Standards Gap Analysis for Cooperative Intelligent Transportation Systems (C-ITS)

Issues and Proposed Resolutions

Document HTG7-3
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Standards Harmonisation Working Group
Harmonisation Task Group 7

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1 Introduction

1.1 Background

Advancements in transportation technologies are rapidly transforming the world's strategies for increasing safety; gaining operational, mobility, and cost efficiencies; opening access to underserved communities; and reducing environmental impacts from transportation. Using new forms of short-range communications, vehicles and devices are now capable of broadcasting or receiving data that allow them to sense the movements and status of other surrounding devices. These cooperative exchanges create a three hundred sixty degree awareness that, when further fused with other open data, can enable drivers and other users of the transportation system to receive alerts and warnings regarding the formation of threats and hazards. The alerts and warnings created through these communication technologies provide the opportunity to prevent some crashes, thereby reducing fatalities, injuries, and property damage. The cooperative exchange of data in this manner can also enhance the benefits of automation.

Access to new data sets can also transform network operations and minimize the capital investment costs of infrastructure owners and operators. Broadcast data sets from users within a highly mobile environment can complement or potentially supersede the need for significant roadside equipment on major roads. These new data can also form a more complete representation of conditions on the arterial network, including road weather impacts, effects of traffic signal timing, support for incident and emergency responders, or changes in traveller decisions, among other conditions.

Standards for interfaces in the public interest can play a key role in delivering these benefits to communities that implement cooperative-ITS technologies. Technical standards are developed to address coordination problems and overcome technical barriers that exist when different organizations need to work together while preserving their institutional and proprietary processes. The International Organization for Standards (ISO) defines a standard as, "… a document, established by a consensus of subject matter experts and approved by a recognized body that provides guidance on the design, use or performance of materials, products, processes, services, systems or persons." The end documents, which frequently represent the interests of the experts and parties that gather to develop them, are vetted by experts. Recognized benefits include improved safety, mobility, and sustainability for the travelling public and enhanced interoperability within an open market environment.[1]

[1] See definitions at: the European Committee for Standardization (CEN): https://www.cen.eu/work/ENdev/whatisEN/Pages/default.aspx; the International Organization for Standards (ISO): https://www.iso.org/sites/ConsumersStandards/1_standards.html; Wikipedia: https://en.wikipedia.org/wiki/Technical_standard; the National Institute of Standards and Technology (NIST): https://www.nist.gov/services-resources/standards-and-measurements.

1.2 History

In 2011, the United States (US) Department of Transportation (USDOT) and the European Commission (EC) approved a **Harmonisation Action Plan** to guide EC-US standards development via Harmonisation Task Groups (HTGs). The plan recognises that successful, interoperable, nationwide or regional, cooperative technology implementations are critically dependent upon consistent application of complete, technically sound standards and policies for critical functions, interfaces, and ***information flows***[2]. This worldwide need applies to the common services of a cooperative systems environment as well as to global markets for vehicles, devices, and applications. While the envisioned end state appears very similar in many parts of the world, past analyses have been regional and independent in nature and have proceeded with varying levels of coordination. The HTGs allow participating countries to collaborate on technical ITS issues that are of common interest and thus leverage critical expertise and resources while potentially realizing more compatible worldwide solutions.

Transport Certification Australia (TCA) joined the HTG initiatives in January 2014 by bringing security expertise and co-leadership to the sixth HTG (HTG6).[3]

1.3 HTG7

With the emergence in 2015 of plans in the US, Europe, and Australia to develop pilot ***Cooperative Intelligent Transportation Systems*** (***C-ITS***)[4] projects, a new HTG was established to identify how existing standards could support new C-ITS installations (i.e., "standards solutions for C-ITS") and, in doing so, identify the issues in standards that could pose risks for deployers. This seventh HTG (HTG7) began in late 2015 as a joint effort between the EC, the USDOT, and TCA, with the Japan Ministry of Land, Infrastructure, Transport and Tourism (MLIT) joining in 2017.

Specifically, the objective of HTG7 was to identify standards that comprehensively support large-scale C-ITS deployments. HTG7 expects that fulfilling this objective will allow:

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[2] Terms that are in ***bold italics*** in this report are defined in a companion report, the **HARTS Reference Compendium (HTG7-5)**, which defines all of the terms used throughout this report set. Terms defined in the reference compendium are bold faced and italicised within each HARTS report upon their first use.

[3] Results of HTG6 are located here: https://ec.europa.eu/digital-single-market/news/harmonized-security-policies-cooperative-intelligent-transport-systems-create-international.

[4] C-ITS is a subset of ITS that requires the mutual, secure exchange of data between *independent* trusted entities (i.e., parties that have no contractual relationship). In other words, while traditional ITS typically deals with exchanges among system components owned and managed by a single or limited number of entities; these new ITS services expand this scope to include system components (e.g., vehicles) that may be owned and managed by any number of different entities. The scope of the HTG7 analysis included the C-ITS interfaces (i.e., exchanges between parties with no contractual relationship but with security and authentication as the basis for trust) as well as the more traditional "back-office" flows (between contracted parties) that enable the provision of the C-ITS services. This architecture presents a level of connectivity suggesting an "Internet of Things" for transportation.

1. **Governments, standards organisations, and other interested stakeholders** to track ***issues*** regarding those interfaces and information flows that are of significant public interest within the C-ITS ***architecture***, facilitating engagement with experts to address them;
2. **ITS deployment teams, device manufacturers, and application developers** to identify candidate standards-based ***solutions*** that are available to them for planning, understand the issues associated with those solutions, and mitigate the risks associated with those issues in their deployments. Future ITS deployment teams around the world will have a clearer understanding about which system functions and interfaces are critical for ***interoperability*** and where standards are defined (or not yet defined) to support interoperability.

1.4 Globally Harmonised Reference Architecture

To establish a foundation for analysing standards, the international HTG7 team first developed the **Harmonised Architecture Reference for Technical Standards (HARTS).** HARTS facilitates the understanding of the applicability of standards (ITS standards and other Information and Communications Technology (ICT) standards) for the successful implementation of ***C-ITS services***[5]. HARTS provided the framework for the HTG7 team to identify key interfaces that need to be standardised in the public interest and served as the basis for performing the ***gap*** and ***overlap*** analysis of C-ITS standards for those interfaces.

HARTS is an internationally harmonised reference architecture based on:

- **National ITS Architecture Framework (NIAF) from Australia**
- **EU's Framework Architecture (FRAME) from Europe**
- **Connected Vehicle Reference Implementation Architecture (CVRIA) from the US**
- **C-ITS architecture constructs from Japan**

The body of work produced by HTG7 includes key resources for industry, such as HARTS and the accompanying HTG7 reports. These tools not only provide a starting point for the ITS community to address the technical and interoperability challenges that face wide-scale ITS deployment; but also provide tactical guidance on standards, solutions, and risks for current or near-term project teams planning and implementing ITS systems. Although the reports are based on a globally harmonised ***reference architecture***, they formally recognise and accommodate regional and local approaches to ITS services, solutions, and standards.

1.5 Format of HTG7 Reports

The results summarized in this Executive Summary are presented in greater detail in the HTG7 series of reports:

- **Executive Overview (HTG7-1)** - A high-level summary of the approach, process and the key results of HTG7.

[5] For the purpose of this report, the term "C-ITS service" is intended to include all ITS services encompassed by the HARTS service packages; at the time of publication 34 are available on the HARTS website (http://htg7.org).

- **Analysis Methodology (HTG7-2)** - Presents the HTG7 methodology used to develop HARTS, perform the gap analysis, and develop proposed resolutions.
- **Issues and Proposed Resolutions (HTG7-3, this document)** - Summarises the issues identified through HTG7 analysis and proposes actions to resolve the issues. It introduces a series of more detailed reports, detailed below, each of which identifies the same set of proposed resolutions but adopts a presentation format and includes details relevant to a different perspective.
    - **Results: Solution Perspective for Deployers (HTG7-3-1-AU, HTG7-3-1-EU, HTG7-3-1-JP, HTG7-3-1-US)** - Addresses development or implementation teams in their planning and procurement processes. This detailed report lists each solution along with its associated issues and proposed resolutions and is divided into four regional sub-reports, one for each participating region. (The region is reflected by the appended 2-letter region code[6]).
    - **Results: Resolution Perspective for Standards Developers (HTG7-3-2)** - Presents each proposed resolution along with its associated issues and the data exchanges affected by these issues. This detailed report can assist standards development communities and governments in their planning and work processes.
    - **Results: Service Package Perspective (HTG7-3-3-AU, HTG7-3-3-EU, HTG7-3-3-JP, HTG7-3-3-US)** - Offers road operators the opportunity to evaluate the "readiness" of ***service packages***. This detailed report lists each service package, the data exchanges contained within the service package, and the issues associated with each solution for each data exchange. In this respect, this report helps deployers understand the levels of risk due to the standards gaps. The report is divided into 4 regional reports, one for each participating region. (The region is reflected by the appended the 2-letter region code[6]).
- **HARTS Website Overview (HTG7-4)** - Provides an overview of the HARTS public website, available at http://htg7.org. It describes each aspect of the website and provides instructions on how to submit comments about the information on the website.
- **HARTS Reference Compendium (HTG7-5)** - Provides reference material including:
    - A glossary of terms and associated definitions
    - Acronyms and associated meanings
    - Graphic symbols and associated meanings
    - Explanations of key terms and their inter-relationships

[6] As defined by ISO 3166-1:2013 *Codes for the representation of names of countries and their subdivisions – Part 1: Country codes*

1.6 Conventions

While the HTG7 Report set was developed using United Kingdom (UK) English, the HARTS (toolset and website) was developed using US English. Whenever an extract from HARTS is presented within the HTG7 Report set, it will retain its US English spelling.

As noted in footnote 2 on page 2, this report is supplemented by the HARTS Reference Compendium (HTG7-5), which defines all of the terms used throughout this report set. Terms defined in the reference compendium are bold faced and italicised within each HARTS report upon their first use.

1.7 Purpose of this Document

This document, **Issues and Proposed Resolutions (HTG7-3),** summarises the results of the HTG7 analysis and provides a set of proposed resolutions for consideration in addressing future C-ITS standards development activities.

2 Overview

The HTG7 team analysed the C-ITS domain according to the methodology described in Analysis Methodology (HTG7-2) and illustrated in **Error! Reference source not found.**.

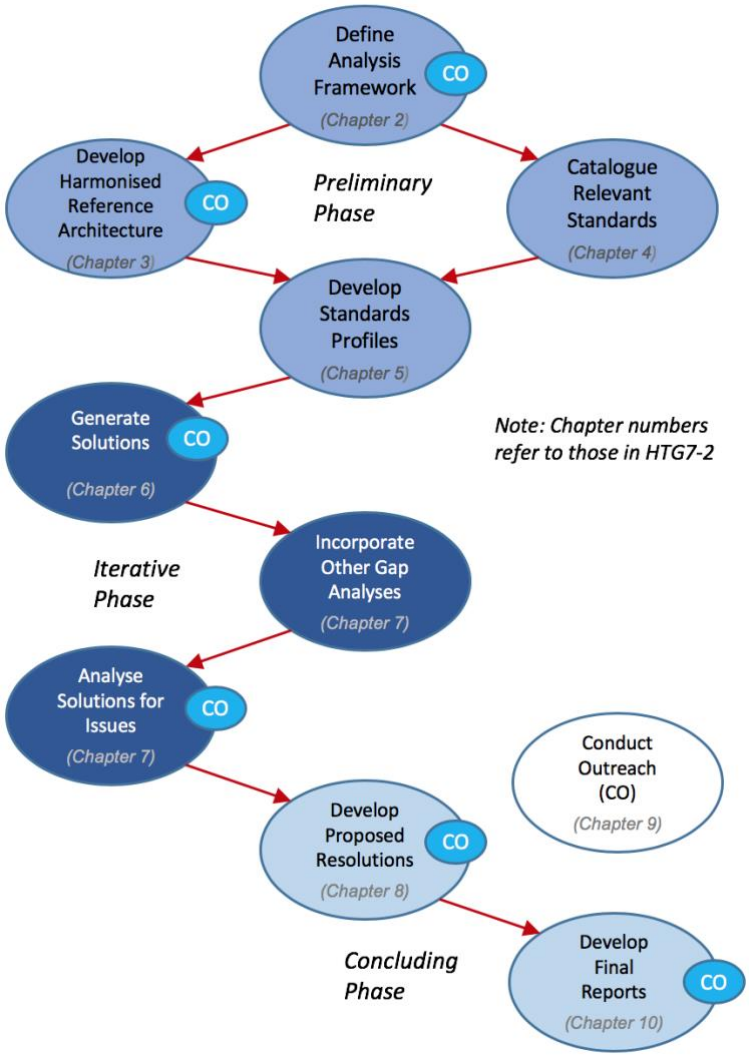

Figure 1 HTG7 Methodology Framework

Chapter 3 of this document extends the high-level overview of the methodology identified in Chapter 7 of HTG7-2, by summarising the results of the analysis. The issues identified during the analysis have broad implications for the interoperability of C-ITS and similar networks such as Cooperative, Connected, and Automated Mobility (CCAM), smart cities, and the Internet of Things (IoT).

Chapter 4 of this document discusses how the proposed resolutions were developed to address the issues and additionally provides details about the most urgent proposed resolutions. The complete set of (non-urgent) issues and resolutions, from different perspectives, are contained within the set of accompanying detailed reports. The methodology for the development of proposed resolutions is explained in more detail in Chapter 8 of HTG7-2.

Chapter 5 then summarizes the overall results of the HTG7 project by discussing the key takeaways from the analysis conducted by the project team.

In conclusion, the HTG7 project team found:

- 112 proposed resolutions addressing the 34 service packages
- 74 of these proposed resolutions are consider “urgent” as they are necessary for successful, interoperable, and secure C-ITS deployments.
- 42 of these proposed resolutions are of multi-regional interest.

Addressing these proposed resolutions in an international context can offer significant additional benefits, as described in Chapter 5.

3 Summary of Findings: Gaps & Overlaps

3.1 Analysis of C-ITS Services

One of the main goals of the HTG7 analysis was to develop a method by which the ***C-ITS stakeholders*** can reach consensus on which issues need to be addressed first. The HTG7 team developed several ranking mechanisms to focus the discussions on the most urgent issues.

The initial step in the approach was to consider the anticipated deployment timeline of each service package as follows:

- **Support** - C-ITS services that enable other C-ITS services. For example, the Security and Credentials Management service package enables a secure environment for all other service packages to operate.
- **Day 1** - Service packages included in current pilot deployments, early deployments, and/or are undergoing prototyping and testing efforts.
- **Day 1.5** - Service packages that are of general interest for near-term deployment but were not as mature as the Day 1 service packages when the HTG7 analysis began.
- **Other** - Service packages that are of interest to the stakeholder community, but they are not expected to be deployed in the near-term.

Once the service packages were categorised, the analysis concentrated on the service packages that were identified as Support, Day 1, or Day 1.5. This allowed for a more detailed analysis of the services currently being deployed or likely to be deployed in the near term, while ensuring that the underlying architecture could support the broader set of services. Furthermore, this approach recognises that many details about the “Other” service packages will likely change before they are actually deployed.

Figure 2 indicates the division among the four service package categories.

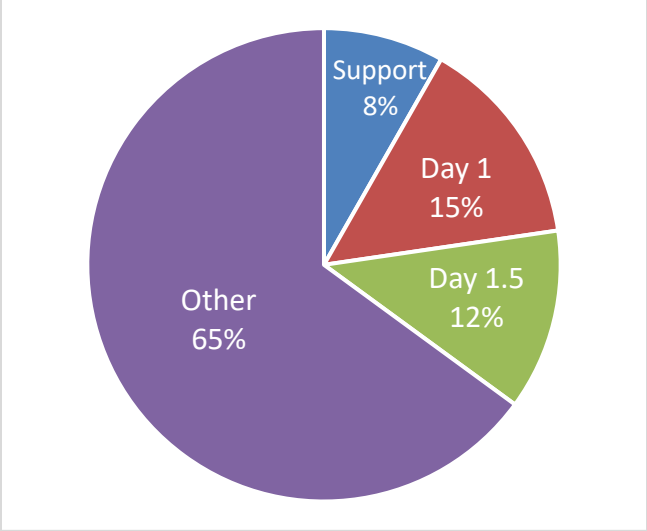

Figure 2: Service Package Deployment Timeframe

3.2 Analysis of Information Triples

Each service package is defined by a set of ***information triples*** that link ***information flows*** with a specific ***source*** object and a specific ***destination*** object.

The HTG7 analysis resulted in the identification of nearly 550 information triples associated with the Support, Day 1, and Day 1.5 services packages. In many cases, the analysis recognised multiple potential solutions for each information triple – these can be attributed to different regions developing different solutions or even alternative solutions within a region. As a result, the HTG7 analysis recognises over 2300 ***triple solutions*** for the Support, Day 1, and Day 1.5 service packages.

For each triple solution, the HTG7 team assessed and, when warranted, identified specific issues that, if resolved, will improve the interoperability of conforming equipment, and thus realise the full benefit of the associated service package. Each issue was categorised as either a:

- ***Gap*:** An issue that indicates a defined architectural need is not currently fulfilled by the triple solution; or
- ***Overlap*:** An issue that indicates that there are two (or more) competing standards to implement an information triple, and that the standards community should perhaps rationalise or indicate the preferred solution.

Each issue was also ranked based on its perceived severity as:

- **Ultra:** standardisation efforts for major aspects of the triple solution have not even begun.
- **High:** the triple solution fails to provide even a base level of interoperability and security as recommended for pilot deployments; or

- **Medium:** the triple solution may be sufficient for pilot deployments but fails to provide sufficient interoperability, management, and security to enable proper, full-scale deployment;
- **Low:** the triple solution may be sufficient for wide-scale deployment, but known issues exist that deployments should consider;

3.3 Overview of Results

Sections 7.3, 7.4, and 7.5 of the HTG7 Analysis Methodology (HTG7-2), explain the process used to associate issues with triple solutions using a three-step process:

1. Define generic ***issue types***
2. Examine each component (e.g., standard, profile, solution, etc.) of each triple solution and ***assign*** issue types as appropriate. Issue assignments ensure consistent presentation of ***issue instances*** within information triples.
3. Generate an instance of an issue assignment for each triple solution where the component is used. This allows the issue to be displayed on the website; the number of times an issue assignment appears as an issue instance indicates the breadth of impact of that issue assignment across the reference architecture.

These relationships are shown in Figure 3.

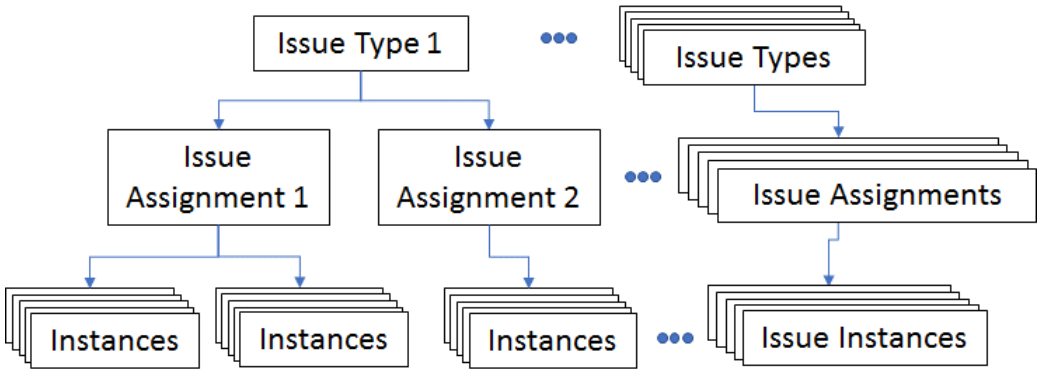

Figure 3: Relationships between Types, Assignments, and Instances

For the roughly 2,300 triple solutions in the Support, Day 1, and Day 1.5 service packages, the analysis identified:

- 43 issue types
- Roughly 450 issue assignments
- Nearly 6,800 issue instances

As a practical example of this process, ISO 19091 defines rules for the use of the ***MAP*** and ***SPaT*** messages. The analysis tools generate triple solutions for each information triple based on these rules; however, this ISO document is currently only a technical specification rather than a full standard. As such, the HTG7 team *assigned* the "Not a Standard" *issue type* to this ISO specification. Each of the 160 triple solutions that contain a reference to ISO 19091 is associated

with an *instance* of the "Not a Standard" issue. This alerts the deployer to when an issue is relevant to a solution being used within their deployment.

The original intent was that the count of issue assignments would represent the number of distinct tasks that would need to be undertaken to address all issues; however, this was not the case for two major reasons:

1. The "Data profile not defined" issue was assigned to a single data profile, "(None – Data)". However, this data profile was then applied to many different flows. Each application of the "(None – Data)" implies the need for a separate task to resolve the issue.
2. Some issues instances that would require a single task to resolve within a standard were assigned multiple times at a different level (e.g., at the triple solution level as shown in Figure 4) because the issue did not affect all instances of using a specific standard.

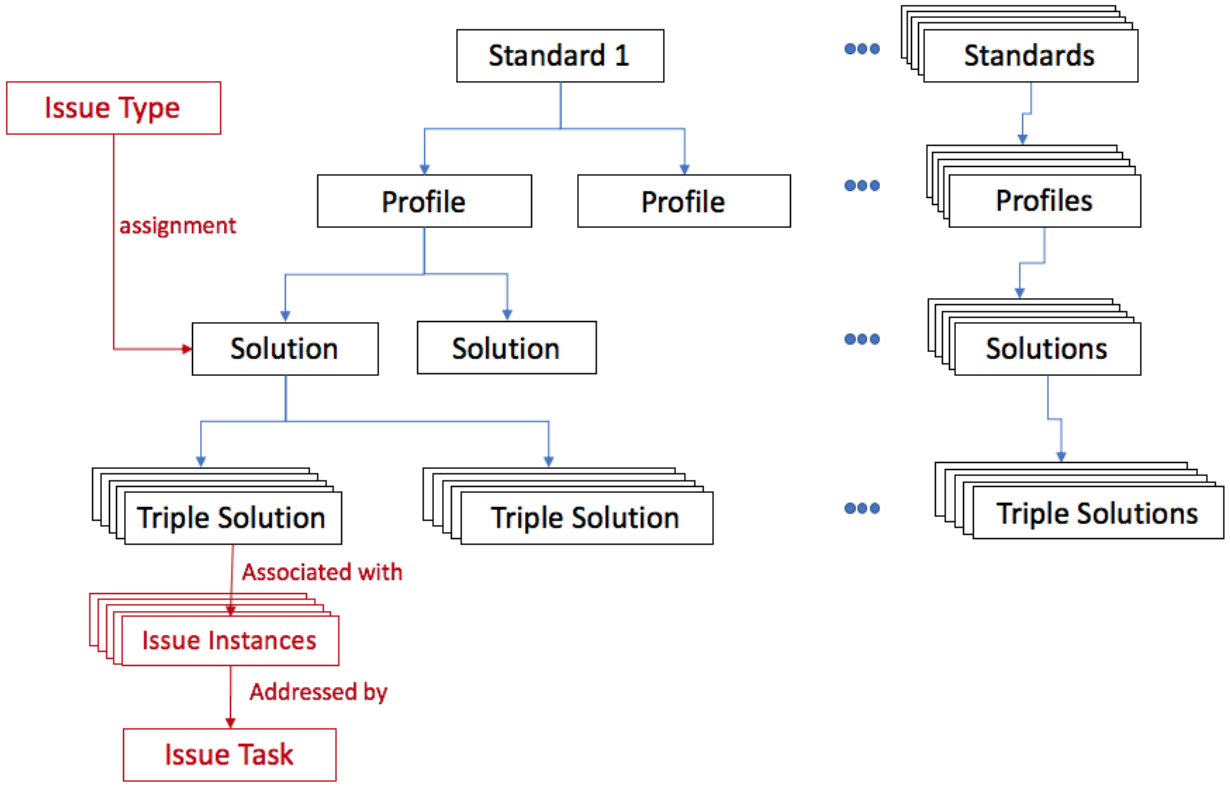

Figure 4: Issue Tasks vs Issue Instances

To overcome these two anomalies and provide more insight into the level of effort required to address all issue instances, the HTG7 team developed algorithms to filter the list of issue instances to provide a count of ***issue tasks***. Figure 5 summarises the levels of severity and the timeline associated with the approximately 400 issue tasks associated with the Support, Day 1, and Day 1.5 service packages.

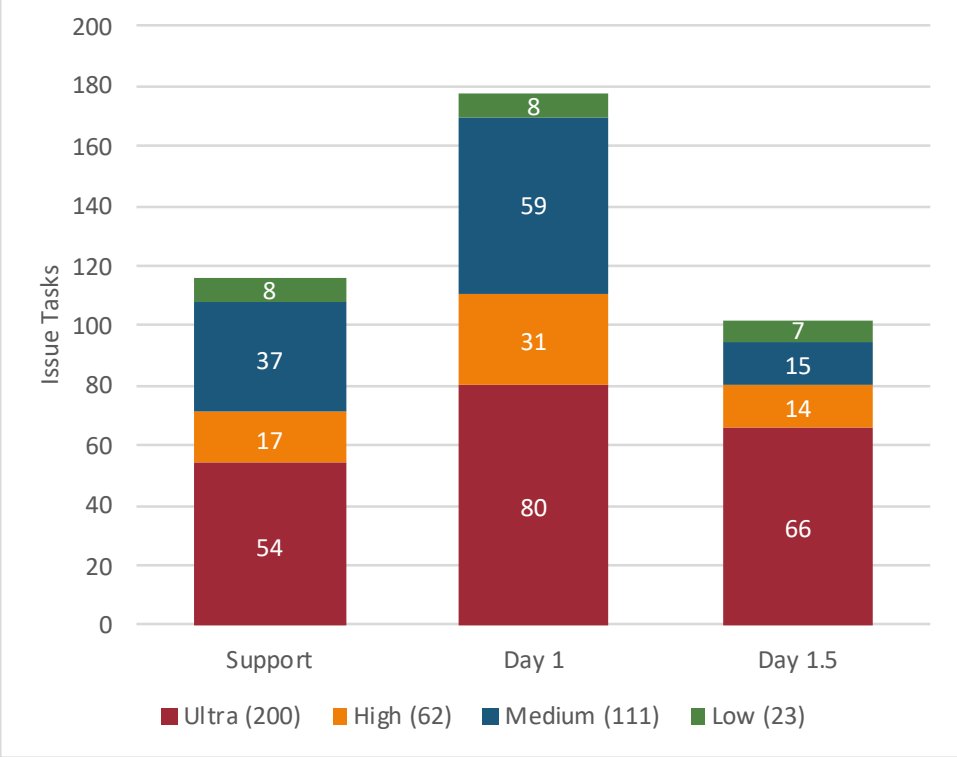

Figure 5: Severity of Issue Tasks by Timeline

4 Summary of Findings: Proposed Resolutions

4.1 Intent of Proposed Resolutions

The proposed resolutions presented in this report generally do not propose technical solutions to the identified issues; rather they are written to merely identify the major standards-related tasks considered to be needed to address the issues, based on HTG7 team expertise and input from stakeholders and experts (many of who work within the standards-setting organizations).

For example, rather than proposing a technical solution to address an information flow for which no standard exists, the proposal merely identifies the need to develop a standard to address the issue. It is then up to the members of the standards working group(s) to develop and form consensus around a technical solution or a set of solutions. Other proposals include research, investigations, or proof-of-concept projects.

Further, while issues tend to identify specific problems, proposed resolutions were written at a sufficiently high level so as to correspond with “projects” or “work items” within a standards development organisation. For instance, a proposed resolution might identify the need to update a standard, but to fully understand and implement the proposal, the reader will need to consider all of the issue instances that have been associated with that proposed resolution.

This higher-level view allows the reader to view the 112 proposed resolutions (as documented in the companion HTG7-3 detailed reports) rather than having to consider the nearly 6,800 issue instances or 450 issue assignments.

4.2 Geographic Region Assignments

Each proposed resolution is also associated with the geographic region(s) in which stakeholders and industry participants are expected to be involved in the resolution. An example of this is where Australia and Europe are identified for proposed resolutions related to resolving issues related to GeoNetworking; while the United States is identified for proposed resolutions related to WAVE standards. In the case where an issue affects multiple regions (there are many of them), the assignments are associated with each region affected.

4.3 Timing of Addressing of Proposed Resolutions

As the analysts began developing proposed resolutions, they focused on issues instances related to Support and Day 1 service packages, recognizing that the priorities might change before there is an opportunity to begin addressing Day 1.5 issue instances. As a part of its development, each proposed resolution was assigned one of the following timing categories:

- **Urgent:** The proposed resolution is important, time-critical, and related to one or more moderate-, high-, or ultra-severity issues that need to be resolved prior to wide-scale deployment of one or more “Support” or “Day 1” service packages. These generally require standards development.

- **Near-term:** The proposed resolution is related to one or more issues that need to be addressed prior to wide-scale deployment of one or more “Support” or “Day 1” service packages. These often may be addressed by guidance for deployments, such as recommending that all deployments use a particular set of options when implementing a general ICT standard.
- **Medium-term:** The proposed resolution is not perceived to be critical for Day 1 deployment projects in general, but may be necessary for some deployments (e.g., optional informational triples of a service package) in the medium-term.
- **Future:** The proposed resolution is not currently considered to be urgent or needed for near or medium-term deployments.

An example of the complexity related to assigning these values can be seen in the (Day 1) Transit Signal Priority service package, where a vehicle may be granted signal priority by requesting it directly from the field equipment, or by the vehicle making its request directly to a central system which will then direct the field equipment. It is expected that most deployments will opt for the former approach while it is also recognized that some systems will opt for the latter. As such, a severe issue instance associated with the former approach would cause the associated proposed resolution to be categorized as “urgent”; a severe issue instance associated with the latter approach would only require a “medium-term” ranking of the proposed resolution. However, the proposed resolution associated with the latter approach may also be associated with other issue instances that are more critical to Support and Day 1 deployments; in which case, the proposed resolution is assigned to the highest possible ranking.

4.4 Characteristics of Proposed Resolutions

Figure 6 combines the results of the region and timeline assignments into a single chart that shows the urgency of proposed resolutions for each region.

The “multi-regional” assignment is made for any proposal that was associated with at least three regions. The only two-region proposals involved Australia and either the United States or Europe, and those are categorised as either US or EU with the assumption that Australia will join those activities as desired.

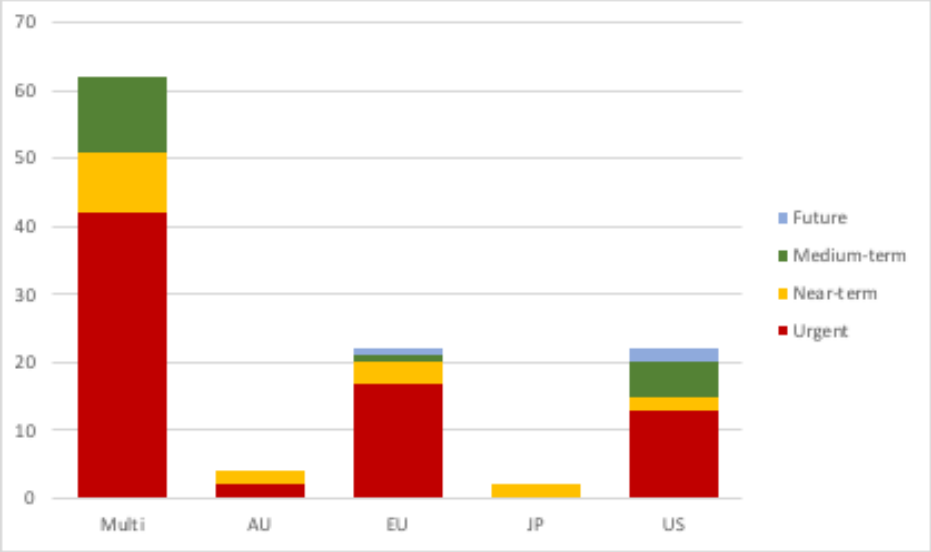

Figure 6: Proposed Resolutions by Region and Timeline

Notably, these results indicate that 57% of the proposed resolutions are of multi-regional interest, which suggests that there is benefit in collaborating on addressing the resolutions. All marketplace and deployment areas of the world need these resolutions to be addressed. There are cost and time savings associated with agreeing to develop collaboratively; and a key benefit to producing a harmonised solution that can immediately be put into use around the world. Collaboration also allows for the ability to access expertise where and when available.

In addition, while not shown in the figure itself, the analysis of the region-specific resolutions indicates that they are mostly proposals to implement minor improvements to existing regional standards.

4.5 Details of Results

Figure 7 further divides the Urgent proposals into additional categories that point to the type of expertise that will be needed to address the specific proposed resolutions. The categories also identify where the majority of issues remain that might negatively impact deployments of Day 1 solutions. The categories are defined as:

- **Foundational:** Proposed resolutions that will have significant impacts on how C-ITS will work or how other C-ITS standards should be developed. This includes proposals related to defining services for specific aspects within the ***HARTS reference model*** as well as proposals related to defining standardised terminology, data definitions, and an identifier registry.
- **Security:** Proposed resolutions related to security issues. Security proposals could easily be considered foundational as well, but they are grouped into their own category since they require a specific type of expertise.
- **Centre-Centre (C-C):** Proposed resolutions related to data exchanges between centres.

- **Field**: Proposed resolutions related to data exchanges between a field (a.k.a., roadway or roadside) device and either a centre or another field device.
- **Vehicle-Local (V-L):** Proposed resolutions related to any data exchange that might use nearby short-range communications. This includes data exchanges involving a vehicle or pedestrian interacting with its local environment such as another vehicle (e.g., V2V), or nearby field infrastructure (e.g., V2I).
- **Centre-Vehicle (C-V):** Proposed resolutions related to data exchanges between a centre and a vehicle.
- **Overlap:** Proposed resolutions that relate to resolving overlaps among existing standards.

The different colours indicate the expertise most likely needed to address the resolution.

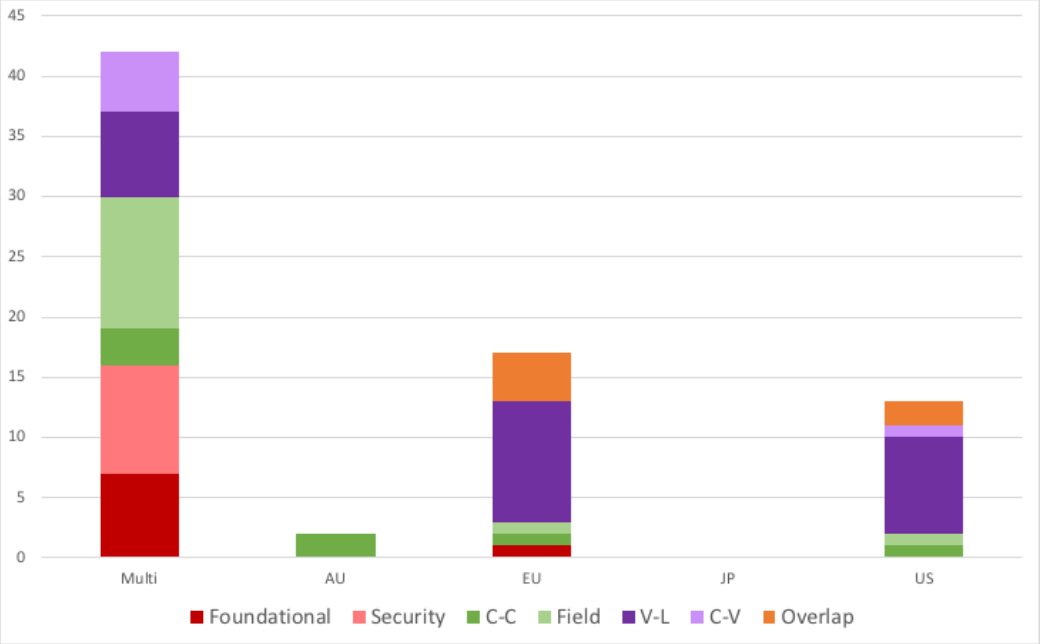

Figure 7: Urgent Proposed Resolutions by Region and Category

An analysis of the regional resolutions reveal that they tend to be focused on resolving overlaps within the region and on enhancing the existing regional vehicular communication standards.

By contrast, the resolutions proposed for multi-regional interest cover all categories of standards. In particular, the analysis indicated that while each region has devoted considerable resources in developing their own vehicular communication standards, the infrastructure (e.g., centre-to-centre and field) communication standards for relaying the collected C-ITS data have received little attention. Likewise, the foundational and security standards also need increased attention, many of which must be addressed in a multi-regional, multi-SDO fashion to ensure the seamless and secure exchange of information among systems while maintaining adequate data privacy.

Finally, Figure 6 provides some good news. While the analysis has identified that a considerable amount of work will be required to address these resolutions, the resolutions cover disparate categories. This should allow multiple resolutions to be addressed in parallel since the expertise

required for one category of resolutions will often be different than that required to address the other resolution categories.

4.6 Highest Urgency Proposed Resolutions

While there are 74 proposed resolutions identified as Urgent, most of these proposals relate to specific data exchanges. However, there are 17 proposed resolutions that have a large effect across many data exchanges; these are grouped into the "Foundational" and "Security" categories.

While all 74 proposed resolutions need to be addressed to enable secure interoperability of all Day 1 services, the 17 Foundational and Security proposals are the most important to address early, as they often will impact how the other 57 Urgent proposed resolutions should be handled.

4.7 Proposed Resolutions

Section 4.7.1 provides a simple listing of all the Urgent proposed resolutions.

Section 4.7.2 introduces the more detailed reports provided in HTG7-3-1, HTG7-3-2, and HTG7-3-3 and discusses the intent of each one. These more detailed reports provide an in-depth presentation of how each of the 112 proposed resolutions (i.e., all Urgent, Near-term, Medium-term, and Future proposed resolutions) address the thousands of issue instances identified to date. While these reports provide a great amount of useful information, they are thousands of pages long and are designed to be a reference resource for technical experts and deployers.

4.7.1 Urgent Proposed Resolutions

The following subsections list the 74 proposed resolutions that have been identified as "Urgent" for each region. The table structure within each subsection is nearly identical and defined as follows:[7]

- **Class:** The classification of the proposed resolution, one of:
  - Foundational
  - Security
  - Centre-Centre (C-C)
  - Field
  - Centre-Vehicle (C-V)
  - Vehicle-Local (V-L)
  - Overlap
- **Name:** A short name for the proposed resolution
- **Description of Proposed Resolution:** The text of the proposed resolution developed by the HTG7 team

[7] Abbreviations, acronyms, and terms used within these tables are defined in **HARTS Reference Compendium (HTG7-5)** even when they are not boldfaced and italicized.

A separate table is presented for each region in addition to the multi-regional table. Each table is sorted by Class and then by Name.

The multi-regional table is used when the proposed resolution is of potential interest to three or more regions. These proposals are likely to be international work items and are therefore of potential interest to all regions, even if our analysis did not show them as such.

The only two-region proposals involve Australia and either the US or the EU. In both cases, rather than duplicating the entries in multiple tables, the proposed resolutions appear within the US or EU tables with an additional column labelled “AU” to indicate that the proposal may be of interest to Australia.

4.7.1.1 Multi-Regional Urgent Proposed Resolutions

There are 42 multi-regional Urgent proposed resolutions as shown in Table 1.

Table 1: Multi-Regional Urgent Proposed Resolutions

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
Foundational	With the continual evolution of broadcast technologies coupled with the mixture of free and subscriber-based systems, it is difficult to identify any single technology that can be used to reliably reach the bulk of drivers in a timely manner.	C-V: Wide-area broadcast subnet and hybrid communications	Standardize one or more mechanisms by which wide-area broadcast messages can be received by a defined minimum percentage of transportation users that are currently operating within a specified geographic area. The required minimum percentage is dependent on the type of information being transmitted and will need to be determined by the expert community. Some alerts (e.g., tornado warnings) will require near 100% reception, while other messages (e.g., road works ahead) may require significantly lower minimum percentages. The minimum percentage may be made up with a variety of technologies using hybrid communications and the ITS station architecture.
Foundational	As connectivity increases, there is an increasing need to share data in a peer-to-peer fashion for a variety of purposes. Rather than developing custom interfaces for each data exchange, the C-ITS community needs to better leverage ICT solutions to provide industry-supported, standards-based, flexible interfaces that will meet its data distribution needs.	Data distribution technologies	Investigate emerging ICT technologies that might offer mechanisms to distribute data among multiple ITS subsystems on an as-needed basis in a more efficient, secure, and scalable manner than existing approaches. Determine where the use of these technologies might be appropriate, and what impacts the adoption of such technologies would have on ITS standards efforts.

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
Foundational	Data are typically defined to address the needs of each specific data exchange; however, in reality, the data is independent of any single data exchange and is often exchanged across multiple interfaces. There needs to be better coordination among these different standards.	Develop ITS-wide reference data model	Develop an internationally representative ITS-wide reference data model that will enable better data sharing across disparate enterprise systems with data defined by different entities, working groups, and standards development organizations.
Foundational	Within the ITS industry, there are a variety of customized terms that many industry participants interpret differently.	Develop an ITS-wide terminology standard	Develop an internationally acceptable ITS terminology standard, complete with a defined concept model as required by ISO 704.
Foundational	Map messages are frequently used in ITS systems and can be quite complex. Ensuring consistency among all standards will assist in lowering costs to implement systems.	Develop map message structures	Develop a model for exchanging detailed map information throughout the ITS environment.
Foundational	As vehicles cross jurisdictional boundaries, they need to be aware of any changes to locally defined “rules of the road”.	Develop standard for electronic distribution of traffic regulations	Develop an internationally acceptable standard to enable the provision and management of electronic traffic regulations to enable proper operation of road users as they cross jurisdictional boundaries.
Foundational	Applications, regions, manufacturers, and other entities all need to be unambiguously identified by C-ITS systems.	Identifier registry	Implement a centralized identifier registry network that ensures the assignment of globally unique C-ITS identifier values, such as ITS application identifiers, regulatory region identifiers, access technology types, etc.

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
Security	Security of existing centre-to-centre protocols are inadequate given the safety-of-life implications involved. While most existing deployments provide security at the network layer (e.g., TLS), they typically provide no or limited capability to authenticate and authorize access among application processes.	C-C: Secure communications	Develop one or more internationally acceptable, secure, center-to-center communication standards and define rules on when to use which one. The standard(s) should include support for authentication, authorization, confidentiality, and non-repudiation, as needed. Once the application layer standard(s) are developed, most ITS Information Layer standards will need to be updated to document data in appropriate format(s).
Security	Security of some centre-to-vehicle protocols, especially for traveler information, are currently inadequate. The types of traveler information involved can affect navigational decisions and the vehicle should verify that the sender is authenticated and authorized to provide the information before accepting it.	C-V: Secure communications	Develop one or more internationally acceptable, secure, centre-vehicle communication standards and define rules on when to use each one. The standard(s) should include support for authentication, authorization, confidentiality, and non-repudiation, as needed. Once the application layer standard(s) are developed, most ITS Information Layer standards will need to be updated to document data in appropriate format(s).
Security	Currently, there are no standards defining how managers can grant specialized rights to C-ITS equipment and for the equipment to use those rights to obtain the necessary security certificates.	Core authorization - base services	Develop an internationally acceptable standard for the user permission sets, permission request, permission update request, permission request received, and device identification information triples contained within the Core Authorization Service Package.
Security	While many of the processes for obtaining security certificates are defined, the credentials management	Credentials management system	Implement regional (security) credentials management systems that are interoperable.

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
	systems do not exist within most countries to enable these processes.		
Security	Security of existing infrastructure-to-field protocols are inadequate. Many deployments provide no significant protection from cyber threats, while those that do provide protection generally only provide network layer security (e.g., TLS). Communications with remote equipment should require the authentication and authorization of all requests.	I-F: Secure communications	Develop one or more internationally acceptable, secure, centre-to-field communication standards and define rules on when to use each one. The standard(s) should include support for authentication, authorization, confidentiality, and non-repudiation, as needed.
Security	The process to securely install and update software on a C-ITS device is critical to the security of the entire C-ITS environment. Compromising a single connected device could potentially lead to catastrophic safety-of-life issues. Currently, security within the software installation and maintenance process is either non-existent or unsystematic; the industry needs standards to ensure that systems do not become compromised, thereby imposing security risks to the entire environment.	Secure installation/update of software	Develop an internationally acceptable standard for the secure installation, update, and validation of software (including application, support, and OS software) on devices. The process should allow a system to determine which devices have been updated and provide a mechanism to define when such updates are allowed, recommended, and required.
Security	In addition to defining how security certificates are distributed, there are no clear rules on how potential	Misbehaviour detection and security revocation	Conduct a field test to prove out the trust revocation mechanisms at all levels, including revoking the privileges of a certificate authority

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
	misbehaviour is reported or on how notice of certificate revocation is distributed.	mechanisms	(e.g., if an authority is no longer recognized within a region) and of an ITS station (e.g., in case an ITS station starts to misbehave).
Security	C-ITS location and time information tends to rely on technologies such as GNSS, which are vulnerable to jamming and spoofing.	Secure and accurate location and time standards	Develop/adopt an internationally acceptable standard/solution for synchronizing and continuously maintaining location and time information throughout the ITS environment in a secure and reliable manner with sufficient accuracy (including leap seconds) and confidence.
Security	There are no standards to define how to distribute and manage security policies and certificates within the C-ITS environment.	Security and credentials management - base services	Develop an internationally acceptable standard for the security policy and networking information, device enrolment information, security credentials, security credential revocations, and misbehavior report information triples contained within the Security and Credentials Management Service Package.
Security	There are not any standards defined for handling information that can be used to infer personally identifiable information (e.g., identifying a vehicle at a residence and tracking)	V-L: Private location and address	Develop an internationally acceptable ITS application specification that defines the operation of a Privacy Protection Gateway.
Center	Currently, there are no rules on when or how to update high-resolution maps for intersections and roadways among central systems.	C-C: Distribute maps	Develop an internationally acceptable ITS application specification that defines the rules for updating maps, roadway geometry, and intersection geometry among centers (e.g., between a Map Update System and a center).
Center	Current standards do not define how a system can monitor or control	C-C: System monitoring	Develop an internationally acceptable ITS application specification for the Service Monitor

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
	another system's operational status. For example, a host system may depend on notifications from a remote system; but the host system also needs to be able to distinguish between silence and failure of the remote system.		System to monitor other centers and support systems and to report issues.
Center	Rules on the use of wide-area broadcast services (e.g., satellite radio) for dissemination of regional traveler information (e.g., road-weather advisories)	C-C: WAID	Develop an internationally acceptable ITS application specification for providing information from a center to a WAID for wide-area dissemination.
Field	Currently, each RSE application defines its own mechanisms for being managed by a remote entity, which increases the cost and complexity of the management entities.	I-F: Application management	Develop an internationally acceptable ITS application specification for generically managing applications (e.g., enabling, monitoring, etc.) within an RSE.
Field	A key responsibility of RSEs is to gather, aggregate, average, and report information received from vehicles to central systems and other ITS components. However, at present, there are no standards defining how this should be accomplished.	I-F: Data aggregation	Develop an internationally acceptable ITS application specification for an RSE to aggregate collected data and report the information to interested parties (e.g., centers).
Field	Currently, there are no rules on when or how to update high-resolution maps for intersections and roadways to field devices (e.g., RSEs and	I-F: Distribute maps	Develop an internationally acceptable ITS application specification that defines the rules for distributing maps, roadway geometry, and intersection geometry between a centers (e.g., a

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
	signal controllers).		Map Update System) and field equipment.
Field	Field devices often need to notify management entities of exceptional conditions (e.g., cabinet door opening, temperature dropping below a threshold, etc.) The current suite of standards do not provide a secure and robust way to provide these notifications.	I-F: Exception-based reporting	Develop an internationally acceptable ITS application specification for managing exception-based reports from other local field devices.
Field	While standards exist to manage message signs, they are not recognized internationally nor do they provide adequate security.	I-F: Message signs	Develop an internationally acceptable ITS application specification for managing message signs for secure communications with proper access control.
Field	While standards exist for broadcasting traffic signal status, the safety-of-life issues involved with signal information require that this information always be consistent with the information displayed on the signal heads. Currently, there are no standards that define how this verification should be achieved.	I-F: Signal conflict prevention	Develop an internationally acceptable ITS application specification for monitoring intersection status information to prevent conflicts between physical displays and broadcast information.
Field	While standards exist for managing traffic signal controllers from a central source within some countries, there are different opinions on how the real-time signal information should be exchanged between the signal controller and an RSE and no	I-F: Signal control	Develop an internationally acceptable ITS application specification for the interface between a traffic signal controller and a roadside station to exchange raw data related to the SPaT, SRM, and SSM using the secure center-to-field protocol.

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
	consensus across national boundaries.		
Field	While there are standards that allow for the collection of speed information and standards that allow for posting messages on signs, there is no standard for the management of speed warning devices that detect speeding vehicles and post warning messages.	I-F: Speed warning	Develop an internationally acceptable ITS application specification for providing roadway configuration data, current speed limits, warning parameters and thresholds to a speed warning application.
Field	While there are national standards that allow for the recording of vehicle sensor data, the existing standards do not provide adequate security.	I-F: Transportation sensor systems	Develop an internationally acceptable ITS application specification for exchanging transportation sensor station data with a management entity that uses the secure center-to-field protocol.
Field	While there are national standards that allow for the recording of weather information, the existing standards do not provide adequate security.	I-F: Weather information	Develop an internationally acceptable ITS application specification for directing an RSE to provide weather information to vehicles.
C-V	Currently, rules are not in place for when or how centres should update vehicles with high-resolution maps for intersections and roadways.	C-V: Distribute maps	Develop an internationally acceptable ITS application specification that defines the rules for distributing maps, roadway geometry, and intersection geometry and associated regulations and restrictions over mobile Internet from a center to user devices (e.g., a vehicle or personal information device).
C-V	While there are standards that define	C-V: In-vehicle	Develop an ITS application specification for in-

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
	how to describe in-vehicle signage and there are standards that define how to convey this information; the performance requirements for this information (e.g., rules defining which information is sent under what conditions, the necessary accuracy of data, etc.) are not defined.	signage	vehicle signage to the vehicle from a center.
C-V	While standards exist to convey signal status from a RSE to a vehicle, there are no performance requirements defined for a centre to provide this information to a vehicle well in advance of the intersection so that (e.g., transit) vehicles can adjust speeds to achieve environmental benefits.	C-V: Signal operations	Develop an ITS application specification for providing intersection status information to vehicles from a center for environmental benefits.
C-V	While there are standards that define safety, probe, and sensor data for a vehicle; the performance requirements for this information are not defined.	C-V: Situation data	Develop an internationally acceptable ITS application specification for the use case of distributing collected situation data (e.g., BSMs/CAMs, sensors, probe data, etc.) between vehicles and remote interested parties (e.g., centers).
C-V	The performance requirements for transmitting weather information from centers to vehicles is not defined in any standard.	C-V: Weather information	Update the international ITS application specification to address road weather advisories.
V-L	Currently, there are no rules on when or how RSEs should update vehicles	V-L: Distribute maps	Develop an internationally acceptable ITS application specification that defines the rules for

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
	with high-resolution maps for intersections and roadways.		distributing maps, roadway geometry, and intersection geometry to a vehicle from a local source.
V-L	While there are standards that have defined how to exchange some environmental data; the performance requirements for these exchanges have not been defined.	V-L: Environmental data sharing	Develop an internationally acceptable ITS application specification for sharing environmental data from vehicles to other local entities. The effort should consider efforts to date under both J2735 and DENM.
V-L	While the concept of intersection infringement has been discussed within standards communities, the details of how to do this and the performance criteria have not been defined.	V-L: Intersection infringement	Develop an internationally acceptable ITS application specification that defines the rules for providing intersection infringement information within a local environment.
V-L	Although ISO has developed TS 19091, the rules defined are still only a technical specification rather than a full international standard.	V-L: Signal operations	Develop an internationally acceptable ITS application specification for signal control information to vehicles from the roadside. (i.e., formally standardize ISO 19091)
V-L	Although messages have been defined to alert road users to the presence of emergency and other special vehicles, the performance requirements for using these messages have not been defined.	V-L: Special vehicle alert	Develop an internationally acceptable ITS application specification for sending special vehicle alerts.
V-L	While standards have generally defined how to implement the vehicle location and motion information flow, the details of how to convey	V-L: Trailer information for vehicle location and motion	Standardize the mechanism for the BSM, CAM, and DENM to accurately convey geometric properties related to articulated vehicles.

Class	Issue Summary	Resolution Name	Description of Proposed Resolution
	information for an articulated vehicle (e.g., a trailer or articulated bus) has not been defined.		
V-L	While one standard does define a mechanism for conveying a wrong-way vehicle warning, the performance requirements are not defined.	V-L: Wrong way vehicle detected	Develop an internationally acceptable ITS application specification for providing distributing wrong way vehicle alerts in real-time.

4.7.1.2 AU

Table 2 identifies the two Urgent proposed resolutions that are specific to Australia. These proposals relate to Australia-specific decisions on which region-specific standards they wish to deploy within their region.

Table 2: AU Urgent Proposed Resolutions

Class	Issue Summary	Name	Description of Proposed Resolution
Center	Standards exist within the US and Europe for providing center-to-center incident information, but Australian experts have not indicated which standards should be used within their country.	C-C: AU incident information	Adopt an existing incident management center-to-center data profile for use within the region.
Center	Standards exist within the US and Europe for providing center-to-center traffic management data, but Australian experts have not indicated which standards should be used within their country.	C-C: AU traffic management data	Adopt an existing traffic management center-to-center data profile for use within the region.

4.7.1.3 EU (Australia[8])

Table 3 identifies the 17 Urgent proposed resolutions that are specific to the European Union nations. These proposals relate to resolving issues in the European-standards domain. As stated previously, they may also be of interest to Australia (indicated by a checkmark in the 'AU' column).

Table 3: EU Urgent Proposed Resolutions

Class	Issue Summary	Name	Description of Proposed Resolution	AU
Center	While standards exist for sharing road work information, there are no performance standards for sharing this information.	C-C: Road work information	Develop an internationally acceptable ITS application specification for C-C exchange of road works and seasonal maintenance data.	✓
Field	Although some national standards exist for a center to manage a signal controller, there are no regional standards to support the changing marketplace for this equipment that support C-ITS.	I-F: EU signal operations	Develop an ITS application specification for exchanging configuration, plans, status, and commands for signal control and signal systems using the secure center-to-field protocol.	
Foundational	The performance requirements to implement GeoNetworking have not been defined.	V-L: GeoNetworking	Determine how to implement GeoNetworking without unduly flooding the network and, if feasible, prove out concept.	✓
Overlap	Currently, there are two major technical solutions to provide the lower layers of vehicle to local communications without any	V-L: BTP/ GeoNetworking/G5 and FNTP/M5	Standardize on a single solution for providing DSRC communications within Europe and Australia; currently BTP/GeoNetworking/G5 and	✓

[8] Australia may also be interested in some of these proposed resolutions.

Class	Issue Summary	Name	Description of Proposed Resolution	AU
	rules on when either should be used.		FNTP/M5 are competing solutions that are not interoperable at the Subnet or Transnet layers.	
Overlap	Vehicle event information can be transmitted as a part of CAM or DENM. There is confusion in the marketplace on which message to use and under what conditions – this leads to increased deployment costs, increased bandwidth consumption, and/or decreased interoperability.	V-L: CAM and DENM	Standardize on a single solution for providing vehicle event information; currently this information can be transmitted using CAM or DENM.	✓
Overlap	Fields exist that allow signal priority to be requested using either the CAM or SRM. There is confusion in the marketplace on which message to use and under what conditions – this leads to increased bandwidth consumption, decreased interoperability, and/or increased deployment costs.	V-L: CAM and SRM	Standardize on a single solution for requesting signal priority; currently this request can be transmitted using CAM or SRM.	✓
Overlap	Various types of traveler information can be transmitted via a variety of protocols. There is confusion in the marketplace on which message to use and under what conditions – this leads to decreased interoperability, increased deployment costs,	V-X: DENM, IVI, TPEG2, TMC and Contextual Speed Information	Standardize on a single solution for providing traveler information, lane closure information and speed information; currently this information can be sent via DENM, IVI, TPEG2, TMC, or Contextual Speed Information (speed information only). Use cases need to consider the various environments (e.g., Centre-Vehicle, Roadside-Vehicle, Special Vehicle-Vehicle, etc).	✓

Class	Issue Summary	Name	Description of Proposed Resolution	AU
	and/or increased bandwidth consumption.			
Security	The GeoNetworking standard does not provide data privacy protection for a message that is relayed by an intermediate station.	V-L: Update GeoNetworking security	Update the GeoNetworking standard to provide secure data exchange where the transmitter of a message is not the same of the generator of the message (e.g., a message generated by a central system and sent to the RSE for transmission or a message generated by one vehicle and rebroadcast by another vehicle).	✓
V-L	The CAM message contains many optional fields and there are no performance requirements defining when the message or optional fields should be sent.	V-L: CAM	Develop an internationally acceptable ITS application specification for CAM for each use case where it applies and when the CAM should include optional fields for each condition.	✓
V-L	The DENM message contains many optional fields and there are no performance requirements defining when the message or optional fields should be sent.	V-L: DENM	Develop an internationally acceptable ITS application specification for DENM for each use case where it applies and when the DENM should include optional fields for each condition.	✓
V-L	The conditions under which intersection status messages are sent; the rules defining which data fields to populate for each condition; and the latency, accuracy, and performance requirements related to these messages are not defined.	V-L: EU signal operations	Develop an ITS application specification for providing intersection status information to vehicles from the roadside.	✓

Class	Issue Summary	Name	Description of Proposed Resolution	AU
V-L	The conditions under which signal priority messages are sent; the rules defining which data fields to populate for each condition; and the latency, accuracy, and performance requirements related to these messages are not defined.	V-L: EU signal priority	Develop an ITS application specification for a traffic signal to provide pre-emption or priority to authorized vehicles.	✓
V-L	The conditions under which vehicle signage data are sent; the rules defining which data fields to populate for each condition; and the latency, accuracy, and performance requirements related to these messages are not defined.	V-L: EU vehicle signage data	Develop an ITS application specification for providing vehicle signage data to vehicles over DSRC.	✓
V-L	The conditions under which in-vehicle information is sent; the rules defining which data fields to populate for each condition; and the latency, accuracy, and performance requirements related to these messages are not defined.	V-L: IVI	Develop an ITS application specification for in-vehicle information for each applicable use case.	✓
V-L	The conditions under which vehicle collision warning information is sent; the rules defining which data fields to populate for each condition; and the latency, accuracy, and	V-L: Vehicle collision warning	Standardize the complete ITS application specification for exchanging alerts locally that vehicles are about to collide.	

Class	Issue Summary	Name	Description of Proposed Resolution	AU
	performance requirements related to these messages are not defined.			
V-L	Standardized messages for requesting headlight dimming do not exist.	V-L: Vehicle headlight dimming	Develop an ITS application specification for a vehicle to request another vehicle to dim its headlights. NOTE: This analysis should consider whether this information flow is still needed or whether existing market products adequately address this issue.	
V-L	There are currently no standards for providing vehicle route plans to a vehicle from a roadside device.	V-L: Vehicle route plan	Develop an internationally acceptable ITS application specification for the use case of providing detailed vehicle route information to the RSE for collection of Vehicle Data for Traffic Operations. This might be combined with V-I: Situation Data.	

4.7.1.4 Japan

Japan's analysis of HARTS was more limited than the other regions with a specific focus on vehicular communications. This analysis did not reveal any Urgent proposed resolutions unique to Japan, but there are a couple of less urgent issues as included in the HTG7-3-2 detailed report and the HTG7-3-1-JP and HTG7-3-3-JP regional detailed reports.

In addition, as Japan continues to deploy additional C-ITS services, it is likely that they will be interested in the results for the other regions and that they are likely to favourably consider collaboration on proposed resolutions.

4.7.1.5 US (Australia[8])

Table 4 identifies the 13 Urgent proposed resolutions that are specific to the United States. These proposals relate to resolving issues in the US-standards domain. As stated previously, they may be of interest to Australia (indicated by a checkmark in the 'AU' column).

Table 4: US Urgent Proposed Resolutions

Class	Issue Summary	Name	Description of Proposed Resolution	AU
Center	While standards exist to report sensed information from vehicles, standards for exchanging collected information among centers are incomplete (i.e., does not cover all information collected), and do not define performance requirements for these exchanges.	C-C: Situation data	Develop an internationally acceptable ITS application specification for the use case of distributing collected situation data (e.g., BSMs, CAMs, sensors, etc.) among various centers.	✓
Field	While a standard does exist for a center to manage a traffic signal controller, the standard does not provide adequate data protection for the safety-of-life issues involved.	I-F: US signal operations	Develop an ITS application specification for exchanging configuration, plans, status, and commands for signal control and signal systems using the secure center-to-field protocol.	✓
C-V	The US has not defined a standard for center-to-vehicle traveler information; however, some deployments have used TPEG, but there are still no standardized performance requirements.	C-V: Tailoring of TPEG2	Tailor TPEG2 for use within the US for center-vehicle communications.	
V-L	Messages for queue warning have not been standardized within the US.	V-L: Queue warning	Develop an ITS application specification for providing queue warnings to vehicles from the roadside or other vehicles that is harmonized with DENM.	
V-L	The standard defining performance requirements for safety awareness messages is still under development.	V-L: Safety awareness	Develop an ITS application specification for vehicle-to-vehicle safety awareness.	
V-L	Performance characteristics for a vehicle reporting itself as stationary is not defined.	V-L: Stationary vehicle	Develop an ITS application specification harmonized with DENM for a vehicle to self-	

Class	Issue Summary	Name	Description of Proposed Resolution	AU
			report when it is stationary and a potential hazard.	
V-L	The standard for defining performance requirements for signal priority is still under development.	V-L: US signal priority	Develop an ITS application specification for the performance requirements related to pre-emption and priority for authorized vehicles at a signal.	
V-L	The conditions under which messages are sent; the rules defining which data fields to populate for each condition; and the latency, accuracy, and performance requirements related to these messages are not defined.	V-L: US traveler information	Develop an ITS application specification for providing in-vehicle signage and other traveler information to the vehicle from the roadside. This will also need to address issues such as when and how to locally generate traveler information messages and how to sign these messages.	
V-L	While messages for work zone information have been drafted, there are no standardized messages or performance requirements from an RSE to a vehicle for this information within the US.	V-L: US work zone information	Develop an ITS application specification for providing work zone information to vehicles within a local area. This should be based on the currently defined mechanisms in J3067, TPEG2, IVI, and DENM and assist in the development of an ITS-Wide Data Model.	
V-L	The standard for defining performance requirements for providing weather information from an RSE to a vehicle is still under development.	V-L: Weather information	Develop an acceptable ITS application specification for providing weather information to vehicles from the roadside or other vehicles. The specification should consider the use of DENM and/or TPEG2 as already implemented in Europe.	
V-L	The standard that defines US-specific performance requirements for signal status	V-L: US signal operations	Develop an ITS application specification for the performance requirements related to	

Class	Issue Summary	Name	Description of Proposed Resolution	AU
	information from an RSE to a vehicle is still under development.		sending signal control information to vehicles from the roadside.	
Overlap	There are multiple standards that define how to exchange parking information, including ATIS, TMDD, and TCIP. There is confusion in the marketplace on when to implement which message that can lead to increased deployment costs, increased bandwidth consumption, and/or decreased interoperability.	C-C: ATIS/TMDD/ TCIP for parking information	Standardize on a single solution for providing parking information; currently this information is defined within ATIS, TMDD, and TCIP (using alternative approaches).	✓
Overlap	Incident information can be transmitted using TCIP, IM, TMDD, or ATIS standards. There is confusion in the marketplace on when to implement which message that can lead to decreased interoperability , increased deployment costs, and/or increased bandwidth consumption.	C-C: TCIP/IM/TMDD/ ATIS for incident information	Standardize on a single solution for providing incident and incident management information; currently this information is defined within APTA TCIP, IEEE 1512 (IM), ITE TMDD, and SAE ATIS.	✓

4.7.2 Detailed Reports

Nine detailed reports accompany this HTG7-3 report:

- Four regional detailed reports for Results: Solution Perspective for Deployers (HTG7-3-1-<R>)
- One report, Results: Resolution Perspective for Standards Developers (HTG7-3-2)
- Four regional detailed reports for Results: Service Package Perspective (HTG7-3-3-<R>))

Altogether, these reports show how the proposed resolutions are mapped to the issues identified in the analysis. The nine different detailed reports present the same set of 112 proposed resolutions but sort the information using different criteria to accommodate the different perspectives of different users.

All of the detailed reports contain the following columns:

- Solution
  - Name
- Triple
  - Source
  - Destination
  - Flow
- Issue
  - Name
  - Description
  - Severity
- Proposed Resolution
  - Name
  - Description
  - Urgency
  - Regions

4.7.2.1 Solution Perspective

The first detailed report is divided into four regional detailed reports (HTG7-3-1-AU, HTG7-3-1-EU, HTG7-3-1-JP, HTG7-3-1-US); these are intended primarily for developers of components and other project teams that consist of technical experts required to implement and deploy the standards. These teams are most interested in the issues related to the specific solution that they are responsible for implementing. In addition to the columns described above, the report also includes a solution region column. The table is sorted as follows:

- **Solution Region:** This column allows the reader to quickly locate the solutions related to the region of interest.
- **Solution Name:** Developers and project teams are primarily interested in understanding all of the issues with the specific solutions that they plan to implement and deploy. Using

the solution as the second sort criteria allows all of the related issues to be grouped together.

- **Issue Name:** This column organises the issues related to the triple solution in a consistent manner.
- **Triple:** This column allows the reader to focus on issues related to the specific instance of the solution within the architecture.

4.7.2.2 Proposed Resolution Perspective

The second detailed report (HTG7-3-2) is intended primarily for governmental agencies, standards development organisations, and other associations that have an interest in resolving the identified issues in the standards. These groups are primarily interested in each proposed resolution and the specific issue instances that need to be addressed when implementing the proposal. The table is sorted as follows:

- **Proposed Resolution Urgency:** The proposed resolutions are sorted first by urgency to allow the focus to be on the most urgent needs.
- **Proposed Resolution Regions:** The proposed resolutions are then sorted by region to allow readers to identify which items might be specific to them.
- **Proposed** Resolution Name: Finally, each proposed resolution is presented alphabetically to allow the reader to understand all of the issues related to each item.

4.7.2.3 Service Package Perspective

The third detailed report is divided into four regional detailed reports (HTG7-3-3-AU, HTG7-3-3-EU, HTG7-3-3-JP, and HTG7-3-3-US); these are intended primarily for local government agencies and other organisations that are interested in deploying specific service packages. These groups are interested in understanding the existing issues as well as considering the different options available for implementing each information triple within the specific service package of interest.

In addition to the standard columns, the report also includes a service package name column. The table is sorted as follows:

- **Service package name:** The proposed resolutions are sorted first by the service package name to make it easy to locate relevant triples.
- **Solution region:** The proposed resolutions are then sorted by the solution region to allow the agency to focus on their potential solutions.
- **Triple:** The proposed resolutions are then sorted by the triple so that the user can find the triple of interest.
- **Solution Name:** The proposed resolutions are then sorted by solution name so that the user can find the solution of interest.
- **Issue Name:** The specific issues associated with the triple solution are then listed alphabetically.

5 Key Takeaways

5.1 Criticality and Urgency

Many of the issues identified in the HTG7 analysis have been documented in previous reports and are well known; others resulted from the HTG7 comprehensive, in-depth analysis. In synthesising known issues together, the result is a list of issues that need to be addressed by the ITS community in order to achieve successful, interoperable, and secure C-ITS deployments.

Further, as mentioned previously, many of these issues have broader implications into the interoperability and success of similar networks such as CCAM, smart cities, and the IoT. The sooner these issues are addressed, the more rapidly and easily deployments will proceed. Beginning the discussion on how best to resolve them is deemed an important and time-critical next step.

Failure to address these issues in a timely manner can result in significant fragmentation of research and development leading to: delays to deployments; additional costs for deployers; diminished effectiveness of solutions; reduced stakeholder benefits; increased future costs due to a need for post-deployment compatibility; and inhibited global marketplace opportunities.

6 Conclusion

At the time of publication, the results have had limited review by the ITS community as a whole. The proposed resolutions will need to be presented to major industry stakeholders and experts to ensure that there is agreement with these proposals and determine appropriate next steps.

The HARTS-based standards gap analysis has proved useful by identifying 74 urgent proposed resolutions that are essential for the proper deployment of C-ITS; 42 of these proposed resolutions are defined as being of international interest.

Addressing the 74 urgent proposed resolutions will facilitate the successful, interoperable deployment of Day-1 C-ITS services by:

- Reducing risks for future deployments by developing a common framework that can be leveraged by other C-ITS standards;
- Addressing cross-jurisdictional issues related to operational constraints, regulations and policies in a consistent and interoperable basis;
- Enabling secure and reliable communications between C-ITS applications in all environments and operational domains;
- Ensuring authorisation of C-ITS operations (e.g. for traffic signal priority) in all environments and operational domains;
- Addressing the secure distribution of software updates with minimal disruption of ongoing C-ITS operations;
- Defining performance requirements for many of the functions and information flows necessary for C-ITS operations;
- Leveraging the common framework and security policies as new C-ITS standards are developed and existing standards are updated;
- Incorporating the decisions made in relation to the proposed, foundational and security-focused resolutions into new standards, and retrofit to existing standards;
- Resolving known issues or ambiguities with existing standards;
- Mitigating interoperability concerns due to overlapping standards within a specific region (e.g. which standard to use for US-based incident management).

Addressing these proposals within an international context is perceived to offer a number of significant benefits, including:

- Reduced costs due to greater efficiencies in the development of standards realised by eliminating duplicated efforts;
- Faster completion and deployment of standards resulting in the transportation industry realizing the benefits of C-ITS at an earlier date;
- A more global and competitive marketplace;
- Increased interoperability of systems which reduce barriers to deployment;

- A paradigm shift resulting in new innovations enabled by the critical-mass adoption of common technologies.

Each region and its experts and standards development organizations now have the information needed to assist in determining appropriate next steps.

With the HARTS detailed reports providing traceability between proposed resolutions and underlying issues, each region will have the tools necessary to properly gauge the scope and level of effort needed to address the proposed resolutions and, therefore the associated issues. In fact, the status and progress of work efforts to address the proposed resolutions can be dynamically tracked within the existing HARTS toolset. A benefit to using the HARTS toolset to record and track progress is the inherent ability to generate updated versions of the HARTS website that will allow the ITS community to stay informed of the current progress on addressing each issue recorded on the site and to become aware of on-going efforts to improve ITS standards.

Initial feedback regarding HARTS has been quite positive. Several countries, including the UK and Canada, have expressed interest in how they would be able to capture the information within HARTS and customise it in documenting their own project architectures.

The development of HARTS and the collaborative standards gap analysis has demonstrated that the different ITS reference architectures from the various regions of the world are actually quite similar. Further, there are significant industry trends that are driving these architectures and standards to become even more similar, including:

- Differences in regional standards (e.g., CAM/BSM, MAP and SPaT) have been/are being harmonised to facilitate global deployment of equipment;
- Many core communication technologies (e.g., DSRC, LTE CV2X, upcoming 5G, IEEE 1609.2, ISO 21177, etc.) are expected to be deployed worldwide;
- Efforts are starting to identify options for how data distribution technologies might enable ITS services in a more open, scalable, and efficient manner;
- ISO has approved the development and maintenance of a freely-available data model to enable easier sharing of information through a data distribution system;
- The marketplace for ITS equipment is becoming increasingly global in nature;
- Trends towards automation and global mobility of people and goods encourages support for standards with worldwide support;
- Many regions are now working to expand their architectures to include automated technologies and will likely perform similar analyses on what standards may be needed to support connected and automated environments.

Given the long-term trends of globalisation, more integrated networks, and the ever-increasing mobility of the populace (who travel with mobile phones and connected devices), it seems clear that international coordination in the development and maintenance of the HARTS ITS reference

architecture and collaboration on key C-ITS standards can offer real benefits to the ITS community.