related variation in required level of traceability, the standard needs to provide sufficient flexibility to ensure the required safety and enable cost effective solutions.

In many situations it is sufficient to identify instances at the class level.

Lot level identification allows to distinguish narrower groupings, such as instances from a given manufacturing batch or refurbishment batch.

Serialised identification, in which each MRO-object has a globally unique identifier that is different from every other object, is the most precise and allows to link to data about the individual instance.

Important: The scenario to be used will depend on the most stringent scenario.
For example: When a manufacturer applies serial level identification based on the most stringent customer requirements, other customers will in principle not be allowed to require a less granular identification (such as lot level or even class level identification). In case of conflict between different customer requirements, using the most flexible solution offered by this standard is recommended. For instance, the use of serialised GTINs instead of GIAIs, as the former allows for more flexibility for customers with less granular identification requirements.

5.1.1 Class-level identification

The object class ID (SKU number) is the primary ID used in manufacturing, ordering and warehousing processes. It also will be the main way to exchange master data about the MRO-object.

The object class ID is less important in maintenance, repair and overhaul processes. The object class ID will help to identify the type of item, but it will not provide a way to access the manufacturing and maintenance history of the instance.

Important: It is important to note that the master data related to the object class ID will no longer apply when the instance has been refurbished causing a change of the technical specification.

5.1.2 Lot-level identification

When the manufacturing lot ID is marked on the item, a more precise link to the manufacturing history is enabled. If the associated data have been recorded properly this will for example allow to locate and recall all instances with a specific production defect.

Similarly, marking of the refurbishment lot ID, will allow a link to the refurbishment data of a group of instances.

5.1.3 Serialised identification

A serialised ID provides the highest level of traceability. It is the only suitable identification option for MRO-objects that have an instance BOM.

Furthermore, serialised identification eliminates the need for marking of manufacturing and refurbishment lot ID, since such data can be linked to the serialised ID.

Two types of serial identification exist:

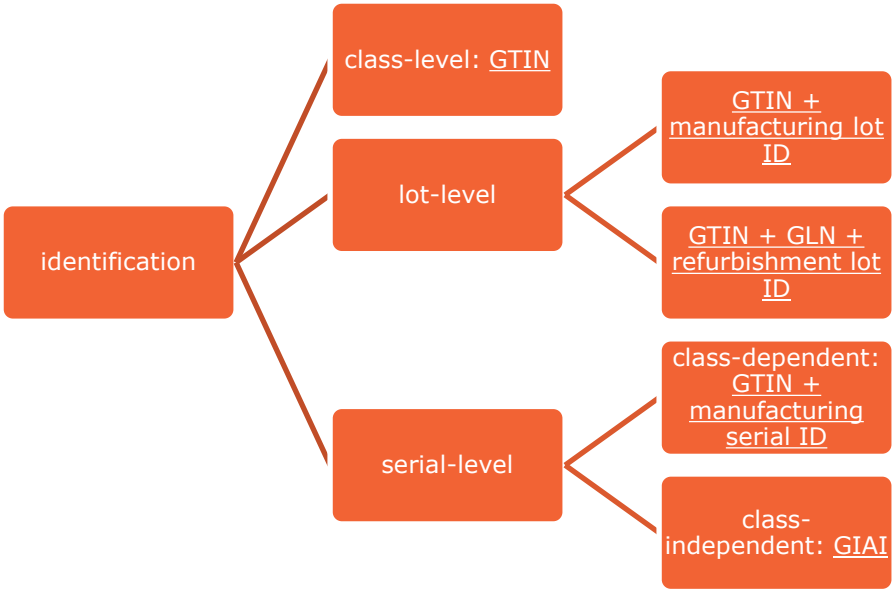
1. Class dependent serialised ID (containing the object class ID): The type of part can be recognised by reading the ID
2. Class independent serialised ID: The type of part cannot be recognised by reading the ID.

Ideally the serialised ID is allocated and marked by the manufacturer at time of production. In absence of a manufacturing assigned ID, the operator or workshop may need to assign a serialised ID, to enable recording of the maintenance and usage history.

5.1.4 Mapping to GS1 identification keys

The diagram below lists the various identification options and the way these are implemented using the GS1 standards.

Figure 5-1 Identification levels and GS1 identification keys



5.2 Functional status and revision status

The functional status and revision status allow for the identification of attributes of a product or component, which are below the thresholds requiring a GTIN change as per the GTIN management rules. For example, a component with a specific GTIN is sold into different countries and may undergo different regulatory approvals, which can be addressed by indicating functional status or functional status and revision status.

As practiced by industry for decades, the functional status defines a version below GTIN level, while the revision status applies to a minor version, subordinate to a given revision status.

Example:

*If a component undergoes a minor drawing adaptation which is not sufficient to require allocation of a new GTIN, then the component's **functional status** can be changed, (for example) as follows:*

Component with old drawing: `(01)09521450000088(7021)A`

Component with new drawing: `(01)09521450000088(7021)B`

*Within this functional status, if further differentiation is required, for example between two otherwise identical drawings showing different measurement points for two different clients, this distinction can by indicated by further qualifying the functional status with a distinct **revision status**, (for example) as follows:*

Component with drawing for client X: `(01)09521450000088(7021)B(7022)1`

Component with drawing for client Y: `(01)09521450000088(7021)B(7022)2`

While the GTIN – and corresponding GTIN-level master data -- is static at GTIN-level over the entire product life cycle, the functional status and revision status can change during the product life cycle of a given GTIN. For this reason, it is recommended to encode and store both the functional status and revision status off-carrier (i.e., in a database or other persistent repository) wherever possible, only encoding them on the physical data carrier (i.e., GS1 barcode or EPC/RFID tag) where this is necessary.

Note that on-carrier indication of functional status or revision status is not needed for components which are uniquely identified by means of a serialised identifier (e.g., SGTIN or GIAI). This is because the unique identifier allows for retrieval of supplemental attributes (including but not limited to functional status or revision status) specific to that component, which have been stored off-carrier.

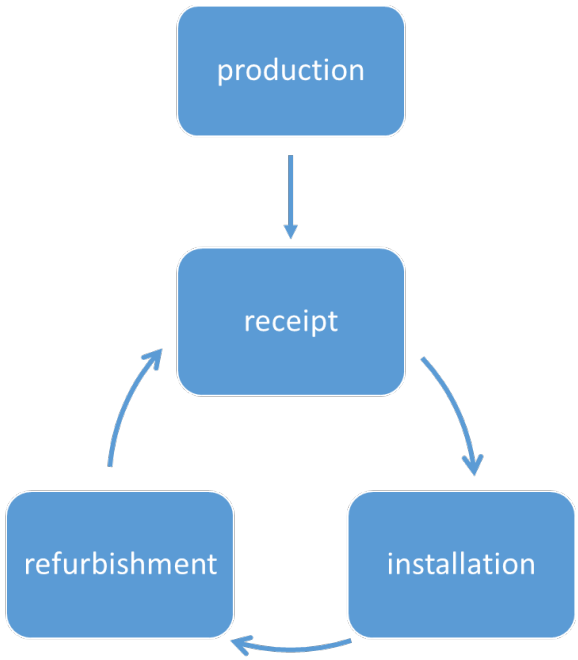
5.3 Direct marking events

Four main event types have been identified at which marking of unpackaged instances will occur:

- production
- receipt
- installation
- refurbishment

As illustrated in figure 5-2 the production event will occur only once during the lifetime of the instance, while the other events may occur multiple times, depending on the type of object.

Figure 5-2 Marking events during the MRO-object lifecycle



Important: Best practice is to limit the number markings / marked data to a minimum, and to rely on digital data exchange to the maximum extent possible. The rules in this standard have been based on this principle.

Marking at time of production

At the time of production, the ID of the instance will be marked by the manufacturer. Depending on the MRO-object type also the functional status and current revision status may need to be marked.

Marking at time of receipt

At the time of receipt, the operator may find that the marking on the instance is not readable or not of the right level of detail and needs to be complemented / replaced by a new marking. Also it is possible that the supplier is not obliged to mark the instances under the current contract.

Marking at time of installation

At the time of installation, the identification marking will not be changed, but an additional marking with configuration data may need to be applied, for example for non-serialised MRO-objects or when no reliable electronic data source is available.

Also the ID marking may need to be repaired in case it is not readable or no longer present (e.g. lost during transport).

Marking at time of refurbishment

At the time of refurbishment any missing or unreadable marking will be added or replaced. Also, as a result of the refurbishment e.g. washing with a pressure of 2,500 bar, the marking may need to be replaced as a general routine.

For non-serialised instances the refurbishment lot ID may need to be marked (in a separate marking) in order to provide a link between the instance and its maintenance history.

5.3.1 Overview of main scenarios

The table below lists the main identification and marking scenarios that have been identified.

Table 5-1 Identification and marking scenarios

Main scenario	Sub-scenario	GTIN	Manufacturing lot ID	Manufacturing serial ID	GIAI	Refurbishment lot ID	Additional data
marking at time of production	**A**	**X**					**(1)**
	B	**X**	**X**				**(1)**
	C	**X**		**X**			**(2)**
	D				**X**		**(2)**
marking at time of receipt	**E**	**(3)**					
marking at time of installation	**F**	**(3)**					**(4)**
marking at time of refurbishment	**G**	**(3)**				**(5)**	**(5)**

Notes:

(1) Marking of additional data such as functional status and revision status linked to the instance may be needed

(2) Additional data should be avoided, since the serialised ID provides a way to associate the data digitally

(3) The original marking may need to be refreshed or updated, or an owner assigned GIAI may need to be marked

(4) Marking of configuration data may be required legally

(5) For non-serialised instances functional status and revision status may need to be updated, and also the refurbishment lot ID may need to be marked.

Examples

MRO-object	Scenarios
RAIL FASTENING MATERIALS These are typical consumable MRO-objects where clear part marking and identification are crucial. These are safety relevant parts (it is important the correct object classes are assembled). Instance level however is not of importance (as the failure of one instance is not critical. What is critical are repetitive / serial failures and / or mistakes).	A, B, E
ISOLATORS Another example of consumable MRO-objects are isolators for power switches. Here production batch information is important for traceability reasons, as they are manufactured in batches and are expensive parts.	B
WHEELSETS These are typical rotable MRO-objects for which maintenance history (at instance level) is kept. Wheelsets come into refurbishment approximately every 1.2 million kilometres or after a use of maximum 6 years.	D, E, F
ELECTRICAL RELAYS These are repairable MRO-objects that are refurbished in batches (washed for instance). In some refurbishments the individual serial number may be of no concern, and only the production and refurbishment batch numbers are used (for traceability reasons).	B, C, D, E, G

MRO-object	Scenarios
FIRMWARE VERSION FOR ETCS-SYSTEMS (EUROPEAN TRAIN CONTROL SYSTEM). Here we need to know which instance (module) is configured with which firmware version. So the instance bill of material per configuration is crucial before the ETCS-system is installed on a loco and the loco re-commissioned to service.	C, D, E, F, G

5.4 Marking of composed MRO-objects

Composite MRO-objects do not have a surface uniquely belonging to the object, and not to any of its subcomponents, where a marking could be placed. Therefore, the only available surface will be on one of the subcomponents that makes up the composite MRO-object. And such subcomponents will have their own markings.

Approaches

Two main approaches are applied in practice:

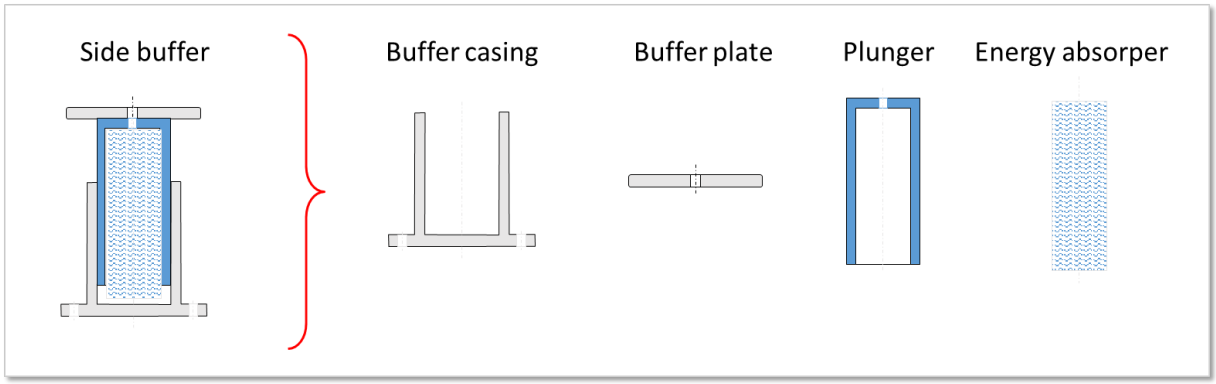
1. Avoid double markings by letting one of the subcomponents (the leading part) play a double role. The ID marked on the leading part plays two roles, depending on its state (assembled or not-assembled) it identifies either the parent component or itself.
   In this approach the ID marked on the subcomponent is used to identify both the subcomponent as well as the parent component. This approach fits well with the way operators look at the MRO-object, using an 'installation BOM' where only components that physically exist are identified.
2. Apply an additional marking on one of the subcomponents (the leading part) that identifies the parent object.
   In this approach one of the subcomponents will have two markings [AI (8004) or AI (01) and AI 21) for the subcomponent and AI (7023) for the assembly]. The first marking holds the ID of the subcomponent; the second marking holds the ID of the parent component. This approach fits well with the way the MRO-object is manufactured.

Solution

The standard will support both approaches and provide a bridge between the two. Two markings will be allowed, but in that case parties will have a way to easily recognise the second marking (the two barcodes will use different GS1 Application Identifiers).

Example

Figure 5-3 Side buffer (example of composed MRO-object)



The example shows a side buffer, which is a composed MRO-object consisting of 4 subcomponents. The buffer casing is the leading part.

Option 1 (the preferred option):

The buffer casing gets one marking. In assembled state the ID identifies the side buffer, in dis-assembled state the ID identifies the buffer casing.

Option 2:

The buffer casing gets two markings, one to identify the buffer casing, one to identify the side buffer. The latter marking will be recognisable as being a 'parent mark'.

5.5 Identification and marking of packaging

MRO objects come in all sorts and sizes, and this means there is a wide variety of packaging forms.

Furthermore, the way MRO objects are handled once in inventory can vary:

- Stays on pallet
- Picked from pallet
- Picked from secondary packaging
- Secondary packaging is minimum pick quantity
- Stored in bins – either in primary packaging or unpackaged

Depending on the type of item the ID that needs to be recorded when an item is picked from inventory may vary from class level to fully serialised. This impacts the information to be marked on the packaging.

Figure 5-4 Packaging level identification

Packaging level	Marking
Primary packaging containing 1 instance	Same as unpackaged instance ID
Grouping (including primary packaging containing multiple instances)	GTIN of the grouping, optional manufacturing lot ID / serial ID (to be further specified in a future version of this standard)
Kit	GTIN of the kit, optional manufacturing lot ID / serial ID (to be further specified in a future version of this standard)

PART II - RULES

6 Identification rules

6.1 Identification keys

A key is an attribute (or group of attributes) of an entity that serves to uniquely identify that entity, within some specified domain of entities. Often a single attribute is usable as a key, but sometimes a group of attributes is required. In data modelling terminology these are called simple keys and compound keys, respectively.

Table 6-1 lists the identification keys that are applied to identify MRO-objects.

Table 6-1 Overview of identification keys

key attribute(s)	key type	level of identification
GTIN	simple key	class level
GTIN + manufacturing lot ID	compound key	lot level
GTIN + GLN + refurbishment lot number	compound key with supplemental AIDC data	lot level
GTIN + manufacturing serial ID	compound key	instance level
GIAI	simple key	instance level

Note: See section 9 for the data formats of the keys.

6.2 GTIN

[6-1] The GTIN SHALL be assigned in accordance with the general GTIN management rules as defined in [GTINMan] and the rail sector specific rules as defined in section 7 of this standard.

[6-2] The GTIN SHALL be assigned by the party that has functional and constructional responsibility and/or is responsible for regulatory acceptance. This means one of the following parties (in order of importance) SHALL assign the GTIN using their GS1 company prefix:

a. The brand owner who owns the specification of the MRO-object, regardless of where and by whom it is manufactured.

b. The party manufacturing the MRO-object, the so-called Original Equipment Manufacturer (OEM).

c. If a distributor wishes to bring an MRO-object to the market that does not have a GTIN, the distributor SHALL take steps to mandate a GTIN from the brand owner or OEM and in the meantime MAY assign a GTIN using its own GS1 company prefix.

6.3 GTIN + manufacturing lot ID

[6-3] The manufacturing lot ID SHALL be unique in combination with the GTIN, and never be reused.

[6-4] The manufacturing lot ID SHALL be assigned by the manufacturer.

[6-5] The attributes identified with the GTIN + manufacturing lot number SHALL correspond to a group of instances that were produced as part of the same production batch.

6.4 GTIN + manufacturing serial ID

[6-6] The manufacturing serial ID SHALL be unique in combination with the GTIN, and never be reused.

[6-7] The manufacturing serial ID SHALL be assigned by the manufacturer.

6.5 GIAI

[6-8] The GIAI SHALL be unique and never be reused.

[6-9] The GIAI SHALL be assigned by the operator or by the manufacturer (see rule [6-2]).

6.6 GTIN + GLN of workshop + refurbishment lot ID

[6-10] The refurbishment lot ID SHALL be unique in combination with the GLN of the workshop (production / service location) that carried out the refurbishment, and never be reused.

[6-11] The refurbishment lot ID SHALL be assigned by the workshop.

6.7 GS1 Company Prefix (GCP)

The GS1 Company Prefix is included at the beginning of the GS1 identification keys and so establishes global uniqueness (see section 9 for more information).

[6-12] The GS1 Company Prefix SHALL be only be used to issue keys by or on behalf of the company that is the licensee of the GS1 Company Prefix, in accordance with the key allocation rules specified in GenSpecs section 4 Application rules and management practices.

[6-13] When the ownership or legal structure of the company that assigned the key changes, for example due to a merger, acquisition, split or spin-off, the responsibility for the GS1 Company Prefixes SHALL be re-arranged according to the rules in GenSpecs section 1.6 Allocation.

7 GTIN management rules

These rules explain the way GTINs need to be assigned to MRO-objects for catalogue and order management purposes. These rules will also be included on the GTIN management page.

7.1 General principles

At least one of the guiding principles must apply for a GTIN change to be required.

- Is a consumer and/or trading partner expected to distinguish the changed or new product from previous/current products?
- Is there a regulatory/liability disclosure requirement to the consumer and/or trading partner?
- Is there a substantial impact to the supply chain (e.g., how the product is shipped, stored, received)?

[source: GTINMan]

7.2 Adding a new MRO-object class

[7-1] When a new MRO-object is created that is different in form, fit and function (FFF) from any of the existing objects a new GTIN SHALL be assigned.

Examples:

- *Introduction class B balise 3 MM thicker, higher water resistance is introduced next to the existing class A balise*
- *Connector types supporting different voltages. Each connector type requires a separate GTIN.*
- *Copper cables with different diameters will need to be distinguishable via separate GTINs.*

[7-2] Any hierarchy level that is priced, ordered or invoiced individually at any point in the supply chain SHOULD receive its own GTIN.

Examples:

- *Carton containing 100 power relays requires a GTIN that is different from the GTIN of the individual power relay.*
- *Pack with a pair of screen wiper blades requires GTIN that is different from the GTIN of the single wiper blade.*

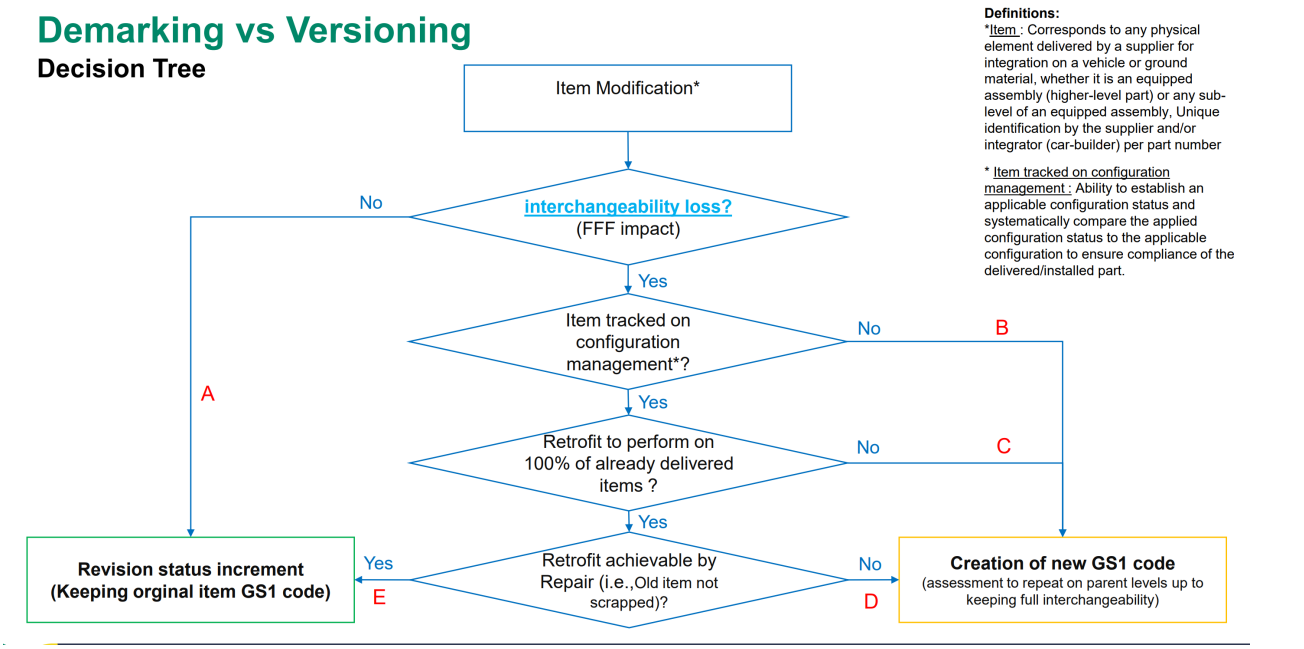
7.3 Changing an existing MRO-object class

[7-3] When the form, fit and function (FFF) of an existing MRO-object is changed a new GTIN SHALL be assigned, unless rule 7-4 applies. The newly produced instances SHALL be marked with the new GTIN. The GTINs as marked on already produced items SHALL remain the same.

Examples:

(NOTE that these examples might be specific to only one or a few countries. They are not intended to be exhaustive and do not necessarily represent a change in existing GTIN allocation rules.)

- **Handrail colour**: In passenger coaches, handrail colour is a critical safety feature. In some countries (e.g., Switzerland), a change in handrail colour requires a **new GTIN**.
- **Balise colour**: The respective national regulatory body determines a different colour for the balises of the ETCS (European Train Control System). This requires a **new GTIN**.
- **Surface roughness**: Modification of mobile access plate / step to train, increasing its anti-slip characteristics, means that the same GTIN can be used. A decrease in roughness would require a **new GTIN**. ~~*would require a NEW GTIN.*~~
- ~~*Modification to the control unit of a HVAC (heating, ventilation and air conditioning*~~



Note that this decision tree is deliberately high level, and not intended to be exhaustive. Additional factors (e.g., change in certification, depending on local regulations) might influence GTIN allocation rules for Rail components.

[7-4] When the MRO-object is marked with a GTIN as well as the functional / revision status, regulations MAY allow the GTIN to remain the same for certain types of changes to form, fit and function (FFF).

Examples for which original GTIN might be retained, qualified by change to functional status or revision status:

("*NOTE that these examples might be specific to only one or a few countries. They are not intended to be exhaustive and do not necessarily represent a change in existing rules.*")

- Modification of the protective cover.
- Use of a different plastic of balise for the ETCS
- Additional attribute marked on the type plate.
- Taking one country as an example, the regulatory body in Switzerland does not require a part number change if ALL of the following conditions are met:
  - The function does not change
  - The scope of use does not change
  - The interfaces to the outside world do not change
  - The risk analysis and function test documentation do not change
  - The risk by the MRO-object is not increased (it can be reduced or remain the same)
  - There is a marking which clearly allows the user to distinguish between the GTIN and the revision / functional level. If there is no such composite marking on the component, a GTIN change is compulsory

For additional clarification, please refer to the GS1 **Rail GTIN Management Rules wizard** at:

https://www.gs1.org/1/mro/en/management-rules/menu/1

[7-5] When the form, fit and function (FFF) of an existing instance is changed as a result of a refurbishment, the GTIN and any function or revision levels as marked on the instance SHALL remain the same.
Exception: See rule 8-10 for MRO-objects that are refurbished to be sold 'as good as new'.

Important: The master data related to the GTIN (and any function or revision levels) marked on an MRO object reflect the status at the time of first delivery. Special care should be taken in managing master data that can change as a result of refurbishment.

Note: If the instance is identified on object class level it is possible to add a refurbishment lot number referring to the change of the technical specification or to add the functional/revision status. If the instance is serialised, the information of the changed technical specification is recorded and shared digitally.

Examples:

- *MRO-object gets software update.*
- *MRO-object was produced as functional level A, revision status 2, and now is refurbished to meet functional level B, revision status 1.*

7.4 De-activating an existing MRO-object class

[7-6] A GTIN allocated to an MRO-object that was taken into production SHALL never be reused.

Examples:

- *MRO-object X becomes obsolete and is no longer sold. However, it is still in use. Its GTIN will not be reused to identify a different MRO-object.*

[7-7] A GTIN allocated to an MRO-object that was never taken into production MAY be reused for a different MRO-object.

8 Marking rules

8.1 Introduction

Information marked on objects comes in two basic forms.

1. Information to be used by people: HRI and non-HRI text.
2. Information designed for data capture by a machine: Barcodes and EPC/RFID tags.

Barcodes and RFID tags are machine readable and are a secure and efficient method for conveying structured data, while text and graphics allow people general access to basic information at any point in the supply chain and serve as fall-back positions for unreadable AIDC data. Both methods often co-exist.

This standard defines rules for the marking of unpackaged instances (direct marking) as well as for the marking of primary and secondary packaging. Figure 8-1 lists the marking scenarios that are supported in this standard. The rules for each scenario are defined in the next paragraphs.

Figure 8-1 Overview of marking scenarios

Direct marking	Marking at time of production
	Additional marking at time of receipt, installation or refurbishment
	Repairing lost or damaged markings
Packaging marking	Marking of primary packaging
	Marking of secondary packaging

8.2 Direct marking

8.2.1 General rules

[8-1] Allowed AIDC carriers for direct marking:

- GS1 DataMatrix (preferred) or GS1 QR Code
- EPC/RFID as additional option (unless RFID is the only technical option)

Note: GS1 DataMatrix is generally more compact, particularly for rail application data.

8.2.2 Marking at time of production

[8-2] At the time of production a marking SHOULD be applied on each instance, containing either:

- GTIN, or
- GTIN + manufacturing lot ID, or
- GTIN + manufacturing serial ID, or
- GIAI

[8-3] The marking SHOULD contain data in AIDC and HRI format and be applied using a permanent direct marking technique.

[8-4] The identification level to be applied SHALL be determined by the manufacturer of the MRO-object, based on the most stringent customer requirements.

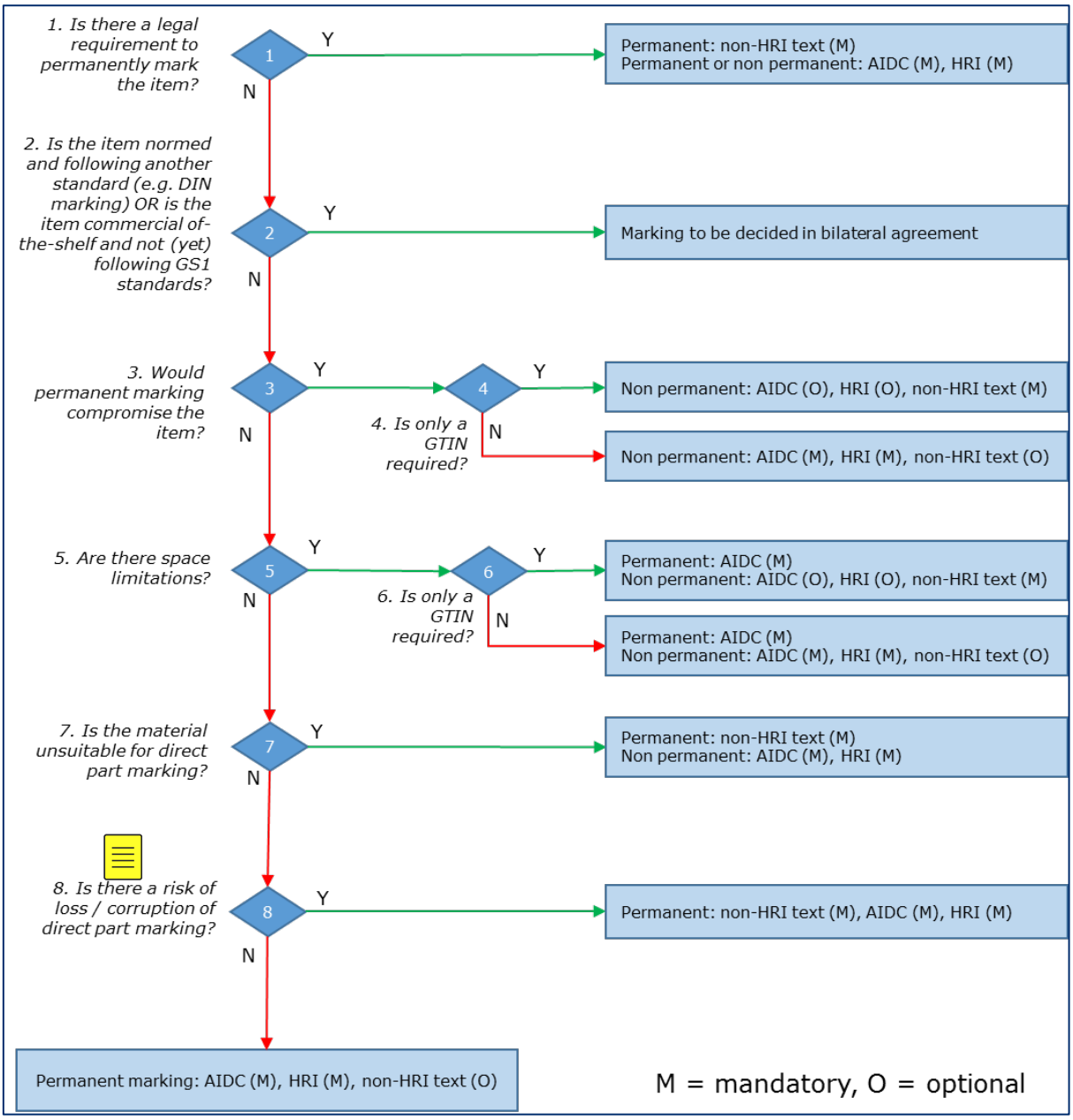
[8-5] Customers SHALL accept a more precise level of identification than they require for a particular MRO-object. In case of conflicting customer requirements, manufacturers MAY choose to include additional attributes. For example, GTIN + manufacturing lot number + manufacturing serial ID supports both class-level, lot-level and serial-level identification.

[8-6] In GTIN-based markings additional attributes MAY be included. Besides the functional status, revision status as listed in section 9, also additional trade item attributes as defined in [GenSpecs] MAY be included, for example production date, expiration date.

Important: For instances with a serialised ID there is no technical need to encode these additional attributes in the AIDC carrier, since they can be exchanged digitally and linked to the serialised ID. Legal requirements may mandate the marking of these attributes as human readable text.

[8-7] If marking according to rules [8-2] and [8-3] is not possible an alternative marking SHOULD be applied following the criteria in figure 8-2, and in bilateral agreement with the customer.

Figure 8-2 Direct marking exceptions – decision tree



Leading parts

[8-8] If the instance is the leading part of a composed MRO-object, an additional marking containing the GIAI of the parent component MAY be applied.

[8-9] A component can only be the leading part of one higher composed MRO-object. Therefore, any MRO-object SHALL NOT have more than one parent component marking. Also see sections 5.4 Marking of composed MRO-objects and 9.1.5 GIAI of an assembly.

Remanufactured MRO-objects resold to new customers 'as good as new'

[8-10] MRO-objects that are refurbished to be sold to other clients MAY require an update of functional status and current revision status that were applied at the time of production.

8.2.3 Additional marking at time of receipt, installation or refurbishment

Important: For serialised items the inclusion of additional markings SHOULD be avoided, since such data can be exchanged digitally and linked to the serialised ID.

Additional marking at time of receipt

[8-11] In case the original ID does not provide a detailed enough level of identification an additional marking containing a GIAI allocated by the operator or MRO workshop may be applied, using a permanent or non-permanent direct marking technique.

[8-12] The marking MAY be applied using a permanent or non-permanent direct marking technique, and SHALL be clearly distinguishable from the marking containing the original ID.

Additional marking at time of installation

[8-13] At the time of installation an additional marking MAY be applied on an instance containing configuration data.

[8-14] The marking SHALL be applied using a non-permanent direct marking technique, and be clearly distinguishable from the marking containing the primary identification.

[8-15] Software, once installed and separated from its medium, packaging and documentation, SHALL remain identifiable.

Additional marking at time of refurbishment

[8-16] An additional marking MAY be applied on an instance containing the refurbishment lot ID + GLN of the production / service location.

[8-17] The marking SHALL be applied using a direct marking technique (preferably non-permanent) which will guarantee the marking readability until the next refurbishment cycle. The marking SHALL be clearly distinguishable from the marking containing the primary identification.

8.2.4 Repairing lost and damaged markings

At any time during the lifetime of an MRO-object the original marking may have gone missing or may have been damaged and become partly or fully unreadable.

[8-18] In case of lost or damaged markings a new marking SHOULD be applied, containing the original ID as allocated by the manufacturer, using direct marking technique as defined in rules [8-2] through [8-7] and in figure [8-2].

[8-19] In case the original ID cannot be reconstructed:

- For serialised items a GIAI allocated by the operator or MRO workshop SHALL be used.
- For non-serialised items a GTIN or GTIN + lot ID allocated by the operator or workshop SHALL be used.

Important: In such cases in the database and when sharing data on such MRO-objects with trading partners it SHOULD be clearly indicated that the ID of the instance is not the original ID, and that the full history of the instance is unknown.

[8-20] In case the original ID is known but reconstruction of the marking will take too much time, an additional marking containing a GIAI MAY be applied, using a permanent or non-permanent marking technique, and clearly distinguishable from the marking containing the original ID. In this case the GIAI will be linked to the original ID in the IT system, and act as a proxy.

8.2.5 Direct marking placement rules

Three main direct marking methods have been identified: Permanent marking directly on the MRO-object (such as DPM), non-permanent marking using a durable label such as a printed label or tag, and tagging using EPC-RFID.

The following rules apply to the placement of direct markings covered in this standard:

[8-21] Direct markings SHALL be attached to the MRO-objects in a way that they are easily visible even in operating mode of the identified object – for instance from the safety space alongside a track or when an object is installed on a rail vehicle.

[8-22] Direct markings SHALL not hinder any function of the object they are attached to, for example of movable equipment found in switches.

[8-23] Scan and read devices (like smart phones, tablets or similar devices) SHALL be able to retrieve data from the type plate / label from a frontal angle.

***Note that** this statement implies a non-DPM reading environment, i.e., that which is governed by [ISO/IEC15415]. If the reading environment is non-DPM capable scanning using ambient light, then marking methods will necessarily need to be narrowed and or specific testing performed.*

[8-24] Direct markings with barcode symbols SHOULD not be placed in a shaded location to avoid reduction of contrast and difficulties in scanning.

[8-25] Direct markings SHALL be placed on plane surfaces whenever possible. Curved surfaces may cause reduction of the readability of the barcode (thus, check the quality after attaching carefully - e.g. through the verification service provided by GS1) and complicate gluing of the plates / labels.

[8-26] Direct markings SHALL be placed in a way that protects them from mechanical damage (for instance by placing them in the shadow zone or slip stream of objects).

[8-27] Affix direct markings whenever possible at a minimum angle of 45° which allows water to drain off and prevents dust from settling. In addition, this helps to reduce the risk of damage due to flying debris.

8.3 Packaging marking

8.3.1 General rules

[8-28] Allowed AIDC carriers for packaging marking:

- GS1 DataMatrix, GS1 QR Code or GS1-128
- EPC/RFID as additional option

8.3.2 Primary packaging

[8-29] Primary packaging of MRO-objects SHALL be marked with the ID of the unpackaged instance.

[8-30] The marking SHALL contain data in AIDC and HRI format.

[8-31] In case the primary packaging contains multiple instances the primary packaging SHOULD be marked with a single marking containing a GTIN that identifies the primary packaging as trade item grouping, optionally in combination with a manufacturing lot ID or serial ID. If this is not feasible a solution will need to be chosen in bilateral agreement.

[8-32] Software distributed via a dedicated physical medium SHALL be marked with the GTIN used to identify the software. If the medium is not a dedicated medium, no marking SHOULD be applied.

8.3.3 Secondary packaging

[8-33] Secondary packaging of MRO-objects SHALL be marked with the GTIN of the trade item grouping or kit.

[8-34] The marking SHALL contain data in AIDC and HRI format.

9 Technical standards

9.1 Data formats

9.1.1 Length of the data content of attributes

The GS1 General Specifications provide for sector-independent maximum lengths of the data content of individual attributes. To achieve compatibility of the individual ERP systems in the railway sector, the lengths of some attributes are restricted compared to the General GS1 Specifications. This is noted in each case for the corresponding attribute.

9.1.2 GTIN

In this standard three GTIN formats are applied: GTIN-12, GTIN-13, and GTIN-14 (see figure 9-1).

[9-1] Classes of MRO-objects SHALL be identified with a GTIN-12 or GTIN-13 or GTIN-14.

Note: Additional rules apply for the use of indicator digit '9' in the GTIN-14 format. Please refer to [GenSpecs] for more information.

[9-2] If the GTIN-14 is used to identify a grouping of identical trade items, the GTIN-14 SHALL be based on the GTIN-12 or GTIN-13 of the contained trade item. See *GS1 General Specifications section 2* for more information.

Figure 9-1 Overview of GTIN formats

	GTIN Formats ← – – – – – – – – – – – – – – – →													
(GTIN-12)			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)		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)	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}

[Adapted subset of GenSpecs Figure 2.1.1.10-1]

Note: The GS1 Company Prefix (GCP) is a string of 4 to 12 digits. Depending on the GCP length this provides users with a basic numbering capacity of 100,000,000 items (GCP of 4 digits, item reference of 8 digits) to 1 item (GCP of 12 digits, item reference of 0 digits). Companies may license multiple company prefixes if necessary, so even with non-reuse of GTINs they will have sufficient numbering capacity.

Barcode format

[9-3] When encoded in a GS1-128, GS1 DataMatrix or GS1 QR Code, GS1 Application Identifier (01) GTIN SHALL be used.

[9-4] When encoding a GTIN-12 two leading zeroes SHALL be added, and when encoding a GTIN-13 one leading zero SHALL be added (see figure 9-2).

Figure 9-2 14-digit representation of the GTIN-12, GTIN-13 and GTIN-14

	added zero(es) ← – – – – – – – – – – – – –		right aligned GTIN string – – – – – – – – – – – – – →											
(GTIN-12)	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	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)	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}

[Adapted subset of GenSpecs Figure 2.1.1.10-2]

HRI and Non-HRI formats

[9-5] When any of these GTINs is encoded in a data carrier that must encode a fixed-length data string of 14-digits, the GTINs less than 14-digits in length must be prefixed by leading zeroes that simply act as filler digits.

When indicating this element string in the non-HRI text section of a barcode label, the following data title SHOULD be used: **GTIN**

EPC/RFID format

[9-6] When encoded in an EPC/RFID tag the GTIN SHALL be encoded in combination with the manufacturing serial ID, as an SGTIN-96, SGTIN-198 or SGTIN+, in the EPC Memory Bank (MB 01). See section *9.3.2*.

9.1.3 Manufacturing serial ID

Barcode format

[9-7] When represented in a barcode GS1 Application Identifier (21) Serial number SHALL be used. The AI (21) indicates that the data field contains a serial number. The data is alphanumeric and may include all characters contained in character set 82 (see section *9.7*).

Figure 9-3 AI(21) Serial number

Application Identifier	Serial number
2 1	X_1 ——— variable length ———› X_{20}

[source: GenSpecs]

[9-8] AI (21) The manufacturing serial ID SHALL be limited to a maximum 18 characters to ensure interoperability with main ERP systems.
Note: If EPC/RFID is used in conjunction with the barcode further restrictions may apply, see section *9.3.2*.

[9-9] AI (21) Serial number SHALL be used in combination with AI (01) GTIN.

Non-HRI format

[9-10] When indicating this element string in the non-HRI text section of a barcode label, the following data title SHOULD be used: **SERIAL**

EPC/RFID format

[9-11] When encoded in an EPC/RFID tag the manufacturing serial ID SHALL be encoded together with the GTIN, as an SGTIN-96, SGTIN-198 or SGTIN+, in the EPC Memory Bank (MB 01). See section *9.3.2*

9.1.4 Manufacturing lot ID

Barcode format

[9-12] When represented in a barcode GS1 Application Identifier (10) SHALL be used.

AI (10) indicates that the data field contains a batch or lot number. The data is alphanumeric and may include all characters contained in character set 82 (see section *9.7*).

Figure 9-4 AI(10) Batch or lot number

Application Identifier	Batch or lot number
1 0	X_1 ———› variable length ———›X_{20}

[source: GenSpecs]

[9-13] The manufacturing lot ID SHALL be limited to a maximum 10 characters to ensure interoperability with common ERP systems.

[9-14] AI (10) Batch / lot number SHALL be used in combination with AI (01) GTIN.

Non-HRI format

[9-15] When indicating this element string in the non-HRI text section of a barcode label, the following data title SHOULD be used: **BATCH/LOT**

EPC/RFID format

[9-16] When represented in an EPC/RFID tag the manufacturing lot ID SHALL be encoded either in User Memory (MB 11) or as "+AIDC data" (MB 01) following the EPC, using GS1 Application Identifier (10). See section *9.3.4* .

9.1.5 GIAI

Barcode format

[9-17] When represented in a barcode GS1 Application Identifier (8004) GIAI SHALL be used.

Figure 9-5 AI (8004)

Application Identifier	Global Individual Asset Identifier (GIAI)				
	GS1 Company Prefix →		Individual asset reference →		
8 0 0 4	N_1 ...	N_i	X_{i+1} ...	variable length	$X_{j\ (j<=30)}$

[source: GenSpecs]

A GIAI is a string of maximum 30 characters, starting with the GS1 Company Prefix (numeric) followed by the individual asset reference. The individual asset reference is alphanumeric and may include all characters contained in character set 82 (see section *9.7*).

Note: If EPC/RFID is used in conjunction with the barcode further restrictions may apply, see section *9.3.3*.

Non-HRI format

[9-18] When indicating this element string in the non-HRI text section of a barcode label, the following data title SHOULD be used: **GIAI**

EPC/RFID format

[9-19] When encoded in an EPC/RFID tag the GIAI SHALL be encoded in the EPC Memory Bank (MB 01) as a GIAI-96, GIAI-202 or GIAI+. See section *9.3.3*.

9.1.6 GIAI of assembly

Barcode format

[9-20] When represented in a barcode GS1 Application Identifier (7023) GIAI of an assembly SHALL be used.

Figure 9-6 AI (7023)

Application Identifier	Global Individual Asset Identifier (GIAI) of an assembly				
	GS1 Company Prefix →		Individual asset reference →		
7 0 2 3	N_1 ...	N_i	X_{i+1} ...	variable length	$X_{j\ (j<=30)}$

[source: GenSpecs]

A GIAI of an assembly is a string of maximum 30 characters, starting with the GS1 Company Prefix (numeric) followed by the individual asset reference. The individual asset reference is alphanumeric and may include all characters contained in character set 82 (see section *9.7*).

Note: If EPC/RFID is used in conjunction with the barcode further restrictions may apply, see section 9.3.3.

Non-HRI format

[9-21] When indicating this element string in the non-HRI text section of a barcode label, the following data title SHOULD be used: **GIAI - ASSEMBLY**

EPC/RFID format

[9-22] When encoded in an EPC/RFID tag the GIAI of an assembly SHALL be encoded in the EPC Memory Bank (MB 01) as a GIAI-96, GIAI-202 or GIAI+. See section 9.3.3.

Note: Unlike barcodes, EPC/RFID tags that contain the GIAI of an assembly cannot be distinguished from EPC/RFID tags that contain the GIAI of the component.

9.1.7 GLN of production / service location

Barcode format

[9-23] When represented in a barcode GS1 Application Identifier (416) Production / Service location SHALL be used.

Figure 9-7 AI (416)

Application Identifier	GS1 Company Prefix →								← Location reference				Check digit
4 1 6	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}

[source: GenSpecs]

Non-HRI format

[9-24] When indicating this element string in the non-HRI text section of a barcode label, the following data title SHOULD be used: **PROD/SERV LOC**

EPC/RFID format

[9-25] When represented in an EPC/RFID tag the GLN of production / service location SHALL be encoded either in User Memory (MB 11) or as '+AIDC data' (MB 01) following the EPC, using GS1 Application Identifier (416). See section 9.3.4.

9.1.8 Refurbishment lot ID

Barcode format

[9-26] When represented in a barcode GS1 Application Identifier (7020) Refurbishment lot ID SHALL be used.

Figure 9-8 AI (7020)

Application Identifier	Refurbishment lot ID
7 0 2 0	X_1 ——— variable length ———→ X_{20}

[source: GenSpecs]

[9-27] The refurbishment lot ID SHALL be a string of maximum 17 characters.

[9-28] AI (7020) Refurbishment lot ID SHALL be used in combination with AI (416) Production / Service location and AI (01) GTIN.

Non-HRI format

[9-29] When indicating this element string in the non-HRI text section of a barcode label, the following data title SHOULD be used: **REFURB LOT**

EPC/RFID format

[9-30] When represented in an EPC/RFID tag the refurbishment lot ID SHALL be encoded either in User Memory (MB 11) or as '+AIDC data' (MB 01) following the EPC, using GS1 Application Identifier (7020). See section 9.3.4.

9.1.9 Functional status

Barcode format

[9-31] When represented in a barcode GS1 Application Identifier (7021) Functional status SHALL be used.

Figure 9-9 AI (7021)

Application Identifier	Functional status
7 0 2 1	X_1 ————variable length ————›X_{20}

[source: GenSpecs]

[9-32] The functional status SHALL be a string of maximum 5 characters to ensure interoperability with common ERP systems.

[9-33] The functional status SHALL be used in combination with AI (01) GTIN.

Non-HRI format

[9-34] When indicating this element string in the non-HRI text section of a barcode label, the following data title SHOULD be used: **FUNC STAT**

EPC/RFID format

[9-35] When represented in an EPC/RFID tag the functional status SHALL be encoded either in User Memory (MB 11) or as '+AIDC data' (MB 01) following the EPC, using GS1 Application Identifier (7021). See section 9.3.4.

9.1.10 Revision status

Barcode format

[9-36] When represented in a barcode GS1 Application Identifier (7022) Revision status SHALL be used.

Figure 9-10 AI (7022)

Application Identifier	Revision status
7 0 2 2	X_1 ————variable length ————›X_{20}

[source: GenSpecs]

[9-37] The revision status SHALL be a string of maximum 5 characters to ensure interoperability with common ERP systems.

[9-38] The revision status SHALL be used in combination with AI (01) GTIN and AI (7021) Functional status.

Non-HRI format

[9-39] When indicating this element string in the non-HRI text section of a barcode label, the following data title SHOULD be used: **REV STAT**

EPC/RFID format

[9-40] When represented in an EPC/RFID tag the revision status SHALL be encoded either in User Memory (MB 11) or as '+AIDC data' (MB 01) following the EPC, using GS1 Application Identifier (7022). See section 9.3.4.

9.2 Barcode symbologies

[9-41] For direct marking a GS1 DataMatrix (preferred) or GS1 QR Code barcode SHALL be used, following symbol specification table 7 (*Direct part marking*) or 13 (*Durable labelling and durable marking enabling long distance scanning*) [GenSpecs].

[9-42] For packaging marking either a GS1 DataMatrix, a GS1 QR Code or a GS1-128 barcode SHALL be used, following symbol specification table 4 [GenSpecs].

9.2.1 GS1 DataMatrix

Fragments taken from [GenSpecs]:

GS1 DataMatrix is a standalone, two-dimensional matrix symbology that is made up of square modules arranged within a perimeter finder pattern.

ISO/IEC 16022 [ISO/IEC16022] Data Matrix, version ECC 200 is the only version that supports GS1 system data structures, including Function 1 Symbol Character. The ECC 200 version of Data Matrix uses Reed-Solomon error correction, and this feature helps correct for partially damaged symbols.

Some of the production processes that are used to produce GS1 DataMatrix symbols are as follows:

- Direct part marking, such as is done by dot peening on items, such as automotive, aircraft metal parts, medical instruments, and surgical implants.
- Laser or chemically etched parts with low contrast or light marked elements on a dark background (e.g., circuit boards and electronic components, medical instruments, surgical implants).
- High-speed ink jet printed parts and components where the marked dots cannot form a scannable linear symbol.

GS1 DataMatrix symbols are read by two-dimensional imaging scanners or vision systems. Most other scanners that are not two-dimensional imagers cannot read GS1 DataMatrix.

9.2.2 GS1 QR Code

Fragments taken from [GenSpecs]:

GS1 QR Code is a standalone, two-dimensional matrix symbology that is made up of square modules arranged in an overall square pattern, including a unique finder pattern located at three corners of the symbol.

It is the only member of the QR Code family [ISO/IEC 18004 (QR Code bar code symbology specification)] that supports GS1 system data structures, including Function 1 Symbol Character. [ISO/IEC18004] also contains specifications for Micro QR Code, but this symbology is not supported for the GS1 system. QR Code uses Reed-Solomon error correction (four selectable levels of error correction are specified), and this feature helps correct for partially damaged symbols.

GS1 QR Code symbols are read by two-dimensional imaging scanners or vision systems. Scanners that are not two-dimensional imagers, e.g., laser scanners, cannot read GS1 QR Code.

9.2.3 GS1-128

Fragments taken from [GenSpecs]:

The GS1-128 barcode has been carefully designed through joint co-operation between GS1 and AIM (Association for Automatic Identification and Mobility). Use of GS1-128 barcodes provides a high degree of security and distinguishes GS1 system element strings from extraneous non-GS1 barcodes.

The GS1-128 symbology is a subset of the more general Code 128 symbology. By agreement between AIM and GS1, use of the Function 1 Symbol Character (FNC1) in Code 128 symbols in the first symbol character position following the start character has been reserved exclusively for the GS1 system.

9.3 EPC/RFID

9.3.1 Gen 2 RFID Tags

From [TDS]:

The term "Gen 2 RFID Tag" (or just "Gen 2 Tag") as used in this specification refers to any RFID tag that conforms to the EPCglobal UHF Class 1 Generation 2 Air Interface, Version 1.2.0 or later [UHFC1G2], as well as any RFID tag that conforms to another air interface standard that shares the same memory map. The latter includes version 2.0 (and later) of GS1's "Gen2" UHF Air Interface [UHFGen2].

9.3.2 SGTIN

Coding schemes and limitations

The SGTIN is the EPC format to encode the GTIN + manufacturer serial ID. The Tag Data Standard [TDS] defines three coding schemes for the SGTIN:

- SGTIN-96: Numeric-only, no leading zeros, decimal value must be less than 2^{38} (i.e., decimal value less than or equal to 274,877,906,943).
- SGTIN-198: All values permitted by GS1 General Specifications (up to 20 alphanumeric characters). [GenSpecs]
- SGTIN+: Introduced in TDS 2.0 (August 2022) to optimise SGTIN encoding efficiency and interoperability with GS1 identifiers across various carriers; provides for variable length Serial Number and supports all values permitted by the GS1 General Specifications (up to 20 alphanumeric characters) [GenSpecs]. TDS 2.0 introduces alternative modernised EPC binary encodings for all EPC schemes based on GS1 identifiers, for which a binary encoding was already defined in TDS 1.13. These new EPC binary encodings have much simpler translation to/from GS1 element strings on barcodes.
-

[9-43] Use of the SGTIN-96 is not recommended, due to the aforementioned encoding limitation. To allow for full interoperability with GS1 barcodes as per the GS1 General Specification, the SGTIN-198 or SGTIN+ SHOULD be used.
Note: An EPC/RFID tag's EPC Memory Bank (MB 01) requires a minimum capacity of 208 bits to support encoding of the SGTIN-198. Memory requirements for the SGTIN+ depend on the length and character set used in its variable length Serial Number.

Filter values

[9-44] At the present time, application of specific filter values has not yet been standardised. For this reason, when *writing* a tag, filter value '0' ("all others") SHOULD be used; when *inventorying* or *reading* a tag, the filter value SHOULD be ignored.

9.3.3 GIAI

Coding schemes

The Tag Data Standard [TDS] defines three coding schemes for the GIAI:

- GIAI-96: Numeric-only, no leading zeros, decimal value must be less than a limit that varies according to the length of the GS1 Company Prefix.
- GIAI-202: All values permitted by GS1 General Specifications (up to 18 – 24 alphanumeric characters, depending on company prefix length).
- GIAI+: Introduced in TDS 2.0 (August 2022) to optimise GIAI encoding efficiency and interoperability with GS1 identifiers across various carriers; provides for variable length Individual Asset Reference and supports all values permitted by the GS1 General Specifications (up to 18 – 24 alphanumeric characters, depending on company prefix length) [GenSpecs]. TDS 2.0 introduces alternative modernised EPC binary encodings for all EPC schemes based on GS1 identifiers, for which a binary encoding was already defined in TDS 1.13. These new EPC binary encodings have much simpler translation to/from GS1 element strings on barcodes.

[9-45] Use of the GIAI-96 is not recommended, due to the aforementioned encoding limitation. To allow for full interoperability with GS1 barcodes as per the GS1 General Specification, GIAI-202 or GIAI+ SHOULD be used.
Note: An EPC/RFID tag's EPC Memory Bank (MB 01) requires a minimum capacity of 208 bits to support encoding of the GIAI-202. Memory requirements for the GIAI+ depend on the length and character set used in its variable length Individual Asset Reference.

Filter values

[9-46] At the present time, application of specific filter values has not yet been standardised. For this reason, when *writing* a tag, filter value '0' ("all others") SHOULD be used; when *inventorying* or *reading* a tag, the filter value SHOULD be ignored.

9.3.4 User memory

Normatively specified in [TDS]:

User Memory (MB 11 of a Gen2 EPC/RFID Tag) may be used to hold supplementary information beyond the primary identifier encoded in the EPC Memory bank. This includes support for encoding of GS1 Application Identifiers, such as AI (10) BATCH/LOT.

[9-47] EPC/RFID tag support for User Memory is optional, and where present, capacity may vary between specific chip models. Vendors SHOULD be consulted about the size of available User Memory to ensure it meets the requirements.

9.3.5 '+AIDC data' following new (TDS 2.x) EPC schemes in the EPC memory bank

As a more user-friendly and GS1 AI-interoperable alternative to User Memory, all of the new EPC schemes introduced in TDS 2.0 (including SGTIN+ and GIAI+) support appending of a AIDC data beyond the end of the EPC within the EPC Memory Bank (MB 01).

Vendors SHOULD be consulted about the size of available EPC Memory to ensure it meets requirements.

9.4 GS1 Application identifiers

Please refer to section 3, "*GS1 Application Identifier definitions*", of [GenSpecs], which describes the meaning, structure and function of the GS1 system element strings so they can be correctly processed in user's application programmes.

9.5 HRI

Characters, such as letters and numbers, which can be read by persons and are encoded in GS1 AIDC data carriers confined to a GS1 standard structure and format. The human readable interpretation is the encoded data. Start, stop, shift and function characters, as well as the symbol check character, are not shown in the human readable interpretation [GenSpecs, glossary].

Please refer to section 4.14 of [GenSpecs], "*Human readable interpretation (HRI) rules*", for complete details.

9.6 Non-HRI text

Characters, such as letters and numbers that can be read by persons and may or may not be encoded in GS1 AIDC data carriers and are not confined to a structure and format based on GS1 standards (e.g., a date code expressed in a national format that could be used to encode a date field in a GS1 AIDC data carrier, brand owner name, consumer declarations). [GenSpecs, glossary].

[9-48] For each included data field representing a barcoded data element the GS1 data title related to the AI (see section 9.1) SHALL be included.

[9-49] Data titles SHOULD follow the format as specified in the 'GS1 General Specifications', in particular they should be presented in UPPERCASE when indicated.

[9-50] A clearly legible font SHALL be used (e.g., OCR-B as defined in ISO 1073-2). Reasonable alternative type fonts and character sizes are acceptable provided the interpretation is clearly legible.

9.7 Character set 82

Please see section 7.11 of [GenSpecs], "*The GS1 subset of International Standard ISO/IEC 646*", for complete details.

10 Dos and Don'ts

	Dos	Don'ts
1	Accept both GTIN and GIAI as valid GS1 identification keys for rail parts and components.	(do not) Enforce the use of one of the keys (GTIN or GIAI), instead of supporting both.
2	Use the GTIN as non-significant identifier that is linked to the internal article number in your system	(do not) Give GTINs a "meaning" beyond being a pure identifier (do not) Try to "squeeze-in"/pack in your internal article number into the GTIN, introduce logic such as classifying elements
3	Use the GIAI as a non-significant identifier that is linked to the internal article number in your system *Note: Any exceptions to this practice should be documented in official GS1 guidelines. An example is embedding the European Rail Vehicle Number (EVN) in the GIAI of a rail vehicle, as defined in the GS1 in Europe Rail Guideline.*	(do not) Give GIAI a "meaning" beyond being a pure identifier (do not) Introduce logic such as classifying elements.
4	Accept company prefixes as they are, the GS1 identification system ensures that all allocated GTINs and GIAIs will be unique across different suppliers.	(do not) Enforce your GS1 Company Prefix to be used by your suppliers
5	Limit the information marked in the GS1 DataMatrix symbol or on an EPC/RFID tag on the MRO object to the minimum necessary (data such as serial number, batch/lot, expiry date, date of production). Use a database for the additional information	(do not) Encode any extra information in the GS1 DataMatrix symbol or on an EPC/RFID tag that could be stored in a database and may change over time. (do not) Mark additional company specific identifiers on the MRO object.
6	Keep the serial number in an SGTIN (GTIN + serial number) as short as possible in order to overcome current limitations of some ERP systems.	(do not) Issue serial numbers that are longer than absolutely necessary.
7	Exclusively use officially approved GS1 Application Identifiers in the barcode and on EPC/RFID tags.	(do not) Mix or require mixing ANSI Data Identifiers (DIs) and GS1 Application Identifiers (AIs) in the same barcode, to avoid scanning errors.
8	Place the GS1 keys at the beginning of the data in the barcode	(do not) start data sequence in barcode by an attribute data such as serial or Customer Part Number

11 References

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