The Global Language of Business

Data Carriers and GS1

GS1 Architecture Group Finding

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1.0.2	Mar 2021	Ralph Troeger	Errata fix: renamed '2D Composite Component' and 'GS1 Composite Code' to 'GS1 Composite' in Figure 3-1, Figure 3-2 and Table 3-3. GS1 Architecture Group confirmed 17 March 2021

Disclaimer

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1 Executive summary

In early 2020, the following request was brought to the attention of the GS1 Architecture Group (AG): "**What should be the GS1 policy regarding** the reference on **non-GS1 data carriers** (both open and commercial) **in the GS1 system of standards**?" This document contains the AG's findings related to this subject.

After naming a couple of examples for non-GS1 data carriers (e.g. NFC tags), the introductory chapter delineates why this matter is important for the GS1 community and defines the scope of this Request for Finding (RfF).

The analysis chapter starts with the introduction of a **framework to categorise data carriers** in the GS1 system of standards (see section 3.1). Similar to the GS1 identification key class concept, we can distinguish three data carrier types:

- **Type A Data Carrier** (technology carrying GS1 data structures, specified in a GS1 application standard and meeting adoption criteria per GS1 Policy)
- **Type B Data Carrier** (able to carry GS1 data structures, but not specified in a GS1 application standard)
- **Type C Data Carrier** (not capable to carry GS1 data structures)

To shed light on what interoperability between different data carriers actually means, section 3.2 then clarifies the **layers constituting data carrier interoperability**, namely data content, syntax, semantics, and physical conformance. This is followed by an **explanation of GS1's policy on adopting new data carriers** as part of the GS1 Operational Manual ('**Policy B-11**'). In a nutshell, the latter comprises five principles: (1) freely implementable, (2) able to exclusively indicate GS1 data structures, (3) sufficiently tested, (4) compliant with AIDC data carrier specifications, and (5) implemented in 90%+ of scanners. These principles reinforce industry priorities for data carrier adoption as industry must balance benefits/capabilities with costs/disruption.

The next two sections should be especially appealing for practitioners dealing with the adoption of data carrier technologies: whereas section 3.4 outlines the **value proposition of Type A Data Carriers** along with a synopsis of their core characteristics, section 3.5 provides an **assessment of three concrete examples of Type B Data Carriers** which are actively discussed in the GS1 community at the time of writing this RfF: **Digital Watermark**, **NFC Tag**, and **Han Xin Code**. The underlying matrix can also serve as a **template for assessing future data carrier technologies**.

The closing chapter contains the **AG's view and recommendations**. It advises **a revision of policy B 11** (which may not just address data carriers, but also their supported syntax), based on recommendations the AG will develop in 2021. It also recommends that the data carrier classification framework as introduced in this RfF is **applied in future standardisation activities** as well as **incorporated into** the next revision of the **GS1 System Architecture** document.

For the purpose of completeness, the annex contains **Policy B-11** (as approved in 2010), the **assessment of QR Code (GS1 URI)** and **DataMatrix (GS1 URI)** which were recently ratified as Type A Data Carriers as well as the **original RfF** as submitted to the AG.

2 Introduction

2.1 Question of the RfF

This document aims at addressing the following question: "**What should be the GS1 policy regarding the reference on non-GS1 data carriers (both open and commercial) in the GS1 system of standards?**"

The subject was brought to the attention of the GS1 Architecture Group (AG) (and formally approved) on 5th February 2020 (#20-001).

2.2 Examples of non-GS1 data carriers

There is a growing number of situations in which GS1 or GS1 Member Organisations (MOs) are being asked about or endorse non-GS1 data carriers. These data carriers are capable of encoding GS1 identifiers per one or more syntax, but are not currently approved for use within a GS1 application standard. For instance:

- **NFC Tag**, encoding e.g. a GS1 Digital Link URI
- **Digital Watermark**, encoding GS1 keys/AIs as digital watermarks invisible to the human eye
- **Han Xin Code**, encoding GS1 AIs/GS1 Digital Link URIs and able to also encode Chinese, Japanese and Korean characters

Though the above-mentioned technologies constitute only a few (though prominent) examples, we can already perceive a couple of obvious distinction criteria: commercial vs. non-commercial, global vs. regional/local applicability, open vs. proprietary, and different capture technologies. Further, some address business needs which have not been prioritised for standardisation, at least so far, by GS1 members. Subsequent sections of this document will elaborate in greater detail on this.

2.3 Need for action

The most apparent (though not the only) development as of recently is that the trusted EAN/UPC is now being joined and, in some cases, replaced by other symbols (barcodes, tags and images) to meet use cases that demand more data richness and/or consumer interactions. The engagement between the consumer and the product is far more pervasive with brand owners utilising technology to connect with customers, build loyalty and differentiate from competitors. Beyond this, consumers are much more educated in the use of technology. Scanning a barcode is no longer a foreign concept for the consumer today and they are demanding proof of authenticity, sustainability, traceability and access to key data at their fingertips.

The core of GS1 standards is open, global, unique identification of business objects. In this regard, GS1 is also expected to provide standards and detailed technical guidance on the use of data carriers encoding GS1 identifiers. However, users are also leveraging data carrier technologies that are not (or not yet) included in the GS1 system of standards for use cases which existing GS1 data carriers do not enable.

Against this background, GS1 has Policy B-11 which specifies the principles and adoption conditions for data carriers to be used as 'global, open' standards by GS1.

2.4 In scope / out of scope

In scope of this RfF is a comprehensive analysis on the subject of data carriers 3.1 inside and outside the GS1 system of standards. This includes an account of the current situation, a clarification of the relevant terminology, a presentation of the value proposition for 'global, open' data carriers endorsed by GS1 and an assessment of various Type B Data Carriers about which MOs frequently encounter inquiries. It concludes with the GS1 Architecture Group's recommendations with regard to the GS1 Policy B-11, which defines GS1's adoption conditions for AIDC data carriers, standards, and GS1 System Architecture.

Out of scope are the following subjects:

a. draft/make changes to any GS1 standards or GS1 documents (including the *GS1 System Architecture* and Operational Manual),

b. issue GSMP work requests,

c. discuss related matters pertaining to the share layer of the GS1 system of standards,

d. develop tools/software,

e. provide advice for solution providers/end user companies (e.g. as to investments in appropriate software modifications in the upcoming years),

f. address data carriers which are not designed to encode GS1 data structures in the first place ('Type C Data Carriers', see section 2.1), and

g. address technologies (e.g., REALBarcode) that are not stand-alone data carriers themselves and are used in addition to a data carrier, but do not themselves carry GS1 data structures

An RfF constitutes a recommendation only. At the same time, it typically contains useful material a GSMP working or governance group may leverage in their discussions and/or development activities.

3 Analysis

3.1 Terminology clarification

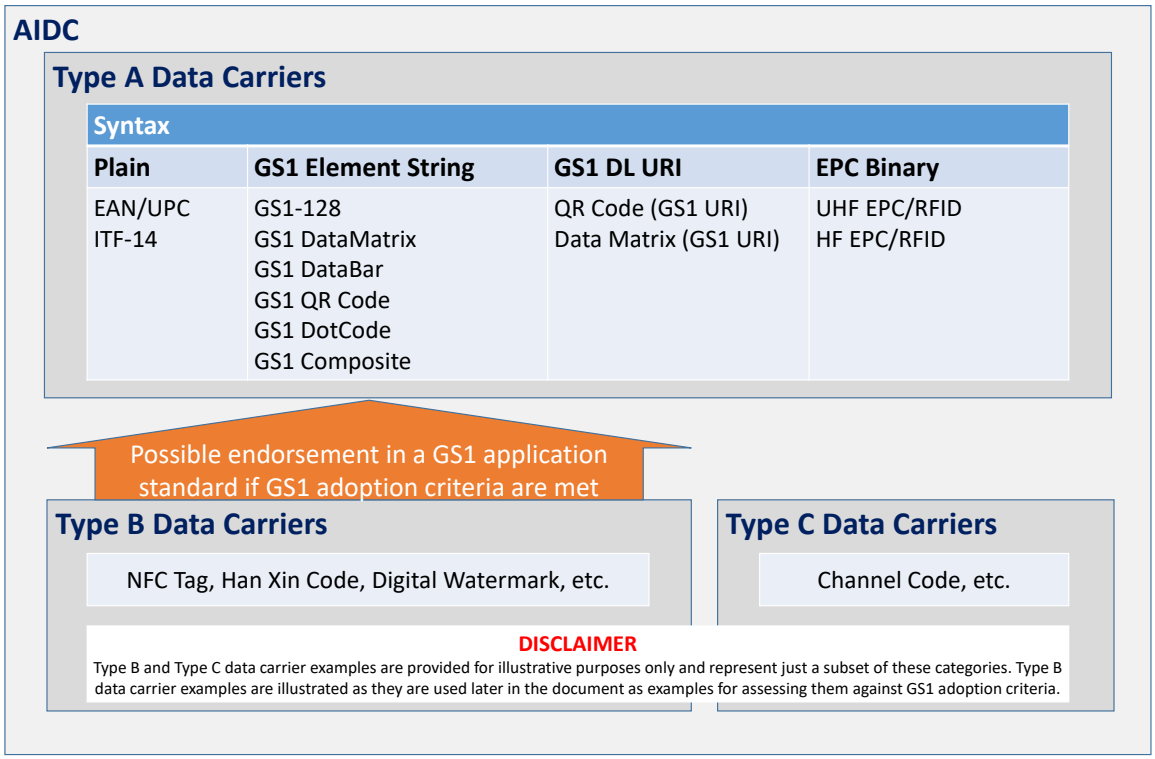
In pursuing the question of this RfF, a first appropriate step consists in developing a framework to categorise data carriers related to the GS1 system (see Figure 3-1).

Term	Definition
Type A Data Carrier	Technology (e.g. barcode, tag) attached to or integrated in a physical object for representing data attributes in machine-readable format that **carries GS1 data structures**, which is **specified for use by a GS1 application standard and** which **meets GS1's adoption criteria** (as defined per "Policy B 11").
Type B Data Carrier	Technology (e.g. barcode, tag) attached to or integrated in a physical object for representing data attributes in machine-readable format which is **able to carry GS1 data structures but** is **not specified in a GS1 application standard**.
Type C Data Carrier	Technology attached to or integrated in a physical object for representing data attributes in machine-readable format which is **not capable of carrying GS1 data structures**.

Table 3-1: Data Carrier Types

All examples mentioned in section 1.2 (thus being subject to analysis in Section 1.9 of this RfF) are instances of Type B Data Carriers. Figure 3-1 illustrates all three types, thereby allocating a number of examples.

Figure 3-1: Data Carrier Systematisation



Though this terminology is – to date – not yet used in any existing GS1 document, we apply it for the remainder of this RfF as it enables a precise understanding of which type of data carrier is referred to.

Thus, one of the first important implications of the above systematisation framework is that there is no concept of a non-GS1 data carrier as indicated in the Request for Finding. Irrespective of whether a data carrier is specified in a GS1 standard or not, if it is commercial or not, whether it is applied globally or not, etc. – the framework enables the GS1 community to assign any data carrier to one of the three types during discussion and assessment.

3.2 Data carrier interoperability

Section 2.1 of the GS1 System Architecture states that the first objective of standards is "to facilitate interoperability in open value networks". As interoperability is vital "...to enable the widest adoption and the greatest value to the GS1 community" (GS1 Architecture Principles 2020), an equally important subject to the above terminology is a clear understanding as to what interoperability between data carriers actually means. According to the GS1 Architecture Principles (2020), we understand interoperability as "... the capability of different systems to exchange data based on a shared understanding of business processes, to read and write in compatible formats and use compatible protocols".

An important related principle is that the GS1 system "... shall be developed to suit open supply chains and value networks (...) [which] provides interoperability without the need for organisations (...) to negotiate [on data carriers] in advance.

In the context of this RFF, a good instance of this is found in the GS1 System Architecture, section 2.2: "For example, a manufacturer may mark a product with machine-readable data in a barcode, the product may then be sold to retailers through distributors. In this case, the barcode can be read by all retailers who receive the product (because of the use of a common standard). In this example, the barcode is an interface between the manufacturer and the retailers, but the manufacturer's only direct business relationship is with their distributors". This example illustrates that open data carrier interoperability means that data carriers applied on physical objects can be used by every trading partner without any bilateral agreement. It is not existent though if supply chain parties e.g. need to (a) apply customer-specific data carriers, (b) invest in specific readers mandated by a business partner, or (c) modify their IT systems to be able to interpret specific AIDC data content.

In this regard, data carrier interoperability within a given context (as defined in an open GS1 application standard) comprises several layers: data content, syntax, semantics, and physical application. Taking an example from the healthcare sector, the following table provides an illustrative explanation.

Exemplary context

Minimum AIDC marking level for regulated pharmaceutical products and medical devices

Layer		Interoperability	References
Data content	Primary key	Specified GS1 key, here: GTIN	GS1 General Specifications → Application Standard
	Attributes	Specified set of elements (incl. cardinality), here: batch number, serial number, expiration date	

Syntax	Symbology	E.g. ISO/IEC or AIM symbology, here: DataMatrix	ISO/IEC 16022:2006
	Indicator of GS1 Data Structure	Here: Symbology identifier prefix (FNC1) indicating GS1 DataMatrix and by extension, GS1 as the ISO/IEC 15459-2 Issuing Agency	GS1 General Specifications → GS1 DataMatrix symbology
	Data format	Consistent usage of GS1 data element characters, here: e.g. 6 digits (YYMMDD) for expiration date	GS1 General Specifications → GS1 Application Identifier definitions
Semantics	Data definition	Common understanding of terms	GS1 General Specifications → GS1 Application Identifier definitions, GS1 Global Data Dictionary
	Data model	Common abstract model of data elements and how they relate to each other	
Physical conformance		Consistent implementation of factors such as quality, size and placement as specified by an application standard to increase scan/read performance	GS1 General Specifications → Application rules and management practices → Symbol placement guidelines GS1 DataMatrix Guideline

Table 3-2: Layers of data carrier interoperability

It follows that if companies, within a given context, apply different data carriers, data carrier interoperability is given when business partners:

a. encode the **same data content**,

b. use the **same semantics** and

c. ensure a **consistent physical application**.

With regard to **syntax**, there also must be specified which data carriers are permitted in the first place, so that all industry partners in a given sector and/or domain can enable their AIDC infrastructure to properly decode the contained data. For GS1, the data carriers permitted are specified at the Application Standards level.

3.3 GS1 policy for the adoption of new data carriers

As the question forming the basis of this RfF concerns GS1's policy on Type B Data Carriers, it is appropriate to delineate GS1's hitherto policy in the first place as well as briefly outline the respective content. The policy is specified in section B-11 of the GS1 Operational Manual (see Annex A-1) and provides GS1's policy, principles and process on the adoption of new (i.e. according to our new terminology) Type B Data Carriers, thereby defining five conditions to evaluate a new data carrier technology for approval in the context of the GSMP:

(1) *Technology is freely implementable to the best of our knowledge*

This objective is closely tied to the GS1 Architecture Principle 'Royalty free'. It states that each component of the GS1 system of standards, i.e. including data carriers, shall, to the greatest extent possible, "...not require the payment of any type of royalties, fees or other considerations to third parties and shall not impose any conditions or restrictions on the use of any technologies or methods."

So, for instance, this means that organisations should be discouraged to apply Type B Data Carriers whose use would impose costs, beyond initial implementation related to package design, printing, quality conformance, and scanning/reading, for trading partners.

(2) *A technique must be available and allocated exclusively to GS1 in order to enable unambiguous identification of GS1 data structures*

When reading a data carrier, one needs to know how to interpret the encoded data, unless there is a pre-defined agreement between parties (which is not the case in an open

environment). The policy adopted by GS1 for that purpose is to specify artefacts enabling an application to recognise a Type A Data Carrier and, in addition, to restrict the data encoded in it to GS1 standard data. Here is a summary of how this is accomplished for Type A Data Carriers:

Data carrier	Means of recognition
EAN/UPC	Restricted to GS1
GS1 DataBar	Restricted to GS1
GS1 Composite	Restricted to GS1
ITF-14	None
GS1-128	FNC1
GS1 QR Code	FNC1
GS1 DataMatrix	FNC1
GS1 DotCode	Absence of FNC1
QR Code (GS1 URI)	GS1 DL URI Regular Expression
Data Matrix (GS1 URI)	GS1 DL URI Regular Expression
UHF EPC/RFID	Toggle bit set to zero
HF EPC/RFID	Toggle bit set to zero

Table 3-3: Means of indicating GS1 data structures in Type A Data Carriers

If the standards are properly implemented, a data carrier application can be programmed to read only Type A Data Carriers and process only GS1 standard data. This is an important asset in open automated environments.

(3) *Tested to ensure it will not substantially disrupt scanner or reader performance for existing AIDC data carriers*

To enable that organisations and their trading partners can reliably, rapidly and efficiently read a given data carrier, it needs to be sufficiently tested.

For that purpose, a given AIDC technology should ideally be tested against well-documented test requirements by at least one testing facility exhibiting the necessary level of expertise, authority, and neutrality. Specifically, the AIDC technology solution provider and the testing party should not be one and the same entity.

In addition, industry should be involved in testing to ensure:

- Human factor (e.g., data carrier placement, size) and process (e.g., POS, logistics, bedside) considerations are weighed
- The new data carrier does not perform with less efficiently than a current data carrier or disrupt the performance of existing operations
- Quality conformance minimums are established in a balance to lower costs of production but ensure performance in all scanning/reading destinations.

(4) *Capable of being compliant with equivalent specifications in Symbol Specification Tables (or RFID equivalent) for global AIDC data carriers (e.g., encodation, quality, placement, human-readable, size, read/write)*

This condition means that normative technical standards are available for a given AIDC technology in support of their use in application standards.

One example is the Symbol Specification Tables (SSTs) for barcodes. In the GS1 General Specifications, the SSTs provide the minimum and maximum size for barcode printing and the minimum quality conformance grade for barcode scanning. They are organised according to support a subset of application standards (e.g., scanning at POS or bedside in a hospital).

Another example is the 'EPC Radio-Frequency Identify Protocols Generation-2 UHF RFID Standard'. Based on this protocol, GS1 specified a conformance requirements document and provides a certification program to testify that a given RFID tag conforms to the EPC UHF Class

1 Gen 2 Standard. Based on that, users can have confidence that any certified RFID tag interoperates smoothly with any UHF Gen 2 compliant RFID reader.

(5) *The new AIDC data carrier option can be implemented exclusively in 90%+ of installed scanner/reader locations for a given Operative Scanner Environment as defined by the GS1 General Specifications without significant disruption to the performance of existing AIDC data carriers.*

This condition ensures that a vast majority of potential scanner/reader locations is capable to use a given AIDC technology. It is important to note that this requirement refers to a specific operative scanner environment. For instance, if a Type B Data Carrier is considered for use cases at retail point of sale, it must be ensured that more than 90% of all cash desks/registers are able to scan that data carrier. Similarly, if an application standard deals with consumer interaction (meaning that consumer's mobile phones are the scanning devices), it must be assured that more than 90% of all mobile phones have the capability to read it.

In exceptional cases, the GS1 Management Board and General Assembly (GA) may decide to approve a new data carrier even if this 90% requirement is not met. In order to reach that threshold, a waiver would be approved and program management introduced to report progress on adoption to determine when the data carrier could be considered sufficiently supported as a global, open standard.

3.4 Value proposition of Type A Data Carriers

The basic value proposition of a Type A Data Carrier is the expectation that all parties marking or scanning objects may have confidence that any data carrier and any corresponding AIDC system within a given environment (e.g., retail Point-of-Sale, bedside, transport and logistics) will interoperate. This is quite different than proprietary or niche applications with user-specific marking and typically entails:

- significant savings in costs,
- rapid time-to-market,
- enabling packaging that serves multiple markets,
- sufficient market availability of AIDC system components (printers, labels, readers/scanners, middleware, etc.)
- smooth integration between AIDC system components and standard software,
- reduce industry and consumer confusion over multiple data carriers on packaging,
- low risk of running into a vendor lock-in,
- higher level of efficiency,
- lower expenditure of human labour,
- auto-discrimination between different data carriers (i.e. being able to distinguish a given data carrier from all others),
- support by GS1/GS1 solution partners: specifications, guidelines, tools (e.g. for translating between different syntax forms), advice on technology migration, etc.
- etc.

Moreover, end users and solution providers can have confidence that, at the global level, new AIDC data carriers are only added to the GS1 system of standards if there is industry consensus on whether a business case or regulation justifies its inclusion and if the data carrier candidate complies with GS1 Policy (see annex A.1).

In some cases, an application standard may specify an AIDC data carrier that is not yet pervasively implemented per the waiver discussed above. If so, GS1 supports industry in migrating to a new data carrier especially through:

- communicating the objectives of industry regarding adoption,
- measuring adoption of industry,

- reporting adoption to inform industry on when new AIDC provisioned data, data carrier technology, or data carrier syntax can be marked exclusively, and
- (if applicable) ensuring backward compatibility to ease migration

The figure below provides a snapshot view of Type A Data Carrier characteristics.

Figure 3-2: Characteristics of Type A Data Carriers

Data Carrier	Data payload (encoded data)	Capture Technology			Syntax supported				Application Standard Summary
		Laser (optical)	Image (optical)	RFID	Plain (without explicit AIs etc.)	GS1 Element Strings	GS1 Digital Link URI	EPC Binary	
EAN/UPC	GTIN, Add-On, special applications								Trade items, coupons, special applications
ITF-14	GTIN								Trade items
GS1 DataBar Omni-directional	GTIN, GCN								Trade Items, Global Coupon Number
GS1 DataBar Expanded	GTIN and related Application Identifiers (AIs)								Trade items, Global Coupon Number + SN, service relationships
GS1-128	AIs								Trade items, logistics, assets, locations, service relationships
GS1 DataMatrix	AIs								
GS1 QR Code	AIs								
Data Matrix (GS1 URI)	Equivalents of AI data elements								Currently approved for extended packaging, but under consideration in a broad set of application standards
QR Code (GS1 URI)	Equivalents of AI data elements								
GS1 DotCode	GTIN & AI (235) only								Restricted to EU 2018/574 regulation
GS1 Composite	Attributes of GTIN	Area-CCD and raster laser scanners							GS1 DataMatrix is preferred by healthcare but Composite Component is still permitted
EPC RFID (UHF/HF) Tag – EPC Memory Bank	EPC based on instance-level GS1 ID								Trade items, logistics units, assets, locations
EPC RFID (UHF/HF) Tag – User Memory Bank	Equivalents of AI data elements							e.g. Packed Objects	

Legend

applicable | not applicable | partially applicable

3.5 Capabilities and constraints of Type B Data Carriers

There are AIDC data carrier technologies capable of carrying GS1 data elements that are not approved as global, open standards by industry. This means a company marking an object cannot use them instead of a globally approved Type A Data Carrier and expect all companies scanning/reading the object to support the technology. Even so, these technologies may provide

business value to a subset of GS1 members within a specific application context. For this reason, where these data carriers are used outside an open standards context, implementation of them should occur in a manner which does not disrupt the use of existing standards.

The following subsections summarise several of these technologies per the same characteristics as above, but also provide a summary of their capability and a brief assessment against the criteria GS1 uses to evaluate new data carriers. The assessment represents a snapshot at the time of editing this RfF. As there are a large number of Type B Data Carriers, the below selection was based on a representative few that have been the subject of discussions within the GS1 community.

The following sections assess, from today's view, the following Type B Data Carriers:

- Digital Watermark (section 3.5.1)
- NFC Tag (section 3.5.2)
- Han Xin Code (section 3.5.3)

3.5.1 Digital Watermark technologies that carry GS1 data structures

Data Carrier Assessment Matrix	
Name	Digital Watermark technologies that carry GS1 data structures
Potential data payload (encoded data)	Multiple encoding schemes including, but not limited to, GS1
Capture technology	Image, infrared, or ultraviolet (e.g. optical or laser)
Syntax	Binary encoding (based on e.g. spread spectrum, grey scale or colour coding)
Potential areas of application	e.g. check display compliance, speed up checkout process, ease plastic recycling, anti-counterfeit, etc.
Capability	Encodes data (e.g. a GS1 Key) as a digital watermark on an object's surface, often invisible to the human eye. For robustness and reliability reasons, a Digital Watermark is usually embedded several times into a host signal (for instance, a packaging artwork).
Evaluation against GS1 adoption criteria	(1) Freely implementable? Yes and no: some technologies require a licensing agreement with a solution provider. In addition, each Digital Watermark needs to be individually embedded in a product packaging's print layout file. While SDK software licensing terms with scanner manufacturers are confidential, solution providers known to GS1 seek widespread adoption, and software licensing fees, to the extent they have them, are designed not to be a barrier to this goal. As we know, software providers typically do include maintenance and or support fees, for example. (2) Able to exclusively indicate GS1 data structures? Yes. However, the means to accomplish this has not been standardised yet. In addition, the payload is limited. (3) Sufficiently tested? In progress for some technologies and applications (e.g. to accelerate retail checkout and optimise recycling). Unfortunately, there's little independent testing. (4) Compliant with AIDC data carrier specifications? No. Solution providers known to GS1 have devised a basic set of measurements to determine the quality of the watermark from the perspective of what the scanner is going to see. This method does not align with traditional symbol verification methods. (5) Implemented in 90%+ of scanners? No – there is no environment known to the GS1 AG where this has been accomplished yet.

Table 3-4: Assessment matrix for Digital Watermark

3.5.2 NFC Tag

Data Carrier Assessment Matrix	
Name	NFC (Near Field Communication) Tags
Potential data payload (encoded data)	Multiple encoding schemes including, but not limited to, GS1
Capture technology	RFID
Syntax	Binary encoding
Potential areas of application	Payment, access control, consumer engagement
Capability	Provides the capability for contactless data transmission across small distances (few centimetres), which is especially appealing for security-relevant applications such as payment and access control.
Evaluation against GS1 adoption criteria	(1) Freely implementable? No. Manufacturers of devices using NFC functionality (e.g. smartphones) have to acquire a license to be entitled to use NFC-related patents. In addition, NFC Forum technical specifications are available for members only or have to be purchased. (2) Able to exclusively indicate GS1 data structures? Yes. For instance, the NFC Data Exchange Format (NDEF) makes provision for a URI Record Type Definition including e.g. EPC URIs, URI Patterns and Tag URIs. Moreover, if an NFC Tag encodes a GS1 Digital URI, a GS1 Digital Link URI can be recognised similarly as it is the case with a QR code encoding it (i.e. via a regular expression). (3) Sufficiently tested? Yes. First, there are numerous both open (e.g. access information at points of interest, open parking barriers) as well as secure applications (e.g. contactless payment, admission ticket) in productive use. Moreover, NFC Forum offers a certification program that checks whether a given device, tag or reader is compliant with the NFC Forum specifications. (4) Compliant with AIDC data carrier specifications? Yes. The NFC Forum provides specifications (freely available only for NFC Forum members though) which are also the basis for their certification testing (see previous point). In order to apply this at the application standard level, a methodology for grading similar to the Tagged-Item Performance Protocol (TIPP) may be required. (5) Implemented in 90%+ of scanners? This depends on the context. If we take the example of payment, NFC's most prominent application domain, 90% has not been achieved at the time of writing this RfF: the NFC Forum (2020) estimates that there are around 2 billion NFC-enabled devices worldwide, while there are 3.4 billion active smartphones in total. That said, for devices which are sold to support payment, NFC would likely be at or above 90%.

Table 3-5: Assessment matrix NFC Tag

3.5.3 Han Xin Code

Data Carrier Assessment Matrix	
Name	Han Xin Code
Potential data payload (encoded data)	Multiple encoding schemes including, but not limited to, GS1
Capture technology	Image (optical)
Syntax	GS1 Element Strings, GS1 Digital Link URI
Potential areas of application	Similar to GS1 QR/DM Code or QR/DM Code, especially in Asian countries.
Capability	Han Xin Code uses locational features and four levels of error correction similar to QR Code for fast response when scanned. Han Xin code is an efficient symbology using one character to encode HTTPS and encodes commonly used Chinese, Japanese and Korean characters at 12 bits per character. Han Xin Code's encoding effectiveness results in a smaller symbol size when compared to QR Code and Data Matrix.
Evaluation against GS1 adoption criteria	(1) Freely implementable? Yes. GS1 China is the owner of the Han Xin Code patent and has declared that Han Xin Code is free of all use restrictions, licenses, and fees. Han Xin Code is moving through the ISO/IEC standardisation process and is in the final text review before publication. (2) Able to exclusively indicate GS1 data structures? Yes. This is accomplished through mode indicators: if it is 'GS1 mode', a Han Xin Code encodes GS1 element strings. If it is 'URI mode' and the symbology encodes a GS1 Digital Link URI, a GS1 data structure is recognisable with a regular expression. (3) Sufficiently tested? Yes. In this context, there are various applications in China already. In addition, some label design software, printing and scanning companies have implemented encoding/decoding capabilities. (4) Compliant with AIDC data carrier specifications? No. The GS1 Gen Specs do not have specification for Han Xin Code as it is not a permitted data carrier within an AIDC Application Standard. However, similar to GS1 QR Code and GS1 DataMatrix, one could logically specify symbol size, conformance specifications for the various scan environments. (5) Implemented in 90%+ of scanners? No. So far, all known implementations are based in China. At a global level, adoption is still low, but could increase once the ISO/IEC 20830 Han Xin standard is published.

Table 3-6: Assessment matrix for Han Xin Code

4 Recommendations for Policy, Standards, & Architecture

The GS1 Architecture Group has three primary recommendations:

- clarify GS1's policy on data carrier adoption (see section 3.1)
- introduce the developed concepts of this RfF in upcoming GS1 standardisation activities (see section 3.2)
- incorporate the developed concepts of this RfF in next release of the GS1 System Architecture (see section 3.3)

4.1 Policy

This RfF has shown that the policy would benefit by a review of the GS1 Architecture Group which is responsible for recommending changes for it to the Board Committee for Standards. For example, who does 'freely available' apply to? Should the policy refer to sunrise dates or simply program management to communicate, measure, and report adoption until a global, open status is agreed by the General Assembly?

Against this background, the GS1 Architecture Group work plan for 2021 will include a review of Policy B11 with recommendations being made to the Board Committee for Standards upon completion.

Further, GS1 standardisation groups may encounter a situation where additional guidance on Policy B-11 would prove beneficial. After the policy revisions are approved by the BCS, the GO AIDC Team, with AG consultation, could develop greater guidance in parallel to ensure even application of the policy over time.

4.2 Standardisation

In parallel to the development of this RfF, the ID SMG added, revised or removed a number of terms in the GS1 Standards glossary of terms. Based on that, GS1 now has the expressiveness to differentiate between Type B Data Carriers (e.g. "QR Code") and Type A Data Carriers (e.g. "GS1 QR Code" when encoding GS1 element strings and "QR Code (GS1 URI)" when encoding a GS1 Digital Link URI).

A reasonable addition to the GS1 Standards glossary of terms are the concepts of 'Type A Data Carriers' and 'Type B Data Carriers' as introduced in section 3.1.

New and future releases of GS1 application standards or implementation guidelines should apply this set of terms to ensure that users and solution providers can understand and implement GS1 standards in an unambiguous way.

4.3 GS1 Architecture

Similar to the class concept developed for GS1 Identification Keys (which enables the grouping of a given key into one out of four classes), a future release of the GS1 System Architecture document should apply the classification framework developed for data carriers as developed in this RfF (see section 3.1).

5 Annex

5.1 GS1 Operational Manual: Policy B-11

GS1 Policy, Principles and Process for the Adoption of New AIDC Data Carriers

1. Policy

GS1 AIDC (automatic identification and data capture) data carrier standards must be relevant and applicable to any supply chain, independent of who assigns, receives, and processes the standards. New AIDC data carrier and identification technologies should only be introduced to the standard if they enable new applications or better ways to perform existing functions. The AIDC data carrier must operate with existing carriers in existing applications without causing disruption.

If an Industry User Group requirement identifies a new AIDC data carrier technology that provides a better way to perform an existing function, then it can be added as a globally approved Data Carrier specification in GS1 General Specifications Data Carrier Section and to all applicable, global AIDC Application Standards and related Symbol Specification Tables (and the RFID equivalent). The addition is contingent on proper approval through GSMP.

2. Guiding Principles in Technology Adoption

2.1 Backward Compatibility
A new AIDC data carrier must be able to carry an application standard-defined subset of GS1 data structures, and hence allow users to work with existing systems that rely on data structures within the defined subset for the application. For example, an AIDC Application Standard requires the mandatory use of GTIN (Global Trade Item Number) and the optional use of GTIN attributes serial number, lot number, and expiration date. The new AIDC data carrier, if approved for use in this example, would be required to support AIs (01) Global Trade Item Number, (10) Batch or Lot Number, (17) Expiration Date, and (21) Serial Number.

2.2 Forward Capability
A new AIDC data carrier must be expected to show, over time, the capability to deliver the needed ranges of cost/performance.

2.3 Exclusivity
A technique must be available and allocated exclusively to GS1 in order to enable unambiguous identification of GS1 data structures.

2.4 Data Structure Use
When a GS1 Application Standard specifies the use of a GS1 AIDC data carrier, the AIDC Application Standard shall specify exclusive use of GS1 data structures.

2.5 Intellectual Property
AIDC data carriers must comply with the GS1 IP policy, with preference to AIDC data carriers in the public domain and freely available. It is very important to perform due diligence on a new AIDC data carrier.

2.6 Auto-discrimination
AIDC data carriers must not interfere with one another and must be capable of unambiguous translation.

2.7 Human Factors
Consideration should be given to efficient keystroke entry (or equivalent data entry method), error handling, and placement as key factors in effective implementation.

2.8 Performance Requirements
The new AIDC data carrier must have proven both cost/performance and quality across the

expected range of applications, materials, and operational environments. This evidence must be properly documented.

2.9 Business Requirements

At a minimum, a request for a new AIDC data carrier must address why the new technology is required (what unmet business requirement is met) and what effect the new technology will have on legacy solutions built based on GS1 standards. An approval plan must include a migration path to support the new technology, must support current business practices, and must provide benefit above and beyond existing technologies.

3. Process

3.1 Global Standards Management Process (GSMP) Groups

The GS1 Global Standards Management Process (GSMP) is the mechanism to approve the adoption of new technology for the GS1 System. For Work Requests to add an AIDC data carrier that is not currently used in an AIDC Application Standard to an existing or new AIDC Application Standard and for it to be used exclusively in place of a currently approved GS1 data carrier, an evaluation based on the following conditions is required as a part of the GSMP approval.

1. Technology is freely implementable to the best of our knowledge
2. A technique must be available and allocated exclusively to GS1 in order to enable unambiguous identification of GS1 data structures.
3. Tested to ensure it will not substantially disrupt scanner or reader performance for existing AIDC data carriers
4. Capable of being compliant with equivalent specifications in Symbol Specification Tables (or RFID equivalent) for global AIDC data carriers (e.g., encodation, quality, placement, human-readable, size, read/write)
5. The new AIDC data carrier option can be implemented exclusively in 90%+ of installed scanner/reader locations for a given Operative Scanner Environment as defined by the GS1 General Specifications without significant disruption to the performance of existing AIDC data carriers.

The GS1 MB and General Assembly (GA) may decide to make an exception to the 90%+ minimum by establishing a Sunrise Date to reach the minimum and deploying Program Management to reach that goal.

3.2 Formation of policy and principles

The Architecture Group forms the policy and principles for evaluation of new AIDC data carriers and the GS1 Board Committee for Standards approves the policies and principles. These policies and principles steer the evaluation of AIDC data carriers throughout the entire GSMP.

Latest update – approved by the General Assembly on 19 May 2010

Note: The General Assembly might have approved a revised version of Policy B-11 since this RfF was published. To access the most recent release, go to: *https://www.gs1.org/standards/development/how-we-develop-standards*.

5.2 Technology Assessment for QR Code and Data Matrix (GS1 URI) symbols

For information purposes, this appendix provides insight into the AIDC technology assessment of QR Code/Data Matrix encoding GS1 Digital Link URIs per Policy B11 as part of GS1's due diligence process. After their positive evaluation, both data carriers were specified in a global GS1 Application Standard, i.e. have become Type A data carriers (see GS1 General Specifications, release 21.0).

The assessment addressed the following criteria:

1. Capability of encoding GS1 data structures
2. Ability to unambiguously identify that data carrier encodes GS1 data structures
3. Capability of being compliant with specifications equivalent to GS1 General Specification's Symbol Specification Tables (e.g., encodation, quality, placement, human-readable, size, read/write)
4. Intellectual property assessment
5. Data carrier adoption in application standard area of interest

The following sub-sections summarise the most recent assessment performed by GS1 GO AIDC when QR Code (GS1 URI) and Data Matrix (GS1 URI) were presented for ratification to the Board Committee for Standards to recommend their ratification.

5.2.1 Capability of encoding GS1 data structures

The first assessment is whether the data carrier can encode a GS1 data structure. The data carrier must be capable of encoding GS1 data structures. The data carrier must also be able to output the GS1 data structures when decoded by a scanning device. Both native QR Code *ISO/IEC 18004* and native Data Matrix *ISO/IEC 16022* support the use of GS1 Digital Link URI syntax.

Figure 5-1: QR Code / DataMatrix (GS1 URI) examples

https://id.gs1.org/01/09506000134352

https://id.gs1.org/01/09506000134352

5.2.2 Ability to unambiguously identify that data carrier encodes GS1 data structures

As noted above, both QR Code and Data Matrix support the use of GS1 Digital Link URI syntax. However, they also support encoding of other data such as URLs with non-GS1 identifiers. Therefore, a technique must be available and allocated exclusively to GS1 in order to enable unambiguous identification of GS1 data structures. Today's GS1 barcodes (GS1-128, GS1 DataBar, GS1 DataMatrix, etc.) have a mechanism to alert a scanning system that the barcode carries GS1 data. QR Code and DM do not natively utilise this mechanism.

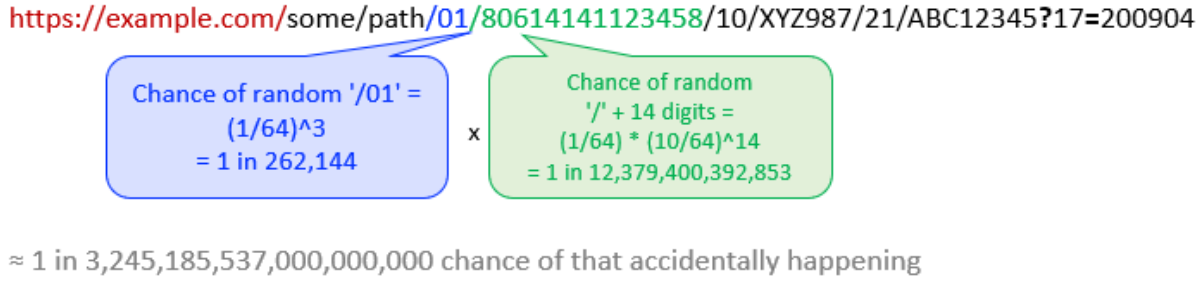
For this reason, GS1 created an approach (regular expression test) that scanner systems can leverage to determine, with sufficient certainty, that a given data carrier encodes the GS1 DL syntax. The following regular expression will match a valid GS1 Digital Link URI. Failure to match means it definitely is not a GS1 Digital Link URI. In addition to the GS1 Digital Link syntax, the regular expression provided below supports the inclusion of a user name and a port number in the URL. These are rarely used in practice, but are part of the formal URL syntax.

Regular expression:

```
^https?:(\/\/((([^\/?#]*)@)?([^\/?#:]*)(:([^\/?#]*))?))?([^?#]*)(((\/(01|8006|8013|8010|414|417|8017|8018|255|00|253|401|402|8003|8004)\/)(\d{4}[^\/]+)(\/[^/]+\/[^/]+)?[/]?(\?([^?\n]*))?(#([^\n]*))?))
```

It is unlikely, although not impossible, that it will match a URL that is not also a conformant GS1 Digital Link URI. For GTIN (Application Identifier 01) this routine has a 1 in 3,245,185,537,000,000,000 chance of failing to plausibly recognise that the data carrier (QR Code or Data Matrix) encodes the GS1 Digital Link URI syntax.

Figure 5-2: Probability calculation of erroneously recognising an arbitrary URI to be a valid GS1 Digital Link URI



This does not prohibit someone from using QR Code or Data Matrix with a duplication of the string, though the same can be said of today's GS1 barcodes as well which cannot prohibit illegitimate encoding.

5.2.3 Capability of being compliant with specifications equivalent to GS1 General Specification's Symbol Specification Tables

To be included in the GS1 system, the data carrier must have well established quality standards for e.g. encodation, scanning (read/write), and size (design). QR Code has ISO/IEC 18004 and Data Matrix ISO/IEC 16022 standards for encodation and design. Both data carriers reference the ISO/IEC 15415 2D (Two Dimensional) standard for verification and quality. The GS1 General Specifications also set the size and quality limits for an open global standard as shown below for QR Code and Data Matrix approved for use within the Extended Packaging Application Standard:

Symbol(s) specified	X-dimension mm (inches)			Minimum symbol height for given X mm (inches)			Quiet Zone	Minimum quality specification
	Minimum	Target	Maximum	For minimum X-dimension	For target X-dimension	For maximum X-dimension	Surrounding Symbol	
Data Matrix (ECC 200) (*)	0.396 (0.0150")	0.495 (0.0195")	0.743 (0.0293")	Height is determined by X-dimension and data that is encoded			1X on all four sides	1.5/12/660
QR Code (*)	0.396 (0.0150")	0.495 (0.0195")	0.743 (0.0293")	Height is determined by X-dimension and data that is encoded			4X on all four sides	1.5/12/660

(*)	2D X-dimension - Optical effects in the image capture process require that the Data Matrix and QR Code symbols be printed at 1.5 times the equivalent X-dimension allowed for linear symbols.

Table 5-1: Symbol specification table for DataMatrix / QR Code (GS1 URI)

5.2.4 Intellectual property assessment

Any data carrier technology must be freely implementable to be included in the GS1 General Specifications. To ensure this, GS1 is required to do an exhaustive review of intellectual property claims (patent fillings and awards) and review all patents with GS1 legal counsel. For this purpose, GS1 leverages e.g. patent search tools and the GS1 IP Policy (*https://www.gs1.org/docs/ip/GS1_Intellectual_Property_Policy-Review_Version.pdf*).

The latter stipulates to obtain royalty-free or RAND (reasonable and non-discriminatory) licensing commitments from working group participants whose patent claims ("Necessary Claims") would be infringed by the implementation of the standard. As noted, both QR Code and Data Matrix are open ISO/IEC symbologies. However, implementations may have IP that could cause the combination of the data carrier with the GS1 data structure to fail GS1's royalty-free or RAND (reasonable and non-discriminatory) licensing commitments. GS1's analysis showed that the extended packaging

application standard utilising QR Code and Data Matrix with GS1 Digital Link URI syntax is freely implementable.

5.2.5 Data carrier adoption in application standard area of interest

GS1 requires the AIDC data carrier option can be implemented exclusively in 90%+ of installed scanner/reader locations for a given operative scanner environment as defined by the GS1 General Specifications without significant disruption to the performance of existing AIDC data carriers. The addition of QR Code and Data Matrix encoded with the GS1 Digital Link URI standard is limited to the extended packaging application standard because this is the only application standard that meets the 90% requirement for “global open standards”.

The information obtained from a consumer trade item’s packaging can be extended when consumers using mobile devices scan barcodes on the package, which leads them to more information or an application. The consumer mobile devices like smart phones have QR Code with URI recognition and decoding solutions embedded in their operating system. This same capability is now appearing for Data Matrix carrying URIs. Consumer mobile devices are also capable of purpose-built applications that utilise the device’s camera (imager) to decode data carriers such as QR Code and Data Matrix and automatically redirect the consumer to the online content.

Figure 5-3 compares the functionality of GS1 QR Code and GS1 DataMatrix with QR Code (GS1 URI) and Data Matrix (GS1 URI) and illustrates why each one is appropriately defined as a Type A data carrier for GS1.

Figure 5-3: Comparison of QR Code / DataMatrix (GS1 URI) with GS1 QR Code / DataMatrix

QR Code Comparison	Native Camera	Purpose-built APPs
QR Code with GS1 DL URI Syntax	YES	YES
GS1 QR Code with AI Syntax	NO	YES

https://id.gs1.org/01/09506000134352

(01)09506000134352(8200)https://id.gs1.org/01/

Data Matrix Comparison	Native Camera	Purpose-built APPs
Data Matrix with GS1 DL URI Syntax	Potentially	YES
GS1 DataMatrix with AI Syntax	NO	YES

https://id.gs1.org/01/09506000134352

(01)09506000134352(8200)https://id.gs1.org/01/

Therefore, QR Code and Data Matrix encoded with the GS1 Digital Link URI standard within the extended packaging application standard meet the requirements for adoption in to the GS1 General Specifications

5.3 The Request for Finding

Request for Finding – Brief Summary (one phrase or sentence)
What should be the GS1 policy regarding the reference of Non-GS1 data carriers (both open and commercial) in the GS1 System of Standards?

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Statement of Question or Concern (please be specific as to what you want answered)

There is a growing number of situations in which GS1 or GS1 MOs endorse, refer or market non-GS1 data carriers, for instance DWCODE (*https://www.digimarc.com/dwcode*), QR Code (e.g. in the S4T Application Standard), REALBarcode (*https://www.gs1hk.org/REALBarcode/overview*), NFC tags (e.g. in the GS1 Digital Link Standard) or Han Xin Code (*http://www.ancc.org.cn/GS1ChinaEN/GS1ChinaENTest/hanxincode.aspx*).
What should be the GS1 policy regarding the reference of these (as well as further and future) Non-GS1 data carriers (both open and commercial) in the GS1 System of Standards?
Similar to the classification system the GS1 Architecture Group developed for GS1 Keys, a corresponding grading of data carriers that are applied throughout the GS1 System of Standards would be helpful to inform both end users as well as solution providers on potential interoperability issues.

Relevant GS1 Standards or other GS1 System Components (omit if unsure)

n./a. (GS1 Operational Manual, GS1 System Architecture Document)

To be filled in by Architecture Group			
Request #	**Date Submitted**	**Date Accepted for Consideration**	**Date Completed**
20-001	**2020-02-05**	**2020-02-05**	**2021-02-05**
Link to Architecture Finding	***https://gs1.org/architecture/***		