INTERNATIONAL ITS COOPERATION

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

Executive Overview

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Standards Harmonisation Working Group
Harmonisation Task Group 7

MLIT Ministry of Land, Infrastructure, Transport and Tourism
European Commission
tca Transport Certification Australia
U.S. Department of Transportation

Harmonisation Task Group 7 Project Team	
Gianmarco Baldini	European Commission's Joint Research Centre
Hans-Joachim Fischer	Fischer Tech
Chuck Gendry	Iteris
Junichi Hirose	Highway Industry Development Organisation (HIDO)
Ron Ice	Ice & Associates
Tom Lusco	Iteris
Jim Marousek	Booz Allen Hamilton
David Rowe	Transport Certification Australia (TCA)
Ken Vaughn	Trevilon
Jason Venz	Queensland Transport & Main Roads
Takeshi Wada	Highway Industry Development Organisation (HIDO), formerly
William Whyte	Security Innovation
Bob Williams	Consultancy Services International (CSI)
Harmonisation Task Group 7 Leadership	
Knut Evensen	Q-Free, European Commission
Peter Girgis	Transport Certification Australia (TCA), formerly
Wolfgang Höfs	European Commission: DG Communication Networks, Content and Technology
Shinji Itsubo	National Institute for Land and Infrastructure Management (NILIM) – Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan
Phillip Lloyd	Transport Certification Australia (TCA)
Steve Sill	US Department of Transportation (USDOT)
Suzanne Sloan	US Department of Transportation (USDOT)

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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 Purpose of This Document

This document, **Executive Overview (HTG7-1),** provides:

- A high-level summary of the results of the HTG7 project and analysis
- An overview of the process used by the project
- A summary of the key results
- A detailed description of each of the other reports produced by the project
- A set of observations on the potential implications for the industry

This document is appropriate for executives and government decision makers that need to be aware of the project results at a high level. It is a useful introduction to the other reports in the series that provide readers with specific details about the methods used and the specific challenges and opportunities that face the industry in their deployment of C-ITS.

2 Approach

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.

The process used to perform this analysis is summarized in Figure 1 and further explained in the bulleted lists below. For a more detailed description of this process, see **Analysis Methodology (HTG7-2)**.

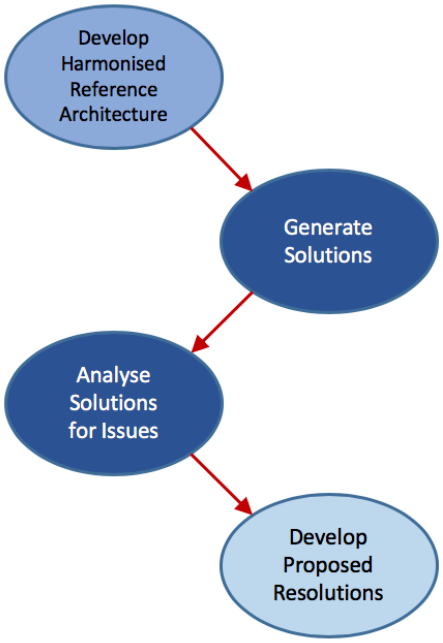

Figure 1: Approach

Develop Harmonised Reference Architecture

- HARTS is not a new architecture, but a merging of the following existing regional architectures:
  - National ITS Architecture and Framework (NIA/F) from Australia[6]
  - EU's Framework Architecture (FRAME) from Europe[7]
  - Connected Vehicle Reference Implementation Architecture (CVRIA) from the US[8]
  - C-ITS architecture constructs from Japan[9]
- Merging regional architectures was not difficult and is extensible, both to support new service packages and to incorporate other regional architectures
- The architecture was peer-reviewed and has received positive feedback and encouragement.

[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).

[6] https://austroads.com.au/network-operations/network-management/national-its-architecture

[7] https://frame-online.eu

[8] https://local.iteris.com/cvria/

[9] https://www.hido.or.jp/

Generate Solutions

- C-ITS experts from each participating region developed standards-based solutions for the data exchanges in HARTS.
- The resultant solution set allows the C-ITS community to gain a global perspective on available standards for the first time, by allowing experts to examine, assess and potentially adapt solutions from other regions in the absence of established solutions for their own region.

Analyse Solutions for Issues

- By leveraging previous standards analyses along with input from C-ITS standards experts and stakeholders from each participating region, the HTG7 team conducted a systematic, consolidated, and up-to-date[10] analysis looking for gaps and overlaps.
- The resultant set of identified issues allows the C-ITS community to gain a global perspective on the potential impacts to existing, under development, or planned deployments.

Develop Proposed Resolutions

- Assessed issues for characteristics such as urgency, severity, and timeline (i.e., category of the related service package)
- Analysis of the characterised issues yielded a smaller set of potential resolutions which were down-selected to focus on those needed to enable Day1 deployments.
- Proposed resolutions were vetted with C-ITS community.

[10] Updated though January 2018

3 Key Results

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.

The HTG7 reports identify and summarise the standards-related issues associated with the harmonised set of ***ITS services*** included in the ***reference architecture*** as well as proposed resolutions for addressing them. Key results, as detailed in reports HTG7-2 and HTG7-3, include:

- **Service Packages** - Development of 96 harmonized C-ITS service packages of interest to Australian, European, Japanese, and U.S. deployers (a number of which are in use or under deployment as of 2019)
- **Information Triples** - Identification of over 1400 information triples (source, information flow, destination) used within the 96 service packages where standardised communication solutions are in the public interest; roughly 550 of these were related to near-term (Day 1, Day 1.5 and Support) service packages
- **Solutions** - Identification of over 2300 triple solutions for the roughly 550 information triples of public interest included within the near-term service packages
- **Issues** - Identification of approximately 400 ***issues tasks***[11] (i.e., specific tasks required to resolve identified gaps or overlaps) related to the 2300 triple solutions that pose risk to implementations (ranging from low risks to “ultra-high” risks)
- **Proposed Resolutions** - Approximately 100 proposals to Standards Development Organizations, governments, and other interested parties to address the roughly 300 issues associated with Support and Day 1 service packages.

Each of these results are further detailed in the sections below.

3.1 Harmonised Service Packages

The HARTS architecture consists of 96 service packages. Each of these were categorized as one of the following:

- **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.

[11] The same ***issue task*** will often appear in multiple solutions; as a result, there are nearly 6800 issue instances across the 2300 triple solutions in the near-term service packages

- **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.

Figure 2 indicates the division among the four service package categories. At the time of publication, 34 service packages in the Support, Day 1, and Day 1.5 categories are published on the http://htg7.org website and analysed for gaps and overlaps.

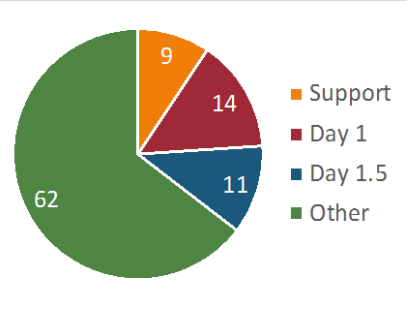

Figure 2: Service Package Timeline

3.2 Information Triples

Each service package specifies the information that needs to be exchanged among defined physical objects to enable the associated C-ITS services. Each information exchange is also called an information triple because it identifies (1) the source device, (2) the information, and (3) the destination device. Some of these information triples are used within multiple service packages. In total, the 34 Support, Day 1, and Day 1.5 service packages include 547 information triples out of the 1437 information triples. The breakout of these service packages to the different categories are shown in Figure 3.

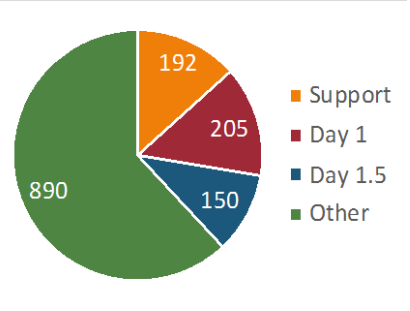

Figure 3: Information Triple Timeline

3.3 Solutions

For each information triple within the Support, Day 1, and Day 1.5 service packages, the HTG7 team identified solutions that allow the information exchanged to be achieved by a communications stack using appropriate standards. In many cases, this resulted in identifying different solutions for different regions (although some standards might appear in the solutions for multiple regions), with a total of over 2,300 triple solutions through Day 1.5. Figure 4 shows how these triple solutions align with the service package categories. This chart omits the "Other" service package category because the analysis did not comprehensively include solutions for these.

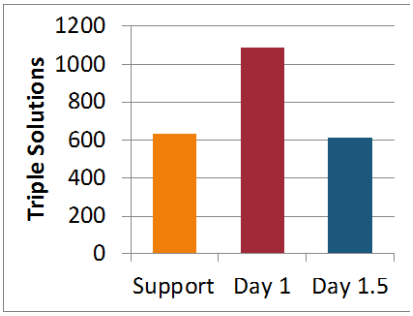

Figure 4: Solution Timeline

3.4 Issues

As a part of the analysis, the HTG7 team identified two types of issues: (1) gaps, which are instances where existing standards do not fully address all aspects of the communications stack and (2) overlaps, which indicate ambiguities regarding which standards should be used. Within the 2300-plus near-term triple solutions, the HTG7 team identified nearly 6800 issue instances that require attention to properly implement all of the identified triple solutions for Support, Day 1,

and Day 1.5 service packages. However, as shown in Figure 5, in many cases, the same fundamental issue type (i.e., some gap) associated (i.e., issue assignment) with an artefact (e.g., a standard, profile, solution, etc.) that appears in multiple triple solutions (i.e., issue instances) can be resolved through completing one issue task (i.e., activity addressing the gap in the standard). After identifying all issue instances, the team queried the database and determined that there were roughly 400 unique issue tasks that would be required to resolve all issue instances through Day 1.5.

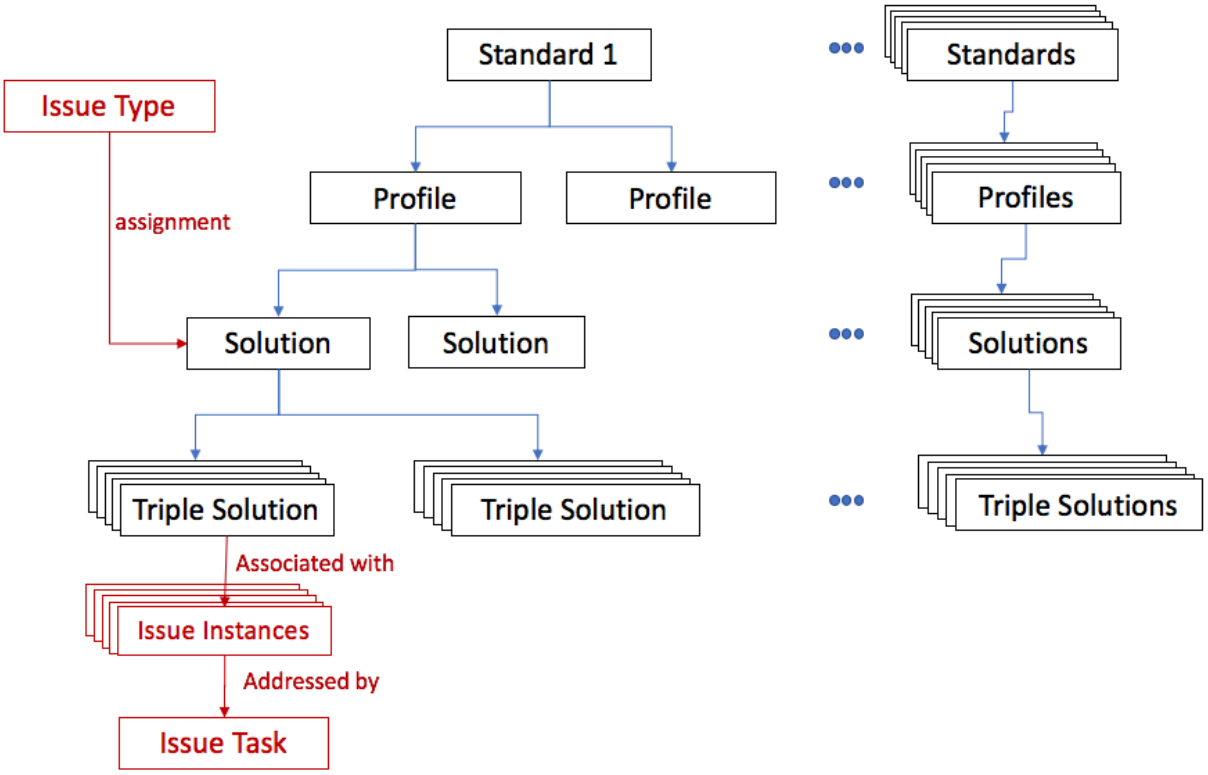

Figure 5: Issue Tasks vs. Issue Instances

Figure 6 depicts the result of categorising each of the roughly 400 issue tasks based on their service package timelines and the level of issue severity, as follows:

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

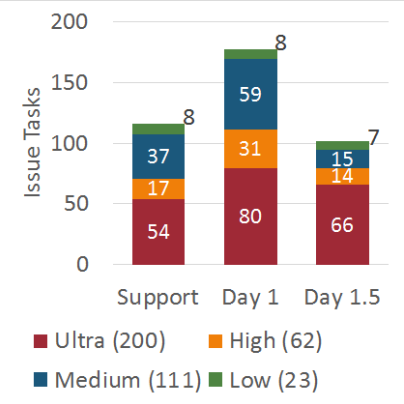

Figure 6: Issue Severity Timeline

3.5 Proposed Resolutions

Finally, the HTG7 team developed a set of proposed resolutions to address all of the issues associated with Support and Day 1 service packages. The proposed resolutions were defined at a high-level, such as an effort to develop or update a standard rather than proposing any technical details. As a result, multiple issues could often be assigned to the same proposed resolution and the roughly 300 issue tasks associated with the Support and Day 1 service packages resulted in 112 proposed resolutions. As shown in Figure 7, over half (57%) of these were of multi-regional interest, suggesting that there may be significant advantages in cooperatively addressing many of the issues.

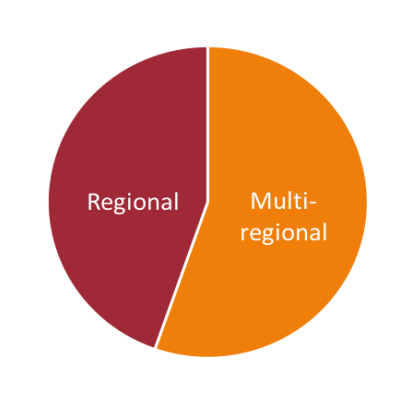

Figure 7: Multi-Regional vs Regional Proposals

The analysis also considered the urgency level of each proposed resolution, as urgent, near-term, medium-term, or future. While the majority of proposals are urgent, as one would expect since these all deal with Support and Day 1 service packages, the analysis reveals that almost a third of the resolutions are not urgent, as shown in Figure 8. Many of these non-urgent items are related to information exchanges that are included within near-term service packages but are not needed for every deployment.

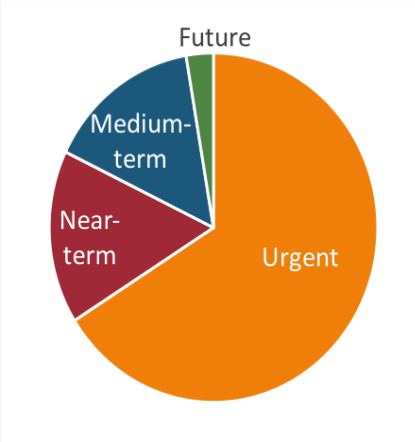

Figure 8: Urgency of Proposals

Finally, the proposed resolutions can also be viewed from the perspective of what type of experts are needed to address the issues, as shown in Figure 9. While there are a large number of proposed resolutions, the analysis indicates that

these proposals span a considerable range of expertise suggesting that much of this work can be performed in parallel rather than having to wait for the availability of experts in a specific sector.

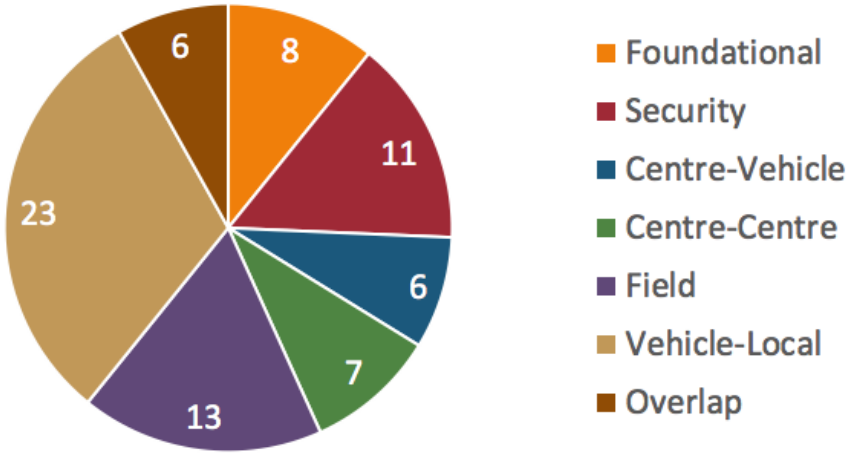

Figure 9: Required Expertise

4 Published Results

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

- **Executive Overview (HTG7-1, this document)** - A high-level summary of the approach, process and the key results of HTG7.
- **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)** - 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[12]).
    - **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[12]).
- **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

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

- Acronyms and associated meanings
- Graphic symbols and associated meanings
- Explanations of key terms and their inter-relationships

5 Observations

The HTG7 work and results are based on a snapshot in time—they reflect the knowledge, experiences, and standards available within the 2016-2018 timeframe. The process of summarizing these results leads to two observations about next steps to consider for the C-ITS community:

I. **HTG7 has established the ability to address gaps/issues in C-ITS Standards.** The categorization of the issues and the proposed resolutions form the basis for key parties and stakeholders to develop action plans and roadmaps based on their interests and priorities.

- The analysis revealed that over half (57%) of the "urgent" proposed resolutions are of multi-regional interest. This implies that the following significant benefits might be gained through collaborative standards adaptation or development:
  - 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, innovative, and competitive marketplace yielding more effective solutions and lower deployment costs
  - Increased interoperability of systems which increases consumer satisfaction and safety as well as reduces barriers to future deployments
  - Decreased costs for standards development in the post-deployment phase, by eliminating the need to harmonise after the fact.
- The proposed resolutions were developed with industry and transportation stakeholder community cooperation in mind. Stakeholders and standards developers can thus:
  - Ensure that there is consensus. Ideally, through international collaboration, the result of each resolution would be a single internationally-acceptable solution that can be adopted or easily adapted to meet national requirements through either companion standards or an annex to the main standard.
  - Create actionable plans by allowing for each participating region to develop its own roadmap and ensure that all of their priority resolutions (both regional and multi-regional) are adequately addressed and that each issue instance is clearly associated to a specific task on the roadmap.
  - Track progress in addressing all known proposed resolutions and associated issues for each region. The tracking of this work can be done within the existing HARTS toolset.

- Achieving these benefits will require targeted investments and commitments, including:
  - Cooperation to define the proper scope and format of standards to ensure that the approach facilitates harmonisation and interoperability with existing regional approaches.
  - Recognition that harmonising among disparate partners requires time, but often produces higher-quality and longer-lasting standards with commensurately lower life-cycle costs.

II. **HARTS is a tool that can be adopted, maintained, and evolved by the C-ITS community.** It has the ability to:
- Serve as a tool for tracking completion of C-ITS standards and can be extensible to any analysis on gaps/issues in automation standards
- Serve as a guide for the next generation of cooperative and automated deployments to inform them of standards solutions available to them.
- Expand to include additional service packages (which might include service packages currently contained in the "Other" category and/or new service packages) as well as incorporate architectural viewpoints of other reference architectures and thus support new C-ITS participants.
- Evolve to incorporate emerging technologies
- Be customized with other features/capabilities that allow planners and implementers to further tailor their deployment plans.
- Be integrated into existing reference architectures to allow for use of specific tool sets (e.g., the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)[13] is associated with two support tools: the Systems Engineering Tool for Intelligent Transportation (SET-IT)[14] and the Regional Architecture Development for Intelligent Transportation (RAD-IT)[15] that may be used with standards solutions).

In providing these final observations, the HTG7 team is hopeful that the reports and tools provided can offer an organized path forward to resolving the standards issues in C-ITS.

[13] http://arc-it.org/

[14] https://local.iteris.com/arc-it/html/resources/setit.html

[15] https://local.iteris.com/arc-it/html/resources/radit.html