The Global Language of Business

The Future Encoding Format of the Electronic Product Code

Request for Finding

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1 Executive Summary

Nearly 15 years after the initial publication of the EPC Tag Data Standard 1.0, the "parsing" (restructuring/reformatting/splitting) of GS1 identification keys in the EPC suite of standards remains a barrier to implementation. For instance, one company participating in the EPCIS/CBV 2.0 MSWG reported that the need to educate its suppliers about this complexity of formatting EPC URIs correctly is costing them 0.15 FTE per 100 suppliers per year.

EPCIS is intended to be agnostic to the choice of data carrier technology. However, when a company receives an object carrying a barcode and no EPC RFID tag, it needs to determine the correct length of the GS1 Company Prefix in order to correctly convert the element string (e.g. SSCC or GTIN + serial number) into the EPC format, so that it can capture EPCIS event data correctly. This relies on a practical and efficient means to determine the length of the GS1 Company Prefix for any GS1 identification key, irrespective of the geographic location of the issuer of that key.

A survey of the EPC RFID and EPCIS community was conducted at the start of this Request for Finding. More than 40% of respondents indicated having encountered difficulties in determining the length of the GS1 Company Prefix in order to correctly format the EPC, with a variety of causes, including but not limited to:

- barcode/EPC interoperability (GCP length) table inconsistent, incomplete, or not updated in a timely manner;
- no guarantee that all parties would do it correctly, with errors causing problems for other parties, who might be doing so correctly themselves but handling incorrectly encoded EPCs from other parties;
- problems with NTINs and other single-issue keys;
- implementation delays due to education requirements;
- confusion between GS1 Company Prefix and U.P.C. Company Prefix; and
- problems with leading digit (indicator digit for GTIN and extension digit for SSCC) and check digit.

These issues aside, a number of implementations depend on the separation of the GS1 Company Prefix, particularly for separating tags or events by trading partner. In one industry with heavy RFID tag usage, the separation of the GS1 Company Prefix from the rest of the key makes extracting the internal asset identifier from a GIAI a trivial process.

Significant issues (>50% of responses) suggests that the effort to change the format of the EPC URIs would be welcomed by a significant share of industry, but conversely, a lot of solutions are built on the separation of the GS1 Company Prefix and any plan would have to include guidance on how to migrate away from such solutions.

All of the options that were considered were measured against the following criteria:

1. Explanation complexity.
2. Standards effort.
3. Hardware implementation effort.
4. Software implementation effort.
5. Impact on large enterprises.
6. Impact on small to medium enterprises.
7. Impact on regulators.

1.1 Principal Recommendation

After careful consideration, this document recommends that the EPC suite of standards permit GS1 Digital Link URIs, alongside and aligned with the EPC URI formats, as a supplementary supported format, as either a set of restricted,

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constrained canonical set that corresponds one-to-one with the set of EPC formats, or without such constraints.

To support this recommendation, this document includes a proposal for enhanced indexing, which is currently under evaluation within the prototype testing phase by members of the EPCIS/CBV 2.0 MSWG. Furthermore, for some time there will be a need for the ability to determine the length of the GS1 Company Prefix in situations where it otherwise can't be determined. At minimum, the existing GS1 Company Prefix length table needs to be maintained and updated regularly with licence data provided by GS1 Member Organisations. Other recommendations are that its existence be better publicised (many respondents to the survey didn't know about it) and that a simple REST API be developed to simplify its use.

Finally, although not directly related to the scope of this work, the document also recommends consideration of a standard request/response interface for requesting and providing serial numbers (e.g. for dealing with lost tags etc.) and that a separate review be conducted on the ongoing usage of the General Identifier (GID), a legacy EPC scheme that is not aligned with the GS1 identification system, with a view to deprecation or at least a formal moratorium on further GID allocation.

1.2 "Modernisation of EPC" Discussion Group

Because of the potentially significant impact of this proposal, we recommend the creation of a GS1 community-wide, "Modernisation of EPC" discussion group, to be convened and managed by the GSMP team. The Architecture Group supports this and defers all discussion of the technical details and business case consensus to that group. Furthermore, the Architecture Group recommends that the discussion group do a full technical review of the examples and proposals in this document, as no such review was done at the Architecture Group level.

1.3 Deprecation of GID

Further discussion withing GS1 Global Office is required to determine the next steps related to the deprecation of the GID. In the meantime, priority should be given to formalizing the moratorium on further GID allocation rather than deprecation of existing GIDs.

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2 Background

Developed under the umbrella of the EPCglobal standards development process (2004-2010), GS1/EPCglobal technical specifications require GS1 identification keys to be converted into Electronic Product Code (EPC) encodings in EPC standards.

EPCs differ from their equivalent GS1 Element Strings in that they:

- take on (non-resolvable) URN form;
- require knowledge of the length of the GS1 Company Prefix, and explicit demarcation of this portion of the string within the URN and in encoding of the RFID tags;
- displace leading digits (for GTIN, SSCC, GRAI) from the front of the GS1 identification key to the front of the second component; and
- strip out the check digit.

This has caused problems for users due to unnecessary complexity, resulting in incorrectly encoded RFID tags, as well as incorrectly encoded GS1 identification keys within EPCIS events. Prevention of such errors has, in turn, required cumbersome and confusing workarounds for and/or incompatibilities with:

- encoding downstream from the brand owner (requiring a GS1 Company Prefix length lookup table);
- encoding of GTIN-8, which has no GS1 Company Prefix;
- encoding of class 2 keys (support for ISBN but not for ISSN); and
- encoding of one-off keys (currently encoded into EPC as if based on a 12-digit GS1 Company Prefix).

The negative impact on a harmonised set of GS1 standards remains an issue, with increasing repercussions in the future due to anticipated growth in both EPC-based (e.g. EPCIS and EPC/RFID) and non-EPC-based (e.g. GS1 Digital Link, Licence Registry) GS1 standards and services.

The purpose of this paper is to review the future of the GS1 Company Prefix within the EPC suite of standards and to provide recommendations on changes that may be required.

2.1 GS1 Company Prefix

As a general rule, the GS1 Company Prefix is a required component of every class 1 GS1 identification key in the "Identification" layer of the GS1 standards and so is at the core of the GS1 system. The issuance, allocation, transfer, and general management of the GS1 Company Prefix are fundamental to delivering the services upon which GS1 member companies depend.

When it was initially conceived, what is now the GS1 Company Prefix was thought of as an identifier on its own (e.g. "manufacturer ID") or as including an identifier (e.g. "GS1 Prefix plus company number"). As the GS1 system grew and companies acquired multiple prefixes, the idea that the GS1 Company Prefix was itself an identifier diminished and that is now no longer the case. Nowadays, the GS1 Company Prefix is considered to be associated with a licensee but doesn't identify them.

In the GS1 General Specifications, the GS1 Company Prefix is used in the construction of all GS1 identification keys (with exceptions outlined below), but once a key is constructed, the GS1 Company Prefix is effectively invisible in that it's not possible to tell from the key alone where the GS1 Company Prefix ends. By contrast, in the EPC suite of standards, the GS1 Company Prefix is a separate field in the EPC URI and the EPC Tag URI.

2.1.1 Exceptions to the Rule

For the sake of simplicity, in this document all class 1 GS1 identification keys are presumed to include a GS1 Company Prefix except where explicitly noted. There are two exceptions to this rule.

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2.1.1.1 GTIN-8

The GTIN-8 was designed to support items whose packaging does not include enough available space to permit the use of an EAN-13 barcode symbol. Due to the limited number available, they are issued on request only.

Unlike other GS1 identification keys, the GTIN-8 doesn't have a GS1 Company Prefix as it's composed of a three-digit GS1-8 Prefix, a four-digit object reference, and a check digit. However, the GS1-8 Prefix may be treated as equivalent to a GS1 Company Prefix by prepending it with five zeros.

2.1.1.2 One-off GS1 Identification Keys

As adoption of the GS1 system grew, many GS1 Member Organisations expanded their licensing services to include individual ("single issue" or "one-off") GS1 identification keys, most commonly the GTIN. Such keys are recommended, but not required, to be based on a GS1 Company Prefix (see section 3.3, "GS1 Operational Manual", for details).

2.1.2 U.P.C. Company Prefix

There is a subset of the GS1 Company Prefix, called the U.P.C. Company Prefix, that is defined in the GS1 General Specifications as follows:

> A U.P.C. Company Prefix is derived from a GS1 Company Prefix that starts with zero ('0') by removing that leading zero. A U.P.C. Company Prefix SHALL only be used to construct 12-digit trade item identifiers.

Throughout this document, all references to the GS1 Company Prefix shall be understood to include the U.P.C. Company Prefix for GTIN-12s.

2.2 GS1 Identification Key Structure

A GS1 identification key is typically made up of a GS1 Company Prefix, an object reference, an optional indicator or extension, optional check characters, and an optional serial identifier.

Component	Description
GS1 Company Prefix	A worldwide unique string licensed to GS1 member companies which they in turn use to generate worldwide unique identification keys. This is a variable-length string, from 4-12 digits long. The shorter the prefix, the more keys it can generate.
Object reference	A string unique within the GS1 Company Prefix and identification key type that refers to a unique instance or class of object. The same string may be used multiple times, but each use must be for a different identification key type. For example, a member company can use the same object reference for both a GTIN and a GLN; it is the context in which it is used that determines which object type or instance the identification key refers to. The term "object reference" is used as a generic term. In key-specific usage, it may be a trade item reference (GTIN), location reference (GLN), serial reference (SSCC), service reference (GSRN), etc.
Indicator or extension	A digit used to qualify the identification key in some way. For a GTIN, the indicator digit is used to identify homogeneous groupings of a trade item. For an SSCC, the extension digit increases the capacity of the prefix for issuing SSCCs.
Check characters	A mathematical calculation that uses the preceding content to generate one or two characters that can be used to verify that the data is entered correctly. All numeric GS1 identification keys require a check character; the GMN supports two check characters but requires them only for some applications.
Serial component	Some keys (in particular, the GRAI, GDTI, and GCN) support an optional serial component to denote an instance of the object.

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2.2.1 Identification in EPC

When the EPC suite of standards was initially developed, the GS1 Company Prefix was given primacy in several ways:

- in the encoding of the GS1 identification keys into EPC/RFID tags;
- in the construction of DNS entries for the Object Name Service (ONS); and
- in the representation of GS1 identification keys as Uniform Resource Names (the EPC URI and EPC Tag URI).

ONS has since been revised so that the GS1 Company Prefix is no longer treated as a separate component within a DNS entry.

2.3 Data Carriers

The representation of a GS1 identification key in a barcode is different from the representation of the same GS1 identification key in an EPC/RFID tag. In a barcode, the GS1 identification key is represented as a contiguous string, whereas in an EPC/RFID tag, the key is represented by its GS1 Company Prefix and object reference as individual components. As a result, while the content of an EPC/RFID tag can be mapped to a barcode, the reverse is not true without knowledge of the length of the GS1 Company Prefix used to generate the key.

2.3.1 Barcodes

Barcode symbology is well-known and well-established worldwide. Many one- and two-dimensional symbologies exist, but regardless of the symbology chosen, GS1 identification keys are always represented as whole strings; there is nothing in the barcode that indicates the length of the GS1 Company Prefix.

2.3.2 EPC/RFID tags

EPC/RFID tags are represented as a continuous stream of bits. There is a great deal of data encoded within a tag, but for the purposes of this document only the GS1 identification key representation within the EPC memory bank will be considered. That content is usually as follows:

Field	Header	Filter	Partition	GS1 Company Prefix	Object reference (optional)	Serial component
Bits	8	3	3	20-40	Variable	Variable

Missing from this is the indicator digit (GTIN) or extension digit (SSCC); in EPC, they are considered part of the object reference.

The header value is used to determine the type of the identification key stored within the EPC/RFID tag. The filter value is specific to each EPC scheme and is used to select a subset of tags for reading.

The most important difference between barcodes and EPC/RFID tags (at least from the perspective of the identification key), is that in a tag the GS1 Company Prefix is easily separated from the object reference. The length of the GS1 Company Prefix is determined by the three-bit partition value:

Partition value	GS1 Company Prefix	
	Bits	Digits
0	40	12
1	37	11
2	34	10
3	30	9
4	27	8
5	24	7

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Partition value	GS1 Company Prefix	
	Bits	Digits
6	20	6

The object reference then takes as many bits as necessary to make up the length of the GS1 identification key.

A significant exception to note is that the length of the GS1 Company Prefix within an EPC/RFID tag is six to twelve digits; in the GS1 General Specifications, it is four to twelve digits. While four- and five-digit GS1 Company Prefixes are rare, they do exist, and encoding them within a tag requires that the first one or two characters of the object reference be moved to the GS1 Company Prefix to pad its length out to six digits. This can result in some GS1 identification keys that can't be encoded in EPC/RFID tags: if the GS1 Company Prefix is shorter than six digits and one of the padding characters is not a digit (e.g. as may be the case for a GIAI), encoding isn't possible.

2.4 EPC URI Representation

There are many ways to represent the identity of an object; in the EPC world, an object is represented as a Uniform Resource Name (URN) as defined in RFC2141[1], where the URN namespace is "epc". More generally, these are referred to as EPC Uniform Resource Identifiers (URIs).

As with the EPC/RFID tags, the GS1 Company Prefix in any representation of an EPC URI must be a minimum of six digits long, with padding to six digits as required.

Individually assigned GS1 identification keys, other than the GTIN-8, regardless of the length of the underlying GS1 Company Prefix, are encoded as if the GS1 Company Prefix is twelve digits long (the maximum length). If one or more of the twelve characters is non-numeric (as may be the case in, for example, a GIAI), the encoding is not supported.

For a GTIN-8, the value is encoded as if the GS1 Company Prefix is eight digits long, consisting of five zeros followed by the three-digit GS1-8 Prefix.

2.4.1 EPC Pure Identity URI

The format of a GS1 identification key expressed as an EPC Pure Identity URI is generally as follows:

```
urn:epc:id:<object class>:<GS1 Company Prefix>[.<Object reference
(optional)>][.<Serial reference (optional)>]
```

The object class dictates the presence and nature of the object reference and the nature of the serial reference as follows:

Object class	Object reference	Serial reference
sgtin	Indicator digit then item reference	Serial number
sscc	N/A	Serial reference
sgln	Location reference	Extension
grai	Asset type	Serial number
giai	N/A	Individual asset reference
gsrn	N/A	Service reference
gsrnp	N/A	Service reference
gdti	Document type	Serial number

[1] http://www.ietf.org/rfc/rfc2141.txt

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Object class	Object reference	Serial reference
cpi	Component part reference	Serial
sgcn	Coupon reference	Serial component
ginc	N/A	Consignment reference
gsin	N/A	Shipper reference
itip	Item reference and indicator digit	Piece + total + serial number (multipart)
upui	Item reference and indicator digit	Third party serial component
pgln	N/A	Party reference

Other object classes exist but are not aligned with the GS1 identification keys.

2.4.2 EPC Class URI

The format of a GS1 identification key expressed as an EPC Class URI is generally as follows:

```
urn:epc:class:<object class>:<GS1 Company Prefix>.<Object
reference>.<Class component>
```

The object class dictates the nature of the object reference and the nature of the class component as follows:

Object class	Object reference	Class component
lgtin	Item reference and indicator digit	Lot

2.4.3 EPC Tag URI

EPC Tag URIs resemble EPC Pure Identity URIs, but with added control information. The GS1 Company Prefix is present and is encoded in the same way as in the EPC Pure Identity URI.

2.4.4 EPC Raw URI

The EPC Raw URI is used when the EPC memory bank does not contain a valid EPC. This includes situations where the toggle bit (bit 17h) is set to one, as well as situations where the toggle bit is set to zero but the remainder of the EPC bank does not conform to the coding rules, either because the header bits are unassigned or the remainder of the binary encoding violates a validity check for that header. Accordingly, the EPC Raw URI is out of scope for this document.

2.4.5 Pattern URIs

Pattern URIs are used in filtering applications at the Application Level Events layer and in some EPCIS queries that make use of the following query constraint parameters:

- MATCH_epc
- MATCH_parentID
- MATCH_inputEPC
- MATCH_outputEPC
- MATCH_anyEPC
- MATCH_epcClass

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- MATCH_inputEPCClass
- MATCH_outputEPCClass
- MATCH_anyEPCClass

Pattern URIs do not make use of URI Template notation defined in RFC 6570, nor regular expressions. Instead they resemble the EPC Pure Identity URI or EPC Tag URI or EPC Class URI but permit the use of a special wildcard character (*) that matches any value for that component or a [low-high] range notation that matches a numeric value provided that low <= value <= high. The GS1 Tag Data Standard specifies further restrictions about where the wildcard or [low-high] ranges may be used. For example, a pattern URI for an SGTIN EPC permits the wildcard or range to appear in place of a fixed value for the serial number component, but it is not permitted to specify a fixed value for the serial number AND use a wildcard or range for the company prefix component or item reference component, because the serial number (21) only has meaning in combination with a specified GTIN.

2.4.5.1 EPC Pure Identity Pattern URI

The format for GS1 identification keys is generally as follows:

```
urn:epc:idpat:<object class>:<GS1 Company Prefix pattern>.<Object
reference pattern>.<Serial component pattern (optional)>
```

The patterns are either explicit values or the wildcard '*', with the requirement that fields with '*' be all on the right (i.e. the wildcard can't be in the object reference pattern space without also being in the serial identifier pattern space). Ranges may not be expressed within EPC Pure Identity Pattern URIs.

2.4.5.2 EPC Tag Pattern URI

EPC Tag Pattern URIs resemble EPC Pure Identity Pattern URIs, but with added control information, enabling the filter value to be a wildcard (*) or a numeric range [low-high]. The GS1 Company Prefix is present and is encoded in the same way as in the EPC Pure Identity Pattern URI.

2.5 2008 Interoperability Review

The issue of interoperability was first discussed as far back as 2008. At that time, the recommendation was to support the separation of the GS1 Company Prefix from the rest of the key, with a significant factor being that of market demand:

> *There is a very strong demand in the market as well to make selections "on the fly" (when reading them) of tags matching a specific GCP pattern. As we studied in our previous phase, the only way to achieve this fast selection mechanism is using the parsed key in the tag. In this case, speed and performance are key, since there is no opportunity to look op the GCP length and perform this selection at the application level instead of at the air interface level.*

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3 Issues

This section presents the issues that have arisen as a result of the GS1 Company Prefix being treated as a separate component in the EPC suite of standards.

3.1 EPC Suite

3.1.1 Education

It has proven to be difficult to educate users about the need to separate the GS1 Company Prefix from the rest of the key, which has in turn been a barrier to adoption of EPCIS. One company participating in the EPCIS/CBV 2.0 MSWG has reported that the need to educate its suppliers about this complexity of formatting EPC URIs correctly is costing them 0.15 FTE per 100 suppliers per year.

3.1.2 GS1 Architecture Principles

The GS1 Company Prefix being treated as a separate component in the EPC suite of standards violates the GS1 Architecture Principles[2] in the following ways:

- Non-significance of keys
  - The presence of the GS1 Company Prefix is a de facto embedding of business information in the EPC/RFID tag or the URI.
- Technology independence
  - The only place the separation of the GS1 Company Prefix exists (except in its definition in the GS1 General Specifications) is in the EPC suite of standards. EPCIS is intended to be independent of data carrier technology; it should be possible to capture an EPCIS event irrespective of whether an EPC RFID tag was read or a GS1 barcode was scanned. However, when scanning a GS1 barcode, it is currently necessary to know the appropriate length of the GS1 Company Prefix component (information which is not encoded within a GS1 barcode), whereas when reading an EPC RFID tag, the partition value already indicates the length of the GS1 Company Prefix component. Therefore, even though EPCIS aims to be technology independent, the current requirement to know the length of the GS1 Company Prefix component when scanning a GS1 barcode introduces an asymmetry that to some extent violates the GS1 architecture principle of technology independence.
- Simplicity
  - The separation of the GS1 Company Prefix has been proven to add complexity to the user implementations.

3.1.3 Workarounds

Since the inception of EPC, the presence of the GS1 Company Prefix as a separate component has required significant workarounds for lost tags and for one-off key licences.

3.1.3.1 Lost or Damaged Tags / Operations Without EPC RFID Tags

In the event that an EPC/RFID tag is lost or damaged, a distributor or other supply chain partner needs to know the length of the GS1 Company Prefix in order to properly encode a replacement tag. In other circumstances, it may be necessary to record EPCIS events with only barcodes available as data carriers, or to apply EPC RFID tags to products for downstream trading partners. In many cases, the length is known, as the supply chain partner (e.g. distributor) will have a strong enough relationship with the brand owner to get the length information directly. The supply chain partner is also statistically likely to have other trade items with the same or related keys. However, for the rare case where the GS1 Company Prefix length isn't known, a publicly available tool[3] was

[2] https://www.gs1.org/docs/architecture/GS1_Architecture_Principles.pdf
[3] https://www.gs1.org/standards/bc-epc-interop

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developed to provide that information. Initially, the underlying database was dependent on length files provided periodically by the MOs, but the tool has since been rewritten to make use of licence data provided by GS1 Member Organisations.

3.1.3.2 One-off Key Licences

In recent years, a number of GS1 Member Organisations have moved towards a model where they issue individual GS1 identification keys (typically GTINs, but also GLNs) instead of a GS1 Company Prefix. While most if not all implementations use an underlying prefix self-licensed to the MO, revealing that prefix to a member so that they can properly encode an EPC/RFID tag or EPC URN has two problems:

- users who need only a handful of GS1 identification keys instead of a prefix are typically small- to medium-sized enterprises (SMEs) with limited knowledge of GS1 standards, so the communication of the prefix may add to their confusion; and
- revealing the GS1 Company Prefix risks the user using it to generate additional keys, which would conflict with those allocated to other companies.

This issue has been addressed by requiring that the GS1 Company Prefix be treated in all cases as if it were 12 digits long, effectively removing the prefix as a separate component, at least for 13-digit keys (GTIN, GLN, GRAI, and GDTI).

3.1.4 EPCIS Query

EPCIS Queries can be formulated using EPC URI patterns in which the GS1 Company Prefix is specified but the subsequent structural components of the EPC URI might be specified or might be a wildcard value, indicated by *.

Prototype testing of EPCIS 2.0 is evaluating the viability of permitting GS1 Digital Link URIs to be used in place of EPC URNs. Because GS1 Digital Link URIs do not artificially separate the GS1 Company Prefix component from the rest of the GS1 identification key, EPC URI patterns are not directly useful for filtering such GS1 Digital Link URI values. It is expected that such EPC URI patterns could be translated to a constrained set of regular expression patterns, using carefully defined rules for such translation. Care must be taken because regular expressions can support too much complexity and flexibility including the possibility of negated patterns, which should be avoided for performance reasons.

3.1.5 EPCIS Capture from Barcodes

EPCIS is intended to function independent of the choice of data carrier technology; it should be possible to correctly capture an EPCIS event irrespective of whether the observed objects were identified using GS1 barcodes or EPC RFID tags. Unfortunately, there are situations in which a party downstream of a manufacturer, such as a distributor, wholesaler, retailer may need to capture EPCIS event data for objects that they receive, which never had an EPC/RFID tag – they were only ever identified using a GS1 barcode such as a GS1 DataMatrix symbol. Whereas the binary string within an EPC RFID tag contains a 'partition value' as an explicit indicator of the length of the GS1 Company Prefix component, a GS1 barcode includes no such indicator. This means that capturing an EPCIS event for an object carrying an EPC RFID tag is relatively straightforward, whereas capturing an EPCIS event for an object that only carries a GS1 barcode requires additional process steps, namely the determination of the correct length of the GS1 Company Prefix component and some rearrangement of the internal structure of the GS1 identification key, in order to transform it into a pure identity EPC URI.

3.1.6 Filtering Over the Radio-Frequency Air Interface

The UHF and HF Gen2 air interface protocols include a Select command which supports efficient filtering of a population of tags, such that only the subset that match the filter criteria expressed through a bitmask will respond, while the remainder remain silent. The starting bit position and bit length of the mask are also specified.

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In the current situation, for any GS1 Company Prefix component value, the bit position and length are well-defined, even though the GS1 Company Prefix component value is efficiently encoded using log(10)/log(2) ≈ 3.32 bits per digit.

In a future situation in which the GS1 Company Prefix component might not be separated from the remainder of the GS1 identification key, the only way to support such filtering using a bit-level mask in a "Select" command over the air interface is to encode digits slightly less efficiently, using 4 bits per digit, so that the bit position of each successive encoded digit remains predictable.

3.1.7 GS1 Digital Link

Although a linkType for "epcis" has been added to the GS1 Web vocabulary[4], it is not currently straightforward to convert to an EPC URI if the length of the GS1 Company Prefix cannot be reliably determined. This means that although a resolver for GS1 Digital Link could point to a relevant EPCIS repository (typically that of the brand owner), there are situations where it would not be easy to formulate an EPCIS query. This is probably more of a B2B concern since it is unlikely that most end-consumers would access EPCIS event data directly; it is more likely that an end-consumer would be provided with more user-friendly and high-level traceability information, mediated either via the brand owner (for details of sourcing, production etc.) or perhaps via the retailer if transit time to the retail store was a concern. GS1 Digital Link Web URIs are now explicitly supported as alternatives to EPC URNs in the draft CBV 2.0 standard and are used alongside EPC URNs in the XML and JSON-LD event examples for EPCIS 2.0.

GS1 Digital Link can translate from barcode to GS1 Digital Link URI format and back, and from EPC. URI and EPC binary formats to GS1 Digital Link URI format, but not from GS1 Digital Link URI format to EPC URI and EPC binary formats without access to a GS1 Company Prefix database or the GCP length tool.

3.2 Splits and Spin-Offs

A split or spin-off is where a company divides itself into two or more entities. Each prefix or key licence can remain with only one of the resulting entities, though it's not required that all of them remain with the same entity. Any key (for a trade item, location, asset, etc.) where the underlying licence isn't transferred with the object must be retired and replaced within one year of the split or spin-off.

At the business level, the split or spun-off company takes over responsibility for all past and present objects (products, locations, assets, etc.) associated with it. Responsibility isn't just about those objects that are current (e.g. products that are sold in the marketplace), it may also be about those that are long past (e.g. products that have been withdrawn from the market but that are still under warranty or that may remain in the possession of the end user for some time). In performing the split or spin-off, the split or spun-off company may be assuming liability for years to come.

The question now is that of what happens to the original keys: the GTINs, GLNs, GIAIs, etc. that represented products, locations, assets, etc. under the original company's GS1 Company Prefix. Before GTIN non-reuse came into effect in 2019, it was simple: all keys reverted to the original company after one year and could be reused according to the allocation rules appropriate to each key type. In the world in which GS1 evolved, with limited use of a GS1 identification key after its retirement (e.g. GTIN on a product that is withdrawn from the market or the GLN on a location that is closed), this was not much of a problem and any transition issues (e.g. queries about a GTIN or GLN) could be handled by the two companies themselves.

In the connected world of today, with information living on in traceability systems, with resale markets, and with regulatory requirements for long-term management of products critical to human health and safety, the GS1 Company Prefix is no longer enough to trace back to the responsible party.

At this time, there is no guidance on this subject in any GS1 standard or policy. Any resolution to this will have to differentiate between a GS1 identification key that is delegated to a split or spun-off company versus a one-off key. Treating the former as a one-off key after the split or spin-off would

[4] https://www.gs1.org/voc/epcis

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result in two different sets of EPC/RFID tag encodings and URI forms for the same identifier. This ambiguity needs to be addressed.

3.3 GS1 Operational Manual

Section B-02, "Allocation of GS1 Company Prefixes", of the GS1 Operational Manual provides a business definition of the GS1 Company Prefix and states that:

> The GS1 Company Prefix assigned to a user company shall entitle that user company to create any of the GS1 identification keys, namely GTIN, GLN, SSCC, GRAI, GIAI, GSRN, GDTI or any other GS1 data element, for example consignment number or shipment number, that uses the GS1 Company Prefix.

Furthermore, it allows for GS1 Member Organisations to issue complete GS1 identification keys one by one and provides guidance for doing so for the GLN, GTIN, SSCC, GIAI, GRAI, GSRN, and GDTI. It recommends, but doesn't require, that a GS1 Member Organisation reserve prefixes in its own name for this purpose.

While the GS1 Operational Manual is out of scope of this Request for Finding, it will likely be impacted by any findings and so this document should be shared with parties responsible for maintenance of the Manual.

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4 Recommendation and Implications

This section presents a recommendation for removing or diminishing the significance of the GS1 Company Prefix from the EPC suite of standards and the impact on EPC implementations. "Removing or diminishing the significance" is only as it relates to EPC; the GS1 Company Prefix as an artefact within the GS1 General Specifications, and all the business processes around it, are out of scope.

4.1 Recommendation

Consider the GTIN 9529999912343, where the GS1 Company Prefix is 95299999, the trade item reference (object reference) is 1234, the check digit is 3, and the (implied) indicator digit is 0. That GTIN, with serial component ABC123456, would be represented as an EPC Pure Identity URI as follows:

```
urn:epc:id:sgtin:95299999.01234.ABC123456
```

After careful consideration, this document recommends that the EPC suite of standards permit GS1 Digital Link URIs, alongside and aligned with the EPC URI formats, as a supplementary supported format[5], as either a set of restricted, constrained canonical set that corresponds one-to-one with the set of EPC formats, or without such constraints. For example, the URI could then be `https://id.gs1.org/01/09529999912343/21/ABC123456`.

- Pros
  - Eliminates issues in determining the length of the GS1 Company Prefix.
  - Enables easy lookup via resolvers for GS1 Digital Link.
  - Leverages existing GS1 URI syntax.
  - Already supported in the open community review of the CBV 2.0 standard.
- Cons
  - Doesn't address EPC RFID tag encoding based on GS1 Digital Link URI.
  - May introduce single point of failure in Resolver if id.gs1.org is the only approved domain name in the GS1 Digital Link URI for use in EPCIS.
  - Significant changes to Tag Data Standard required.
  - Significant changes to software implementations required. Software filtering by GS1 Company Prefix would be more difficult, but section 4.4.1 includes discussion of a potential approach using internal indices to efficiently select event data irrespective of whether the query or the event data was formulated using EPC URN syntax or GS1 Digital Link URI syntax. EPCIS currently supports EPC pattern URIs in which a wildcard (*) may be used to match multiple values of a GS1 key that share the same GS1 Company Prefix component.
  - Staggered implementation by trading partners will create divergent capability and industry requirements to use and/or support it.

The proposal was measured against the following:

1. Explanation complexity. This measures the difficulty in explaining the proposal to someone not intimately familiar with the GS1 system.
2. Standards effort. This measures the work effort required to change the standards for the proposal.
3. Hardware implementation effort. This measures the work effort required to change EPC RFID tag and reader implementations for the proposal.
4. Software implementation effort. This measures the work effort required to change EPCIS implementations for the proposal.

[5] For an example of how this could work, see *https://mh1.eu/epc-dl-translator/* (to be moved to GitHub before final publication).

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5. Impact on large enterprises. This measures the impact on large enterprises, which are assumed to have one or more individuals at least partially dedicated to GS1 standards implementation.
6. Impact on small to medium enterprises. This measures the impact on small to medium enterprises, which are assumed not to have anyone dedicated to GS1 standards implementation.
7. Impact on regulators. This measures the impact on regulators who have device or other product identification requirements (e.g. Basic UDI-DI) that are tied to the GS1 licensing system and are reconciled through the use of the GS1 Company Prefix.

Metric	Impact
Explanation complexity	Moderate
Standards effort	High
Hardware implementation effort	High
Software implementation effort	High
Integration effort for existing implementations	High
Integration effort for new implementations	Low
Incremental effort for regulatory compliance by industry	Moderate

4.1.1 Rejected Options

The following options were considered and rejected:

1. Do nothing (keep the EPC Pure Identity URI, and therefore the EPC tag encoding, as is). The EPC Pure Identity URI would remain as `urn:epc:id:sgtin:95299999.01234.ABC123456`. This option was rejected on the grounds that the previously identified problems would remain and that they are significant enough to warrant a new approach.
2. Define a new subspace (e.g. "`urn:epc:id2:…`"), encode keys without separating the GS1 Company Prefix, keep the indicator digit (GTIN) or extension digit (SSCC) at the beginning, and keep the check digit at the end. The EPC Pure Identity URI would then be `urn:epc:id2:sgtin:09529999912343.ABC123456`. This option was rejected as it would require significant changes and remaining with the URN format would derive no additional benefit beyond no longer having to separate the GS1 Company Prefix.
3. Redefine the EPC Pure Identity URI such that the GS1 Company Prefix component is always six digits long (the minimum). The EPC Pure Identity URI would then be `urn:epc:id:sgtin:952999.0991234.ABC123456`. While beneficial for the GTIN in that it keeps most of the same rules (indicator digit in the component after the GS1 Company Prefix, removal of the check digit), this option was rejected due to the significant complexity in accommodating alphanumeric keys where non-digit characters can appear among the first six.
4. Redefine the EPC Pure Identity URI such that the GS1 Company Prefix component is always twelve digits long (the maximum). The EPC Pure Identity URI would then be `urn:epc:id:sgtin:952999991234.0.ABC123456`. While beneficial for the GTIN in that it keeps most of the same rules (indicator digit in the component after the GS1 Company Prefix, removal of the check digit), this option was rejected due to the significant complexity in

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accommodating alphanumeric keys where non-digit characters can appear among the first twelve.

5. Define a new subspace (e.g. "id2"), encode keys without separating the GS1 Company Prefix, move the indicator digit (GTIN) or extension digit (SSCC) to the end, and remove the check digit. The EPC Pure Identity URI would then be `urn:epc:id2:sgtin:9529999912340.ABC123456`. This option was rejected in favour of the option to keep the indicator digit (GTIN) or extension digit (SSCC) at the beginning and keep the check digit at the end.
6. Define a new subspace (e.g. "id2"), encode keys without separating the GS1 Company Prefix, keep the indicator digit (GTIN) or extension digit (SSCC) at the beginning, and remove the check digit. The EPC Pure Identity URI would then be `urn:epc:id2:sgtin:9529999912340.ABC123456`. This option was rejected in favour of the option to keep the indicator digit (GTIN) or extension digit (SSCC) at the beginning and keep the check digit at the end.
7. Use GS1 element strings in place of URIs. This option has been observed in some implementations but is not syntactically compliant as it doesn't validate against xsd:anyURI in the schema.

4.2 GS1 General Specifications

There is not expected to be any impact on the GS1 General Specifications, except possibly where consideration is given to splits and spin-offs.

4.3 EPC Tag Data Standard

The EPC Tag Data Standard will be most affected by any changes in the management of the GS1 Company Prefix. An exhaustive list of all affected sections is more than would be considered reasonable, but Section 7, "Correspondence between EPCs and GS1 keys", will require review of the following:

- Section 7.1, where it states that "The correspondence between EPCs and GS1 keys relies on identifying the portion of a GS1 key that is the GS1 Company Prefix."
- Section 7.2, "Determining length of the EPC Company Prefix component for individually assigned GS1 Keys", was recently added to TDS 1.13, in order to alleviate growing confusion among users and their traceability vendors, particularly around "where to place the dot" for one-off GTINs and one-off GLNs, particularly in the pharmaceutical sector.

Mapping a GS1 Digital Link URI to a binary encoding can be done in one of two ways.

The numeric nature of the GTIN allows for it to be encoded in binary in its entirety over 47 bits (3.32 bits per digit). This, however, makes filtering on the GS1 Company Prefix difficult because the pattern for the GS1 Company Prefix within the binary string would differ considerably based on the indicator digit and would also be affected by variations in the item reference. This would be further complicated by support for other keys, such as the GIAI, where there could be a non-numeric character introduced into the string at any point after the fourth digit (GS1 Company Prefixes can be as short as four digits).

An optimization whereby the space is rounded up to allow for four bits each would greatly simplify the filtering, but additional work would be required to deal with non-numeric characters. This may be accommodated by including information about the position of the first non-numeric character, either through an index in the header information or with a special 4-bit string "1111" to denote the end of numeric characters.

The diagrams below illustrate the issue.

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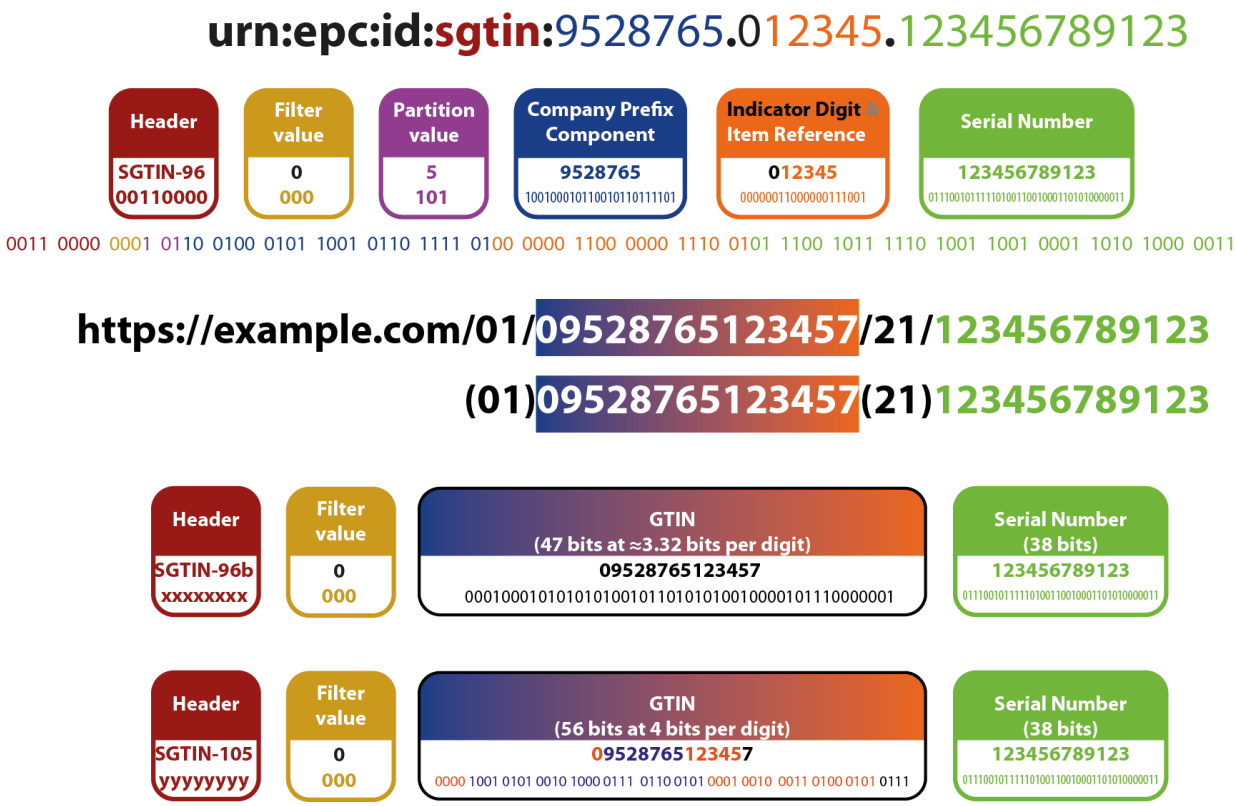

The upper part shows an example of an SGTIN EPC and its SGTIN-96 binary encoding.

The lower part shows two potential alternative approaches to new EPC binary schemes for GTIN+Serial Number without extraction or rearrangement of the GS1 Company Prefix, using either integer encoding (at approximately 3.32 bits per digit) or using numeric string encoding (at exactly 4 bits per digit).

GTIN-14 values Same GS1 Company Prefix Same Item Reference Different Indicator Digit	GTIN-14 encoded as integer in 47 bits (≈ 3.32 bits per digit)	GTIN-14 encoded as numeric string in 56 bits (4 bits per digit)
09528765123457	00010001010101010010110101010010000101110000001	0000 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 0111
19528765123454	00100011100001011100101000110111010101101111110	0001 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 0100
29528765123451	00110101101101100110011100011100100101101111011	0010 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 0001
39528765123458	01000111111001110000010000000001110101110000010	0011 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 1000
49528765123455	01011010000101111010000011100111000101101111111	0100 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 0101
59528765123452	01101100010010000011110111001100010101101111100	0101 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 0010
69528765123459	01111110011110001101101010110001100101110000011	0110 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 1001
79528765123456	10010000101010010111011110010110110101110000000	0111 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 0110
89528765123453	10100010110110100001010001111100000101101111101	1000 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 0011
99528765123450	10110101000010101011000101100001010101101111010	1001 1001 0101 0010 1000 0111 0110 0101 0001 0010 0011 0100 0101 0000
	Difficult to filter on a specific value of GS1 Company Prefix component - potentially needs one bit-mask per indicator digit value	Easy to use a bit-mask to filter on GS1 Company Prefix component / Easy to use a bit-mask to filter on Item Reference

The first column shows a set of GTIN-14 values that share the same GS1 Company Prefix and Item Reference but differ in their Indicator Digit and GS1 Check Digit.

Using integer encoding at approximately 3.32 bits per digit, it is difficult to correlate a particular pattern of bits precisely with the GS1 Company Prefix or Item Reference and may require one bitmask per value of Indicator Digit.

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Using numeric string encoding at exactly 4 bits per digit, it is very easy to correlate a particular pattern of bits with the GS1 Company Prefix or Item Reference, irrespective of the value of the Indicator Digit.

4.3.1 Implication for General Identifier (GID)

The General Identifier EPC scheme is independent of any specifications or identity scheme outside the EPC Tag Data Standard. While the EPC encoding of a GID may look similar to other encodings of GS1 identification keys and while the GID is in the EPC Manager Number range for which GS1 Prefix 951 is reserved, there is no correspondence between this Request for Finding and the GID.

4.3.2 Implication for Class 2 Keys

Class 2 keys are defined in the GS1 System Architecture as follows:

> A class 2 key starts with either a GS1 Prefix or a GS1 Company Prefix, incorporates a key administered by an external organisation, and includes a check digit if required by its corresponding class 1 key format. Class 2 keys are unique with respect to class 1 keys of the same type. Their allocation and lifecycle rules, however, are defined by an organisation external to GS1. The degree to which these rules are compatible with those of the corresponding class 1 keys is specific to each class 2 key.

A class 2 key that starts with a GS1 Company Prefix is implicitly supported in EPC/RFID tags and EPC URI representations, though in some cases it may be treated as a one-off key. Similarly, a class 2 key that starts with a GS1 Prefix only, and for which there is an equivalent to the GS1 Company Prefix, may be supported as well. The most notable example of the latter, documented in the EPC Tag Data Standard, is the ISBN and ISMN.

A class 2 key for which there is no equivalent to the GS1 Company Prefix may not be supported unless the whole key can be considered equivalent to a one-off key. The most notable example of this, documented in the EPC Tag Data Standard, is the ISSN. There is no support for the ISSN at this time.

Any change to the way that the GS1 Company Prefix is encoded will affect class 2 keys.

4.4 EPCIS

This section identifies a number of potential impacts of any change on the URI patterns that are currently used within EPCIS queries in order to select groups of related EPCs, such as those sharing the same GTIN or other class-level identification key or those sharing the same value of the GS1 Company Prefix component.

- The GS1 Tag Data Standard defines Pure Identity EPCs and corresponding EPC Pure Identity Patterns that permit the expression of ranges or groupings of EPCs. EPC Pure Identity Patterns are defined for all EPC schemes.
- EPC Pure Identity Patterns for the GID, DOD, ADI would be unaffected. All other EPC Pure Identity URIs and EPC Pure Identity Patterns currently indicate the end of the GS1 Company Prefix *component* with a dot. Note that the GS1 Company Prefix component does not always encode the actual GS1 Company Prefix; for single issue keys, a 12-digit value is always encoded to ensure that the GS1 Company Prefix component cannot collide with a value assigned to an unrelated key licensee, even though the actual GS1 Company Prefix may be much shorter than 12 digits and held by (self-licensed to) the GS1 MO that issued the single issue keys.
- EPC Pure Identity Patterns are used in the EPCIS query interface to request event data where one of the EPC fields (e.g. epcList, parentID, childEPCs, inputEPCList, outputEPCList) has a value matching a specified EPC Pure Identity Pattern. The following parameters of a SimpleEventQuery permit the use of EPC Pure Identity Patterns:
  - MATCH_epc
  - MATCH_inputEPC
  - MATCH_outputEPC
  - MATCH_anyEPC

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- MATCH_parentID
- MATCH_epcClass
- MATCH_inputEPCClass
- MATCH_outputEPCClass
- MATCH_anyEPCClass

- EPCIS and the GS1 Tag Data Standard do not currently support any matching algorithm other than either an exact string match or the matching procedure defined in the GS1 Tag Data Standard (see section 8.2 of TDS v1.13: URIs for EPC Pure identity patterns: Semantics).
- Removal of an explicit dot would mean that the current matching procedure defined in the GS1 Tag Data Standard becomes insufficient for defining URI patterns for groups of objects whose GS1 identifiers share a common GS1 Company Prefix component and an alternative mechanism such as regular expressions would be needed if there is still a substantial user demand for such patterns.
- However, regular expression pattern matching was deliberately not supported because they include the possibility of negated patterns. Logical 'NOT' (or negated constraints) was excluded throughout the SimpleEventQuery framework because it is potentially too computationally intensive or may result in excessively large result sets. Having said that, regular expressions are natively well supported in most modern programming and scripting languages, whereas the matching procedure defined in the GS1 Tag Data Standard requires a small amount of custom code to be written. If GS1 were to look to regular expression pattern matching as a potential replacement for the pattern matching rules currently defined within the GS1 Tag Data Standard, GS1 would probably be well advised to only require implementations to support a very limited and predefined set of regular expression patterns that correspond to the current matching capabilities, rather than to require implementations to support any regular expression that is specified in an EPCIS query or ALE filter. In other words, with this highly constrained prescriptive approach, the risks are minimised, and implementations would be at liberty to reject a query that used a regular expression that is more flexible than the defined subset of regular expressions. It is also worth noting that regular expressions are available in a number of different flavours, e.g. POSIX, PCRE etc., some with subtly different syntax especially for extended features. GS1 needs to take this into account and as far as possible restrict itself to one flavour and core features that are common to all flavours of regular expressions.
- The GS1 Company Prefix length table at *https://www.gs1.org/standards/bc-epc-interop* provides a partially complete list of mappings between the initial digits of the Company Prefix and the corresponding length. This could be used in combination with capture solutions and implementations of the GS1 Tag Data Standard and GS1 Tag Data Translation standard to correctly place the dot when constructing a Pure Identity EPC URI / URI pattern.
- If there were to be no dot indicating the end of the GS1 Company Prefix component, then we need to discuss what the replacement URI structure looks like. It is probably not desirable to use the same URI prefix such as `urn:epc:id:sgtin:` for two different URI structures that either include or omit the dot. This probably means that at minimum, we'd need separate URI prefixes that correspond to EPCs in which no "dot" delimiter was present after the GS1 Company Prefix component.
- At that point, it makes sense to investigate whether industry is best served by simply removing the dot and continuing to use URNs for EPCs or whether permitting or even switching to GS1 Digital Link URIs (or a highly constrained subset of these, such as the canonical GS1 Digital Link URI syntax) is more beneficial than persisting with URNs.
- Within traceability applications, the Simple Event Query is often not sufficient. For example, when using EPCIS for compliance checks (e.g. whether actual origin data corresponds to information indicated on the product packaging), recall support (e.g. inferring which raw material went into which intermediate or final products), or for regulatory compliance (e.g. to check whether there is a complete and unbroken chain of events), organisations require a fast way to return related sets of visibility events. For this purpose, an iterative query approach based on the Simple Event Query is neither efficient nor appropriate. Against this background, a growing number of EPCIS applications index EPCIS events in a graph database, which enables them to return a sequence of related EPCIS events through just one query operation. In particular, this linkage is based on the EPC URIs populating the respective events and requires a

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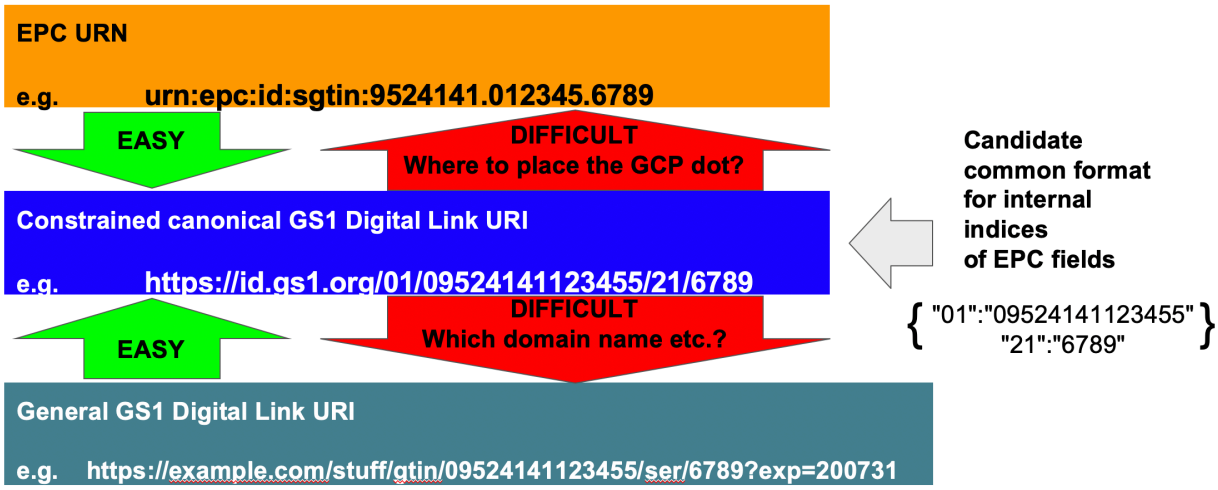
precise positioning of the dot, as a relationship between two or more events can only be established once there is an exact string match.

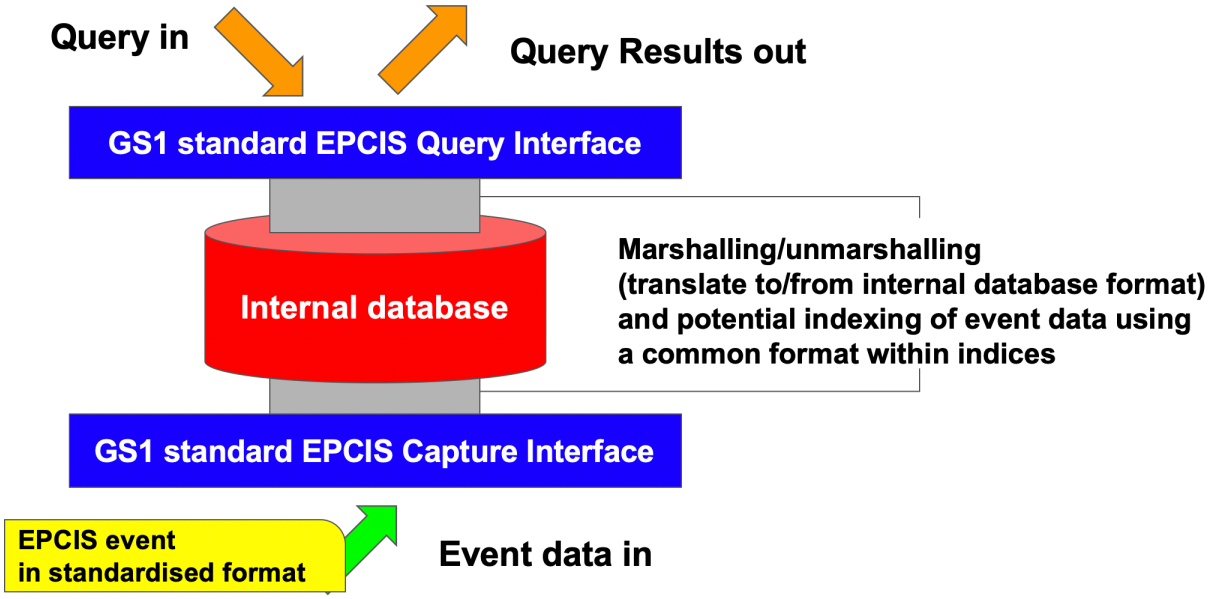
4.4.1 Potential Indexing Solution for EPCIS

The following figure shows that it is easy to translate from either a general GS1 Digital Link URI or an EPC URN to a common index format consisting of attribute-value pairs where each attribute is a GS1 Application Identifier. However, translation in the opposite direction is not straightforward:

- translating from the common index to the EPC URN is difficult because of the need to know the length of the GCP component; and
- translating from the common index to a general GS1 Digital Link URI is difficult because the domain name / hostname is not obvious.



In the proposed indexing approach, an internal index would be populated and updated as each event is captured by the capture interface. This avoids the need to translate all events in the repository at query time; instead, any query parameters (whether expressed as EPC URIs, EPC URI patterns or in GS1 Digital Link URI syntax) would be translated to the format of the internal index and the internal index used to select which event data to consider including in the response to a query. This indexing approach is intended to support coexistence of EPC URIs with GS1 Digital Link URIs in a way that does not adversely affect performance of EPC implementations. It is currently under evaluation during prototype testing of EPCIS / CBV 2.0.



Adding an indexing specification to EPCIS would promote compatibility between EPC URNs and GS1 Digital Link URIs:

- When event data is received by the capture interface, every field that may be populated with an EPC URN would have its values translated so that the values correspond to the primary GS1 identification key (e.g. GTIN, SSCC, GRAI etc.) and the key qualifiers associated with the EPC format (e.g. Serial Number, AI (21), GLN extension, AI (454)) would be stored in an internal index for that field, for that event. Indexing is performed once, when the data is received at the EPCIS capture interface.
- When a query is received or specified at an EPCIS query interface, any EPC-related query constraints are also translated into constraints on the primary GS1 identification key and any associated qualifiers.

  In addition to the current mechanism for matching queries and event data for fields whose values cannot be represented as EPCs, the internal indices are checked to identify and matches and to determine whether or not to include each event within the result set for the query.
- For example, an EPCIS event might specify that an object was observed at a specific location and specific time and that it was identified by GTIN 09524141123455 and Serial Number 6789. This might be expressed as EPC URN `urn:epc:id:sgtin:9524141.012345.6789` or as a GS1 Digital Link URI such as `https://example.org/01/09524141123455/21/6789`.
- An EPCIS query might request events matching GTIN 09524141123455. This might be expressed using an EPC pure identity URN pattern such as `urn:epc:idpat:sgtin:9524141.012345.*` or it might be expressed using a GS1 Digital Link URI such as `https://example.org/01/09524141123455` or `https://id.gs1.org/01/09524141123455`.
- Whether the query and EPCIS data both use the same format (e.g. both use EPC URN syntax or both use GS1 Digital Link URI syntax) or they use a mix of these two formats, it is clear that the event in this example should be considered to match and should be included in the result set, subject to any other specified query constraints also supporting a match.
- By making use of internal indices for checking matches for all EPCIS fields that support EPC values, it is not necessary to do any translation of data at query time – only the values specified within the query constraints would need to be translated for comparison against the values of the internal indices.

This internal indexing approach provides greater flexibility so that a query constraint expressed using an EPC URN pattern can still match data in which the matching data is expressed using GS1 Digital Link URIs – or potentially vice versa, thus enabling the existing EPC URN format to coexist with an equivalent GS1 Digital Link URI format that is more capable and more forward-looking.

4.5 Application Level Events

- The GS1 Tag Data Standard also defines URIs for EPC Tag Encoding patterns. These are structurally fairly similar to EPC Pure Identity URI patterns discussed in the previous section except that they also express a filter value as well as a specific tag encoding scheme such as sgtin-96 vs sgtin-198 etc.
- Like the Pure Identity EPC URI patterns used in EPCIS, a dot indicates the end of the Company Prefix component.
- Such Tag Encoding patterns are used within ALE to provide a high-level declarative filter for the object identifiers to be included within Event Cycle reports from logical readers. Implementations may translate these into lower-level bitmasks that support efficient filtering at the air interface layer.
- Similar considerations apply regarding the matching of tag-encoding URI patterns, and a similar compatibility solution may be available, using the internal indexing approach described in section 4.4.1.

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4.6 EPC/RFID Class 1 Gen2 (ISO/IEC 18000-63)

Gen2 *Select* operations allow an Interrogator to address a particular subset of an EPC/RFID tag population prior to *Inventory* operations.

Most GS1 EPC schemes defined in the GS1 Tag Data Standard normatively specify a 3-bit *Partition* value, which indicates the length of the encoded EPC's GS1 Company Prefix, at address 31h-33h of Memory Bank 01. The Partition is immediately followed by the *GS1 Company Prefix* component, with a variable length (of 20-40 bits) specified by the *Partition.*

Addition to TDS of an additional, alternate set of binary encoding schemes, from which GCP length significance is removed (and to which the check digit is restored and the indicator returned to the front of the identifier), would require RFID readers, middleware and other applications to support the new binary alternative to support both approaches.

Despite this, filtering of EPC/RFID tag population subsets, whose GCP is an inclusion criterion leveraged by the Gen2 *Select* command, would still be possible, given knowledge of the GCP, although this can be made much easier if the GS1 primary identification key is encoded using 4 bits per digit (numeric string encoding) instead of log(10)/log(2) ≈ 3.32 bits per digit (integer encoding). Some GS1 identifiers (e.g. the GIAI) are particularly problematic since they contain an all-numeric GS1 Company Prefix component followed by an alphanumeric asset reference – so these may need to use 7-bit encoding.

Ironically, it is currently not possible to query specific AI-based attribute data values (e.g., expiration date within a given window, or lot/batch) as encoded in the User Memory bank (MB 11) via the Packed Objects approach (standardised in TDS 1.5, in 2010); current discussions are looking at adding TDS support for a compressed GS1 Digital Link URI encoding in User Memory, which has the advantages of:

- natively AI-friendly, less complicated alternative to Packed Objects approach; and
- interoperability and synergy with an already GS1-standardised encoding algorithm (chapter 8 of GS1 Digital Link 1.1.

4.7 GS1 Digital Link

The GS1 Digital Link standard doesn't treat the GS1 Company Prefix as a separate component. Some implementations of the standard (a GS1 Digital Link Resolver) may, however, allow for some form of templating mechanism based on a GS1 Company Prefix (e.g. for linkType=gs1:recallStatus, direct queries for all GTINs based on GS1 Company Prefix 952420 to a single URL). This is implementation-dependent, and as such there is no connection to this work.

4.8 Application Standards and Guidelines

A number of EPCIS-centric application standards and guidelines have been written based on EPCIS and other standards that would be affected by the potential removal of the dot. Each group responsible for the application standard or guideline should come up with clear guidance on which URI syntax should be applied and include a migration path or coexistence strategy, if applicable. In addition, this may require additional non-EPC URI examples to be included in such documents. These include but are not limited to:

- GS1 EPCIS for Rail Vehicle Visibility Application Standard
- GS1 US Implementation Guideline: Applying GS1 Standards for DSCSA and Traceability
- Brazilian Medicine Traceability using GS1 EPCIS
- Fighting Illicit Trade with EPCIS Application Standard
- Exchange of component/part lifecycle data in the rail industry Application Standard
- GS1 Foundation for Fish, Seafood and Aquaculture Traceability Guideline
- EPC-based RFID Item Level Tagging – Implementation Guideline for Companies of the Apparel, Fashion and Footwear sector

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5 Additional Recommendations

5.1 Review by Wider GS1 User Community

Because of the potentially significant impact of this proposal on the installed user base(s) of EPCIS and EPC/RFID, we recommend the creation of a GS1 community-wide "Modernisation of EPC" discussion group, in order to establish community requirements and a holistic plan for review and revision of existing standard(s) in cohesion with the needs of the broader GS1 user community. The discussion group's outcomes could provide the mandate for GSMP workstreams to undertake technical revision and modernisation work with cross-sector applicability.

5.2 Indexing

An indexing approach has been described in section 4.4.1 and is currently under evaluation within the prototype testing phase by members of the EPCIS/CBV 2.0 MSWG.

5.3 EPC/Barcode Interoperability Tools

Regardless of any change proposed and supported by the user community, there will be a need for some time for the ability to determine the length of the GS1 Company Prefix in situations where it otherwise can't be determined. This is particularly important where the data carrier is a 2D barcode such as GS1 DataMatrix or GS1 QR Code and parties downstream of the brand owner / manufacturer are attempting to correctly capture EPCIS event data for objects they handle; for such parties it is very important that needing to know the length of the GS1 Company Prefix component is not an obstacle to their processes or the capture of EPCIS data. At minimum, the existing GS1 Company Prefix length table needs to be maintained and updated regularly with licence data provided by GS1 Member Organisations. Other recommendations are that its existence be better publicised (many respondents to the survey didn't know about it) and that a simple REST API be developed to simplify its use.

- The main advantage of a publicly available list of the rules that determine the length of a GS1 Company Prefix from its initial digits is that it can be used within translation software, cached for used (with periodic checking for updates) and the availability of such data means that is no limit imposed on the number of translations that can be made within a specified time period. However, some parties still consider that such data may be too revealing about the number capacity of a GS1 Member Organisation or may be used by unauthorised parties, to issue apparently plausible GS1 Company Prefixes or individual keys.
- Authenticated access to determine the length of a GS1 Company Prefix requires network connectivity at query / translation time and may also be further subject to rate-limiting / throttling, even for authenticated users. Reliance solely on such an approach also makes it more difficult to distribute open source toolkits for EPC/barcode interoperability / translation, since it would not be advisable or desirable to embed the authentication credentials within the source code. However, some Member Organisations have expressed that they would be more willing to make their rules for determining GCP length available to authorized authenticated users, rather than via a publicly available list.

5.4 Serialization Service for Lost or Damaged Tags

Replacing a lost or damaged tag requires knowing not only the GTIN but also the serial identifier. Inferring the GTIN is generally simple: it may be read from the barcode, it may be inferred from similar products (e.g. on the same pallet or in the same shipment), it may be inferred by its storage location, and more.

Inferring the serial identifier is more difficult. The serial identifier may not be barcoded, or the label may be lost or damaged. Transaction records that include the serial identifier may require scanning all tags to figure out which one isn't present (assuming only one is lost or damaged).

To get around this, it is recommended that there be a standardised service, similar to the GS1 Lightweight Messaging Standard for Verification of Product Identifiers, that is discoverable via a GS1 Digital Link Resolver, to assign a new serial identifier. The link to the service would have to be defined by the brand owner, to ensure that the service issues serial identifiers that conform to the

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brand owner's practices and aren't duplicates. Furthermore, the service would require strict authentication security to limit access to prevent counterfeiting and other nefarious activities.

This service is unlikely to be permitted in the pharmaceutical industry due to traceability regulations and may not be supported by brand owners in industries such as consumer electronics, where the serial identifier on the package is expected to be the same as that encoded into the product. High-volume commodity products such as apparel and footwear may support such a service, however.

5.5 Request for Finding for General Identifier (GID)

This document recommends a separate Request for Finding to review ongoing usage of the GID with a view to deprecation, given the following:

- General Manager Number allocation is handled by GS1 Global Office, individually, on demand.
- Allocation of General Manager Numbers (based on GS1 Prefix 951) is independent from allocation of GS1 Company Prefixes in any other range.
- There are currently 87 allocated, valid EPC Manager Numbers.
  - A total of 91 EPC Manager Numbers were allocated between 2004 and 2012, but four were cancelled at some point.
- Demand for GIDs has tapered off since 2009 (i.e. since the sunsetting of the EPCglobal Subscription model).
- An EPC Manager Number was last allocated in 2012.
- Because is it not based on a GS1 Company Prefix, the GID is regarded by the GS1 System Architecture[6] as a Class-3 Key (like the DoD and ADI EPC schemes in TDS).

[6] https://www.gs1.org/docs/architecture/GS1_System_Architecture.pdf

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A Survey and Results

A survey was distributed to multiple GSMP working groups, GS1 Member Organisations, and other interest groups in May 2020.

A.1 Survey

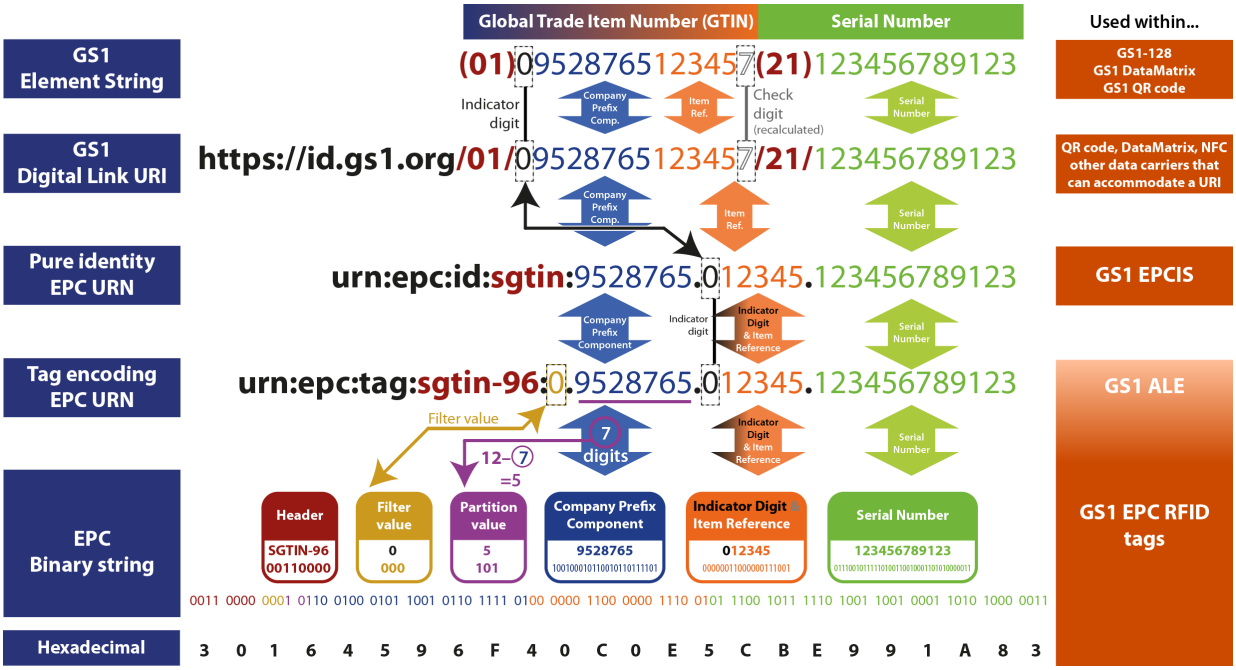
Electronic Product Code (EPC) standards includes specific formatting rules for GS1 identification keys. Specifically, they require:

- an explicit indication of the length of the GS1 Company Prefix;
- positioning the indicator digit for the GTIN and the extension digit for the SSCC at the start of the object reference portion; and
- elimination of the check digit.

The GS1 Architecture Group is conducting this survey in order to understand the implications of a restructuring of the EPC formats to align them with the formats used elsewhere in the GS1 system. This means:

- eliminating the separation of the GS1 Company Prefix from the rest of the key;
- moving the indicator digit for the GTIN and extension digit for the SSCC to the start of the entire key; and
- inclusion of the check digit.

The mapping of the GS1 element string to other formats is shown below.



1. Have you implemented or would you like to implement either EPC RFID or EPCIS?
   a. Yes
   b. No
2. Which have you implemented or do you intend to implement? (check all that apply)
   a. EPC RFID
   b. EPCIS
3. What industry sectors do you support? (check all that apply)
   a. Apparel

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b. Fresh food
c. Consumer packaged goods
d. General merchandise
e. Pharmaceutical
f. Medical devices
g. Other healthcare
h. Trucking
i. Rail
j. Maritime & ports
k. Customs
l. Aerospace
m. Automotive
n. Construction
o. Defence
p. Transport & logistics
q. Foodservice
r. Technical Industries
s. Humanitarian logistics
t. Other (specify)

8. Have you encountered difficulties in determining the length of the GS1 Company Prefix in order to correctly format the EPC? If yes, please elaborate on the challenges you encountered.
   a. Yes
   b. No
   c. Skip this question
9. Do other specific formatting features (leading digit, check digit) create specific difficulties? If yes, please elaborate on the challenges you encountered.
   a. Yes
   b. No
   c. Skip this question
10. Does your implementation make use of the EPC Pattern URI in EPCIS queries (e.g. MATCH_epcClass with urn:epc:idpat:sgtin:9521234.*.*)? If yes, please indicate how.
    a. Yes
    b. No
    c. Skip this question
11. Do you have any use cases requiring an explicit separation of the GS1 Company Prefix in the EPC URI? If yes, please indicate how.
    a. Yes
    b. No
    c. Skip this question
12. What do you see as the benefits of removing the need to separate the GS1 Company Prefix in the various EPC formats?

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13. What do you see as the drawbacks of removing the need to separate the GS1 Company Prefix in the various EPC formats?
14. Are you making use of the EPC Tag Data Translation standard? If yes, please indicate how.
    a. Yes
    b. No
    c. Skip this question
15. Please provide any additional comments.
16. What is your name?
17. What company do you represent?
18. What is your email address?

A.2 Results

A.2.1 Highlights

- 162 responses
  - 119 have implemented or would like to implement either EPC RFID or EPCIS
  - 43 discarded
- 84 have implemented or would like to implement EPC RFID
- 83 have implemented or would like to implement EPCIS
- 48 have implemented or would like to implement both

A.2.2 Top Industries

- Pharmaceutical (58)
- Apparel (57)
- Transport & logistics (50)
- Consumer packaged goods (43)
- Other healthcare (43)
- Medical devices (39)
- General merchandise (33)
- Fresh food (31)

A.2.3 Key Question

"Have you encountered difficulties in determining the length of the GS1 Company Prefix in order to correctly format the EPC?"

- Yes: 49
- No: 54
- Skip: 16

Even though "No" was the majority answer, the details provided in response to "Yes" were significant.

A.2.4 Length of the GS1 Company Prefix

- GCP length table

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944 - Not complete
945 - Not consistent
946 - Not up to date (often have to add new client prefixes manually)
947 - Conflicts with GEPIR
948 - No guarantee that all parties will do it correctly
949 - Even causes problems for downstream parties that do
950 - Many reported problems with NTINs
951 - Implementations can be delayed by weeks when educating trading partners
952 - Hard to find the right person in the organization who can provide the necessary information
953 - Confusion between GS1 Company Prefix and U.P.C. Company Prefix
954 - Took time to understand how to encode 5-digit GS1 Company Prefix
955 - EPC format too complicated for many people
956 - Hard to identify one-off keys
957 - GS1 Company Prefix isn't shared with master data so needs to be determined through a lengthy
958 out-of-band process
959 - As RFID is adopted by smaller and smaller players, problems will increase

960 ### A.2.5 Leading Digit and Check Digit

961 - Difficult to explain and implement
962 - Different key types have different rules, making it hard to implement consistently
963 - GTIN hidden indicator digit 0 confusing
964 - Want consistency in indicator digits (fixed alignment with packaging level)
965 - Recalculating check digit when converting to barcode is an extra, complex step

966 ### A.2.6 Other Findings

967 - Use of EPC Pattern URI
968 - Yes: 30
969 - No: 59
970 - Filtering and grouping
971 - Allows for EPCIS event sharing by trading partner
972 - Used for Electronic Article Surveillance
973 - Overreporting of usage of Tag Data Translation Standard, confused with Tag Data Standard

974 ### A.2.7 Use Cases

975 - GCP used to differentiate products by manufacturer
976 - Filtering of tags, especially when nearby businesses also using RFID
977 - Easy separation of internal asset ID encoded in GIAI
978 - GCP used to decide where to send outbound documents
979 - GCP used to lookup the URI of the company web site to access product database etc.

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A.2.8 Benefits of Removing Explicit GCP

- Easier to implement
- Reduced need for education and training
- Less room for mistakes
- Consistency between EPC and other formats
- Faster time to market
- No need to maintain GCP as part of master data

A.2.9 Drawbacks of Removing Explicit GCP

- Transition of existing implementations
- Education
- Binary encoding likely to be very challenging
- May have issues with backward compatibility
- Expense of rewriting software
- Market confusion
- Would need to interrogate full GTIN to determine validity of source for transactions
- Effort required to transfer thousands of existing and active encoding formats
- Loss of filtering
- May prevent adoption of global solution for tire industry
- Existing install base of tags and users may impede adoption of new format

A.3 Summary

- No clear support for changing the format, and no clear resistance to changing it
  - Significant issues (>50% of responses) suggests that effort to change the format would be welcomed by significant share of industry
- A lot of solutions are built on the separation of the GS1 Company Prefix
  - Any plan would have to include guidance on how to migrate away from such solutions

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