2ND ANNUAL ELECTRIC VEHICLE SAFETY STANDARDS SUMMIT

SUMMARY REPORT

27 & 28 September 2011
Detroit, Michigan

Co-Hosted by SAE and NFPA

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EXECUTIVE SUMMARY

In the last several years has seen a resurgence of electric vehicles and hybrid electric vehicles in the passenger vehicle marketplace. The successful proliferation of these new vehicles is partially dependent on the safe implementation of this new technology, and how well safety codes and standards address this overall topic is a key component to this success.

Strong incentive exists to proactively address all the safety concerns relating to these new vehicles, their components such as batteries, and the supporting technology in the built infrastructure like charging stations. As a result, the *U.S. National Electric Vehicle Safety Standards Summit* was held during October 2010 in Detroit Michigan. This earlier Summit developed the base elements for an action plan in support of the safe implementation of electric vehicles, using safety codes and standards as the primary mechanism for this action plan.

The purpose of the *Second Annual Electric Vehicle Safety Standards Summit* (September 2011) was to bring appropriate stakeholder groups together to further refine a shared implementation plan to ensure that fire and electrical safety standards impacting electric vehicles do not serve as a barrier to their deployment. In doing so, the intent has been to build on the success of the previous Summit (October 2010). The specific objectives of this latest event were:

- Review the significant progress since the previous Summit (October 2010) and apply the lessons-learned for future enhanced action plans;
- Further clarify the relevant fire and electrical safety codes, standards and specifications which address the safety hazards associated with the widespread implementation of electric vehicles;
- Review progress to fill identified gaps in these codes, standards and specifications (i.e. changes/enhancements and/or new standards), and identify new gaps that have arisen;
- Review progress to fill related gaps in research, training, and communications; and
- Refine and enhance the previously established action plan to fill these gaps for necessary standards development and associated support activities.

Noteworthy activity and progress has occurred since the previous Summit in all the important topical areas. Significant revision and update efforts have been on-going within multiple established codes and standards activities focused on vehicles, batteries, electric vehicle supply equipment, and the supporting electrical infrastructure. Training and education initiatives have made impressive progress, primarily for emergency responders and (separately for) electricians, including content development and dissemination efforts. Electric vehicle supply equipment is maturing and experiencing growing implementation, and includes the coordination of important technical details to support the widespread implementation of electric vehicles. Batteries for electric vehicles continue to experience new technological developments, and

research has been completed and is continuing to address the battery hazards for all anticipated settings, including beyond the vehicle (e.g., bulk storage and transportation).

Several broad underlying themes manifested themselves during the Summit. One is the need to consider batteries as a technology distinct from vehicles. Another is to consider extrapolating our collective out-reach to includes all important stakeholders such as vehicle dealers, public garage operators, automobile insurers, vehicle technicians, etc.

The information exchanged and collected throughout the Summit has been reviewed, consolidated, synthesized and distilled into its essential characteristics, resulting in the following key identified topic issues:

(I) Battery hazards;
(II) EVSE component and electrical load standardization;
(III) Comprehensive stakeholder involvement; and
(IV) Vehicle and component standardization

These key identified issues have risen to the top for consideration as the primary elements for an action plan or plans going forward. In addition, two broad concepts of training & education and data analysis are also included as supplements to these four primary topic issues. Going forward these key identified issues represent the basis of the primary deliverables from the Summit, for use in support of an action plan or plans, or in other ways as deemed appropriate.

A significant by-product of this Summit has been the dialogue facilitated between key stakeholders on critical issues. The Summit provides a unique venue for diverse groups (e.g., vehicle designers, battery manufacturers, emergency responders, charging station suppliers, public utilities, facility insurers, salvage operators, etc) to engage in important dialogue on a common platform. All of these constituency groups have interests and concerns that need to be considered in a coordinated manner for the successful implementation of electric vehicle technology. Continuing the facilitation of this dialogue, on all levels, is an important outcome from this Summit.

ACKNOWLEDGEMENTS

This Summit was co-hosted by SAE International and the National Fire Protection Association. Appreciation is expressed to all who were involved with and assisted in the planning and implementation of the event, in particular the staffs of the respective co-hosting organizations.

SAE International has more than 121,000 members - engineers, business executives, educators, and students from more than 97 countries - who share information and exchange ideas for advancing the engineering of mobility systems. SAE is your one-stop resource for standards development, events, and technical information and expertise used in designing, building, maintaining, and operating self-propelled vehicles for use on land or sea, in air or space.

The mission of the international nonprofit National Fire Protection Association (NFPA), established in 1896, is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. NFPA is the world's leading advocate of fire prevention and an authoritative source on public safety, NFPA develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks. NFPA membership totals over 75,000 individuals around the world.

2nd Annual Electric Vehicle Safety Standards Summit
Co-Hosted by SAE and NFPA

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1. INTRODUCTION AND BACKGROUND

The concept of passenger vehicles powered by electric propulsion systems is not new. In 1913 there were an estimated 30,000 electric vehicles in the United States, and Detroit became the first American city to use electric taxi cabs in 1914.[1] Depending on marketplace dynamics and multiple other influencing factors, the popularity of electric powered passenger vehicles has come and gone several times through the decades; witness vehicles such as the GM Electrovair fifty years ago and the GM EV-1 twenty years ago.[2]

The last several years has seen a strong resurgence of electric vehicle technology on the roadways in the North America and elsewhere. Today, technology and legislative trends are aligned to drive significant growth in vehicular electrification. In 2009, President Barack Obama established a goal to have one million electric vehicles on U.S. roads by 2015, and his administration has championed a $2.4 billion initiative through the American Recovery and Reinvestment Act to promote electric vehicle research and development.[3]

The technology involving passenger motor vehicles reaches far beyond the vehicle itself, and safety codes and standards relating to vehicles and their support infrastructure address a wide range of issues. As new technology emerges that is supporting the proliferation of vehicles based on electrical power sources, questions exist as to how well the current codes and standards adequately address all the safety concerns relating to these new vehicles, their components, and the supporting technology in the built infrastructure.

The original Summit held in September 2010 was based on the following three basic realms of codes and standards activity relating to electric vehicle safety: (1) vehicles; (2) built infrastructure; and (3) emergency responders.[4] Based on the information gleaned from that event, as well as our evolving understanding of the overall electric vehicle topic, this year's Summit was based around the following four main subject areas:

- Vehicles/Batteries: Standards-developing-organization (SDO) Standards and original-equipment-manufacturer (OEM) manuals addressing safety in the vehicle or batteries;
- Emergency Response: SDO Standards addressing emergency response to vehicle related emergencies in all possible settings;
- Built Infrastructure: SDO Codes and Standards addressing the built infrastructure that support electric vehicles (e.g., recharging stations, battery storage, etc); and
- Support Services and User Perspective: Other related Codes and Standards that support the safe implementation of this technology (e.g., battery bulk storage, salvage, etc).

These four subject areas are illustrated in Figure 1, *Basic Topic Areas Addressed at the 2011 Summit*. It is noted that these subject areas co-exist with equal importance, such that a critical safety concern in any one area can have significant overall impact. Understandably some areas precede others, e.g., the manufacture of vehicles would naturally lead to the evolution of

required support services. Some activities are reactionary, such as emergency response, versus proactive marketplace-driven initiatives such as new battery technology.

But regardless of the distinctly different characteristics of each of these four areas, they are woven together in a complex interdependent fabric that requires coordinated attention among diverse stakeholders to address important identified safety concerns. Barriers or problems that arise in any one area have the capacity to cripple the overall electric vehicle initiative. Success requires collaborative dialogue and coordinated effort.

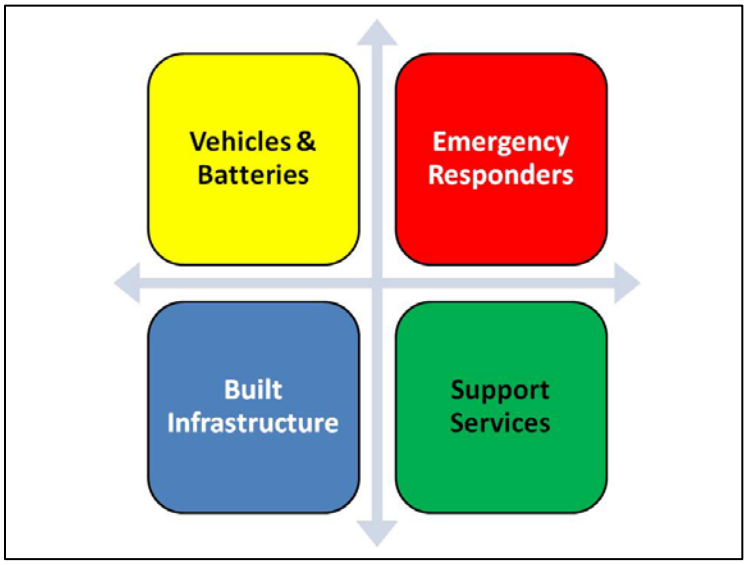

Figure 1: Basic Topic Areas Addressed at the 2011 Summit

In the United States there are a wide range of consensus model codes and standards that address electric vehicles and the multitude of issues relating to and supporting electric vehicles. These address or relate to safety issues for EVs and HEVs either in whole or in part, which are of interest to emergency responders and other safety professionals. They address concerns and provide information about not only the vehicle itself but also for the supporting infrastructure (e.g., charging stations and other similar auxiliary support equipment), as well as operational information for direct use by emergency responders.

A vast, diverse and decentralized network of private codes and standards developers exists around the world today, and in the United States the codes and standards community maintains an inventory of almost 100,000 documents covering a great range of topics.[5] Table 1 provides a summary of the Codes and Standards documents and developers in the United States. It includes model documents developed by private codes and standards developers, and documents developed directly by the federal government.

Table 1: Codes & Standards Documents and Developing Organizations in the United States[6]

	Developer / Organization	Total # of Standards	Percent	Total # of Organizations	Percent
Private Sector	Codes & Standards developing organizations	17,000	18%	40	6%
	Trade association	16,000	17%	130	19%
	Scientific and professional societies	14,000	15%	300	43%
	Developers of informal standards	3, 000	3%	150	21%
	Private Total	49,000	53%	620	89%
Federal Govt	Department of Defense	34,000	37%	4	1%
	General Services Administration	2,000	2%	1	1%
	Other	8,000	8%	75	10%
	Federal Government Total	44,000	47%	80	11%
	Overall Total	93,000	100%	700	100%

One activity of significance initiated since the previous Summit in October 2010 is the Electric Vehicle Standards Panel (EVSP) under the auspices of the American National Standards Institute (ANSI). The ANSI EVSP was formed earlier in 2011, and has been capturing the various standards-related activities and compiling them in one place to provide greater clarity. They are not developing standards and do not intend to duplicate the work of others. The ANSI EVSP is attempting to address the following tasks:[7]

- Catalog existing standards (published, in development, under revision)
- Define where gaps exist / identify priorities for needed standards, organizations that may be able to perform the work, and target dates
- Identify harmonization / coordination issues of concern and make recommendations for addressing them
- Do the same for related conformity assessment programs, codes and regulations as needed and appropriate

Chapter One Footnotes

1) Bohn, T., "Progress & Gaps on Vehicle Research: Issues with PEV Standards", presentation at *Second Annual Electric Vehicle Safety Standards Summit*, Detroit MI, September 2011.
2) ibid
3) NFPA Press Release, "NFPA Receives Grant to Develop Electric Vehicle Training Program for Emergency Responders", www.nfpa.org, National Fire Protection Association, Quincy MA, 16 June 2010.
4) Grant, C., "U.S. National Electric Vehicle Safety Standards Summit", Fire Protection Research Foundation, October 2010.
5) Cote, A.E., Grant, C.C., "Codes and Standards for the Built Environment", Fire Protection Handbook, 20th edition, National Fire Protection Association, Quincy MA, Sect. 1, Chap. 3, Tables 1.3.3 & 1.3.4, 2008, pg. 1-61 & 1-62.
6) Toth, R.B., "Standards Activities of Organizations in the United States", NIST Special Publication 806, National Institute of Standards and Technology, Gaithersburg MD, 1996.
7) Pauley, J., "The ANSI EV Standards Panel – Importance of Linking the Standards Together", presentation at *Second Annual Electric Vehicle Safety Standards Summit*, Detroit MI, September 2011.

2. SUMMIT FORMAT, AGENDA AND VENUE

The *Second Annual Electric Vehicle Safety Standards Summit* was a two-day information sharing and planning event held on 27-28 September 2011 at the Detroit Marriott at the Renaissance Center, Detroit, Michigan, USA. Over 140 attendees participated in the meeting that was co-hosted by SAE International and the National Fire Protection Association.

This latest Summit follows the successful *U.S. National Electric Vehicle Safety Standards Summit* held on 21-22 October 2010 in Detroit Michigan. The October 2010 Summit was a ground-breaking event that addressed safety related codes and standards issues relating to electric vehicles, the built infrastructure supporting these vehicles, and the concerns of the emergency response community. The report on the first Summit (October 2010) is available at the following link: www.nfpa.org/assets/files//PDF/Research/RFUSNEVSSSummit.pdf.

The purpose of the *Second Annual Electric Vehicle Safety Standards Summit* was to bring appropriate stakeholder groups together to further refine a shared implementation plan to ensure that fire and electrical safety standards impacting electric vehicles do not serve as a barrier to their deployment. In doing so, the Summit intended to build on the success of the previous Summit (October 2010). The specific objectives of this latest event were:

- Review the significant progress since the previous Summit (October 2010) and apply the lessons-learned for future enhanced action plans;
- Further clarify the relevant fire and electrical safety codes, standards and specifications which address the safety hazards associated with the widespread implementation of electric vehicles;
- Review progress to fill identified gaps in these codes, standards and specifications (i.e. changes/enhancements and/or new standards), and identify new gaps that have arisen;
- Review progress to fill related gaps in research, training, and communications; and
- Refine and enhance the previously established action plan to fill these gaps for necessary standards development and associated support activities.

This Summit took place over two full days. Day One of the Summit involved multiple speakers and presentations, mostly based on a panel format, which covered an array of topics and facilitated additional discussion involving all the Summit attendees. Day Two involved separate Workgroups intended to further enhance participant interaction that reported back to a Summit plenary session.

The Summit presentations and discussions were grouped according to the following four main subject areas: vehicles/batteries; emergency response; built infrastructure; and support services. The Day One panel presentations and panel discussion followed this grouping, as did the Workgroups on Day Two. For Day Two, the attendees separated into four concurrent Workgroups with stakeholders assigned to each Workgroup, to review and complement the Day One discussions. Stakeholders were assigned to each Workgroup in a balanced manner,

and an effort was made to evenly distribute individuals from the same organizations among each of the groups.

Each of the four Workgroups on Day Two had a central theme that served as their primary focus that they were to address first, followed by the other themes that were not their particular priority. Thus, no issue was necessarily exempt from any particular Workgroup, despite their priority theme. The Workgroup assignments and their respective primary themes were: Workgroup #1: Vehicles/Batteries; Workgroup #2: Emergency Responders; Workgroup #3: Built Infrastructure; and Workgroup #4: Support Service and User Perspective.

At the end of Day Two a final plenary session reported the results of each Workgroup's discussions to the full assembly, and allowed a single final collective discussion. This overall Report serves as the documentation of the Summit, and includes the essential information that provides the basis for codes and standards development and associated supporting activities to facilitate the safe implementation of electric vehicles.

3. DAY ONE PRESENTATION SUMMARY

The purpose of Day One of the Summit was to provide baseline information in support of the overall event. The information provided during Day One focused on the following: a review the significant progress since the previous Summit (October 2010); how lessons-learned for future enhanced action plans have been applied; clarification of the relevant fire and electrical safety codes and standards; clarification of the relevant research and training activities; review of progress to fill identified gaps; and refinements to action plans going forward.

The Day One presentations were designed to be relatively succinct and to stimulate further interactive discussions among all participants. Table 2 provides a summary of the speakers who made presentation during Day One of the Summit.

Throughout Day One participants provided additional input and clarification through questions and answers involving a facilitated panel discussion at the end of each session. This was intended to prepare for Day Two, which involved separate Workgroups that provided further participant interaction that would ultimately report back to a Summit plenary session. This arrangement was consistent with the Summit's goal to provide a venue for the gathering of key stakeholders composed of individuals, organizations and agencies to develop a shared implementation plan to ensure fire and electrical safety standards addressing electric vehicles will facilitate their deployment while maintaining safety.

The Day One presentations were grouped around four main subject areas. The approach used was for each presenter to briefly (approximately 15 minutes each) present on their topic, including information such as an assessment of existing on-going standards activities in that area, identified potential gaps in both existing content and needed new standards, and recommendations of next steps. The four main subject areas addressed during Day One of the summit were:

- Vehicles/Batteries: Standards-developing-organization (SDO) Standards and original-equipment-manufacturer (OEM) manuals addressing safety in the vehicle or batteries;
- Emergency Response: SDO Standards addressing emergency response to vehicle related emergencies in all possible settings;
- Built Infrastructure: SDO Codes and Standards addressing the built infrastructure that support electric vehicles (e.g., recharging stations, battery storage, etc); and
- Support Services: Other related Codes and Standards that support the safe implementation of this technology (e.g., battery bulk storage, salvage, etc).

Following a keynote presentation, the lead-off session first focused on "the big picture" and provided useful background information on the present state of the electric vehicle topic. This included a review of the details of the October 2010 *U.S. National Electric Vehicle Safety Standards Summit*, an update on federal regulatory policy, and discussion on present and anticipated trends within the electric vehicle market. For future trends, the prediction was

offered that the cost-effectiveness of electric vehicles will match internal combustion engine vehicles by 2018. This session provided a big picture perspective on where we've been, where we are now, and where we are going.

Table 2: Speakers and Presentations during Summit Day One

Welcoming Remarks
• *Jack Pokrzywa, Director of Operations of SAE Automotive Headquarters and Manager of SAE Ground Vehicle Standards, SAE International*
• *Christian Dubay, Vice President and Chief Engineer, National Fire Protection Association*
Keynote Presentation
• **Electric Vehicle Safety Integration** *– Robert C. Lange, Vice President for Vehicle Engineering, Exponent*
Session: The Big Picture
• **Review of U.S. National Electric Vehicle Safety Standards Summit: October 2010** *– Casey Grant, Fire Protection Research Foundation*
• **Update on Federal Regulatory Policy** *– Phil Gorney, National Highway Traffic Safety Administration*
• **Trends with the Electric Vehicle Market** *–Aaron Tweadey, PwC's PRTM Management Consultants*
Session One: Vehicles/Batteries
• **Progress & Gaps on Vehicle Battery Safety Standards** *– Rajesh Nagappala, General Motors Corporation*
• **Vehicle Battery Safety Standards Update** *– Bob Galyen, Magna e-car*
• **Progress & Gaps on Vehicle Research***–Ted Bohn, Argonne Laboratories*
• **Standards Implications of Current Battery Research** *– Alvaro Masias, Ford Motor Company*
• **Plenary Discussion with Facilitated Q&A** *– Facilitator: Jack Pokrzywa, SAE International*
Session Two: Emergency Responders
• **Electric Vehicle Safety Training for Emergency Responders** *– Andrew Klock, Emergency Responder Electric Vehicle Training Project*
• **Case Study Review of Multiple Electric Vehicle Fire** *– Bob Duval, NFPA Senior Fire Investigator*
• **Enforcement Officials Update** *–Jon Nisja, Office of Minnesota State Fire Marshal*
• **Plenary Discussion with Facilitated Q&A** *– Facilitator: Ken Willette, National Fire Protection Association*
Session Three: Built Infrastructure
• **The ANSI Electric Vehicle Standards Panel: Importance of Linking Standards Together***– Jim Pauley, Schneider Electric, EVSP Co-Chair*
• **Electric Vehicle Charging and Electrical Safety Codes and Standards** *–Lonny Simonian, California Polytechnic State University*
• **National Electrical Code Update** *– Mark Earley, National Fire Protection Association*
• **Utility Perspectives** *– Seth Gerber, Consumer Energy*
• **Electric Vehicle Supply Equipment (EVSE) Standardization** *– Ken Boyce, Underwriters Laboratories*
• **Plenary Discussion with Facilitated Q&A** *– Facilitator: Bill Burke, National Fire Protection Association*
Session Four: Support Services and User Perspective
• **Electric Vehicle Towing, Road Service and Recovery** *– Bill Giorgis, Michigan Towing Association*
• **Lithium Ion Batteries: Property Insurance Perspective** *– Rich Gallagher, Zurich Services Corporation*
• **Clean Cities and Electric Vehicles** *– Carl Rivkin, National Renewable Energy Laboratory*
• **Plenary Discussion with Facilitated Q&A** *– Facilitator: Chris Dubay, National Fire Protection Association*
• **Day1 Summary Observations, and Overview of Day2** *– Casey Grant, Fire Protection Research Foundation*

The session on "Vehicles/Batteries" focused on the activities surrounding vehicles, as well as on batteries and electrical propulsion systems. Much activity has been on-going in these areas, with presentations suggesting significant progress on vehicle issues, and likewise on batteries

though with arguably greater challenges based on the diversity of the emerging battery technologies. Mention was made of the different standards applicable to the different types of electric vehicles and batteries, and safety features included in today's vehicle designs. Different and somewhat unexpected implications are continually being surfaced, such as, for example, the evolving communications protocols between the vehicles and infrastructure introducing new vulnerabilities (e.g., intentional cyber disruption).

During the discussion in the session on Vehicles/Batteries, it was pointed out that the illustration derived from last year's Summit on the primary realms of focus has been helpful, but it also needs to be updated. As background, Figure 2 illustrates the original realms of focus from the October 2010 Electric Vehicle Summit.

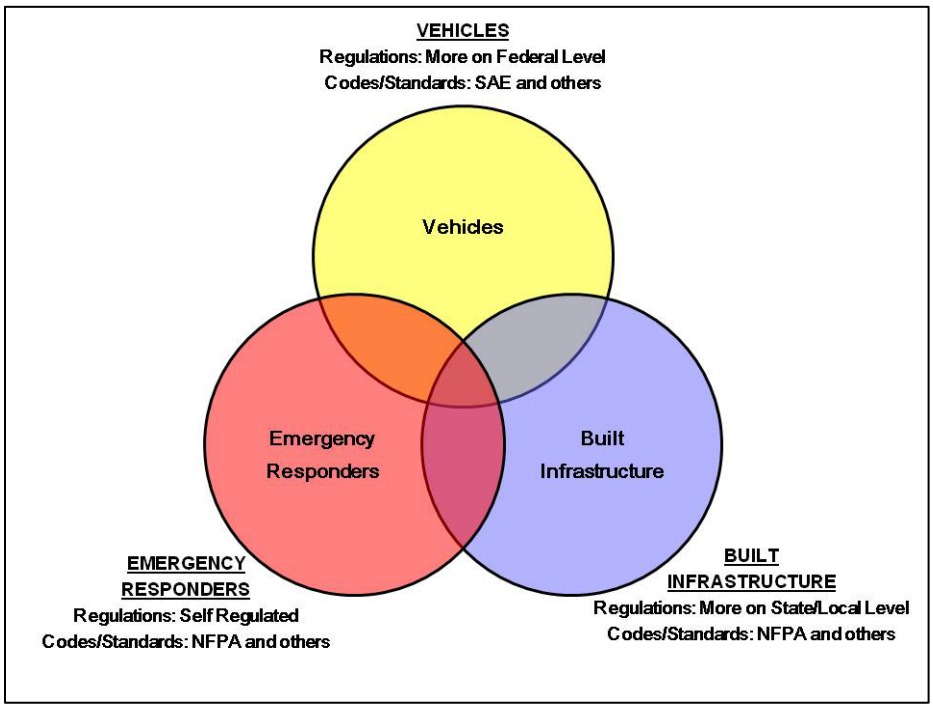

Figure 2: Original Realms of Focus from October 2010 Electric Vehicle Summit

It was indicated that this illustration should be further refined based on current standardization efforts. In particular, while vehicles and batteries are closely related they are deserving of separate consideration due on the complexities of the technology and other influencing factors. For example, unlike other sources of power, batteries are an active power source that are always providing output and require different emergency responder considerations.

Further, the discussion to modify the illustration from last year's Summit indicated that support services were likewise absent and should be included. Based on this discussion, and additional feedback throughout the Summit, this illustration has been further revised and is included herein as Figure 3, *Basic Realms of Focus on Electric Vehicle Related Codes and Standards*.

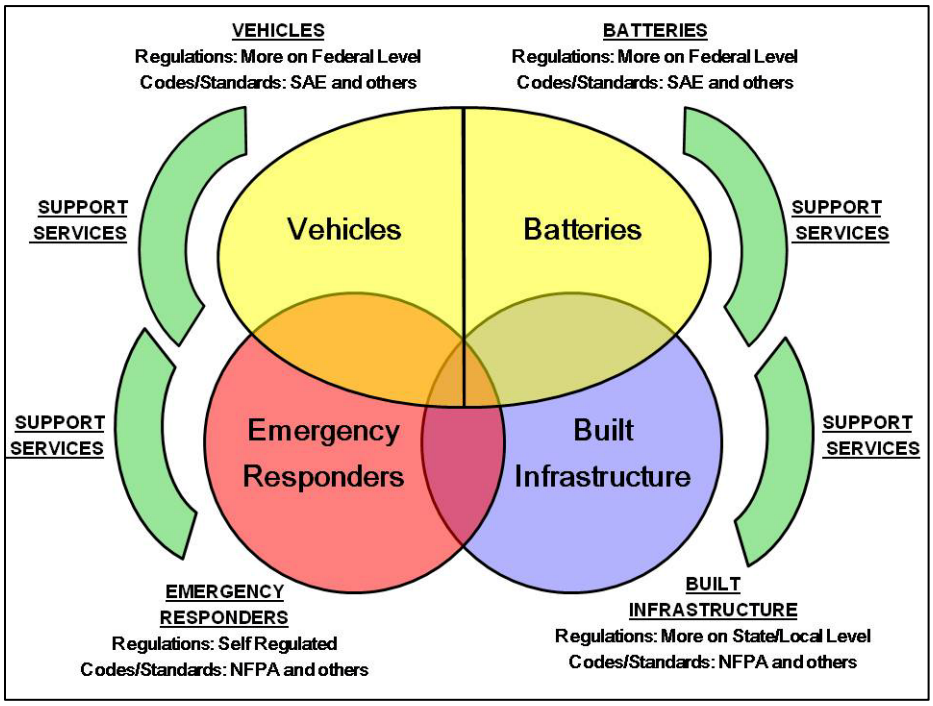

Figure 3: Basic Realms of Focus on Electric Vehicle Related Codes and Standards

The "Emergency Responder" session addressed the interests and concerns specific to the emergency response community. Updates were provided on expansive training and education efforts, details of a specific high-profile fire event involving multiple electric vehicles that had received national news attention when it occurred, and clarification of the efforts of enforcers and emergency responders for dealing with built infrastructure and other safety related emergencies. The opportunity to consider the details of an actual event that was not hypothetical provided a useful backdrop to discussions.

The significant progress that has been made on training and education of emergency responders is noteworthy, in particular through the NFPA electric vehicle emergency responder training initiative. The need to address this topic was one of the key findings from last year's Summit. Research has likewise supported the development of training materials, such as a recent report from the Fire Protection Research Foundation on the challenges of powered rescue tools (for vehicle extrication) due to the high-strength steels being used in electric vehicles. In discussion on where to go next on this topic, it was clearly noted that this effort needs to extend beyond the present focus with the fire service and include others in the emergency response community.

Specifically, this discussion invoked further feedback on the concept of emergency first responders and emergency second responders, and the need to clarify these terms. During discussion, participants at the Summit from law enforcement echoed the need to extrapolate established training and education materials to better serve their constituents. Likewise, other

responders such as tow operators, electrical utilities, and fire investigators beyond the wave of initial emergency first responders need to be considered.

Figure 4 is offered to illustrate the emergency responder infrastructure. This provides a general framework to assist with understanding the roles of those involved in this infrastructure.

The "*Emergency First Responders"* are those professionals that are normally the first line of defense for handling the emergency, and who have primary authority at the emergency (i.e., incident command). The "*Emergency Second Responders*" are those professionals who also get called to the emergency and serve a specific critical function, though they do so under the direction of the responders with incident command.

It's noted that often the *emergency second responders* may be the first on the scene of an emergency, for example tow operators who provide roadside assistance. A final group of "*Emergency First Receivers*" is also included, which effectively is the destination when transport is involved. These are the professionals that ultimately deal with emergency scenarios by providing long-term solutions.

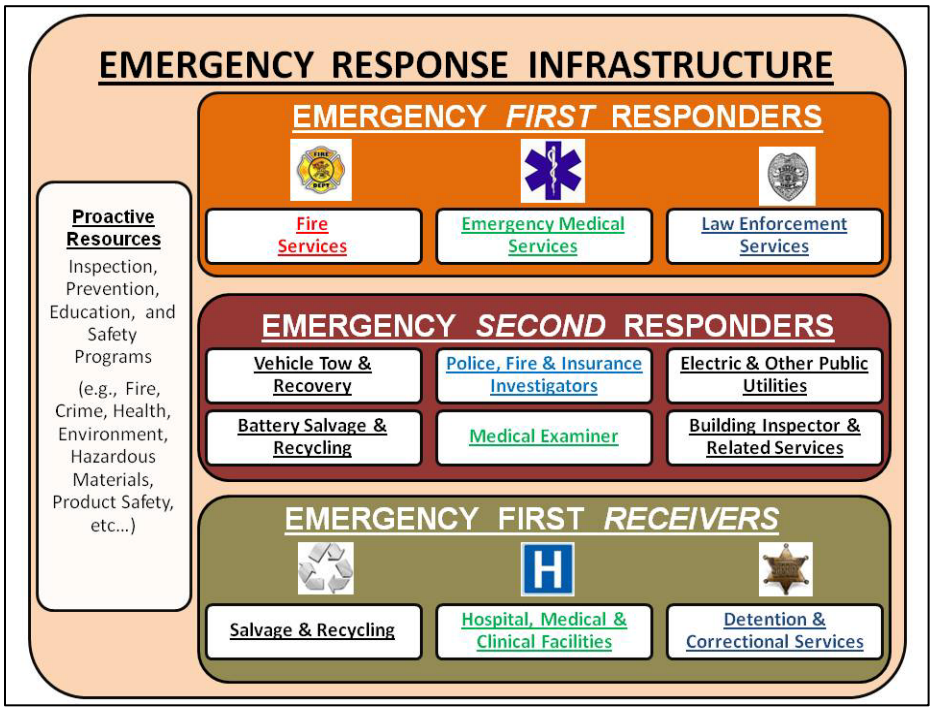

Figure 4: Emergency Responder Infrastructure

The session on the "Built Infrastructure" addressed electric vehicle supply equipment (EVSE), along with equipment, facilities and processes not integral to the vehicles but essential to the success of the overall electric vehicle program. Similar to the earlier sessions, information was provided indicating significant progress in this area.

From the perspective of the ANSI EVSP, the safety issues relating to the built infrastructure are evolving into three basic groupings: general, residential locations and public charging locations. The general issues include: charger connectivity; electricity loads and flow; and environmental conditions. The issues involving residential locations include: installation of charging stations and related components; power capacity assessment; NEC compliance; permitting; and installer qualifications. Public charging locations present different safety issues, including: signage; lighting; security; accessibility; physical protection; maintenance; cord management; and multiple battery storage.

Other presentations and discussions clarified appreciable work that is on-going in key codes and standards related activities, most notably with the National Electrical Code®. Specific issues that were also discussed included charging station designs, other type of supporting equipment and facilities, and electrical infrastructure support through the existing grid, including business models.

Detailed information was provided in this session on certain key infrastructure issues, such as a side-by-side comparison of the multiple charging levels (i.e., levels 1, 2, and 3) based on different available specifications. Examples were provided of established and successful electric vehicle training programs for electricians. The observation was made that the enforcement component of the built infrastructure has not manifested itself as a noteworthy obstacle, as had been suggested from last year's Summit.

"Support Services and User Perspective" was the final session, providing useful information on ancillary activities and programs that, despite being less-obvious among other initiatives, have an equally critical role in the overall safe implementation of electric vehicle technology. This included helpful information on the role of emergency second responders such as tow and salvage operators, an overview of the concerns of property insurers on the bulk storage and handling of lithium ion batteries, and an update on the DOE "Clean Cities" program that is serving as an important venue for promoting and enabling electric vehicle technology.

Appreciable work is on-going on certain subjects that are cross-cutting and of interest to all participants. An example mentioned during this final Day One session is the Lithium-Ion battery research being sponsored by the insurance companies facing the challenges on bulk storage and bulk transportation. Specifically a research project and workshop on battery storage and handling hazard assessment was completed earlier in 2011 through the Fire Protection Research Foundation, and further research is planned.

The discussions based on "Support Services and User Perspective" clarified the tangible progress that has been made to reach out to certain directly affected constituent groups (e.g., emergency responder training). However, it was also a clear result of these discussions that going forward we need to collectively broaden our vision to better engage all affected stakeholders beyond the obvious groups already included. Some are already being engaged first-hand at this latest Summit such as the salvage and tow operators, yet incentive was

expressed to reach even further to other constituents and professionals, such as vehicle technicians, public garage owners and operators, automobile insurers, vehicle dealers, and all others whose involvement is important to the successful roll-out of this technology.

In general, the Day One presentations and participant discussions provided significant value in sharing concepts and enabling appreciation of the wide range of technical issues. This established a baseline of understanding for the Day Two Workgroup discussions.

In closing the Day One discussion, it was expressed that the widely diverse backgrounds and interests of the attendees is a unique feature of this Summit, as compared to other conferences, workshops and meetings that tend to lean toward one (or a group of) subject area(s) or constituent group(s). Although already stated it is worth emphasizing the significance of this dialogue established among key stakeholders on critical issues.

The interests and concerns of vehicle designers, battery manufacturers, emergency responders, charging station suppliers, public utilities, facility insurers, and salvage operators (to name a few), are all different, and yet all of these interests and concerns need to be considered in a coordinated manner for the successful implementation of electric vehicle technology. In this regard, future on-going work on this overall topic should consider all available opportunities (e.g. using social media) to further facilitate this dialogue.

4. WORKGROUP REPORTS

Each Workgroup met on Day Two with an assignment to address a set of similar questions. The purpose of these questions was to facilitate consistency between the independent discussions, and allow coordinated focus on identifying the progress since the previous Summit and what issues still require attention.

Each of the four Workgroups was assigned its own baseline theme. The intent of each baseline theme was to provide the particular group a priority topic area that they addressed first. Workgroups were, however, not excluded from addressing the other themes or topic areas as time permitted. The themes assigned to the Workgroup were:

- Workgroup One (WG1) - Vehicles/Batteries
- Workgroup Two (WG2) - Emergency Responders
- Workgroup Three (WG3) - Built Infrastructure
- Workgroup Four (WG4) – Support Services and User Perspective

The assignment for each Workgroup was a consistent set of questions and case studies. These questions, and the consolidated responses to each question, are summarized in Table 3, *Abbreviated Summary of Workgroup Discussions for Structured Questions*. This table is an abbreviated version of the full information contained in Annex B, which includes more detail for each specific identified item, along with identification of the Workgroup that generated the particular item.

Table 3: Abbreviated Summary of Workgroup Discussion for Structured Questions

1) General.

a) What notable progress has been made since the previous Summit (October 2010)?

- **EVSE Standardization:**
- **Infrastructure Enforcement:**
- **International Harmonization:**
- **Stakeholder Involvement:**
- **Technology Deployment:**
- **Training and Education:**

b) What have been the specific lessons-learned for future action plans, i.e., what still needs to be addressed as part of the on-going action plan?

- **Battery Hazards:**
- **Data Analysis:**
- **Electric Vehicle Supply Equipment:**
- **New Technology:**
- **Stakeholder Involvement:**
- **Training and Education:**

c) What is the single most important issue that needs to be addressed by this topical safety Workgroup?

- **Battery Hazards:**
- **EVSE Electrical Loads:**
- **EVSE Standardization:**
- **Vehicle Standardization:**

2) Safety Codes, Standards and Specifications. For the portfolio of relevant safety codes, standards and specifications that address hazards associated with the widespread implementation of electric vehicles:

a) What are the identified gaps?

- **Battery Hazards:**
- **Emergency Response Guides:**
- **Electric Vehicle Supply Equipment:**
- **Outage Management:**
- **Salvage and Recycling:**
- **Vehicle Disconnects & Shutdowns:**
- **Vehicle Labeling:**
- **Wireless Technology:**

b) What progress has been made to fill these gaps (e.g., changes/enhancements and/or new standards)?

- **Battery Hazards:**
- **EVSE Standardization:**
- **Stakeholder Involvement:**
- **Training and Education:**
- **Vehicle Standardization:**

c) What new gap issues are anticipated?

- **After Market Modifications:**
- **Emergency Response Guides:**
- **Electric Vehicle Supply Equipment:**
- **Materials Fire Performance Testing:**
- **New Technology:**
- **Salvage and Recycling:**
- **Stakeholder Involvement:**
- **Vehicle Disconnects & Shutdowns:**

3) Research, Training, and Communication. For research, training, and communication that addresses hazards associated with the widespread use of electric vehicles:

a) What are the identified gaps?

- **Battery Hazards:**
- **Materials Fire Performance Testing:**
- **Stakeholder Involvement:**
- **Training and Education:**

b) What progress has been made to fill these gaps (e.g., changes/enhancements and/or new standards)?

- **EVSE Standardization:**
- **Stakeholder Involvement:**
- **Training and Education:**
- **Vehicle Standardization:**

c) What new gap issues are anticipated?

- **After Market Modifications:**
- **Data Analysis:**
- **New Technology:**
- **Shutdown Protocols:**
- **Stakeholder Involvement:**

In addition to the assigned question, each of the Day Two Workgroups also addressed four case study situations. Although these case studies were hypothetical, the details are based on real issues that are confronting today's safety professionals. Workgroups were assigned at least one case study, and instructed to address additional case studies as time allowed. The case studies are summarized in Table 4, *Case Studies Addressed by Workgroups*.

Table 4: Case Studies Addressed by Workgroups

CASE STUDY A: NEW BATTERY TECHNOLOGY
Development of revolutionary new battery technology developed by federal government provides dramatic improvements in re-charge times making EVs cost-effective over other vehicles, but it requires raises question on impact to the electrical grid and also introduces a noteworthy potential explosion and hazmat risk during catastrophic failure.
CASE STUDY B: EMERGENCY RESPONDER PERSONAL PROTECTIVE EQUIPMENT
Emergency responders are receiving mixed messages from specific automobile Emergency Response Guides on the use of PPE and safe shutdown procedures (i.e. for removal of fuses and use of service disconnects on high voltage EV systems), with information that is orientated toward fire service PPE/techniques, electrical PPE/techniques, or vehicle technician PPE/techniques.
CASE STUDY C: CHARGING STATION CRASH
A high-profile rescue event involving a public EV charging station raises significant public anxiety as follows: A public EV charging station on a boulevard is hit by a conventional-fueled vehicle. The charging station is displaced and severely damaged, resulting in exposed high voltage that significantly hinders the fire department's efforts to extricate the driver who is trapped, and whose injuries ultimately prove to be fatal.
CASE STUDY D: BATTERY STORAGE FACILITY FIRE
A high-profile fire event involving EV batteries raises significant public anxiety as follows: a large fire at a battery storage facility for a city's taxi fleet results in four fire fighters receiving career-ending injuries.

5. SUMMARY OBSERVATIONS

This report assembles all the pertinent documentation for the *Second Annual Electric Vehicle Safety Standards Summit* held on 27-28 September 2011 in Detroit Michigan. This event revisits this subject, which was originally addressed at the *U.S. National Electric Vehicle Safety Standards Summit* held during October 2010 in Detroit Michigan.

The earlier Summit in October 2010 developed the base elements for an action plan in support of the safe implementation of electric vehicles, using safety codes and standards as the primary mechanism for this action plan. The purpose of the *Second Annual Electric Vehicle Safety Standards Summit* (September 2011) was to bring appropriate stakeholder groups together to further refine a shared implementation plan to ensure that fire and electrical safety standards impacting electric vehicles do not serve as a barrier to their deployment. The intent has been to build on the success of the previous Summit.

Noteworthy activity and progress has occurred since the previous Summit in all the important topical areas. Significant revision and update efforts have been on-going within multiple established codes and standards activities focused on vehicles, batteries, electric vehicle supply equipment, and the supporting electrical infrastructure. Training and education initiatives have made impressive progress, primarily for emergency responders and (separately for) electricians, including content development and dissemination efforts. Electric vehicle supply equipment is maturing and experiencing growing implementation, and includes the coordination of important technical details to support the widespread implementation of electric vehicles. Batteries for electric vehicles continue to experience new technological developments, and research has been completed and is continuing to address the battery hazards for all anticipated settings, including beyond the vehicle.

The information exchanged and collected throughout the Summit has been reviewed, consolidated, synthesized and distilled into its essential characteristics. This has resulted in Figure 5, *Summary of Key Identified Issues*. These represent the key topic issues that have risen to the top for consideration as the primary elements for action plans going forward.

Specifically, the information summarized in Figure 5 highlights the four primary topic areas of paramount interest from Summit discussions. These are: (I) Battery hazards; (II) EVSE component and electrical load standardization; (III) Comprehensive stakeholder involvement; and (IV) Vehicle and component standardization. In addition, two broad concepts of training & education and data analysis are also included as overall supplements to the four primary issues that are more specific in their relative nature.

The genesis of deriving the four primary areas of interest in Figure 5 is rooted to both the Day One panel discussions and the Workgroup questions that identified the most important issues. The first primary area of interest is “(I) Battery hazards.” It was clearly indicated that vehicles

and batteries are deserving of their own centralized focus, which is sensitive to the greater fluidity of evolving battery technology. Battery hazards are now considering questions beyond the direct usage of the battery (i.e., while installed in a vehicle) to address concerns in all realistic settings (e.g., transport, bulk storage, etc).

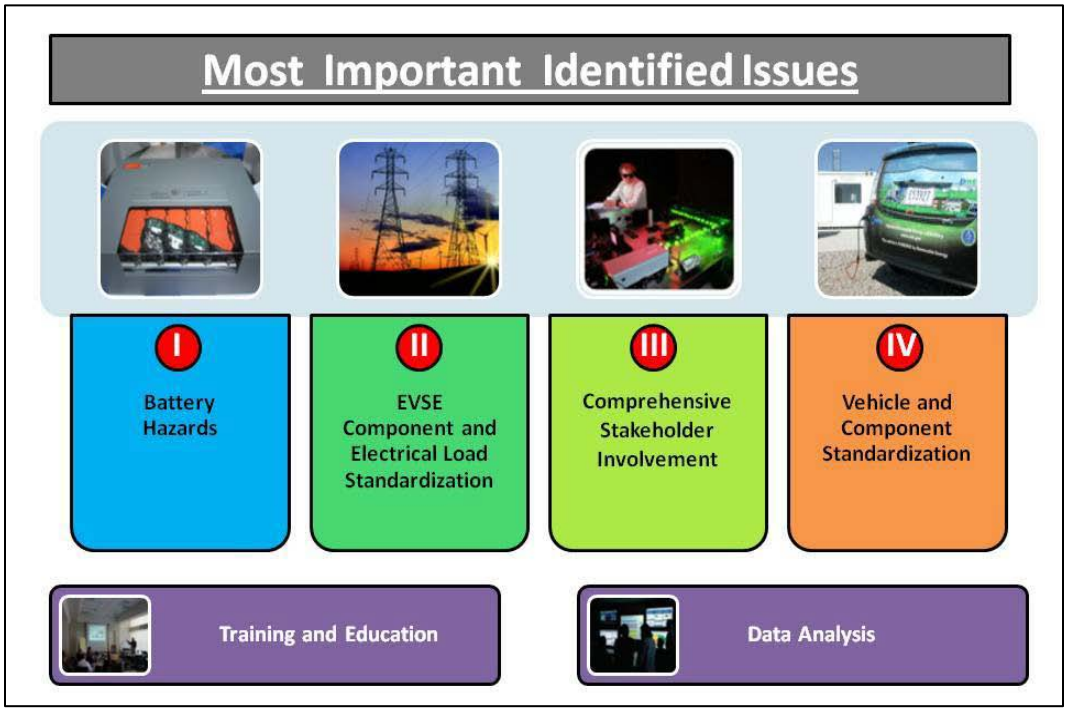

Figure 5: Summary of Key Identified Issues

"(II) EVSE component and electrical load standardization" is the second primary area of interest. Day One discussions indicated that significant progress has been made with EVSE and that it is actively and effectively being coordinated via standards activities. Nevertheless, much remains to be done and concern exists for addressing a myriad of details. In particular, efforts to standardize the technical issues relating to electrical load and the implications it has on the present electrical infrastructure received particular emphasis.

The third primary area of interest is "(III) Comprehensive stakeholder involvement", and this directly relates to the desire to reach constituency groups that are important to this effort but not yet fully engaged. This concept was expressed repeatedly throughout the Summit. In particular, the Day One discussions highlighted this issue with the desire for emergency responder training to extend beyond the fire service to include law enforcement and others, as well as the presentations in the session on Support Services (e.g., salvage and tow operators, property insurers, etc) that likewise highlighted this key finding. Stated differently, this finding recommends taking the good work already done and on-going (e.g. training programs), and to now extend it to other important constituents (e.g., law enforcement, EMS, salvage and tow operators, etc).

"(IV) Vehicle and component standardization" is the fourth primary area of interest identified from the Summit. Numerous points were made on the need to continue on-going efforts to standardize the various features of vehicles (e.g., power-down features, labeling, disconnects, etc). This is intended to include on-board components such as the batteries when part of the vehicle. Again, this is an area where significant progress has been made, but further on-going work continues to be needed.

A wide range of issues were raised during the Workgroup discussions, and most fit directly or indirectly into these four primary areas of interest. Two broad over-arching points of interest that were mentioned on multiple occasions and which do not cleanly fit within one of the aforementioned four key areas of interest are: training and education, and data analysis. These are included in Figure 5 as additional supplemental topics for on-going consideration by all involved with electric vehicle safety.

Additional detail of the Workgroup discussions is offered as further substantiation for the key areas identified in Figure 5. Conveniently, the information collected in sections (2) and (3) of the Workgroup questions (on Day Two) has a consistent parallel format that allows a useful side-by-side comparison. The consolidation of this information is represented in Figures 6 through 8 as follows: Figure 6, S*ummary of Identified Gaps*; Figure 7, *Summary of Progress Made to Fill Identified Gaps*; and Figure 8, *Summary of Anticipated New Gaps*.

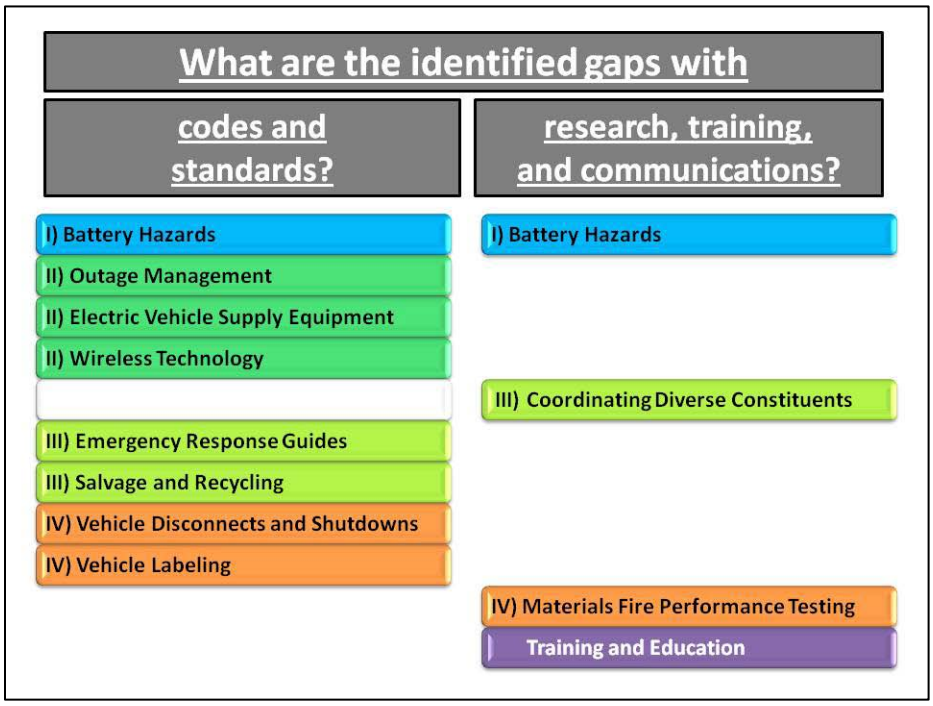

Figure 6: Summary of Identified Gaps

From the perspective of summary observation, it is worth noting several messages and themes that manifested themselves during the Summit. One of the points that became clear early during the Summit was the need to consider of batteries as a technology separate from vehicles. This is the basis for separating vehicles and batteries as illustrated earlier in Figure 3 (see Chapter 3).

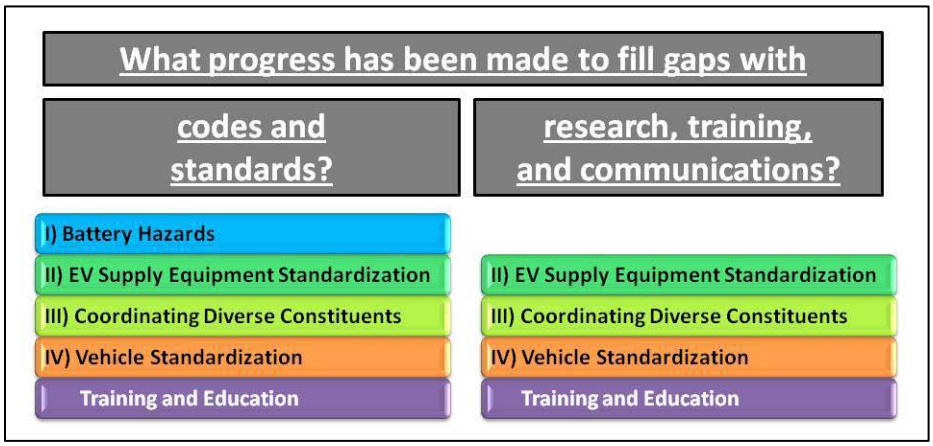

Figure 7: Summary of Progress Made to Fill Identified Gaps

In similar fashion, there was substantive Day One discussion to now extrapolate the impressive training and education programs that have had a focus on fire service and electricians to other identified constituent groups such as law enforcement and salvage/tow operators. The terms "emergency second responders" was used during the Summit (see Figure 4 in Chapter 3) with the purpose to clarify the inter-relationships of these emergency responder groups. As the Summit progressed into Day Two, it became clear that this desire to extrapolate our collective out-reach includes more than emergency responders, and includes others such as vehicle dealers, public garage operators, automobile insurers, vehicle technicians, etc.

Since the previous Summit significant activity has been on-going within established codes and standards activities. A wide range of detailed examples were provided of this activity, primarily focused on vehicles, batteries, electric vehicle supply equipment, and the supporting electrical infrastructure. In certain areas the standards are already relatively well-established, such as for the fire service.

Yet even here (i.e., fire service standards) there are challenging sub-issues requiring attention. An example is the question that was addressed in Case Study B on emergency responder personal protective equipment (PPE), which is representative of a specific problem requiring resolution. Some vehicle emergency response guides (some of which has evolved from vehicle technician information) promotes conflicting information for using emergency responder PPE to achieve vehicle shutdown. Collectively this information is inconsistent and confusing. Fire service PPE is well established, but so too is the entirely different PPE used by electric utilities

for electrical shutdown of electrical power. The PPE and related gear in each arena is significantly different in design and in the user protection it offers, as well as important requirements for operability, maintenance, and training. This is a good example of a specific safety related issue that requires attention going forward.

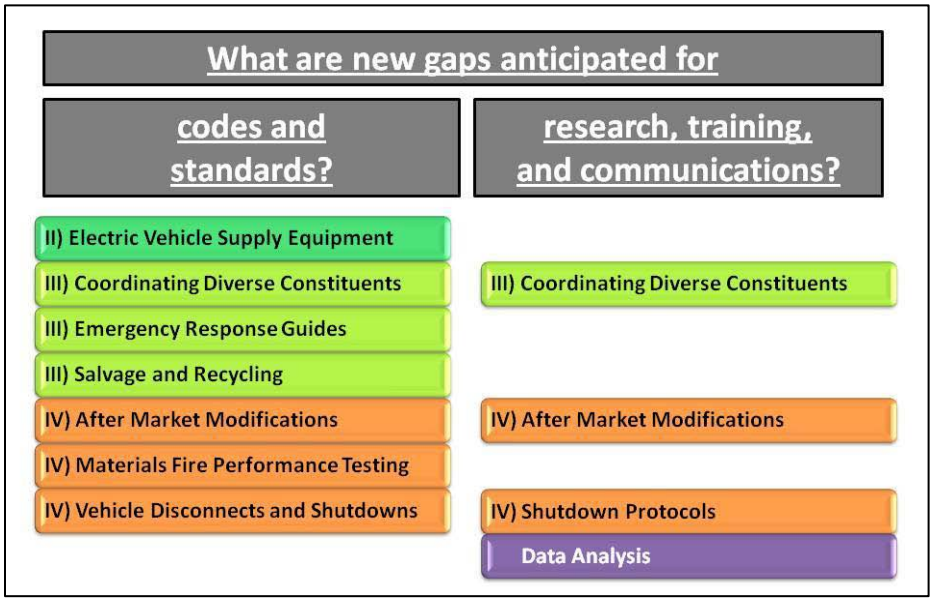

Figure 8: Summary of Anticipated New Gaps

Resolutions of these on-going problems cannot easily be resolved by any one constituent group, at least not effectively and efficiently. One critical by-product of this Summit is the important dialogue it continues to facilitate on critical issues among diverse stakeholders. The venue provided by this Summit has enabled critical information to be exchanged that is needed to support the overall success of electric vehicle technology and facilitated the removal of barriers. Other than by this Summit, it is not obvious where else such diverse groups (e.g., vehicle designers, battery manufacturers, emergency responders, charging station suppliers, public utilities, facility insurers, salvage operators, etc) are able to meet on a common platform and clarify the progress made and effort still required.

From the beginning it has not been the intent of this Summit to engage in tasks such as the development of an exhaustive list of relevant codes and standards, but rather to collectively bring to the surface the topics involving one or more constituent groups that need attention. This is especially important considering the on-going proliferation of electric vehicle technology, and the sensitivity to timeliness to ensure that existing (and lack-of) needed safety standards will not serve as a barrier to the deployment of electric vehicles.

Annex A: Attendees at the 2nd Annual Electric Vehicle Safety Standards Summit

The following is a summary of the attendees at the "2nd Annual Electric Vehicle Safety Standards Summit", held in Detroit, Michigan on 27-28 September 2011.

Table A-1: Attendees at the 2nd Annual Electric Vehicle Safety Standards Summit

First Name	Last Name	Organization	State	Country
Josephine	Agosta	U.S. Army TARDEC	MI	USA
Thomas	Aiken	Applied Sensor, Inc.	NJ	USA
Jonathan	Albrecht	Bae Systems	NY	USA
Brian	Anderson	Michigan State University	MI	USA
Nadia	Anderson	Alliance of Automobile Manufacturers	VA	USA
Kurt	Ansorge	L3 Combat Propulsion Systems	MI	USA
Michael	Anthony	AEC-Architecture & Engineering	MI	USA
Ray	Bakerjian	SAE	MA	USA
John	Bogart	Integro	CT	USA
Theodore	Bohn	Argonne National Lab	IL	USA
Kevin	Boice	US Army TARDEC	MI	USA
Ken	Boyce	UL	IL	USA
Judy	Brunson	Mercedes Benz RDNA	MI	USA
William	Burke	National Fire Protection Association	MA	USA
Peter	Byk	SAE International	MI	USA
Gregory	Cade	National Fire Protection Association	DC	USA
Jim	Carroll	NAFTD, CT Fire Academy	CT	USA
Jacqueline	Casas	CODA Automotive	CA	USA
Christopher	Caserta	TUV SUD AMERICA	FL	USA
Wesley	Chestnut	Spartan Motors, Inc.	MI	USA
Edward	Clancy	Mitsubishi Motors R & D of America, Inc.	MI	USA
Philip	Clark	City of Detroit	MI	USA
Mike	Clemmons	NECA-IBEW #176 JATC	IL	USA
Thomas	Coleman	SAE International	PA	USA
Andrew	Cook	AVL Powertrain Engineering	MI	USA
Roy	Cooper	KAR Auction Services, Inc.	IN	USA
Jamison	Cummings	Tesla Motors Inc	CA	USA
John	Cunningham	Nova Scotia Fire Fighters School	MA	USA
Richard	Dee		FL	USA
Cathleen	DeLoach	National Fire Protection Association	DC	USA
Yi	Ding	US Army TARDEC	MI	USA
Arlene	DiSilvio	SAE International	PA	USA
Christian	Dubay	National Fire Protection Association	MA	USA
Robert	Duval	National Fire Protection Association	MA	USA
Mark	Earley	National Fire Protection Association	MA	USA

First Name	Last Name	Organization	State	Country
Jeffrey	Edge	John D. Dingell VAMC	MI	USA
Kyle	Edwards	Cummins	IN	USA
Timo	Elze		CO	USA
Jason	Emery	National Fire Protection Association	CT	USA
Nori	Fought	SAE	MA	USA
Gregory	Frederick	Louisville Fire & Rescue	KY	USA
John	Frooshani	Subaru of America, Inc.	MD	USA
Richard	Gallagher	Zurich Services Corporation	DE	USA
Robert	Galyen	Testing Labs, Battery Cell & Pack	MI	USA
Gary	Gao	Magna E-Car Systems	MI	USA
Seth	Gerber	Consumers Energy	MI	USA
Mark	Gielow		MI	USA
Bill	Giorgis	Michigan Towing Association	MI	USA
MARIO	GOMEZ	TE Connectivity (Tyco Electronics)	CA	USA
Marco	Gomez			Mexico
Phillip	Gorney	U.S. Department of Transportation/NHTSA	MI	USA
Casey	Grant	Fire Protection Research Foundation	MA	USA
John	Halliwell	Electric Power Research Institute	TN	USA
Mazen	Hamdan	Meritor Inc.	MI	USA
George	Hamilton	TARDEC	MI	USA
Jun	Haruhara	Polyplastics Co Ltd		Japan
Deborah	Hattrup	SAE	MA	USA
Lars	Hessman	e-AAM Driveline Systems AB		Sweden
Li-Pen	Ho		MI	USA
Thomas	Hollenstain	State Farm Insurance	IL	USA
Megan	Housewright	National Fire Protection Association	DC	USA
Jack	Hyde	SFA Consulting, LLC	MO	USA
Jonathan	Jacoby	Azure Dynamics	MI	USA
Steven	Jonas		MI	USA
Tamika	Jones	TARDEC	MI	USA
James	Jongkind	American Honda Motor Co., Inc.	CA	USA
Ghassan	Khalil	US Army TARDEC	MI	USA
Amy	Klinkenberger	Hyundai-Kia Motors	MI	USA
Andrew	Klock	National Fire Protection Association	MA	USA
Patti	Kreh	SAE International	MI	USA
Martin	Lambrecht	Nissan North America, Inc.	TN	USA
Susan	Landry	Albemarle Corporation	LA	USA
Gerald	Lane	US Army TARDEC	MI	USA
Robert	Lange	Exponent Inc	MI	USA
Mike	Larabel	Amway Inc.	MI	USA
Jody	Larson	L3 Combat Propulsion Systems	MI	USA
Jeff	Lindsey	SEA, Ltd.	OH	USA
Matt	London	Nissan North America	MI	USA
Rick	Long	PEI	OK	USA

First Name	Last Name	Organization	State	Country
Nora	Macaluso	MEDIA - BNA	MI	USA
Brad	Mahalak	Toyota Tech Center	MI	USA
Karen	Mann	Dow Kokam	MI	USA
Jorge	Martinez			Mexico
Walter	Maruszczak	DIC International	MI	USA
Alvaro	Masias	Ford Motor Company	MI	USA
Abul	Masrur	US Army RDECOM-TARDEC	MI	USA
Robert	Maxwell		MI	USA
Jim	McCabe	ANSI	MA	USA
Terence	McDonnell	New York State Police	NY	USA
Norm	Meyer	Transport Canada	ON	Canada
David	Moreland	Volkswagen Group of America, Inc	CO	USA
Larry	Munson	BAE Systems	NY	USA
Gary	Murcer	Honda of America Mfg. Inc.	OH	USA
Sean	Murphy	Bae Systems	NY	USA
Stephen	Musur	Chubb & Son. Inc	IL	USA
Rajesh	Nagappala		MI	USA
Nick	Nida	Mercury Marine	WI	USA
Tetsuya	Niikuni	National Traffic Safety and Environment		Japan
Jon	Nisja	Minnesota State Fire Marshal	MN	USA
Dennis	Oddsen		CT	USA
Dan	O'Donnell	State of Michigan	MI	USA
Brad	Onder	Lend Lease	IL	USA
Joseph	Parisi	Product Development	MI	USA
Donald	Parker	Exponent, Inc.	MI	USA
Jim	Pauley	Schneider Electric	KY	USA
Chris	Pepler	National Fire Protection Association	CT	USA
Laura	Peters	ALTe	MI	USA
Jack	Pokrzywa	SAE International	MI	USA
James	Porter	Ford Motor Company	MI	USA
Aloke	Prasad	USDOT NHTSA VRTC	OH	USA
Bryan	Pruess	TARDEC	MI	USA
James	Puckhaber	Dow Kokam	MO	USA
Spencer	Quong	QAI	CA	USA
Thomas	Rathgeber	BAE Systems	NY	USA
Johann	Reithmeier	Audi of America	MI	USA
Cark	Rivkin	Hydrogen Technologies and System Center	CO	USA
Brian	Rock	Hubbell Incorporated	CT	USA
Al	Rosamond	National Volunteer Fire Council	TN	USA
James	Ross	Donan Engineering	IN	USA
Michael	Ruey	628 CES/CEF	NC	USA
Michael	Ruey	628 CES/CEF	NC	USA
Richard	Ruh	Cherokee County Fire & Emergency	GA	USA
Mahesh	Samineni	NextEnergy	MI	USA

First Name	Last Name	Organization	State	Country
Steven	Sawyer	National Fire Protection Association	MA	USA
Becky	Schloff	Pristine Marketing Services	MI	USA
Dwayne	Shumate	AAA	FL	USA
Lonny	Simonian	Cal Poly	CA	USA
Eric	Simons		MI	USA
Dave	Small	Ford Motor Company	MI	USA
Jason	SPina	TARDEC	MI	USA
Sean	Stanley	Bright Automotive	IN	USA
Zak	Stelmaszek	Bright Automotive	MI	USA
Sophia	Suo	Delta Electronics Inc	MI	USA
Priya	Tabaddor		MI	USA
Randall	Talifarro	City of East Lansing Fire Department	MI	USA
Honghao	Tan	Coda Automotive	CA	USA
Xiaodong	Tang	SAIC Motor Passenger Vehicle Co.		China
Robert	Toles		MI	USA
Mark	Trowbridge	CSA International	ON	Canada
Aaron	Tweady	PRTM Management Consultants	MI	USA
Robert	Vondrasek	National Fire Protection Association	MA	USA
John	Warren	NECA-IBEW #176 JATC	IL	USA
Kenneth	Wenzel	Chrysler Group	MI	USA
Ken	Willette	National Fire Protection Association	MA	USA
David	Williams	Delta Township	MI	USA
Keith	Wilson	SAE Global Standards	MA	USA
Andy	Witkemper	Greensburg Fire Department	IN	USA
Mark	Yeldham	BMW NA, LLC	NJ	USA

Annex B: Summary of Workgroup Discussions

Each of the four Workgroups that met on Day Two had their own baseline theme. This assigned baseline theme was intended to be the priority subject for a particular group, and their priority to be addressed first. However, they were not excluded from addressing the other themes as time permitted. The themes assigned to each Workgroup were:

- Workgroup One (WG1) - Vehicles/Batteries
- Workgroup Two (WG2) - Emergency Responders
- Workgroup Three (WG3) - Built Infrastructure
- Workgroup Four (WG4) – Support Services and User Perspective

The structured questions addressed on Day Two of the Summit were separated into the following three basic categories: general; safety codes, standards and specifications; and research, training and communication. In addition, each Workgroup addressed at least one of the four case studies.

Table B-1 summarizes the consolidated Workgroup discussion for the structured questions, and Tables B-2 through B-5 summarizes the Workgroup discussion for the four case studies. It is noted that the origin of each summary recommendation in Annex B indicate the Workgroup of origin by a parenthetical designation, i.e. WG1, WG2, WG3, or WG4. Further, the information provided represents the raw collective discussions from each Workgroup, and thus some duplication exists.

Table B-1: Consolidated Workgroup Discussion for the Structured Questions

1) General.

a) What notable progress has been made since the previous Summit (October 2010)?

- **EVSE Standardization:**
  - North American SDOs (standards Developing Organizations) have been establishing standards for charging related components (e.g., chargers and other infrastructure equipment). (WG2)
  - Much work has occurred in the standards arena itself to update standards and to fill many gaps in standardization. (WG3)
  - The ANSI electric vehicle Roadmap is providing structure for implementation. (WG3)
- **Infrastructure Enforcement:**
  - Built infrastructure permitting has not been a hurdle and has been a non-issue, though identified at last year's summit (e.g., IAEI has worked with sections and chapters to provide training for U.S. inspectors). (WG3)
- **International Harmonization:**
  - There has been increased international dialog on electric vehicles (e.g., consideration of European roadmaps and Chinese battery swapping standards). (WG3)
- **Stakeholder Involvement:**
  - Continued networking and interaction with other emergency response stakeholders has been made (e.g., law enforcement, EMS, and salvage operators). (WG2)

- Networking dialogue among built infrastructure stakeholders has been effective and continues to improve. (WG3)
- Awareness of EV safety issues continues to mature among key stakeholder groups, and this recognition is extending to others now being included (e.g., emergency second responders). (WG4)
- Dialogue, collaboration, and synergy among diverse stakeholder groups that need to work together on safety issues continue to improve, including groups with emerging roles (e.g., fire investigators, salvage and tow operators, etc). (WG4)
- A better understanding and appreciation of support services has been evolving, recognizing the role of stakeholders such as: equipment shipping and storage; dealers and retail; service and repair; consumers; insurers; public utilities; parking facilities; roadside service; salvage and recycling; restoration services; and environmental remediation. (WG4)

- **Technology Deployment:**
  - Progress has been made to balance vehicle "safety" with "green" environmentally-friendly goals (e.g. reducing the carbon footprint). (WG1)
  - We have progressed beyond the novelty phase of this technology, e.g., charging stations and other built infrastructure equipment are being widely deployed. (WG3)
  - Understanding of what we know and gaps of what we don't know continues to be refined. (WG4)
  - Mainstream public has a growing awareness of electric vehicle technology. (WG4)
- **Training and Education:**
  - NFPA Electric Vehicle Training Project has been effective and which is still on-going. (WG2)
  - Training that has been rolled out and has been filling previously identified needs. (WG3)
  - Training and education information has become more widespread and mainstream. (WG4)

b) What have been the specific lessons-learned for future action plans, i.e., what still needs to be addressed as part of the on-going action plan?

- **Battery Hazards:**
  - Battery hazards and concerns (e.g., voltage, toxicity, runaway, hazmat classification, protocol to maintain charge, discharge procedure, handling of post accident damaged battery, rekindle potential, etc). (WG4)
- **Data Analysis:**
  - Identify, collect and coordinate all applicable MVA (motor vehicle accident) crash data collection efforts (e.g., NHTSA FARS, NFIRS, etc) to include distinctive measures for electric and hybrid electric vehicles. (WG2)
- **Electric Vehicle Supply Equipment:**
  - EVSE Business Models: Better understanding for the business models that will influence the proliferation of the charging station installations (e.g., faster charging at retail stores). (WG3)
  - EVSE Compatibility:
    - Backwards compatibility as new charging classes, methods and technology evolve. (WG3)
    - Interoperability and compatibility as charging infrastructure evolves to match that with existing vehicles as well as new vehicles. (WG3)

        - Clarifying the lead technology between vehicles and charging stations, i.e., will we build the infrastructure to get the million vehicles or build the million vehicles to get the infrastructure? (WG3)
    - EVSE Disconnects:
        - Emergency disconnects for charging stations, and especially for some of the new technology such as wireless approaches. (WG3)
        - Automatic charging station disconnects for catastrophic impacts and similar failures. (WG3)
    - EVSE Electrical Loads:
        - Clarification of significant utility load problem from proliferation of the largest DC fast chargers. (WG3)
        - Permitting needs for load calculations for anticipated added load, which are important and need to be considered. (WG3)
    - EVSE Labeling: Charging station signage. (WG3)
    - EVSE Protection: Charging station physical barrier protection requirements (e.g., bollards). (WG3)
- **New Technology:**
    - Wireless charging technologies (which is developing rapidly). (WG3)
- **Stakeholder Involvement:**
    - Continued interaction and dialogue among diverse constituents. (WG1)
    - Coordinating with concerns of insurance stakeholders to provide enhanced training and education (e.g., consideration of consistent denial of claims). (WG3)
- **Training and Education:**
    - Training for all emergency first responders and not only public fire service (e.g. law enforcement, EMS, private fire brigades, etc). (WG2)
    - Training for emergency second responders (e.g., salvage operators, fire investigators, utilities, public safety officers, etc). (WG2)
    - Enhanced training and education to support service stakeholders (e.g., emergency second responders). (WG4)

c) What is the single most important issue that needs to be addressed by this topical safety Workgroup?

- **Battery Hazards:**
    - Classification of the hazards of Lithium-ion batteries (from both a hazardous materials and commodity classification perspective). (WG4)
- **EVSE Electrical Loads:**
    - Further supporting and enhancing electrical communications standards, which seem to be the key to having charging stations not be a load problem for the electrical infrastructure (i.e., electrical grid). Groups are working on these issues but more is needed. (WG3)
- **EVSE Standardization:**
    - Standardizing the equipment and protocols for emergency disconnects and shutdowns for emergency responders to make an electric vehicle “safe.” (WG2)
- **Vehicle Standardization:**
    - Continue on-going standardization activities and initiatives to address the safe implementation of EVs, with understanding and consideration for the unique needs of the competitive automobile marketplace. (WG1)

2) Safety Codes, Standards and Specifications. For the portfolio of relevant safety codes, standards and specifications that address hazards associated with the widespread implementation of electric vehicles:

a) What are the identified gaps?

- **Battery Hazards:**
  - Vehicle battery information needs to be further developed, including clarification of hazard potential and safety related characteristics. (WG1)
  - Standardized bulk battery storage requirements are needed, especially: (1) fire protection criteria for fixed fire suppression measures (i.e., built-in system protection); and (2) manual intervention techniques (i.e., fire fighting protocols). (WG2)
  - Ambiguity exists for performance and evaluation details for United Nations shipping tests (e.g. T8), such as, for example, the forced discharge for batteries with unclear discharge rates. (WG4)
  - Research and testing to clarify extended monitoring concerns for damaged batteries (e.g. rekindle potential). (WG4)
  - Research and testing to clarify standards that requires or recommends fire suppression agents for fires involving batteries (e.g., NFPA 1, 13, 30A, 1620, etc). (WG4)
  - Standards for discharging batteries under normal and emergency conditions. (WG4)
- **Emergency Response Guides:**
  - Standardized vehicle emergency response guides (ERGs) from manufacturers are needed with common formats to enable and facilitate universal use by emergency responders. (WG2)
  - Providing coordinated and consistent information in vehicle emergency response guides. (WG4)
- **Electric Vehicle Supply Equipment:**
  - EVSE Business Models: Standardization to better handle vehicles-to-grid power supply back into homes, which is seen as part of business models to promote electric vehicle programs. (WG3)
  - EVSE Disconnects & Shutdowns: Standardized charging station shutdown procedures are required, including clarification of the role of emergency first responders (e.g. fire service) and emergency second responders (electric utilities). (WG2)
  - EVSE Enforcement: Implementing and enforcing applicable codes and standards, through permitting and other means (e.g., permitting is a problem because homeowners often do electrical work without permits). (WG3)
  - EVSE Labeling: Standardized charging station labeling and markings for emergency shutdown procedures are needed. (WG2)
  - EVSE Protection: Cable management, including public tripping hazard, unusual wear, and protective measures against cable theft. (WG3)
- **Outage Management:**
  - Managing the evolution of the charging infrastructure to avoid utility disruptions in specific areas, i.e., clarifying the communications protocols that will allow the grid to handle these loads. (WG3)
- **Salvage and Recycling:**
  - Standards for salvage and recycling for vehicles and batteries that address expected end-of-life disposal concerns, and which consider all possible influencing factors (e.g., after-market modifications, insurance factors, salvage operators responsibilities, etc). (WG4)

- **Vehicle Disconnects & Shutdowns:**
  - Vehicle power supply disconnects need to be standardized and this information needs to be communicated to emergency responders, including PPE requirements and details such as type, location, function (i.e., what it disconnects), etc… (WG1)
  - Standardized electric vehicle shutdown procedures are required both in equipment design and function (i.e. by SAE) and in operational tactics and strategy (i.e., by NFPA). (WG2)
- **Vehicle Labeling:**
  - Standardized vehicle labeling and badging methods for emergency responders are needed. (WG2)
- **Wireless Technology:**
  - Resolution of wireless compatibility, as products are being developed faster than the standards can evolve. (WG3)

b) What progress has been made to fill these gaps (e.g., changes/enhancements and/or new standards)?

- **Battery Hazards:**
  - Research and testing that continues on-going work on batteries (e.g., follow-up studies to research by the Fire Protection Research Foundation). (WG4)
- **EVSE Standardization:**
  - Multiple proposed revisions are being considered in the latest edition of NFPA 70, National Electrical Code. (WG2)
  - Active on-going work continues with SAE J-1772 on Electric Vehicle and Plug-In Hybrid Electric Vehicle Conductive Charge Coupler. (WG2)
  - The National Electrical Code® (NEC) has been and continues to address this overall topic and is making good progress (e.g. recent NEC amendments have addressed cord-and-plug connection of EVSE and load management). (WG3)
- **Stakeholder Involvement:**
  - Understanding of what we know and gaps of what we don't know continues to be refined. (WG4)
- **Training and Education:**
  - NFPA's Electric Vehicle Training program for emergency responders. (WG4)
- **Vehicle Standardization:**
  - Multiple on-going standardization activities and initiatives by standards developers (e.g. SAE) are in process or being considered. (WG1)

c) What new gap issues are anticipated?

- **After Market Modifications:**
  - After market alterations by consumer and re-sellers for vehicles and EVSE. (WG4)
- **Emergency Response Guides:**
  - Standardization of the service information to be coordinated and consistent with emergency response guide information. (WG4)
- **Electric Vehicle Supply Equipment:**
  - EVSE Business Models: Standardization of approach that maximizes the utilization of idle assets to supply power back into the base or onto the grid. (WG3)
  - EVSE Compatibility: Subsequent firmware upgrades for evolving on-line vehicle-to-grid products because of inability for on-line updates due to hardware orientation. (WG3)
- **Materials Fire Performance Testing:**

- Test information on fire performance characteristics for components and materials in electric vehicles. (WG2)
- Standardization of fire performance characteristics (e.g., flame retardant properties) of high-voltage cables associated with charging stations. (WG2)

- **New Technology:**
  - Other new technology coming in the future, like fuel cells, which may use vehicle platforms similar to electric vehicles. (WG2)
- **Salvage and Recycling:**
  - Salvage and recovery (i.e., towing), and safety concerns addressing other similar secondary emergency responders. This needs to consider details such as: vehicle geometry (e.g. ground clearance of vehicles), further damageability of components during recovery, discharge procedures and how to determine that the vehicle is "dead" or non-functional. (WG1)
- **Stakeholder Involvement:**
  - Standardization of terminology among all stakeholders and applicable standards developing organizations. (WG4)
- **Vehicle Disconnects & Shutdowns:**
  - Standardization of location, function, and identification of vehicle power disconnects and shutdown protocols. (WG4)

3) Research, Training, and Communication. For research, training, and communication that addresses hazards associated with the widespread use of electric vehicles:

a) What are the identified gaps?

- **Battery Hazards:**
  - Hazard concerns of lithium-ion and other batteries (e.g. fire ignition, leaks, etc). (WG2)
- **Materials Fire Performance Testing:**
  - Fire performance test data of materials and components in electric vehicles. (WG2)
- **Stakeholder Involvement:**
  - Engaging emergency second responders (e.g., tow and recovery operators). (WG2)
  - Engaging emergency first responders other than the fire service (i.e. law enforcement and EMS). (WG2)
  - Improving dialogue between emergency responders and vehicle designers to standardize features critical to safe operation during an emergency event (e.g., development of a brief checklist type quick reference for emergency responders). (WG2)
  - Handling and processing safety related information on vehicles and batteries that might also have proprietary characteristics and inhibit full consideration of hazards. (WG4)
  - Enhancing dialogue on lessons learned among emergency responders similar to www.firefighternearmiss.com. (WG4)
  - Coordinate the initiatives in the private sector with similar initiatives in the department of defense and other federal agencies. (WG4)
- **Training and Education:**
  - Training and education of emergency responders; there is presently a lot of good effort but more is needed. (WG1)
  - Fire investigator training for fires in electric vehicles (e.g., IAAI, NFPA 921, etc). (WG2)
  - Law enforcement training for accident reconstruction involving electric vehicles. (WG2)

- Training and education for all topic areas identified as gaps with the development of codes and standards. (WG3)
- Working with less obvious stakeholders (e.g., property insurers concerned with bulk storage and transportation of batteries), to make sure their training and education needs are met. (WG3)
- Training and education to support emergency first responders and emergency second responders. (WG4)
- Training and education on standardized shutdown procedures, which addresses important details such as the PPE required by emergency first responders. (WG4)

b) What progress has been made to fill these gaps (e.g., changes/enhancements and/or new standards)?

- **EVSE Standardization:**
  - Recent amendments to the National Electrical Code® have addressed cord-and-plug connection of electric vehicle support equipment and load management. (WG3)
- **Stakeholder Involvement:**
  - Promotion of conferences, workshops, and meetings that facilitate the required coordination between stakeholders and standard developing organizations. (WG4)
- **Training and Education:**
  - NFPA's Electric Vehicle Training program is now shifting attention to begin addressing the concerns of emergency responders other than the fire service (e.g., law enforcement, EMS, salvage and recovery operators, etc). (WG2)
  - Training has been on-going and continues to be provided for U.S. electrical inspectors through programs organized by the International Association of Electrical inspectors, which has helped minimize permitting concerns. (WG3)
  - Training and education opportunities have become more widely available. (WG4)
- **Vehicle Standardization:**
  - Vehicle manufacturers have been attempting with some success to standardize certain vehicle safety features among different manufacturers, which is inherently challenging in the competitive automobile marketplace. (WG1)

c) What new gap issues are anticipated?

- **After Market Modifications:**
  - After market modifications by consumers will continue to be a challenge. (WG2)
- **Data Analysis:**
  - Data and information collection for extreme emergency situations that push inherent safety features to the design limits, not only for vehicle occupants but also for emergency responders. Better field experience information needs to be collected and circulated. (WG1)
- **New Technology:**
  - Keeping pace with advancing technological developments. (WG3)
- **Shutdown Protocols:**
  - Clarification of the appropriate PPE for disconnecting high voltage electrical systems in electric vehicles. (WG4)
- **Stakeholder Involvement:**
  - Need for continued and additional regulatory participation in certain safety standards activities based on the far-reaching and dynamic nature of this overall topic. (WG4)

Table B-2: Consolidated Workgroup Discussion for "Case Study A: New Battery Technology"

Case Study A: Development of revolutionary new battery technology developed by federal government provides dramatic improvements in re-charge times making EVs cost-effective over other vehicles, but it requires raises question on impact to the electrical grid and also introduces a noteworthy potential explosion and hazmat risk during catastrophic failure.

- **Alternative Technology and Approaches:**
  - New battery technology that provides increased function will naturally lead to increased consumer demand, and this will likewise result in focused attention and resources to address and overcome the problems that arise (i.e., resolving obstacles will naturally occur). (WG1)
  - Solutions to charging problems are not only solved through new-technology enhancements, but also through alternative approaches such as administrative changes that maximize grid efficiency through, for example, charging protocols based on geographic (i.e. regional) or temporal (e.g., time-of day programming) frameworks. (WG1)
  - Battery technology is advancing rapidly and this particular scenario may soon be happening. (WG3)
  - Closely monitor vehicle fleets that implement new power supply technologies, since they are likely candidates for new technology roll-out and they provide useful collective feedback. (WG3)
- **EVSE Compatibility:**
  - Attention is needed to enable backward compatibility as much as possible, so that charging stations installed today can handle the new battery technologies of tomorrow. (WG3)
- **Electrical Infrastructure Management:**
  - Managed charging protocols are needed to coordinate the electrical loads that the grid can realistically handle. (WG3)
  - Address contingencies for short and long term electric utility outages, and how this will ultimately impact transportation dependent on electricity. (WG3)
- **Emergency Response:**
  - The "noteworthy potential explosion and hazmat risk" is considered with respect but it is not considered a significant obstacle, since this would simply be yet another emergency application that emergency responders are already well equipped and trained to handle. (WG2)
  - The present emergency response infrastructure and protocols for handling hazardous materials incidents is already well established, for example, through standards adopted by the U.S. Department of Homeland Security and widely implemented by emergency first responders (e.g., NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, and NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents*). (WG2)
- **Insurance Concerns:**
  - Clarify how liability and property insurance will be handled for vehicles with batteries that introduce new and unusual hazards. (WG3)
- **Risk Assessment:**

- A comprehensive risk assessment or other recognized evaluation technique should be considered for any new technology, including new battery technology, to provide a credible and scientifically-based review that balances the value-added against the potential hazards. (WG1)
- All short and long term factors will ultimately need to be taken into account to clarify overall potential value for any new battery technology that becomes popular, such as overall battery life, carbon footprint, manufacturing costs, end-of-life disposal, etc… (WG1)
- Positive and negative impact on the electrical grid requires a comprehensive approach that involves not only the development of new battery technology, but also all other affected parts of the infrastructure such as the electrical grid itself. (WG1)

- **Training and Education:**
  - Education of all involved in resolving the problem remains paramount. This includes the vehicle manufacturers, battery manufacturers charging equipment manufacturers, electrical utilities, emergency responders, general consumers, and all others impacted. (WG1)
  - Take advantage of getting safety-related information into the mainstream as electric vehicles become the way-of-the-future, and the general population is more and more exposed to high profile information based on a shift in how we interface with automobiles. (WG1)
- **Vehicle Service and Repair:**
  - Review how practical roadside service will be provided for electric vehicles, and what design features will enable convenient and effective roadside assistance. (WG3)

Table B-3: Consolidated Workgroup Discussion for "Case Study B: Emergency Response PPE"

Case Study B: Emergency responders are receiving mixed messages from specific automobile Emergency Response Guides on the use of PPE and safe shutdown procedures (i.e. for removal of fuses and use of service disconnects on high voltage EV systems), with information that is orientated toward fire service PPE/techniques, electrical PPE/techniques, or vehicle technician PPE/techniques.

- **Emergency Response:**
  - Clarify operational tactics through recommended standard operating guidelines (SOGs), or similar methods, for different emergency scenarios (e.g., extrication, fire, etc) faced by emergency responders. (WG2)
  - Standardized shutdown procedures are needed, addressing all important details such as PPE, and provide a consistent universal approach (e.g., (1) cut 12V power, (2) remove fuse for high power relay, and (3) activate service disconnect). (WG2)
  - Clarify the PPE requirements for emergency first responders (e.g. fire service) and emergency second responders (e.g., salvage and recovery operators), including basic clothing requirements versus requirements when performing specific functions (e.g., disconnects for extrication, fire fighting, tow functions, etc). (WG2)
  - Investigate possible electrical interference concerns for other electrical equipment used by emergency responders, such as digital radio interference or inadvertent taser activation. (WG2)
  - Clarify operational tactics for emergency responders to implement power shutdown. (WG4)

- **Hazard Assessment:**
  - Provide a hazard assessment of different types of vehicle fires (e.g., fires originating in engine compartment, passenger compartment, battery area, exterior to vehicle, etc), and provide recommendations for appropriate fire fighting tactics. (WG2)
  - Study the smoke generation during an electric vehicle fire event, and provide recommendations for PPE use and post event maintenance of the PPE. (WG2)
- **Training and Education:**
  - Provide training and education on standardized shutdown procedures. (WG2)
  - Provide training and education on standardized shutdown procedures. (WG4)
- **Vehicle Standardization:**
  - Work with vehicle designers to provide standardized locations and function of the service disconnects. (WG2)
  - Standardize vehicle design and function to provide consistent power shutdown for vehicles to allow better coordination of vehicle emergency response guides and to minimize confusion among emergency responders. (WG4)

Table B-4: Consolidated Workgroup Discussion for "Case Study C: Charging Station Accident"

Case Study C: A high-profile rescue event involving a public EV charging station raises significant public anxiety as follows: A public EV charging station on a boulevard is hit by a conventional-fueled vehicle. The charging station is displaced and severely damaged, resulting in exposed high voltage that significantly hinders the fire department's efforts to extricate the driver who is trapped, and whose injuries ultimately prove to be fatal.

- **EVSE Protection:**
  - Experience on vehicular impact concerns have already been addressed with other technologies (e.g., street lights, utility poles, propane gas exchange stations, etc) and can be adapted for electric vehicle charging stations. (WG3)
  - Design characteristics need to consider break-away features, for the physical unit and the electrical connections, which default to a safe condition in the event of catastrophic equipment failure (e.g., present approach to disconnect from the grid when communications links are lost). (WG3)
  - Physical forms of protection external to the charging stations need to be considered, such as bollards or other concrete barriers, or through design features such as mounting the charging unit at higher elevations away from the potential collision zone. (WG3)
  - Provide improved consideration of physical and cyber security issues since charging stations will likely be targets for abusive treatment (e.g., cutting of cables for metal salvage, tampering with communications to receive free electricity, etc). (WG3)
  - Consider automatic notification through the electrical connections that would immediately alert responsible stakeholders that functionality of the charging station has been impaired (i.e., provide charging station supervisory protocols, similar to fire alarm systems). (WG3)
- **EVSE Standardization:**
  - Provide an assessment of other codes and standards for how physical impact concerns are handled, both with other equipment (e.g. gasoline dispensing) and in other geographic regions (e.g. Europe). (WG3)
  - Clarify the manual disconnecting means, which will be different depending where

charging stations are installed (e.g., private residence, private commercial fleet yard, public parking lot, public boulevard, etc). (WG3)

- **Training and Education:**
  - Provide adequate training and education for manual disconnecting means, including which stakeholders are expected to operate them and under what conditions. (WG3)

Table B-5: Consolidated Workgroup Discussion for Case Study D: EV Battery Storage Fire"

Case Study D: A high-profile fire event involving EV batteries raises significant public anxiety as follows: a large fire at a battery storage facility for a city's taxi fleet results in four fire fighters receiving career-ending injuries.

- **Built-In Fire Protection:**
  - Built-in fire protection measures needs to be provided beforehand consistent with the protection criteria used by insurers and others for "highly protected risks", a.k.a. HPR, for storage of this type of hazardous commodity classification. (WG2)
- **Emergency Response:**
  - Emergency responders need to establish pre-plans for these recognized hazards, consistent with standards such as NFPA 1620, *Standard for Pre-Incident Planning*. (WG2)
- **Training and Education:**
  - Need to consider the perceived optics of the public and how they may react to large-scale high-profile events. (WG4)
  - For purposes of learning lessons and implementing possible changes, the post event investigation should address and clarify the role of the batteries in the event, effectiveness of requirements for fixed fire protection, ability of emergency responders to handle based on available equipment and resources, and special training and education that should be implemented. (WG4)

Annex C: Examples of Codes and Standards Applicable to Electric Vehicles

For electric vehicles, a large number of model codes and standards are provided by SAE International and the National Fire Protection Association, the two organizations that co-hosted the Summit. A summary of some of their applicable documents are provided in Table C-1, *Examples of SAE Standards Addressing Technical Issues Relating to Electric Vehicles*, and Table C-2, *Examples of NFPA Codes and Standards Addressing Technical Issues Relating to Electric Vehicles*.

The documents in Tables C-1 and C-2 are typically in constant revision cycles, resulting in new and/or updated editions on a regular basis. These two tables represent only a partial list of the more relevant codes and standards activities used on this topic. These tables are not intended to provide an exhaustive list of referenced publications, and consideration should be given to the applicable documents of other organizations (e.g. IEC, ICC, IEEE, ISO, NECA, NEMA, UL, etc).

Table C-1: Examples of SAE Standards
Addressing Technical Issues Relating to Electric Vehicles

Document #	Document Title/Section
SAE J-537	*Storage Batteries*
SAE J-1634	*Electric Vehicle Energy Consumption and Range Test* **(WORK IN PROGRESS)**
SAE J-1711	*Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles, Including Plug-In Hybrid Vehicles*
SAE J-1715	*Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology*
SAE J-1766	*Recommended Practice for Electric and Hybrid Electric Vehicle Battery Systems Crash Integrity Testing*
SAE J-1772	*Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler*
SAE J-1773	*Electric Vehicle Inductively Coupled Charging*
SAE J-1797	*Recommended Practice for Packaging of Electric Vehicle Battery Modules*
SAE J-1798	*Recommended Practice for Performance Rating of Electric Vehicle Battery Modules*
SAE J-1850	*Class B Data Communications Network Interface*
SAE J-2288	*Life Cycle Testing of Electric Vehicle Battery Modules*
SAE J-2289	*Electric-Drive Battery Pack System, Functional Guidelines*
SAE J-2293 Part 1	*Energy Transfer System for Electric Vehicles Part 1, Functional Requirements and System Architecture*
SAE J-2293 Part 2	*Energy Transfer System for Electric Vehicles Part 2, Communications Requirements and Network Architecture*
SAE J-2344	*Guidelines for Electric Vehicle Safety*
SAE J-2380	*Vibration Testing of Electric Vehicle Batteries*
SAE J-2464	*Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing*
SAE J-2711	*Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles*
SAE J-2758	*Determination of the Maximum Available Power from a Rechargeable Energy Storage System on a Hybrid Electric Vehicle*

SAE J-2836 Part 1	*Use Cases for Communications between Plug-In Vehicles and the Utility Grid*
SAE J-2836 Part 2	*Use Cases for Communications between Plug-In Vehicles and the Supply Equipment (EVSE)* **(WORK IN PROGRESS)**
SAE J-2836 Part 3	*Use Cases for Communications between Plug-In Vehicles and the Utility grid for Reverse Power Flow* **(WORK IN PROGRESS)**
SAE J2836 Part 4	*Use Cases for Diagnostic Communication for Plug-in Vehicles* **(WORK IN PROGRESS)**
SAE J2836 Part 5	*Use Cases for Communication between Plug-in Vehicles and their Customers.* **(WORK IN PROGRESS)**
SAE J2836 Part 6	*Use Cases for Wireless Charging Communications between Plug-in electric Vehicles and the Utility Grid* **(WORK IN PROGRESS)**
SAE J-2841	*Utility Factor Definitions for Plug-In Hybrid Electric Vehicles Using Travel Survey Data*
SAE J-2847 Part 1	*Communications between Plug-In Vehicles and the Utility Grid*
SAE J-2847 Part 2	*Communication between Plug-in Vehicles and Off-board DC Chargers* **(WORK IN PROGRESS)**
SAE J-2847 Part 3	*Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow* **(WORK IN PROGRESS)**
SAE J2847 Part 4	*Diagnostic Communication for Plug-in Vehicles* **(WORK IN PROGRESS)**
SAE J2847 Part 5	*Communication between Plug-in Vehicles and their Customers* **(WORK IN PROGRESS)**
SAE J2847 Part 6	*Wireless Charging Communication between Plug-in Electric Vehicles and the Utility Grid* **(WORK IN PROGRESS)**
SAE J-2889	*Vehicle Sound Measurement at Low Speeds* **(WORK IN PROGRESS)**
SAE J-2889 Part 1	*Measurement of Minimum Noise Emitted by Road Vehicles* **(WORK IN PROGRESS)**
SAE J-2894 Part 1	*Power Quality Requirements for Plug-In Vehicle Chargers - Requirements* **(WORK IN PROGRESS)**
SAE J-2894 Part 2	*Power Quality Requirements for Plug-In Vehicle Chargers - Test Methods* **(WORK IN PROGRESS)**
SAE J-2907	*Power Rating Method for Automotive Electric Propulsion Motor and Power Electronics Sub-System* **(WORK IN PROGRESS)**
SAE J-2908	*Power Rating Method for Hybrid-Electric and Battery Electric Vehicle Propulsion* **(WORK IN PROGRESS)**
SAE J-2910	*Design and Test of Hybrid Electric Trucks and Buses for Electrical Safety* **(WORK IN PROGRESS)**
SAE J-2929	*Electric and Hybrid Vehicle Propulsion Battery System Safety Standard – Lithium-based Rechargeable Cells*
SAE J-2931 Part 1	*Power Line Carrier Communications for Plug-in Electric Vehicles* **(WORK IN PROGRESS)**
SAE J-2931 Part 2	*Inband Signaling Communication for Plug-in Electric Vehicles* **(WORK IN PROGRESS)**
SAE J-2931 Part 3	*PLC Communication for Plug-in Electric Vehicles* **(WORK IN PROGRESS)**
SAE J-2931 Part 4	*Broadband PLC Communication for Plug-in Electric Vehicles* **(WORK IN PROGRESS)**
SAE J-2931 Part 5	*Telematics Smart Grid Communications between Customers, Plug-In Electric Vehicles (PEV), Energy Service Providers (ESP) and Home Area Networks (HAN)* **(WORK IN PROGRESS)**
SAE J-2931 Part 6	*Digital Communication for Wireless Charging Plug-In Electric Vehicles* **(WORK IN PROGRESS)**
SAE J-2931 Part 7	*Security for Plug-In Electric Vehicle Communications* **(WORK IN PROGRESS)**
SAE J-2936	*Vehicle Battery Labeling Guidelines* **(WORK IN PROGRESS)**
SAE J-2946	*Battery Electronic Fuel Gauging Recommended Practices* **(WORK IN PROGRESS)**
SAE J-2950	*Recommended Practices (RP) for Transportation and Handling of Automotive-type Rechargeable Energy Storage Systems (RESS)* **(WORK IN PROGRESS)**
SAE J-2953	*Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)* **(WORK IN PROGRESS)**
SAE J-2954	*Wireless Charging of Electric and Plug-in Hybrid Vehicles* **(WORK IN PROGRESS)**

Source: "Blake, C., Buttner, W., Rivkin, C., "Vehicle Codes and Standards: Overview and Gap Analysis", National Renewable Energy Laboratory, Technical Report, NREL/TP-560-47336, February 2010" (supplemented with updates from applicable organization staff).

Table C-2: Examples of NFPA Codes and Standards
Addressing Technical Issues Relating to Electric Vehicles

Document #	Document Title/Section
NFPA 1	*Fire Code*
NFPA 30A	*Code for Motor Fuel Dispensing Facilities and Repair Garages*
NFPA 52	*Vehicular Gaseous Fuel Systems Code*
NFPA 70	*National Electrical Code® (NEC®); (Article 220, Branch Circuit, Feeder and Service Calculations; Article 625, Electric Vehicle Charging Systems; Article 626, Electrified Truck Parking Spaces; and other req.)*
NFPA 70B	*Recommended Practice for Electrical Equipment Maintenance*
NFPA 70E	*Standard for Electrical Safety in the Workplace®*
NFPA 73	*Standard for Electrical Inspections for Existing Dwellings*
NFPA 88A	*Standard for Parking Structures*
NFPA 88B	*Standard for Repair Garages*
NFPA 231	*Standard for General Storage*
NFPA 231C	*Standard for Rack Storage of Materials*
NFPA 258	*Recommended Practice for Determining Smoke Generation of Solid Materials*
NFPA 269	*Standard Test Method for Developing Toxic Potency Data for Use in Fire Hazard Modeling*
NFPA 270	*Standard Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber*
NFPA 271	*Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*
NFPA 289	*Standard Method of Fire Test for Individual Fuel Packages*
NFPA 400	*Hazardous Materials Code*
NFPA 450	*Guide for Emergency Medical Services and Systems*
NFPA 471	*Recommended Practice for Responding to Hazardous Materials Incidents*
NFPA 472	*Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*
NFPA 473	*Standard for Competence of EMS Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*
NFPA 484	*Standard for Combustible Metals*
NFPA 502	*Standard for Road Tunnels, Bridges, and Other Limited Access Highways*
NFPA 513	*Standard for Motor Freight Terminals*
NFPA 556	*Guide on Methods for Evaluating Fire Hazard to Occupants of Passenger Road Vehicles*
NFPA 921	*Guide for Fire and Explosion Investigation*
NFPA 1000	*Standard for Fire Service Professional Qualifications Accreditation and Certification Systems*
NFPA 1001	*Standard for Fire Fighter Professional Qualifications*
NFPA 1002	*Standard for Fire Apparatus Driver/Operator Professional Qualifications*
NFPA 1003	*Standard for Airport Fire Fighter Professional Qualifications*
NFPA 1005	*Standard for Professional Qualifications for Marine Fire Fighting for Land-Based Fire Fighters*
NFPA 1006	*Standard for Technical Rescuer Professional Qualifications*
NFPA 1021	*Standard for Fire Officer Professional Qualifications*
NFPA 1026	*Standard for Incident Management Personnel Professional Qualifications*
NFPA 1031	*Standard for Professional Qualifications for Fire Inspector and Plan Examiner*

NFPA 1033	*Standard for Professional Qualifications for Fire Investigator*
NFPA 1035	*Standard for Professional Qualifications for Public Fire and Life Safety Educator*
NFPA 1037	*Standard for Professional Qualifications for Fire Marshal*
NFPA 1041	*Standard for Fire Service Instructor Professional Qualifications*
NFPA 1051	*Standard for Wildland Fire Fighter Professional Qualifications*
NFPA 1061	*Standard for Professional Qualifications for Public Safety Telecommunicator*
NFPA 1071	*Standard for Emergency Vehicle Technician Professional Qualifications*
NFPA 1081	*Standard for Industrial Fire Brigade Member Professional Qualifications*
NFPA 1091	*Standard on Traffic Control Management Professional Qualifications*
NFPA 1192	*Standard on Recreational Vehicles*
NFPA 1194	*Standard for Recreational Vehicle Parks and Campgrounds*
NFPA 1221	*Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems*
NFPA 1500	*Standard on Occupational Safety and Health Program*
NFPA 1561	*Standard on Emergency Services Incident Management System*
NFPA 1600	*Standard on Disaster/Emergency Management and Business Continuity Programs*
NFPA 1670	*Standard on Operations and Training for Technical Search and Rescue Incidents*
NFPA 1710	*Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*
NFPA 1720	*Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations and Special Operations to the Public by Volunteer Fire Departments*
NFPA 1730	*Standard on Organization and Deployment of Code Enforcement, Plan Review, Fire Investigation, and Public Education Operations to the Public*
NFPA 1851	*Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*
NFPA 1852	*Standard for Selection, Care, and Maintenance of Protective Ensembles for Technical Rescue Incidents*
NFPA 1936	*Standard on Powered Rescue Tools*
NFPA 1951	*Standard on Protective Ensembles for Technical Rescue Incidents*
NFPA 1952	*Standard on Surface Water Operations Protective Clothing and Equipment*
NFPA 1971	*Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*
NFPA 1975	*Standard on Station/Work Uniforms for Emergency Services*
NFPA 1976	*Standard on Protective Ensemble for Proximity Fire Fighting*
NFPA 1981	*Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*
NFPA 1991	*Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*
NFPA 1999	*Standard on Protective Clothing for Emergency Medical Operations*
NFPA 5000	*Building Construction and Safety Code®*

Source: "Blake, C., Buttner, W., Rivkin, C., "Vehicle Codes and Standards: Overview and Gap Analysis", National Renewable Energy Laboratory, Technical Report, NREL/TP-560-47336, February 2010" (supplemented with updates from applicable organization staff).

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