Interoperability Roadmap Methodology, V1.1

December 2017

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Summary

The Interoperability Roadmap Methodology document supports the U.S. Department of Energy (DOE) Grid Modernization Laboratory Consortium (GMLC) Interoperability Project's efforts to advance interoperability as an essential component for the successful and more seamless integration of intelligent, communicating technologies into the electric power system. This proposed methodology supports the strategic approach to advance interoperability described in the GMLC Interoperability Project's *Interoperability Strategic Vision: Enabling an Interactive Grid*.[1] That document proposes engaging an ecosystem of businesses interested in integrating smart technology with the electric power system to develop an interoperability roadmap using a methodical approach. This roadmap methodology is to be applied to technology integration ecosystems (e.g., electric vehicles, photovoltaic inverters, or automated buildings), using tools that measure the state of interoperability today, to identify the gaps and challenges that can be overcome to improve interoperability, and thereby, simplify the integration process.

The roadmap methodology considers the interoperability categories defined in the GridWise *Interoperability Context-Setting Framework*.[2] Within and across technology ecosystems, different approaches exist for advancing interoperability and these approaches may change in the future. The interoperability roadmap methodology recognizes that the approach to advancing interoperability must be flexible and not necessarily universally uniform within every ecosystem. The interfaces tend to already be at different levels of maturity of interoperability. Improving interoperability is not a case of starting with a blank sheet of paper. Devices, systems, and processes already exist and improvements mean providing reasonable transition paths from previous integration processes and standards to the new features. The resulting roadmap should clearly portray the stages of evolution anticipated in moving toward a vision that addresses important integration issues.

To help accomplish the process of developing a roadmap, the methodology uses the interoperability maturity model[3] (IMM) as a tool to articulate a baseline level of interoperability and to identify the gaps and priority aspects to consider for evolving toward higher levels of interoperability maturity. The IMM was created in parallel with the roadmap methodology because of their close relationship. The ultimate goal of a roadmap effort is to improve the interoperability maturity level to levels that meet ecosystem objectives while being sensitive to the state of the art, the projected technology advances, and the cost/value of the effort.

In creating the interoperability roadmap methodology, the project team reviewed several technology roadmap processes and found one that fits well with the objectives of this effort. The International Energy Agency's *Energy Technology Roadmaps: A Guide to Development and Implementation*[4] offers a process for creating roadmaps that fits well with the needs for building consensus among the various parties with interest in technology integration and enabling field deployments through standardized agreements. This approach was adapted to the specific needs of electric power system interoperability as described in this document.

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[1] U.S. Department of Energy, GMLC Interoperability Project, "Interoperability Strategic Vision: Enabling an Interactive Grid," April 2017, PNNL-26338. Accessed April 2017, https://gridmod.labworks.org/sites/default/files/resources/InteropStrategicVision2017-04-11.pdf

[2] GWAC–GridWise® Architecture Council. 2008. Interoperability Context-Setting Framework v1.1. Accessed February 2017 at http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf.

[3] U.S. Department of Energy, GMLC Interoperability Project, "Interoperability Maturity Model," April 2017, PNNL

[4] IEA–International Energy Agency. 2014. Energy Technology Roadmaps: A Guide to Development and Implementation. Accessed February 2017 at https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapAguidetodevelopmentandimplementation.pdf.

Acronyms and Abbreviations

DOE	U.S. Department of Energy
EPS	Electric Power System
GMLC	Grid Modernization Laboratory Consortium
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IMM	Interoperability Maturity Model
NIST	National Institute of Standards and Technology
RACI	responsible, authorized, consulted, informed

Contents

Figures

Tables

1.0   Introduction

Specific interoperability characteristics can be stressed differently in different technology domains. As technology and business cases mature, attention paid to reducing integration costs takes on different levels of importance to fit different stakeholder needs. Interoperability is a multi-faceted, complex topic that is nearly impossible to address at once. Instead, the steps to advance interoperability are broken down into a series of efforts to address the priority needs of the community.

This project seeks to advance interoperability, not by creating a single roadmap for advancement, but by developing a methodology through which stakeholders can create roadmaps tailored to the technology domains and business scenarios they intend to address. As a methodology, it is structured and repeatable. The roadmap methodology considers the economic drivers for the interoperability effort and the level of effort required to advance interoperability.

1.1   Past Work on Interoperability

Significant work has already been done to define interoperability concepts and promote advancement for grid modernization efforts. The U.S. Department of Energy's (DOE's) GridWise Architecture Council and the National Institute of Standards and Technology (NIST) Smart Grid Interoperability Panel (now part of the Smart Electric Power Alliance) are two groups created by the U.S. government with industry support that have published guidance in this area. Additional information has been published by numerous other entities and stakeholders including the Electric Power Research Institute, the International Energy Agency (IEA) and the Institute of Electrical and Electronics Engineers (IEEE). As part of this task, the team reviewed the following documents:

- NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0, (NIST-SP-1108r3)

- IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads (IEEE 2030-2011)

- GridWise Architecture Council Interoperability Context-Setting Framework

- GridWise Architecture Council Interoperability Maturity Model Beta Version

- IEA How2Guide for Roadmap Development & Implementation: Smart Grids in Distribution Networks

The project team reviewed these documents to identify lessons and gain insight on implementing interoperability in relevant domains. In large part, these documents provide definition of terms, concepts, and framework that describes principles of system design and overall system architecture that can be helpful, and even essential, to facilitating interoperability.

1.2   Tested Methodology for Developing Roadmaps

The IEA's *Energy Technology Roadmaps: A Guide to Development and Implementation*[1] defines a highly structured, repeatable road-mapping process suitable for this project's needs.

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[1] IEA–International Energy Agency. 2014. Energy Technology Roadmaps: A Guide to Development and Implementation. Accessed February 2017 at

The IEA has produced more than 20 technology roadmaps on topics as diverse as bioenergy for heat and power, cement, nuclear energy, and hydrogen and fuel cells. The IEA guide makes the point that it should be possible to map any supporting project or activity back to the roadmap to show how it contributes to the goals. It also specifies the following:

- how to structure stakeholder participation
- elements for a roadmap statement of purpose and scope
- how to develop a baseline
- how to plan a roadmap workshop
- resource constraints and critical inputs to consider
- considerations for monitoring and tracking progress.

The IEA guide was designed to produce technology roadmaps associated with a specific technology—for instance, a roadmap for deploying advanced metering infrastructure across a large service area. However, a roadmap for interoperability is somewhat different in that interoperability is not one specific technology. Rather, it is an enabling property intended to be incorporated into many different technologies going forward.

Therefore, the IEA process must be adapted somewhat. Fortunately, the IEA document contains a section on "Tailoring the Roadmap Process," which lists six key factors to consider when tailoring:

- stakeholder participation
- resource constraints
- critical inputs
- roadmap design
- buy-in and dissemination
- monitoring and tracking.

Each of these factors is explained, and relevant questions are posed for each factor.

With its emphasis on board-based consensus among stakeholders and built-in flexibility (through the tailoring section), the IEA guide is well-suited to providing a basis for a roadmap methodology. However, while it can provide the bulk of the methodology, it does not fulfill all project requirements. Two new phases were added to aid in the initial outreach and for coordination with wider efforts (see Figure 1). Section 2.0 describes this expanded process.
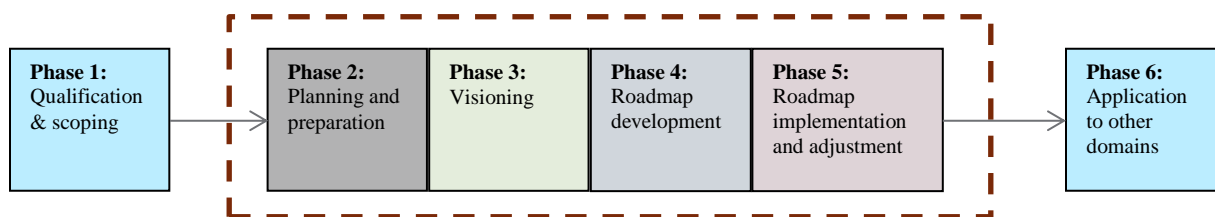

Figure 1. Interoperability-specific roadmap-development process (adapted from IEA)

2.0   Interoperability Roadmap Methodology

The IEA guide describes a roadmap as…

> *"...a strategic plan that describes the steps an organisation needs to take to achieve stated outcomes and goals. It clearly outlines links among tasks and priorities for action in the near, medium and long term. An effective roadmap also includes metrics and milestones to allow regular tracking of progress towards the roadmap's ultimate goals."*[2]

The IEA guide gives some preliminary advice and recommendations. In summary, it recommends evaluating the current situation prior to roadmap development to determine whether a roadmap would be valuable or even necessary. The roadmap process should be considered evolutionary in that as progress is made toward the roadmap priorities, more information becomes available, external factors change, and the roadmap must be revised. A key component of an effective road-mapping process is that it *maximizes stakeholder engagement* in creating the plan. Once consensus is built among the participants toward shared goals and results, these relationships can help support the roadmap implementation and increase the likelihood that the participants will implement the roadmap priorities.

A successful roadmap includes a clear statement of the desired outcome and states specific steps for reaching the goals. Key elements include the following:

- **Goals**. These targets should be clear, concise, and designed so that if achieved, they will result in the desired outcome. If possible, goals should also be quantifiable so that clear, specific guidance can be provided and progress can be measured.

- **Milestones**. These are interim targets for achieving goals and should be keyed to specific dates.

- **Gaps and barriers**. Identifying these develops an understanding of obstacles to achieving milestones and goals. Examples include gaps in knowledge, technology limitations, market structural barriers, regulatory limitations, and public acceptance. These also include gaps between current and desired interoperability.

- **Action items**. Action items are executed to eliminate gaps and barriers. Examples include technology development and deployment, development of regulations and standards, policy formulation, creation of finance mechanism, and public engagement.

- **Priorities and timelines**. These identify the priority actions required to achieve goals within stated timeframes. An important consideration is to evaluate the interrelationships among actions and roadmap participant or stakeholder roles and responsibilities.

The IEA guide notes that *"If designed correctly, a successful roadmap should provide the ability to link any project or activity back through this logical structure to understand how the project or activity ultimately contributes to the achievement of the roadmap goals."* The logical flow of the key elements described above is shown in Figure 2.

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[2] IEA–2014.

Figure 2. Logic and key elements of a successful roadmap[3]

2.1 Roadmap-Development Process

The IEA guide advises that "*the process of developing a roadmap is as important as the final document itself: it represents consensus among the full range of stakeholders consulted in its development, who have considered potential barriers to deployment, sought early solutions and, in some cases, avoided anticipated issues altogether.*"

The roadmap-development process (Figure 3) is designed to ensure that the roadmap identifies shared goals and establishes specific and achievable actions toward realizing a common vision.

The process is comprised of two types of activities (i.e., expert judgment and consensus, and data and analysis) and four phases (i.e., planning and preparation, visioning, roadmap development, and roadmap implementation and revision). The success of a roadmap is based on early planning and foresight, establishing a commonly "owned" vision, gaining a full understanding of the national challenges and opportunities, acknowledging the importance of champions to advance the work, commitment to outcomes by both public and private stakeholders, and ongoing evaluation and progress reports. The development of a common vision can be informed by the desired integration vision espoused in the Interoperability Strategic Vision document and this provides a converging force to separate technology roadmap efforts. Champions of the work need to be recognized early on in order to provide effective leadership and demonstrate their passion for achieving the desired outcomes.

2.1.1 Expert Judgment and Consensus

Participant buy-in is essential and expert judgment and consensus activities are important steps to develop this in the road-mapping process. The primary method of conducting these activities is through workshops that bring together a cross-section of experts to develop roadmap goals and milestones, identify gaps, determine priorities, and assign tasks. The IMM is an important tool to introduce in this early stage. Expert judgment is often necessary to make choices when data and analysis activities identify several possible scenarios or options. Roadmap workshops will seek to bring together diverse technical expertise to ensure a broad set of viewpoints. A critical first step is to develop a good definition of the technology ecosystem and its stakeholders for participation in a road-mapping effort. This will identify the business scenarios and the interfaces that will be evaluated for interoperability maturity. The activities
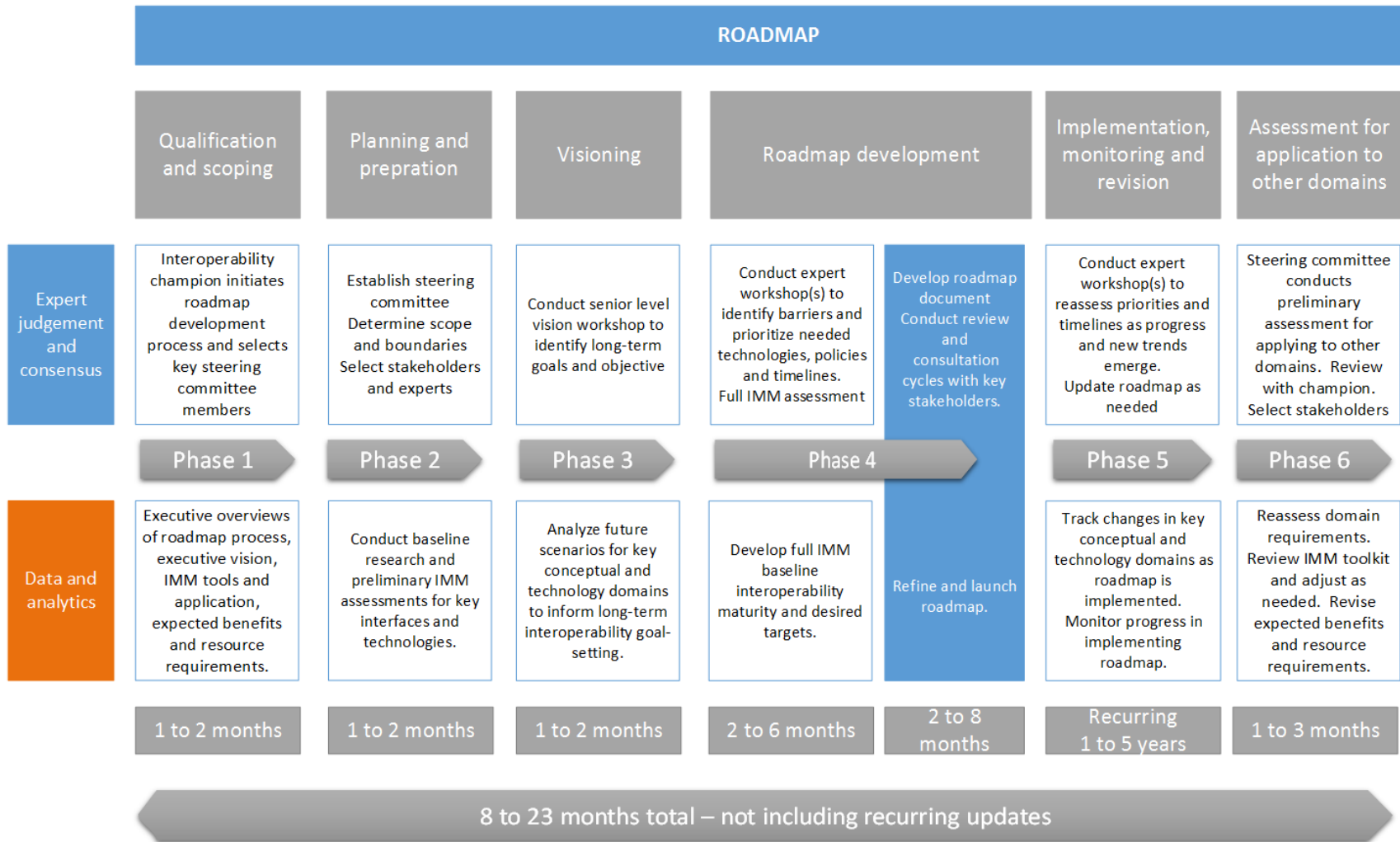
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[3] IEA 2014

Figure 3. Interoperability roadmap-development process

will be structured to develop an overall vision and strategy for interoperability and will seek to accomplish the following goals:

- identify the appropriate parties (stakeholders) who need to be a part of the roadmap process
- define the target scenarios and related technology domains
- build consensus on shared goals, milestones and time frames
- evaluate and verify assumptions
- identify critical market, policy, social, technical, institutional, or regulatory factors
- develop current baseline conditions and interoperability maturity level
- identify key barriers or obstacles
- determine alternatives to overcome barriers
- develop implementation strategies
- prioritize future actions
- decide if the road-mapping process can be streamlined.

2.1.2 Data and Analysis

If needed, expert judgment activities may leverage additional, more detailed data and analysis to support the establishment of current baseline conditions. Definition of the baseline interoperability maturity level is a prerequisite to setting milestone and performance targets and defining strategies to achieve the roadmap goals. The data and analysis activities will be tailored to meet the needs of the expert judgment activities and will also be dependent on the amount and quality of available data and the time and resources available to the road-mapping team.

Key insights and data are derived from results of the Interoperability Maturity Model (IMM). The IMM consists of a set of questions to identify the level of maturity for each criterion. The answers, or output, of the IMM tool at this point show the baseline interoperability capability maturity level. This baseline is compared against the target levels for each criterion and a set of prioritized actions are developed to adjust the baseline to meet target levels where appropriate.

2.2 Phase 1: Roadmap Qualification and Scoping

This phase is primarily the executive action phase. In this phase, the primary champion (recognized leader) has determined a potential business need to make interoperability improvements in one or several areas. The executive champion convenes the core of the steering team. The steering team is responsible for determining if a business case exists for the interoperability efforts to be undertaken. As such, the initial job of the steering committee is to provide business justification so the executive champion can cement the business case for these efforts with other executive leadership. If this is successful, the steering team adds members as necessary to see that the appropriate parties are participating in the roadmap process and proceeds to Phase 2.

In the early stages of investigating the state and future needs for interoperability, the executive champion may choose to host an interoperability "quick-start" workshop to provide a short introduction for the steering committee on how individual organizations can implement interoperability improvements. This introduction is not intended to replace a full maturity baseline and roadmap-development effort. Rather, it is intended to provide the steering team sufficient background on the process and an explanation of interoperability improvement benefits to support a full maturity baseline and road-mapping exercise.

This quick-start workshop would take place over one-week and would introduce tools for assessing and improving interoperability. The sections below describe the mechanics of conducting the workshop, the

main phases of evolving a preliminary interoperability baseline, and a tentative roadmap for improvements during the workshop. The workshop is intended to provide a clear justification to the steering team for further roadmap steps. During the workshop, the steering team gains focus and direction as members discuss interoperability maturity concepts and answer maturity criteria questions.
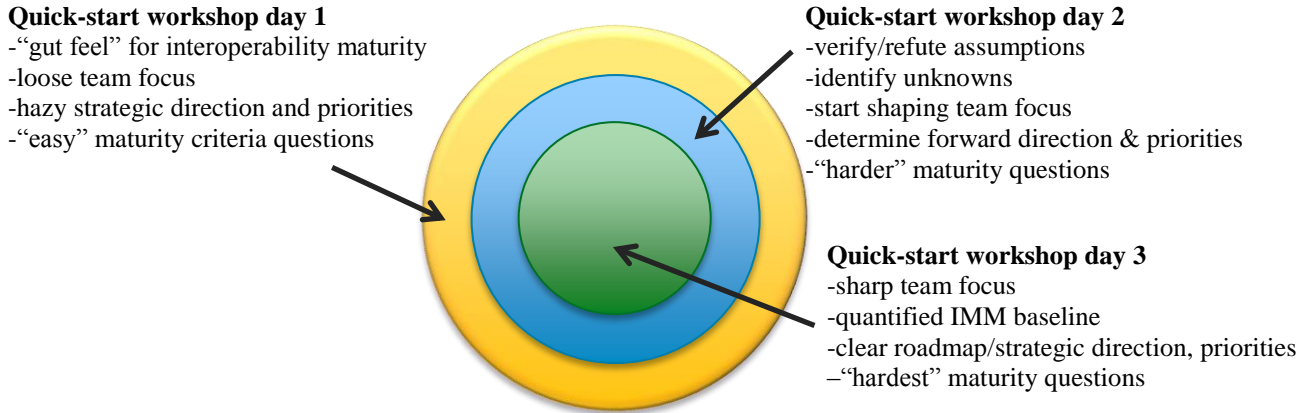
Quick-start workshop day 1
-"gut feel" for interoperability maturity
-loose team focus
-hazy strategic direction and priorities
-"easy" maturity criteria questions

Quick-start workshop day 2
-verify/refute assumptions
-identify unknowns
-start shaping team focus
-determine forward direction & priorities
-"harder" maturity questions

Quick-start workshop day 3
-sharp team focus
-quantified IMM baseline
-clear roadmap/strategic direction, priorities
–"hardest" maturity questions

Figure 4. Increasing levels of interoperability roadmap focus

2.2.1   Interoperability Quick-Start Workshop

A suggested work plan for the quick-start workshop follows:

Preplanning

- Preliminary exchanges with interoperability champion
- Selection of key "steering team" members to manage workshop details and logistics
- "Interoperability readiness checklist" – filled out by steering team
- Preliminary discussions with key steering team members
    - Review of "interoperability readiness checklist"
    - Agreement on workshop approach and goals
    - Confirmation of attendance of key participants

Day 1: Kick Off Meeting

1. Interoperability Team
    a. High-level overview of project, overall DOE perspective and goals
    b. Discussion on terminology (e.g., interoperability and integration)

2. Organization Team
    a. High-level overview of organization, goals, structure, and previous experience with interoperability

3. Declaration of workshop approach and goals

4. Open discussion of interoperability challenges and opportunities

Day 2: (Example) Roadmap Phase 1

1. Overviews of roadmap process

2. Review of IMM criteria and evaluation/scoring

3. **Exercise 1**: Selection of categories to evaluate

4. **Exercise 2**: Identify long-term goals and objective

5. **Exercise 3**: Selection of stakeholders and experts

6. Discussion of expected benefits from interoperability improvements

7. Discussion of costs related to interoperability improvements

8. **Exercise 4**: Determination of scope and boundaries

Day 3: (Example) Roadmap Phase 2

1. **Exercise 5**: Perform preliminary interoperability maturity baseline for one category

2. **Exercise 6**: Discussion of relative priorities among criteria

Day 4: Phase 3

1. Finalize any outstanding tasks from **Exercise 5**

2. Development of deliverables (Word and PowerPoint)
   a. Interoperability roadmap team provides templates

Day 5: Phase 3 (1/2 day)

1. Presentations of findings

Table 1. High-level work plan for interoperability quick-start workshop

Interoperability Road-Mapping Quick Start		Mon		Tue		Wed		Thu		Fri	
		am	pm	am	pm	am	pm	am	pm	am	pm
Preparation											
Preplanning	■	■									
Kickoff meeting			■	■							
Open discussion				■	■						
Interoperability Roadmap Quick Start – Session 1											
Overview of roadmap process				■	■						
Select stakeholders and experts				■	■						
Review IMM (criteria/scoring)					■						
Select a category					■	■					
Discuss expected benefits					■						
Determine scope and boundaries				■	■						
Interoperability Roadmap Quick Start – Session 2											
Discussion of relative priorities						■					
Perform IMM assessment							■	■			
Interoperability Roadmap Quick Start –Session 3											
Finalize IMM assessment (if req'd)								■	■		
Prepare deliverables									■	■	
Present findings										■	■

At the end of the workshop, a roadmap process report should be delivered to document the activities and provide a basis for further road-mapping efforts. The workshop report should include the following sections (note that a complimentary PowerPoint may be prepared with similar content and flow to highlight the findings at the conclusion of the workshop):

About the Interoperability Effort: This is a brief overview of organizational goals and importance of interoperability (half page).

Benefits of Road-mapping: This should indicate why roadmaps are helpful (half page).

About the Roadmap Process: This section will contain information already explained during the week and is included as a summary for those who did not attend and a refresher for those that did (one page).

About the IMM Criteria: This section will contain information already explained during the week and is included as a summary for those who did not attend and a refresher for those that did (one page)

Process Followed: This is an overview of what was performed during the week, why it can only provide limited insights, how a full road-mapping process (specify duration) would lead to more (specified) benefits in general, and additional areas to focus on based on what has been learned from this effort.

Description of Ecosystem: This section describes the ecosystem from the stakeholders' perspectives. It should be worded using the stakeholders' language as much as possible.

Stakeholders Involved: This provides the full scope and description—along with diagrams—of stakeholder needs and a list of those that took part in the exercise.

Systems and Devices: This describes the systems and devices considered in the process. Be sure to indicate that this may only be a subset of the relevant technologies and that results based strictly off this subset could appear biased.

Standards in Use and Planned: This includes a list of relevant standards for further review and evaluation.

Benefits Sought: This is a summary of the first part of the process with the steering team/stakeholders. The language used should be closely reviewed with those present during the exercise.

Barriers to Eliminate: This reflects the barriers that the steering team/stakeholders have discussed. These may or may not represent actual barriers; however, it should give a strong indication of where perceived issues exist and areas where the stakeholders think that eliminating barriers will generate benefits.

Concerns: This reflects input from the steering team/stakeholders including, for example, concerns about the process, lack of interoperability, and overcoming perceived barriers.

Results of IMM Assessment: This should clearly show whether the target interoperability level was met or not. It should indicate areas of strength and weakness. Any uncertainty due to lack of clarity or lack of information should be noted. It may be, for a short effort like this, that *no target level is set* and this is just an exercise to evaluate a part of the ecosystem for one interoperability category. There is a need to remain flexible.

Preliminary Roadmap: This describes the roadmap itself. What can be created realistically from such an abbreviated process requires careful thought and the team organizing the workshop must decide a useful format for communicating the findings.

Recommended Next Steps: This should be linked to content of the roadmap. The quick-start workshop report should inform the next steps in the overall road-mapping process. The steering team should use this input to develop planning and preparation materials for the next stakeholder workshop. In addition, the executive champion should review the workshop report and act based on the recommended next steps.

2.3 Phase 2: Planning and Preparation

During the planning and preparation phase, the road-mapping team will complete the following tasks:

- determine the boundaries of the interoperability road-mapping effort
- identify which technology domains the roadmap will consider
- determine the time frame for the road-mapping effort
- determine the current baseline interoperability maturity level of the domain under consideration using the IMM tool
- identify how the road-mapping participants will implement and use the resulting roadmap, including identification of any external entities that will need to be engaged to achieve goals
- identify any existing tools, analysis, or other roadmaps that can be used to inform decisions.

The following sections provide additional detail and guidance for Phase 2 tasks.

2.3.1 Ensure Leadership Commitment

A top priority of the roadmap preparation and planning process will be to ensure commitment from senior industry executives and/or policy officials. These individuals can champion the interoperability road-mapping effort by authorizing resources to complete the process and can also commit to implementing the findings. A draft statement of purpose, as well as a short, clear presentation of the initiative should be prepared to brief senior executives and policy makers to inform and gain approval, input, and commitment. Participation by senior executives in the road-mapping process is encouraged. This could be in the form of either opening remarks or direct participation in workshops or the provision of staff experts to participate in the workshops and road-mapping process.

2.3.2 Appoint a Steering Committee

The road-mapping efforts are led by a steering committee whose members have the knowledge and authority to decide on goals, scope, boundaries; direct work for obtaining additional data and analytics; and define the team responsible for implementing the roadmap. The number and type of steering team participants will be determined by reviewing the targeted domain, the list of stakeholders (to ensure representation of key interests), and the plan for who will be involved in implementing the roadmap.

2.3.3 Develop a Statement of Purpose and Scope

The team will develop a short (i.e., two- to three-page) document that clearly describes the purpose for developing the roadmap; the scope, objectives and expected outcome of the roadmap; the process for developing and implementing the roadmap; and the list of participants involved in developing and implementing the roadmap.

The statement of purpose and scope maintains focus throughout the roadmap-development process and helps to maintain commitment to the desired goals. The statement can also be used as a tool to educate new or external partners, participants, or other interested parties. The following sections should be included:

- Purpose: explains the reasons for developing the roadmap and the specific issues and challenges that will be addressed.

- Scope and Objectives: explains the type and duration of projects covered by the roadmap.

- Process: explains the methodology for roadmap development, along with time to complete. Specific elements (e.g., vision and roadmap workshops; required data and analysis; periodic feedback and update workshops during implementation; and the process for monitoring, evaluation, and mid-course corrections) will be listed and briefly described in the process section.

- Participant: describes a list of organizations, their types, as well as required expertise from participants and individuals expected to provide feedback during the roadmap process. The exercise of developing a responsible, authorized, consulted, informed (RACI) chart can be an effective means of determining the participant list. See Table 2 for an explanation of RACI charts.

Table 2. RACI chart of stakeholders, categories, and responsibilities

Category	Definition	Responsibility can include
Responsible	• This group, the steering committee, holds the authority to approve the final product. • To determine the size and composition of this group, consider the different stakeholders needed for roadmap implementation. • The steering committee should include senior representatives from the major stakeholder groups to ensure best chances for implementation.	• Approve the roadmap goal, scope and boundaries • Approve the RACI chart • Approve communications to the wider "informed" stakeholder community • Assign the "authorized" members of the roadmap project team • May contribute to direct analytical efforts

Authorized	• This is the project team and will be the core team that performs the majority of work on the roadmap.
	• This team mirrors the composition of the steering committee at a working level.
	• A project leader is needed to coordinate activities and communications with other teams.
		• Project Leader
		  o Manage the project
		  o Communicate with stakeholders
		• Develop drafts
		• Plan workshops
		• Document gathered information
		• Perform analysis

Consulted	• Includes expert representatives from entities that have a key role in the development and implementation of the roadmap – this could include manufacturers, vendors, standards development organizations, trade groups, and other representatives that will be part of the workshops, analysis and roadmap implementation.	• Attend workshops • Provide inputs • Review roadmap drafts • Commit to active participation in the process when appropriate
Informed	• These are stakeholders not directly involved in the roadmap implementation but who may be affected by the roadmap; thus, these stakeholders have an interest in the roadmap and may be helpful during some workshops or during analysis.	• Be informed about roadmap recommendations and milestones • Are not typically directly involved in the workshops or other activities

2.3.4   Conduct Baseline Research

The fourth step in the road-mapping effort begins by developing a baseline for the interoperability maturity level. The methods and tools for conducting the maturity assessment are detailed in the IMM document. The baseline exercise will also identify the key factors affecting interoperability for the specific organization or project that will be implementing the roadmap. Key types of data that may affect the implementation could include the technology to be addressed by the roadmap, the market sectors to which the technology will be applied, and the internal or external policies (or governance) that could help or hinder the roadmap implementation. The aim of the baseline research is to develop accurate information on the status of maturity, costs, performance, technology readiness, manufacturers, vendors, market conditions and limitations, and a forecast or projection with information on the trends expected to affect interoperability in the target technology domain or project. Existing roadmaps may also provide information on relevant interoperability-related topics or technologies.

Figure 5 indicates the types of inputs obtained from the research work done in this phase of the methodology. These reflect the necessary groundwork before applying the IMM tool to see what is important, what cannot be touched or changed, and includes the goals and drivers. Barriers help define the integration barriers or constraints.
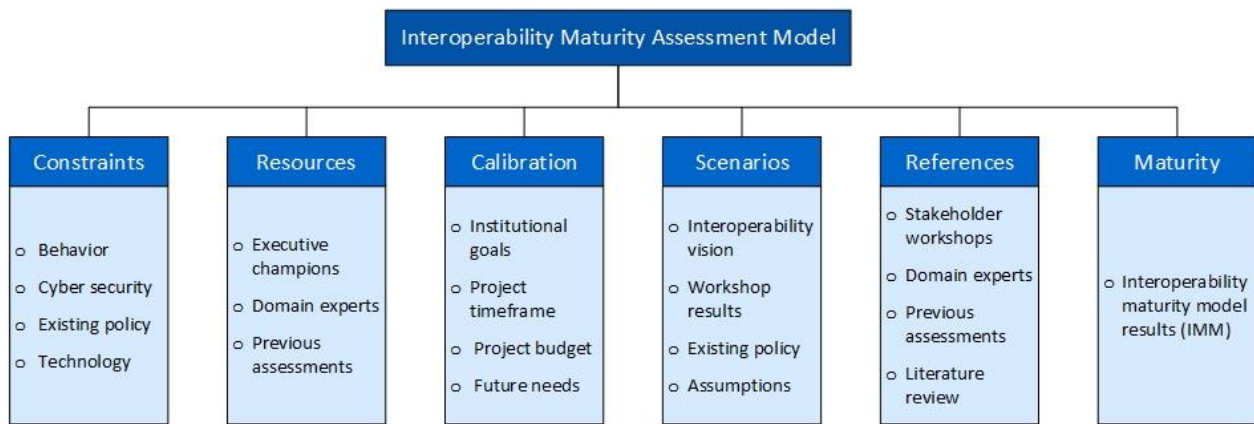

Figure 5. Interoperability maturity assessment model inputs

2.3.5   Select Stakeholders and Experts

Stakeholders, participants, and experts will be engaged as early as possible in the road-mapping process. An important first step will be to identify the roles and responsibilities of organizations and individuals. Decisions on composition of the participants can be informed by reviewing the scope and objectives of the roadmap. Suitable participants will have appropriate levels of responsibility and expertise to provide appropriate guidance throughout the roadmap-development and implementation phases. Suitable individuals should also be willing to serve as roadmap "ambassadors" by educating others during the development and implementation phases. They may also be liaisons to related groups so that knowledge about the roadmap may spread and influence from the consensus process has the greatest chance for widespread adoption.

As a suggested guide for vision workshops, 10 to 40 individuals will be selected to represent leadership in an industry group or technology domain. For expert workshops, from 50 to 200 participants may be recruited to provide input on challenges, needs, and suggested courses of action. A high-level view of the

overall stakeholder involvement strategy is shown in Figure 6. As an aid to the stakeholder selection process, the RACI chart shown in Table 2 can help organize the wide array of participants.
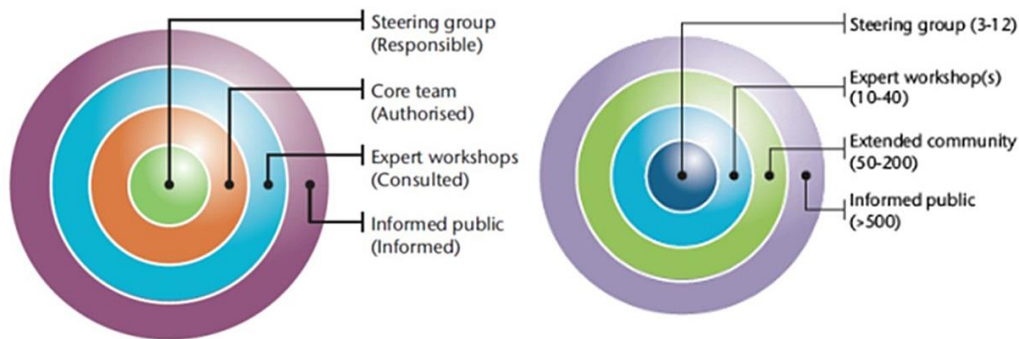

Figure 6. Road-mapping stakeholder involvement strategy[1]

2.4 Phase 3: Visioning

Setting a vision is the process of defining the strategy to be used for implementing interoperability. This process includes consideration of current and future scenarios. Analysis of these scenarios can inform the participants about what future states are possible or likely to evolve. This, in turn, informs the long-term goals of the interoperability roadmap. The visionary aspect described in the Interoperability Strategic Vision document, including the desired integration stories and interoperability goals that transcend individual technology domains can be reviewed at this stage to help bring convergence across grid integration efforts.

Visioning exercises can be included in a vision workshop where domain experts meet to discuss and collectively decide on the desired future interoperability maturity level. Participants can leverage results from data-analysis tasks to review and debate alternative scenarios or forecasts if available. As part of the kickoff for such a workshop, the steering team may share current assumptions, methodologies, analysis, and results to ensure all participants have a common understanding of work and analysis done to date.

2.5 Phase 4: Roadmap Development

The roadmap-development phase follows from the visioning phase, and relies on analysis and expert judgment to define the activities, priorities, and schedule to achieve the desired vision.

The IMM toolkit is required throughout the roadmap-development process to inform the roadmap-development stakeholders. In Phase 1, the interoperability champion requires an executive overview of the IMM and the roadmap process itself to successfully gain buy-in from the rest of executive leadership as well as a to kick off the roadmap process by selecting key steering committee members. The steering committee will require details to determine the composition of the experts needed and to determine workflow during the workshops in Phase 3.

There are several suggested steps in this phase as described below.

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[1] IEA 2014 includes the left drawing.

2.5.1   Holding Roadmap Workshops

Roadmap workshops can be an effective way to solicit ideas from stakeholders and experts. It may be necessary to hold several workshops focused on specific issues or stakeholder groups (e.g., technology or finance/policy). Workshop planning should include defining the workshop process, identifying introductory presentations, creating a list of discussion topics and questions, and planning for the collection of participant input. Breakout sessions can be effectively used to obtain more detailed and targeted information. Prior to the workshop, the steering team should send a background document to participants that states the main questions to be answered at the workshop and a clear statement of the workshop's purpose, scope, process, and expected outcomes. A list of selected references is also recommended. Specific elements of a roadmap workshop background document can be found in the IEA roadmap guide.

2.5.2   Preparing the Draft Roadmap Document

The roadmap document is the means through which a narrative can be shared that describes and integrates the large amounts of information and analysis into a compelling, rational sequence of activities that demonstrate how to achieve the desired maturity level. A variety of audiences should be kept in mind.

2.5.3   Conducting a Roadmap Review

A roadmap review process includes multiple cycles of review, with the first cycle being shared among all contributors to date. A revised draft is based on feedback from the expert community and moves from the initial set of contributors to a wider external audience of domain experts. This second review is presented as a near-final version. A third review may be necessary depending on feedback.

2.6   Phase 5: Roadmap Implementation and Adjustment

This phase is the culmination of many months of effort by many participants. As these steps are executed, close monitoring of progress is necessary and adjustments may still be required.

2.6.1   Launching the Roadmap

The formal launch of the interoperability can be accomplished in numerous ways. When ready, a critical notification is given to the intended audience that the roadmap document has been finalized and is available for the next phase. This may be done during a roadmap launch kickoff meeting.

2.6.2   Beginning Implementation

The roadmap document will describe a set of priorities, gaps that need to be filled, technology demonstrations needed, policy notes and/or regulatory changes, and financial and scheduling commitments needed to meet the roadmap goals. In many cases, the steering committee may evolve into the body that oversees roadmap implementation and tracking.

2.6.3   Monitoring Progress and Adjusting the Roadmap

The roadmap implementation body is responsible for tracking stakeholder effort, gathering and disseminating results, and providing progress updates. If needed, the roadmap is re-evaluated and revised. Workshops can be reconvened if expert judgment is required to revise goals, priorities, and

schedule. In fact, regular workshops every three or five years to revisit key assumptions and progress may be advised.

2.6.4   Managing Expectations

Road-mapping should be approached as a "living process" that will require revisions past the roadmap's initial publication. Regular roadmap revision workshops will be necessary to modify the roadmap goals and priorities based on evolving technology and institutional requirements.

2.7   Phase 6: Assessment for Application to Other Domains

In this final phase, the project team will review lessons learned and make any needed adjustments to the road-mapping methodology itself. The team will then review what changes may be required to apply the road-mapping efforts to additional domains that have been identified earlier.

3.0   Conclusion

The interoperability roadmap methodology concentrates on the process to develop high-level, strategically oriented steps to advancing interoperability in a specific technology integration area. It is designed with a heavy emphasis on understanding the ecosystem of businesses and related stakeholders and the financial and policy drivers that make interoperability a worthwhile topic to invest their time and effort. Such motivation is necessary to garner participation in developing a roadmap, and more importantly, in taking ownership to make progress.

Linked closely with the roadmap methodology is the IMM tool. The IMM provides a structured way to explore the state of interoperability, which has many complex dimensions. It also serves to identify gaps and helps those participating in the roadmap process define their desired goals and prioritize the areas that need attention to achieve them. Because of this the roadmap methodology is able to concentrate on process-related concerns, while the IMM can focus on measuring the characteristic associated with achieving interoperability more simply and reliably.

"SIMPLY WRITING A ROADMAP IS NOT ENOUGH — THE TRUE MEASURE OF SUCCESS IS WHETHER OR NOT THE ROADMAP IS IMPLEMENTED AND ACHIEVES THE ORGANISATION'S DESIRED OUTCOME."

IEA *Energy Technology Roadmaps: A Guide to Development and Implementation*