Interoperability Maturity Model

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Agenda

- Measuring interoperability
- Breakout: Uses of Interoperability Criteria
  - 3 short tasks
  - Consider your perspectives on
    - The value of interoperability (What will this cost, and why should I do it?)
    - Procurement language (How can I get people to conform with this?)

Measuring Interoperability

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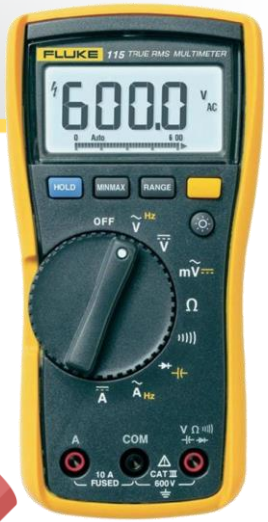
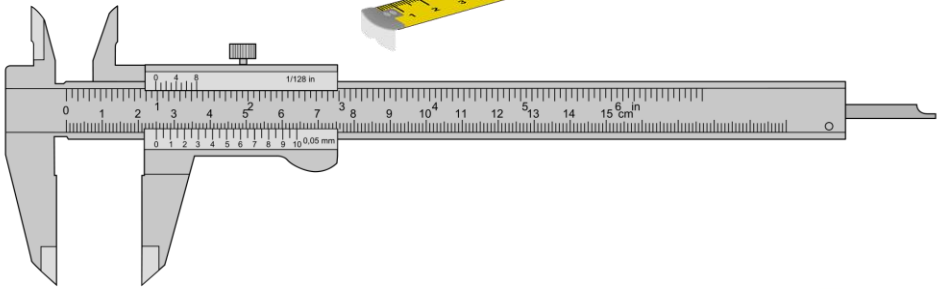
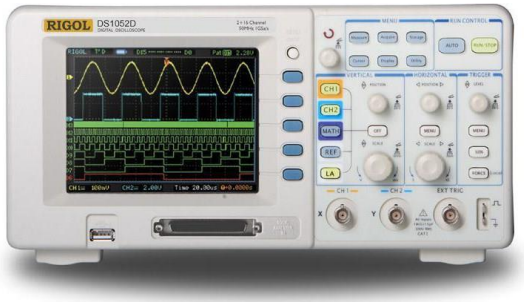
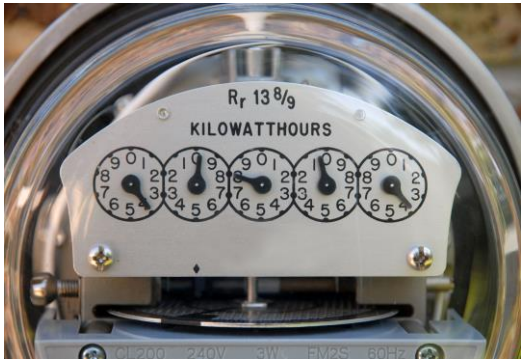
Measuring Interoperability









And the Winner is ……

- Criteria represent the core content of maturity models.
- They are typically based on observed practices, standards, or other expert knowledge, and can be expressed as characteristics, indicators, practices, or processes.
- For a capability maturity model, attributes may also express qualities of organizational maturity that are important for supporting process improvement.

(35) Interoperability Criteria

Ref	Statement	Category
01	The accommodation and migration path for integration between legacy and new components and systems shall be described.	Configuration & Evolution
02	Organizational capability to revise and extend interface capabilities over time (versioning) while accommodating connections to previous versions of the interface shall be supported.	Configuration & Evolution
03	The way regional and organizational differences are supported shall be described.	Configuration & Evolution
04	Configuration methods to negotiate options or modes of operation including the support for user overrides shall be described.	Configuration & Evolution
05	The capability to scale the integration of many components or systems over time without disrupting overall system operation shall be supported.	Configuration & Evolution
06	The ability of overall system operation and quality of service to continue without disruption as parties enter or leave the system shall be supported.	Configuration & Evolution
07	Unambiguous resource identification and its management shall be described.	Configuration & Evolution
08	Resource discovery methods for supporting configuration shall be described.	Configuration & Evolution
09	The requirements and mechanisms for auditing and logging exchanges of information shall be described.	Safety & Security
10	Privacy policies shall be defined, maintained, and aligned among the parties of interoperating systems.	Safety & Security
11	Security policies shall be defined, maintained, and aligned among the parties of interoperating systems.	Safety & Security
12	Failure mode policies shall be defined, maintained, and aligned among the parties of the interoperating systems to support the safety and health of individuals and the overall system.	Safety & Security
13	Performance and reliability requirements shall be defined.	Operation & Performance
14	The way errors in exchanged data are handled shall be specified. Interface definitions may need to specify their error-handling expectations.	Operation & Performance
15	Time order dependency and sequencing (synchronization) for interactions shall be specified.	Operation & Performance
16	Transactions and state management capability for interactions shall be specified.	Operation & Performance
17	Compatible business processes and procedures shall exist across interface boundaries.	Organizational
18	Where an interface is used to conduct business within a jurisdiction or across different jurisdictions, it shall comply with all required technical, economic and regulatory policies.	Organizational
19	Information models relevant for the interface shall be formally defined using standard information modeling languages.	Informational
20	Information exchange relevant to the business context that is derived from information models (i.e., ontologies) shall be specified.	Informational
21	Where the information exchanged derives from multiple information models, the capability to link data from different ontologies shall be supported.	Informational
22	The structure, format, and management of the communication transport for all information exchanges shall be specified.	Technical
23	The informational and organizational categories in an interface definition specification shall be independent from the technical categories.	Technical
24	Stakeholders shall reference openly available standards, specifications, or agreed-upon conventions in interface definitions.	Community
25	Stakeholders shall participate in development of interoperability standards efforts consistent with their businesses.	Community
26	Stakeholders shall support interoperability test and certification efforts and have clear incentives for participation.	Community
27	Stakeholders shall actively identify and share lessons learned and best practices resulting from interoperability improvements.	Community
28	Stakeholders shall periodically review refinements and extensions to interface definitions.	Community
29	Stakeholders shall not compromise security or privacy requirements through efforts to improve interoperability.	Community
30	Stakeholders shall manage the balance between information exchange transparency and privacy agreements across the interface.	Community
31	Stakeholders shall manage the balance between usability and security in interface definitions.	Community
32	Purchasers of connected technology shall specify interoperability performance language in relevant procurement contracts.	Community
33	To sustain interoperability improvement, the creation of an interoperability culture is required using education and marketing, such as material expressing the return on investment of interoperability.	Community
34	Stakeholders shall work to specify existing, mainstream, modern information exchange technologies that fit their business objectives and maximize the longevity of interface definitions.	Community
35	Stakeholders shall not create a new standard where a suitable standard already exists.	Community

Failure mode policies shall be defined, maintained, and aligned among the parties of the interoperating systems to support the safety and health of individuals and the overall system.

Performance and reliability requirements shall be defined.

The way errors in exchanged data are handled shall be specified. Interface definitions may need to specify their error-handling expectations.

Time order dependency and sequencing (synchronization) for interactions shall be specified.

Transactions and state management capability for interactions shall be specified.

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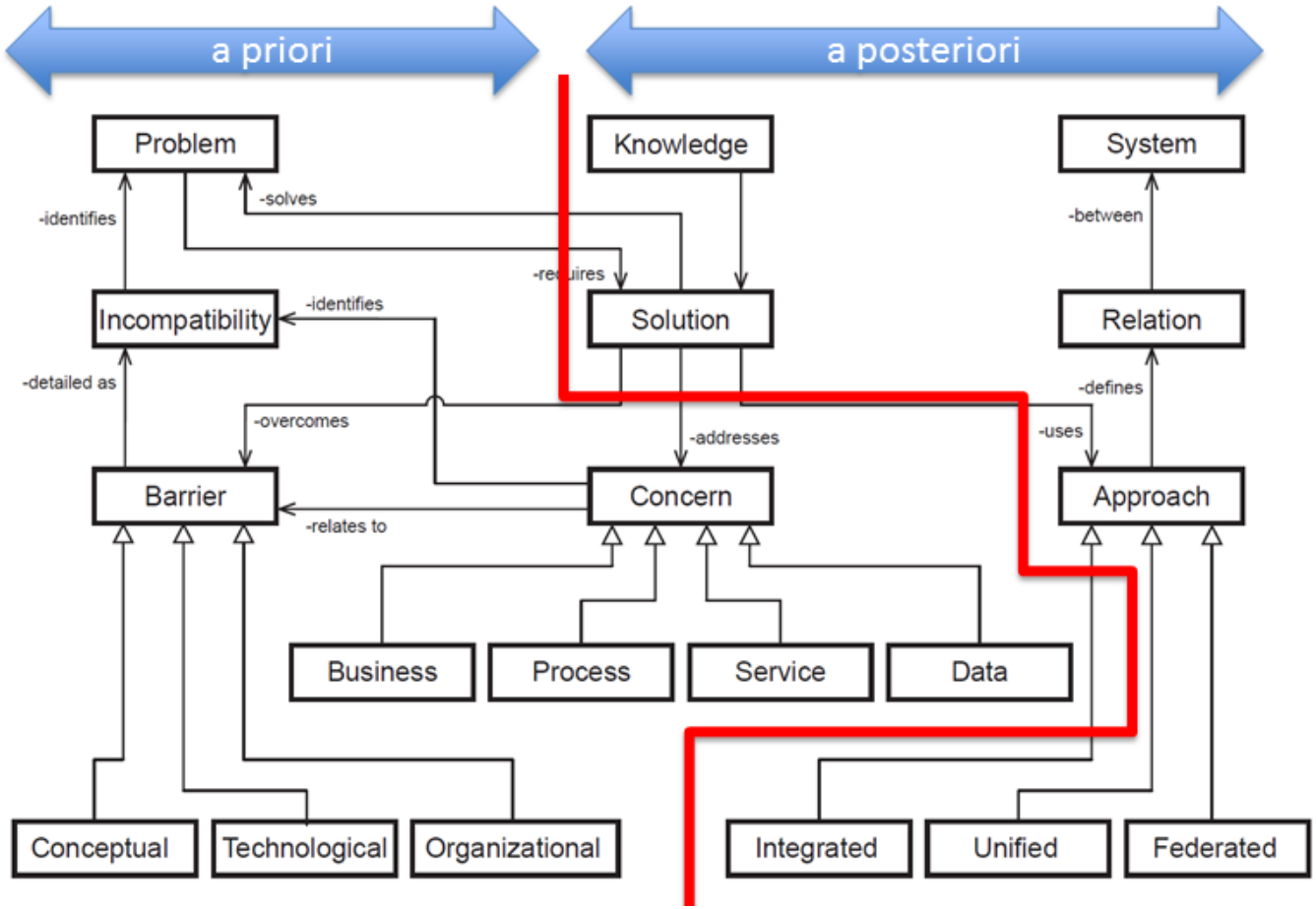
Table 2.1, page 2.1, A Qualitative and Quantitative Approach for Measuring Interoperability

Conceptual Model from ISO 11354



interoperability potential/capability

existing interoperability situation and incompatibilities between systems

Capability Improvements

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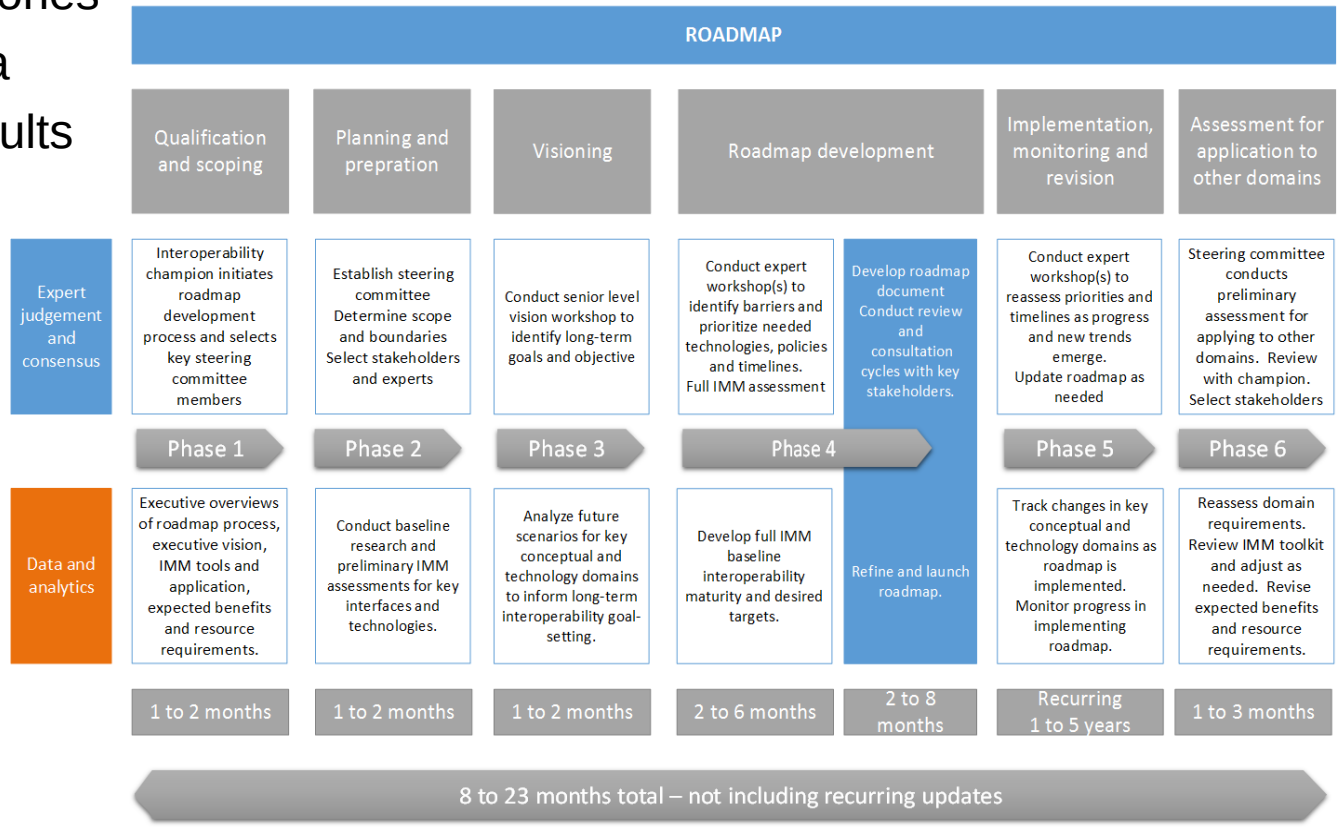
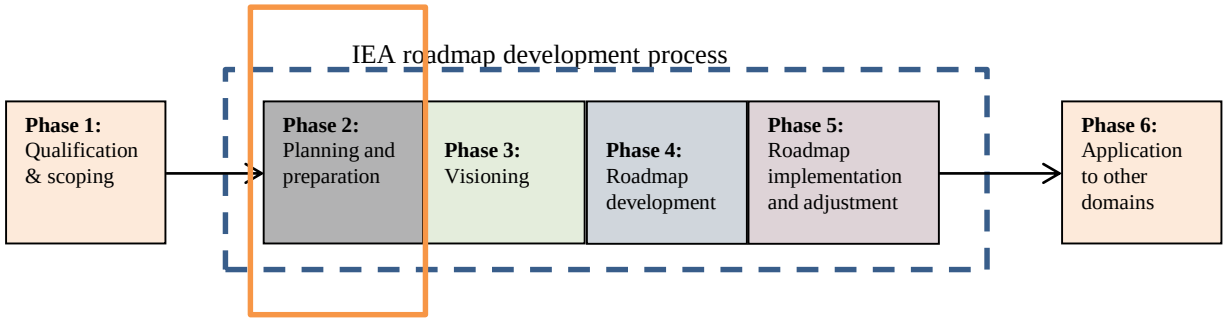
- Studies of the CMMI have demonstrated the improvement impact of applying this type of model and one study listed the top six benefits to be as follows:
  - **Consistency** in dramatically improved project predictability and consistency.
  - **Cost saving** so less is spent on re-work, reductions in schedule variability, and increased cost predictability
  - **Self-improvement** by achieving a level of capability that improved processes to make them more competitive.
  - **Market demand** that enables organizations to best meet the customer demands and competition through community application of the CMMI.
  - **Performance demand** creates a process improvement solution appropriate to each organization and provides a path to achieve performance goals.
  - **Process improvement** delivers a framework within which to standardize processes, ensuring that best practices are captured, shared, and adopted.

Building a Roadmap (Short Version)

- Choose an ecosystem to apply the IMM
  - Discuss the background and drivers
  - Select the categories
  - Apply the criteria
  - Evaluate the results
- Create a roadmap



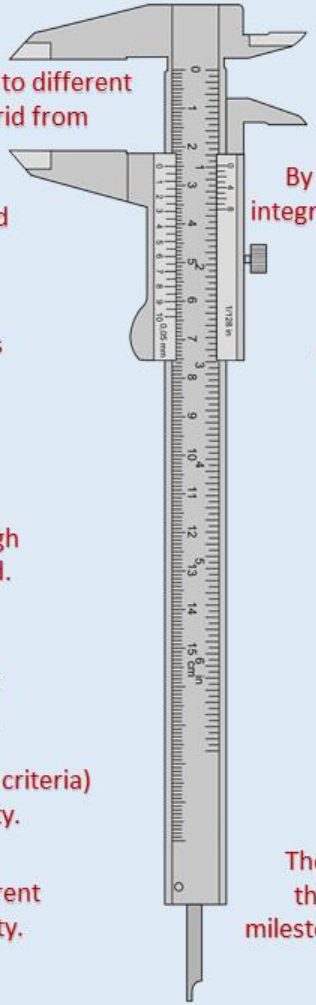
The IMM is a Tool to Help Build a Roadmap



- The IMM Toolkit links to the roadmap methodology in the following ways:
  - **Phase 1**: executive overview of the IMM
  - **Phase 2**: the IMM is used to measure current interoperability levels
  - **Phase 3**: the IMM level descriptions can assist in determining long-term goals
  - **Phase 4**: IMM output from Phase 1 is used to determine gaps and build the roadmap
  - **Phase 5**: IMM can be reapplied during future iterations to continue improvement
  - **Phase 6**: lessons learned can be included in the IMM.

MEASURING INTEROPERABILITY

The Interoperability Maturity Model Plus (IMM) is a tool designed to **measure interoperability**.



The IMM can be applied to different **areas** of the electricity grid from generators to utilities to customers, buildings, businesses and markets.

The IMM can be applied to combinations of areas and technology domains.

Before measuring interoperability some high level questions are asked.

High level questions are followed by a number of interoperability **criteria**.

Each category (and each criteria) has five **levels** of maturity.

The criteria look at different aspects of interoperability.

The IMM identifies gaps between current and desired levels of interoperability.

By improving interoperability, we make integration easier, cheaper, and more cost effective.

The IMM can be applied to **technology domains** such as electric vehicles, microgrids, etc.

Stakeholders apply the IMM as a step in the process to create a roadmap.

Interoperability criteria are grouped into six **categories**.

The criteria selected for review depend on one or more categories selected for measurement.

The gaps are used to create a **roadmap** that is aligned with the goals, drivers, milestones identified by the stakeholders.

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Select the Categories

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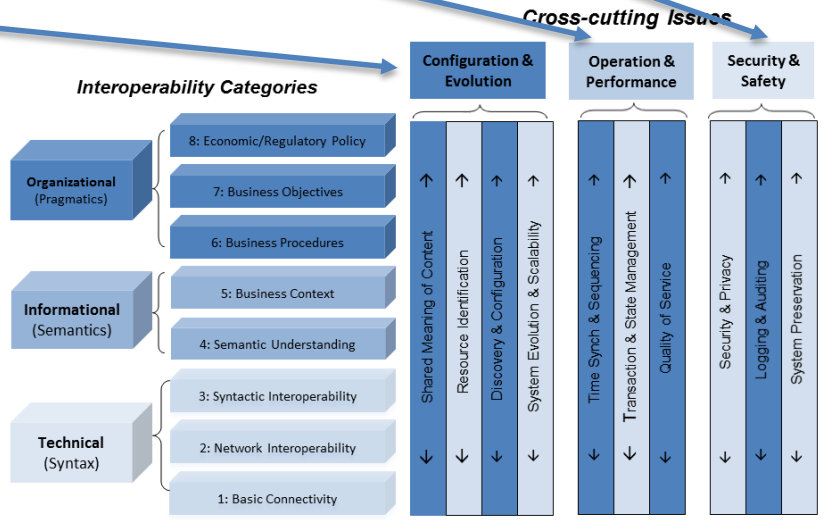
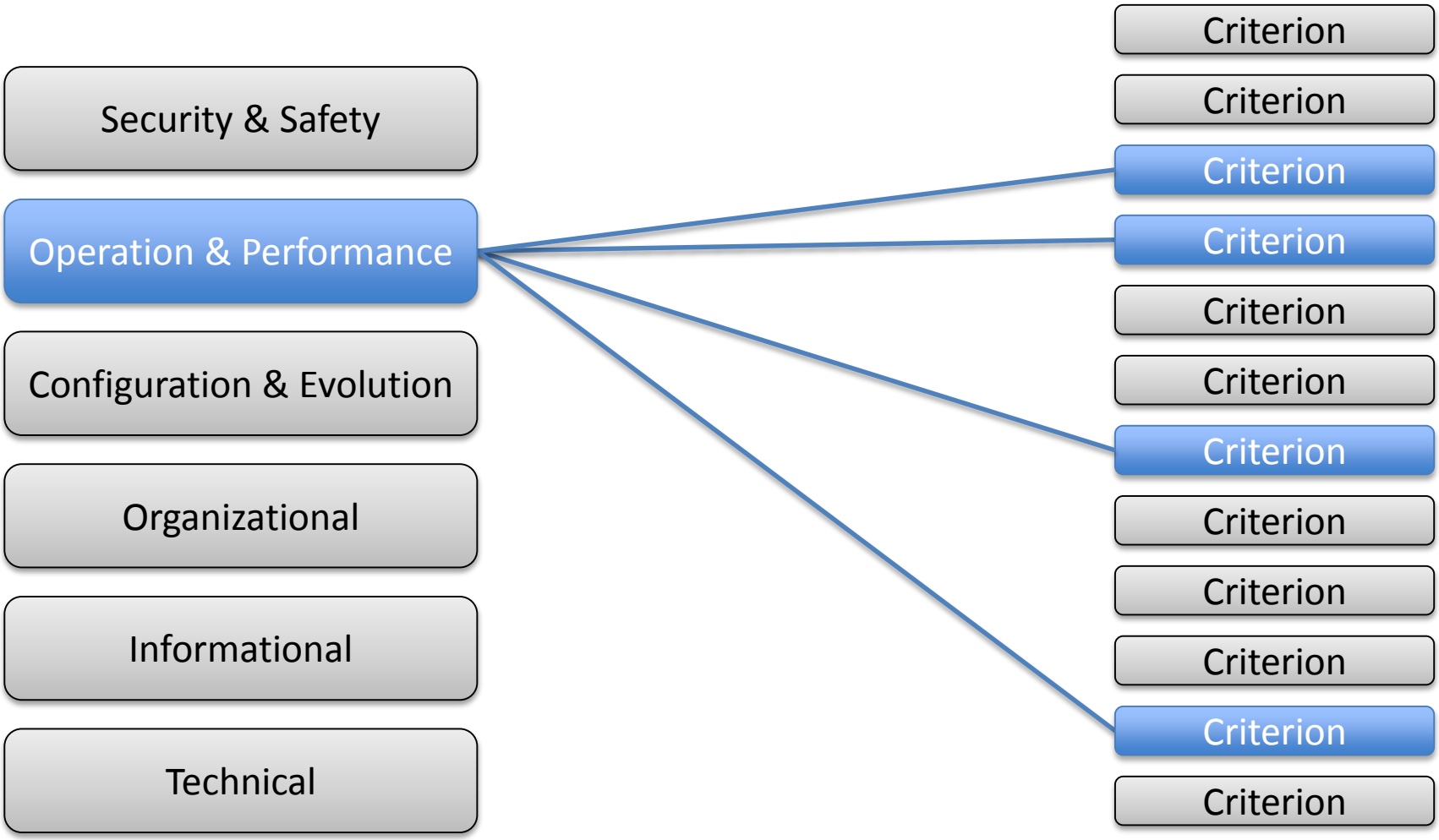
- Security & Safety
- Operation & Performance
- Configuration & Evolution
- Organizational
- Informational
- Technical



Source: GridWise Architecture Council's Interoperability Context-Setting Framework

Apply the Criteria



Discuss the Background (early Phase 2)

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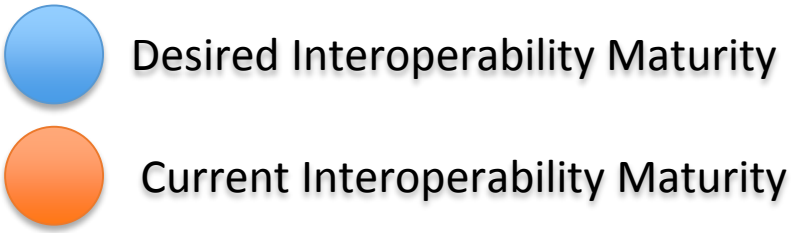
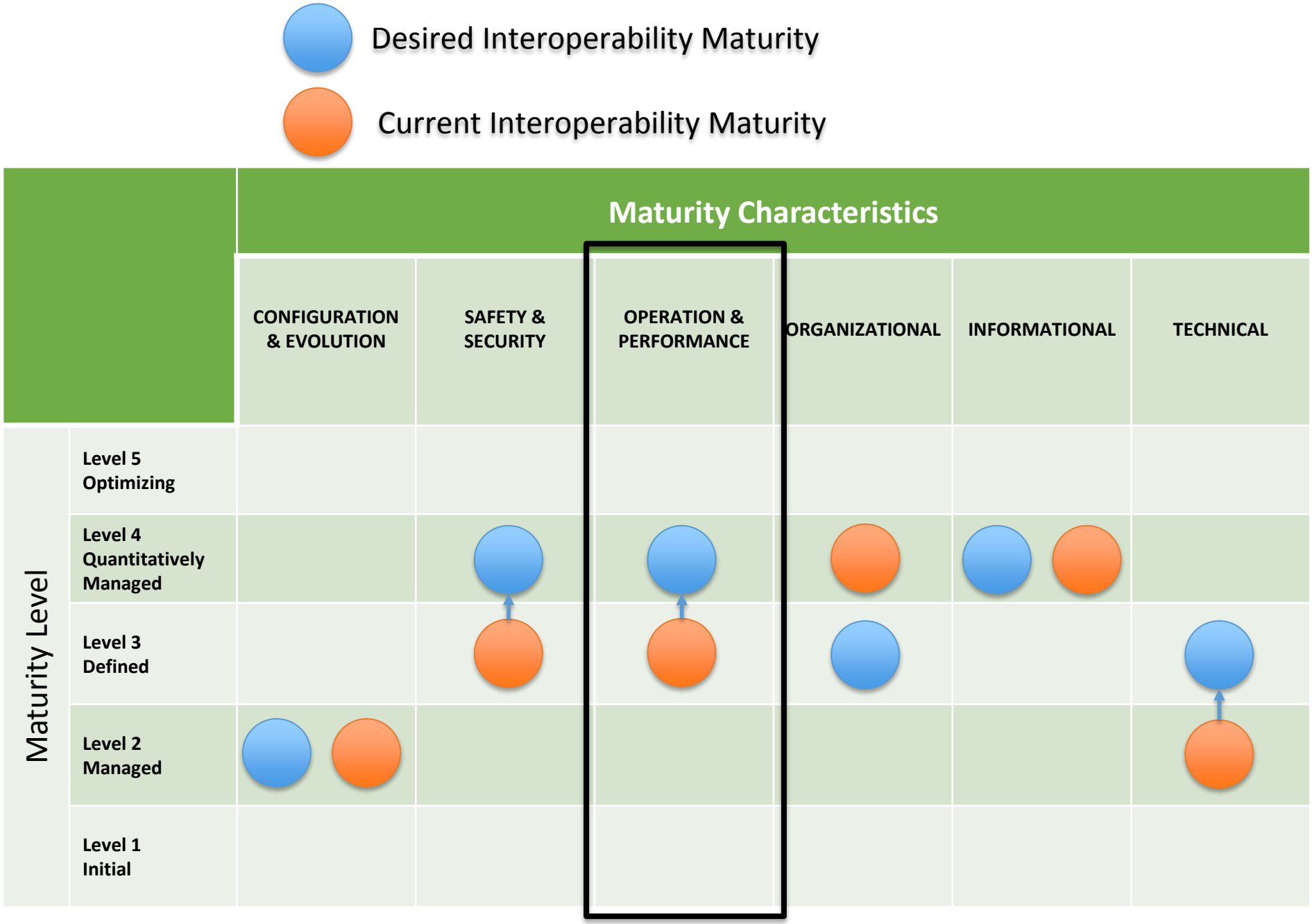
- Why do you want to improve interoperability?
- What problems has interoperability caused recently or in the past?
- What are the perceived barriers to interoperability today?
- What are the perceived barriers to increased levels of interoperability?
- What are the anticipated benefits from improving interoperability?
- What concerns do you have about the impacts of the current levels of interoperability?
- What key issues have driven interoperability cooperation with other organizations?
- What problems do you want to solve?
- What devices/systems need to be interoperable to solve the problems identified?
- What security issues does an interoperable ecosystem need to address?
- Are there any existing/mandated interoperability requirements that need to be considered?
- Are the current interfaces focused on meeting minimum requirements, or looking ahead?
- Do your vendors/integrators fully understand the complexities and nuances of your working environment and the fundamental issues around data standards?



Maturity Level	Maturity Characteristics					
	CONFIGURATION & EVOLUTION	SAFETY & SECURITY	OPERATION & PERFORMANCE	ORGANIZATIONAL	INFORMATIONAL	TECHNICAL
Level 5 Optimizing						
Level 4 Quantitatively Managed						
Level 3 Defined						
Level 2 Managed						
Level 1 Initial						


Desired Interoperability Maturity
Current Interoperability Maturity
Maturity Characteristics
CONFIGURATION & EVOLUTION
SAFETY & SECURITY
OPERATION & PERFORMANCE
ORGANIZATIONAL
INFORMATIONAL
TECHNICAL
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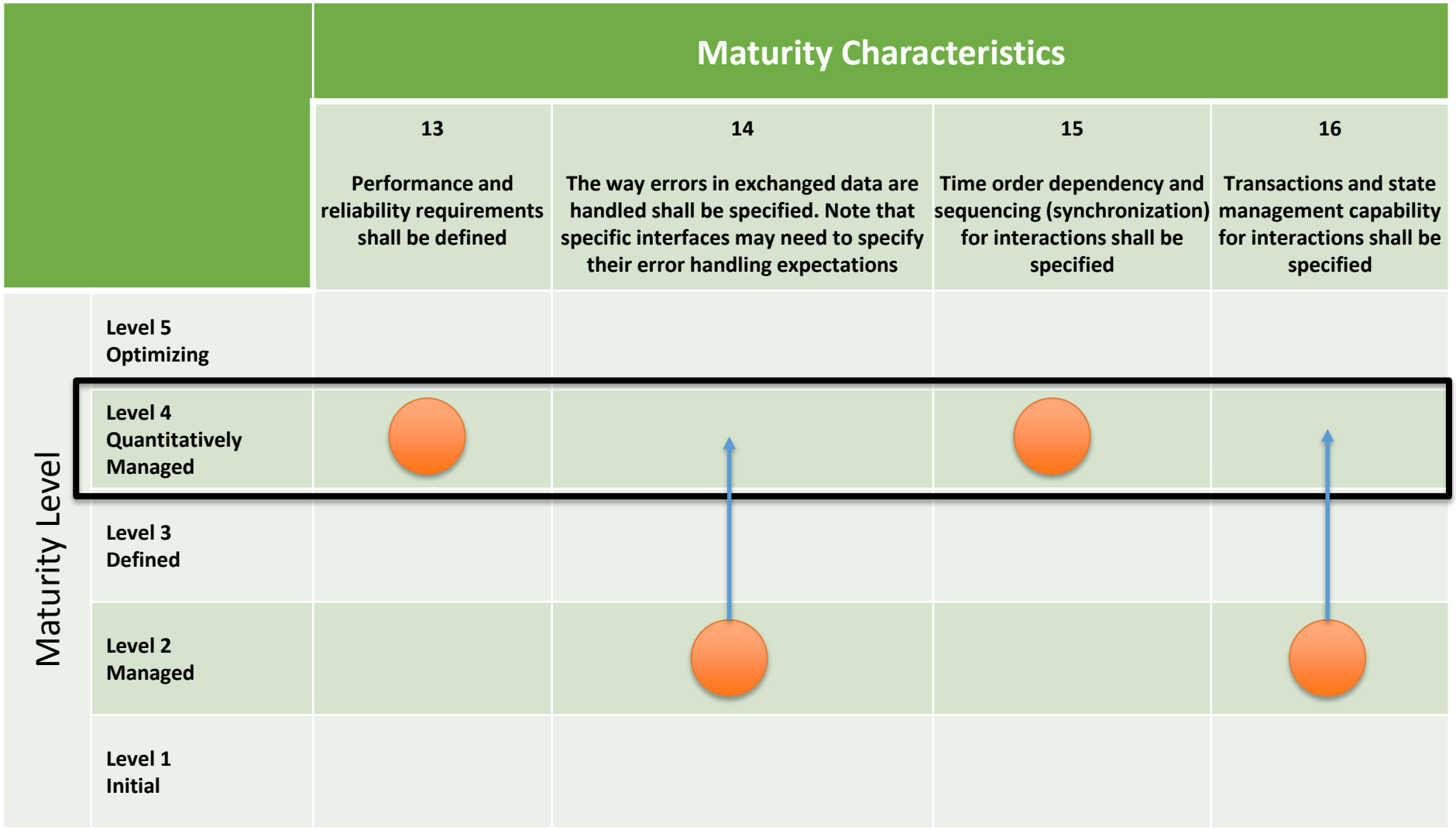
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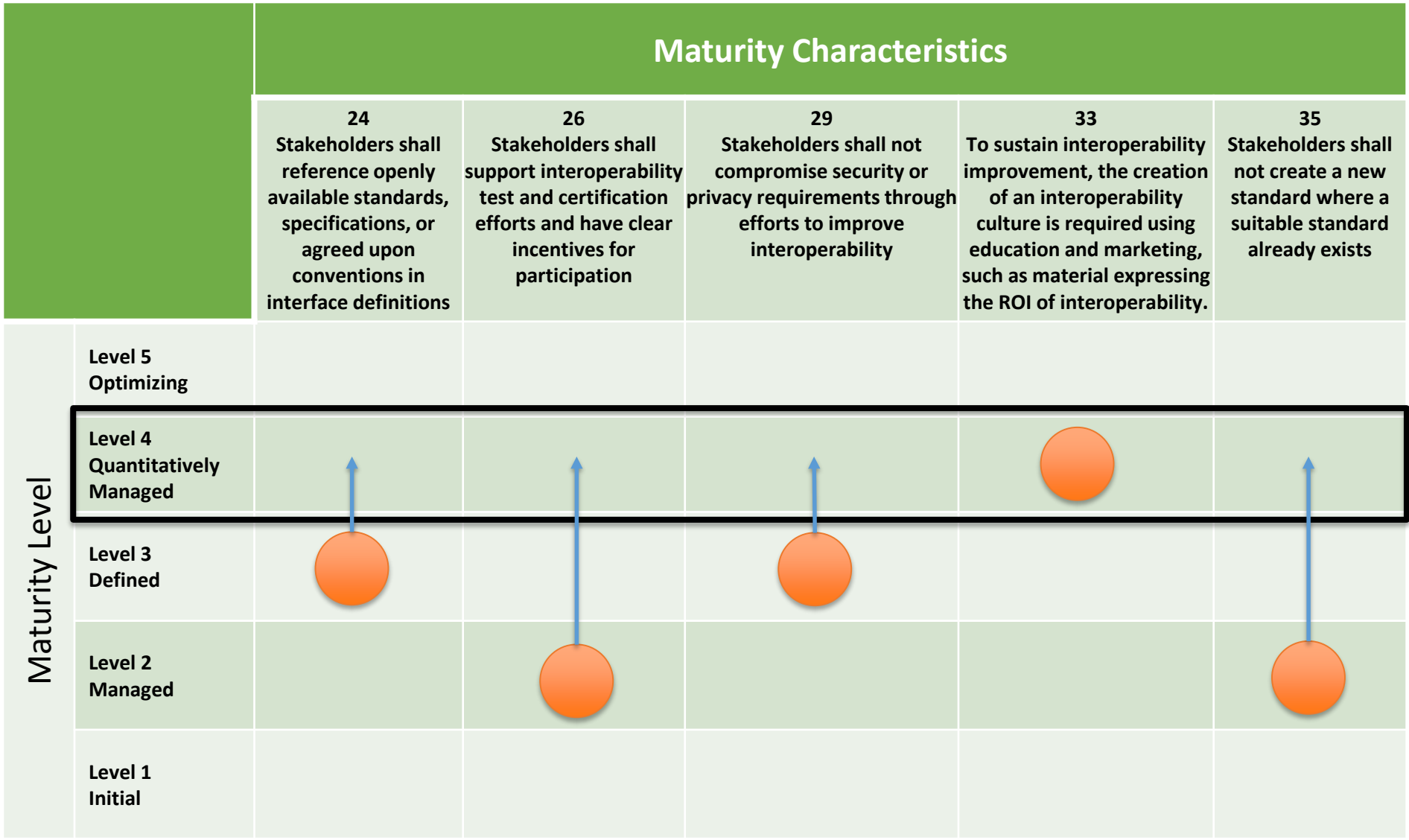
Maturity Characteristics
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Stakeholders shall reference openly available standards, specifications, or agreed upon conventions in interface definitions
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Stakeholders shall support interoperability test and certification efforts and have clear incentives for participation
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Stakeholders shall not compromise security or privacy requirements through efforts to improve interoperability
33
To sustain interoperability improvement, the creation of an interoperability culture is required using education and marketing, such as material expressing the ROI of interoperability.
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2.8

Maturity Characteristics

	24	26	29	33	35
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Maturity Level

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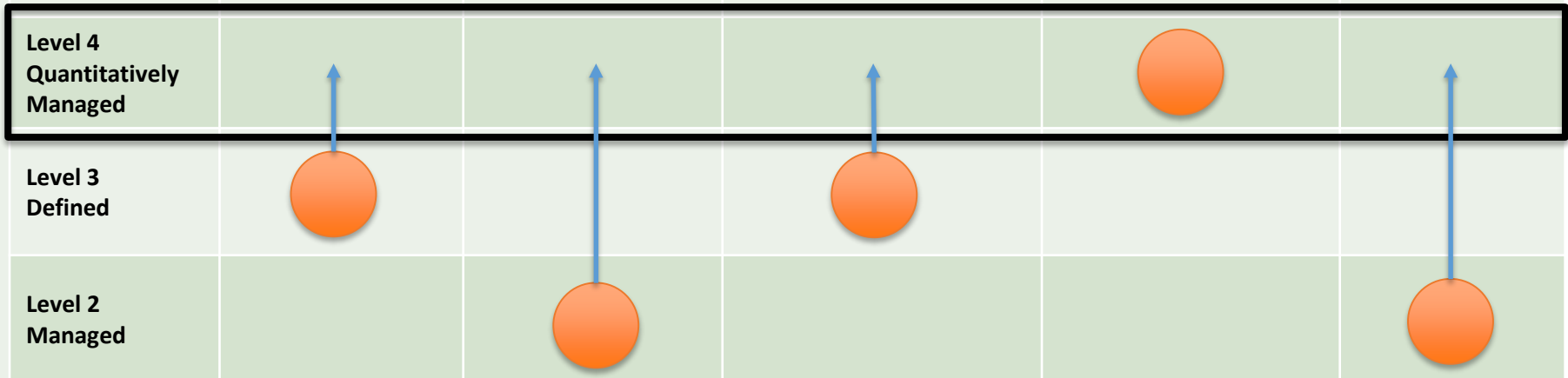

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Maturity Characteristics

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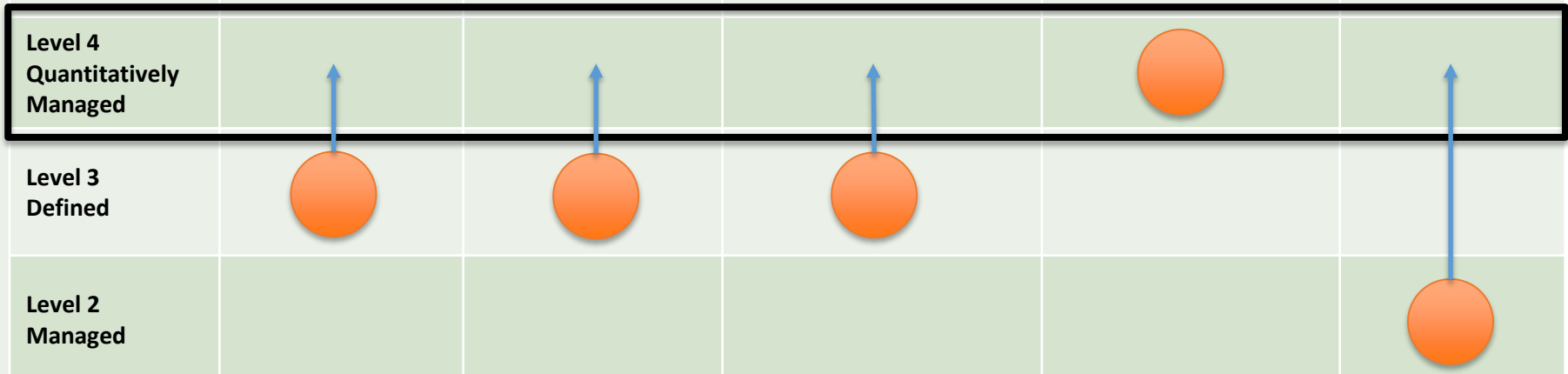

What Do We Really Want to Know?

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- Did we “pass”?
- If so
  - Where are we strong?
  - Where are we weak?
- If not
  - Where did we fall short?
  - Why did we fall short?
  - What do we need to do?
  - What steps should we take?
  - What benefits will that create?
  - How much effort will that take?
  - How much will that cost?

IMM Scoring Rubric

- Step 1: **Score the criteria in each category**.
  - Each criterion in a category is scored by answering whether there is documented evidence to support whether the criterion is being met as defined by the required level description, and scored as follows:
    - ***performed*** when the question is answered with a "Yes"
    - ***not performed*** when a question is answered with
      - Incomplete evidence
      - No
      - Not Answered
    - If the result for a criterion is "Not Answered" the criterion shall be scored the same as a "No"
- Step 2: **Create the score for each Category**. The score (rating) for the category is then determined as follows:
  - ***achieved*** when all practices are performed
  - ***partially achieved*** when some practices are performed
  - ***not achieved*** when no practices are performed

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Partially Achieved	Maturity Characteristics				
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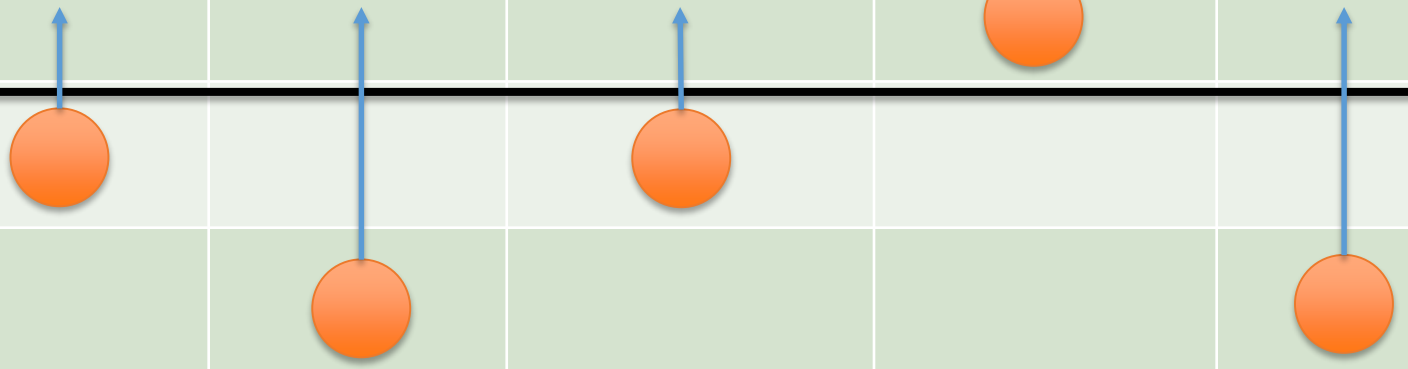

Grid Modernization
LABORATORY CONSORTIUM

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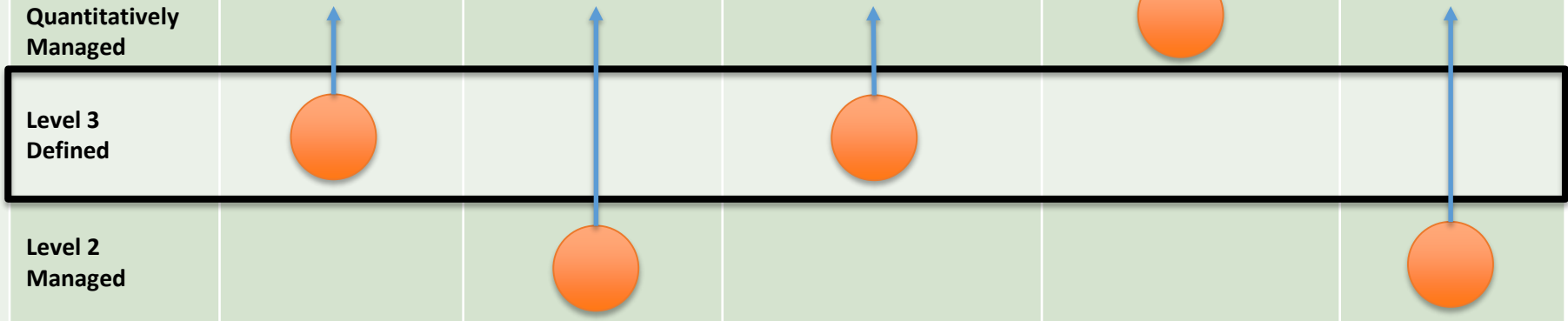
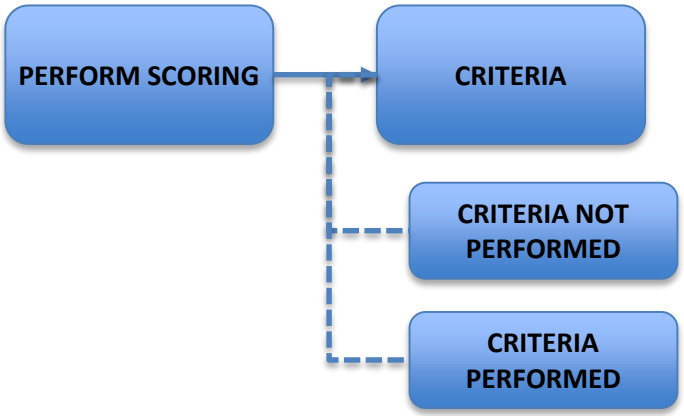


Scoring Summary



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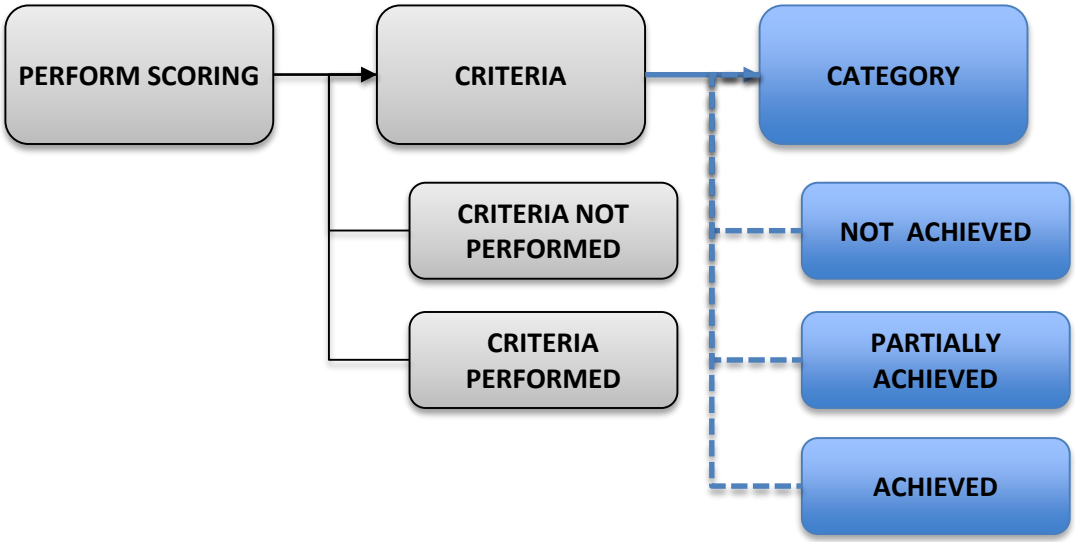

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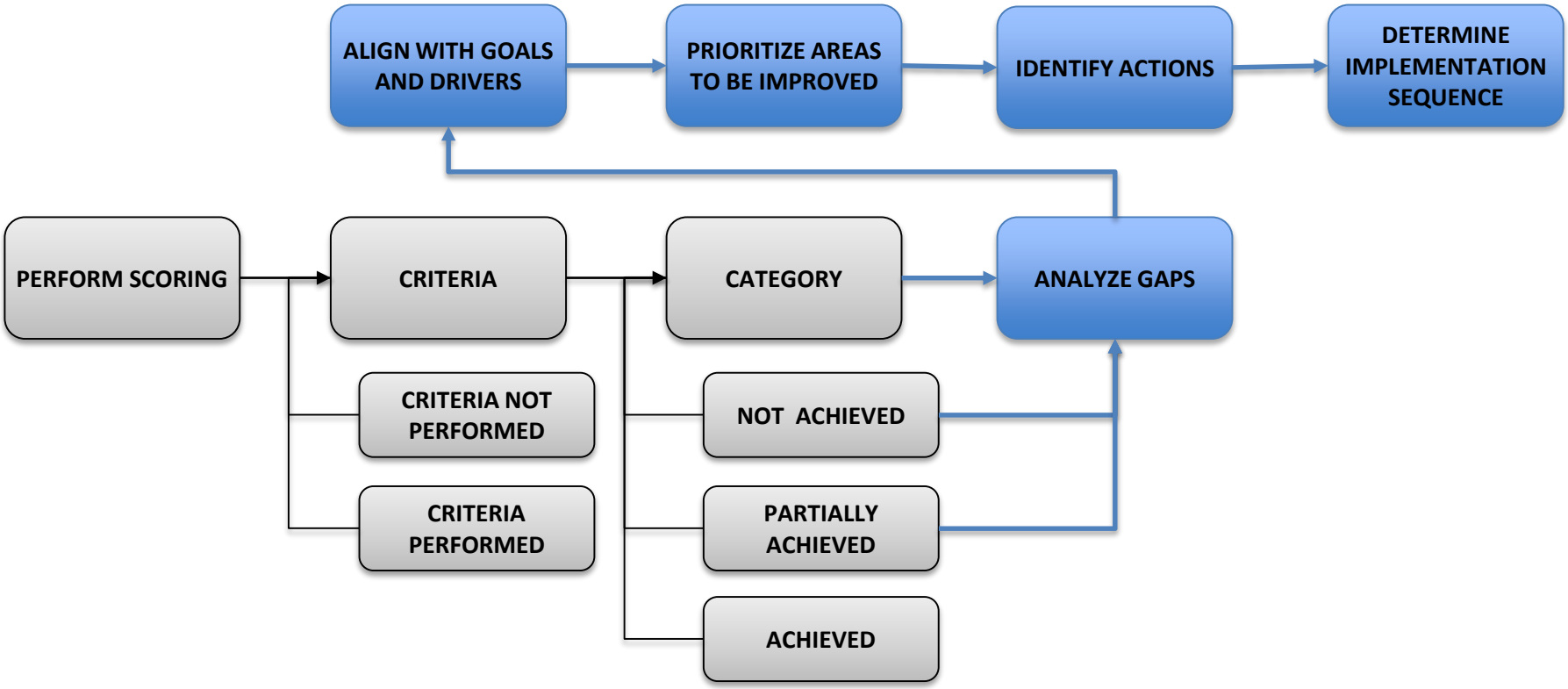

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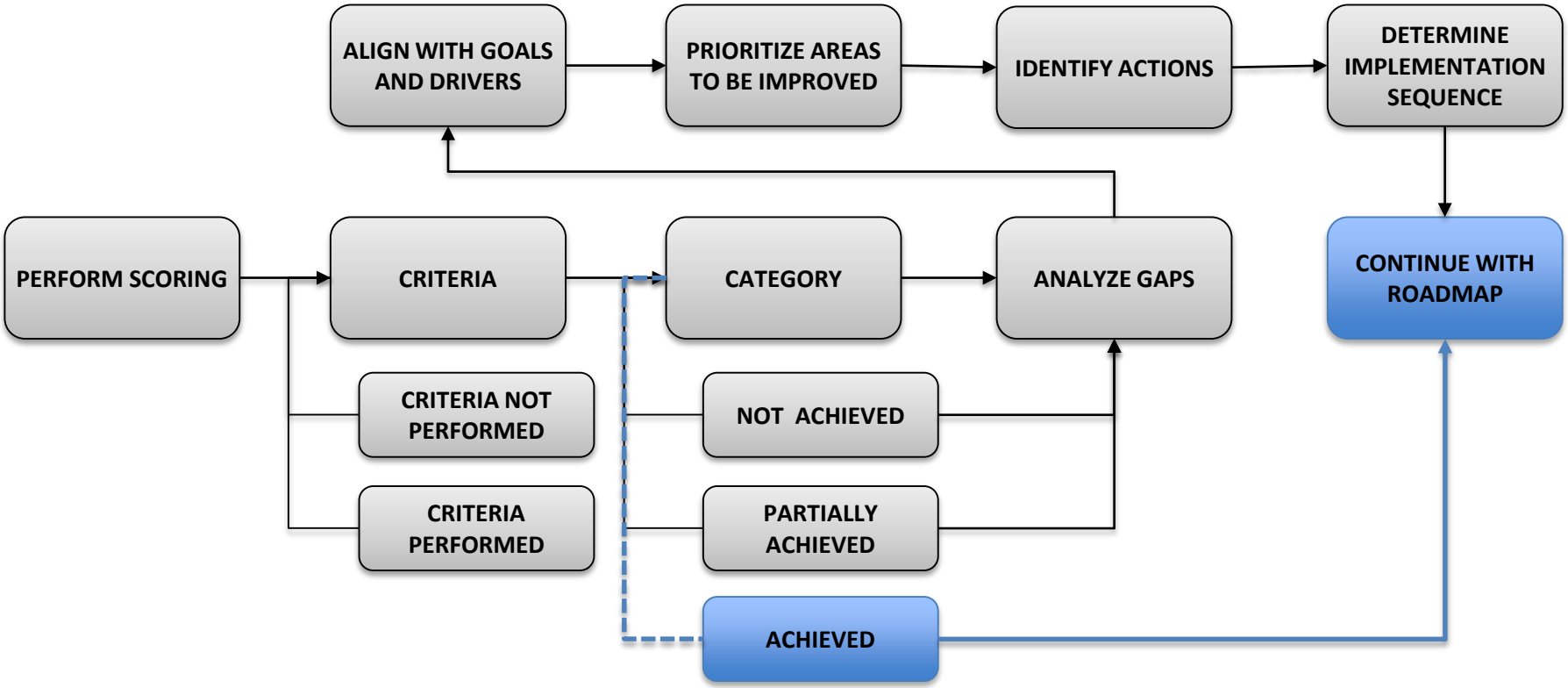

Level Descriptions for Every Category

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Organizational		
Level 5	Community, open standards, continuous improvement	Policies and business processes are represented in standardized forms within a community. Business processes are integrated across all automated interface(s).
Level 4	Managed by community without customization, with testing and metric definition/collection	Policies and business process representation are based on community (open) specifications and policies with very few customizations.
Level 3	Managed by community, repeatable process/effort	Policies and business process representations are based on community specifications and policies with some customization.
Level 2	Managed by system or components, some coordination and guidance	Policies and business process representations are based on project agreed-upon specifications and policies. Interface customization is common.
Level 1	Ad hoc, no guidance	Policies and business process representations are not standardized.

Level Descriptions for Every Criteria

Table 6.7. Example describing contents of maturity levels for each criterion in this section

#	C&E	S&S	O&P	O	I	T
	Statement that describes a situational or capability criterion for interoperability maturity					
Level 5	Scenario/description that describes Level 5 maturity for this criterion.					
Level 4	Scenario/description that describes Level 4 maturity for this criterion.					
Level 3	Scenario/description that describes Level 3 maturity for this criterion.					
Level 2	Scenario/description that describes Level 2 maturity for this criterion.					
Level 1	Scenario/description that describes Level 1 maturity for this criterion					

Reference for the criterion

Interoperability maturity level

Description of what is required for the level of maturity for this criterion

The description of the criterion

These represent the six categories. Blue tabs indicate for which categories this criterion is used.

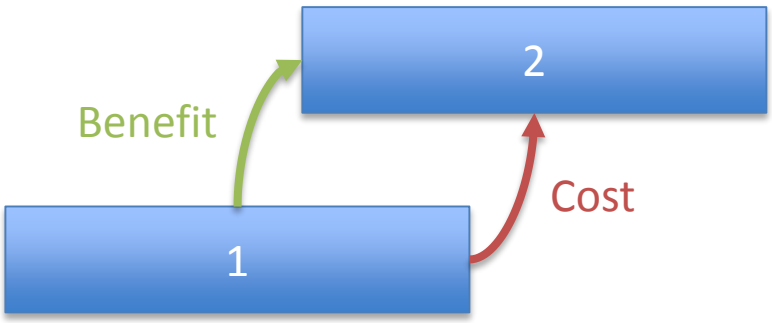
Complexity versus Maturity

- It is important to understand and contrast maturity and complexity. Put simply:
  - The complexity of the business will drive the complexity of the solution required
  - The maturity of the organization (***or ecosystem***) will determine its ability to recognize and implement an appropriate solution
- A very mature organization may choose a simple solution where a naive organization may think that a complex solution will solve all its problems. In truth, there is no universal best practice – only good practice that is appropriate for the operating context of any particular organization.
- For example, an organization that is responsible for managing 100 assets, all in the same location, could use a spreadsheet-based solution for an Asset Register and work management system. This is arguably good practice for that organization. However, for a utility business with thousands of distributed assets, this is unlikely to represent a good practice solution.

*The Institute of Asset Management

Pre-Breakout: Uses of Interoperability Criteria

The Price of Being Better



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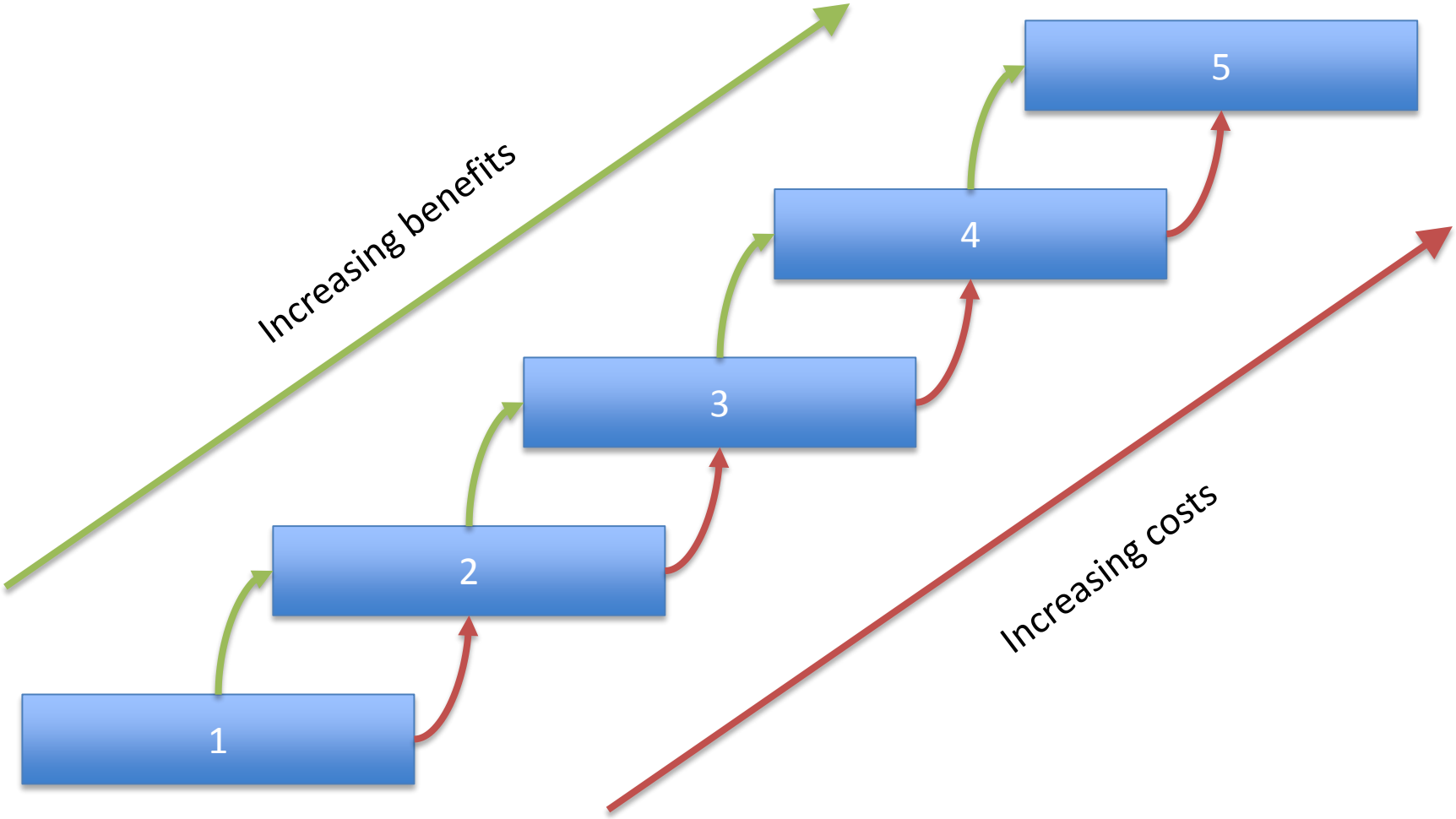
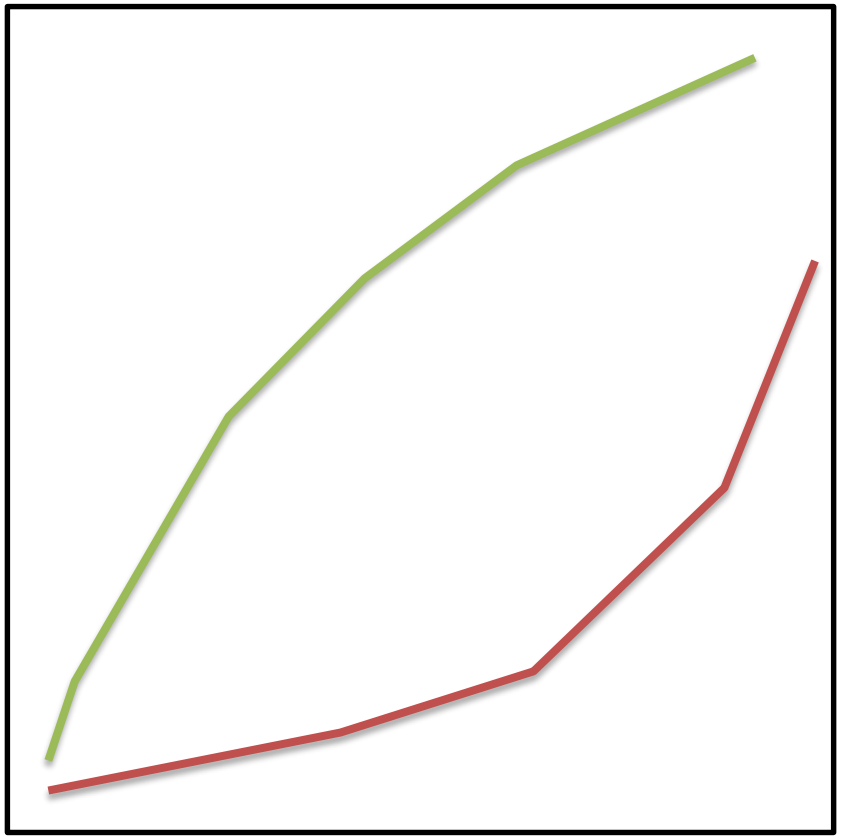
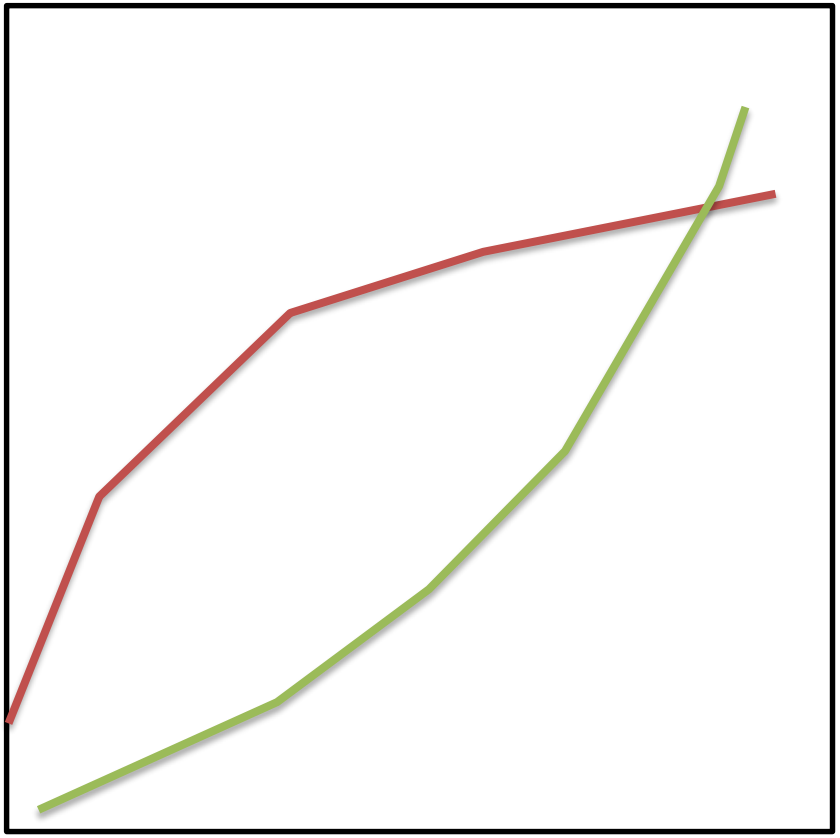


Diminishing Returns?



Enterprise

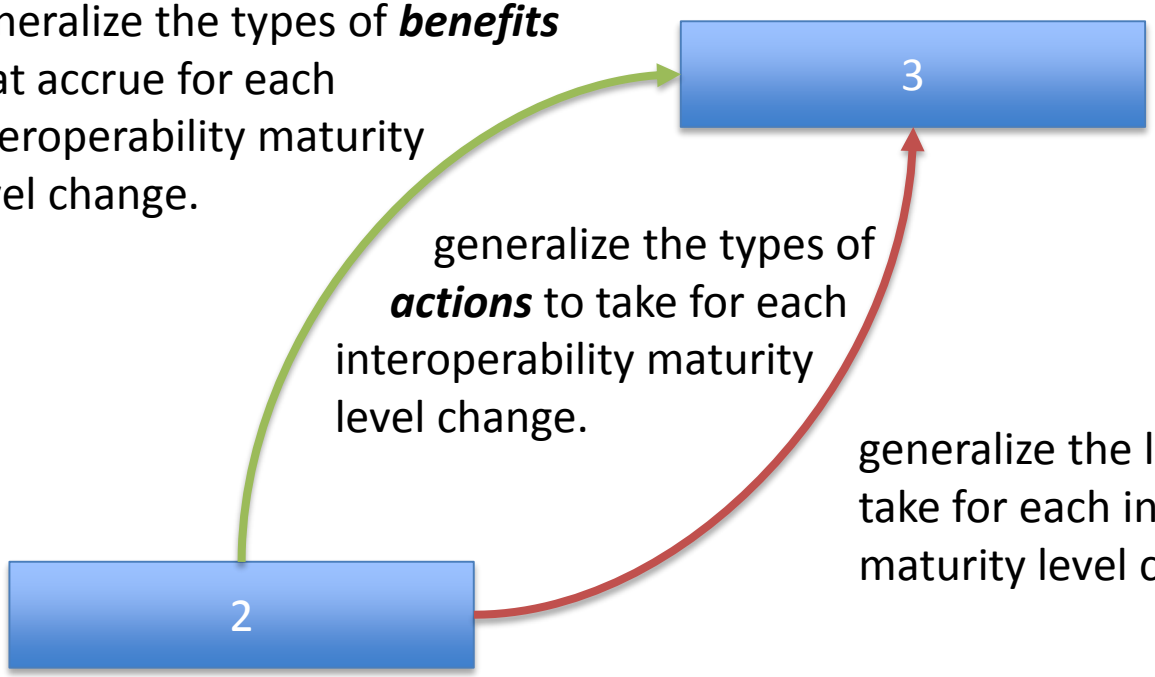


Ecosystem

Costs will vary for each scenario but . . . .

For any given improvement for any criteria or category it would be helpful to….

generalize the types of ***benefits*** that accrue for each interoperability maturity level change.



generalize the types of ***actions*** to take for each interoperability maturity level change.

generalize the level of ***effort*** to take for each interoperability maturity level change.

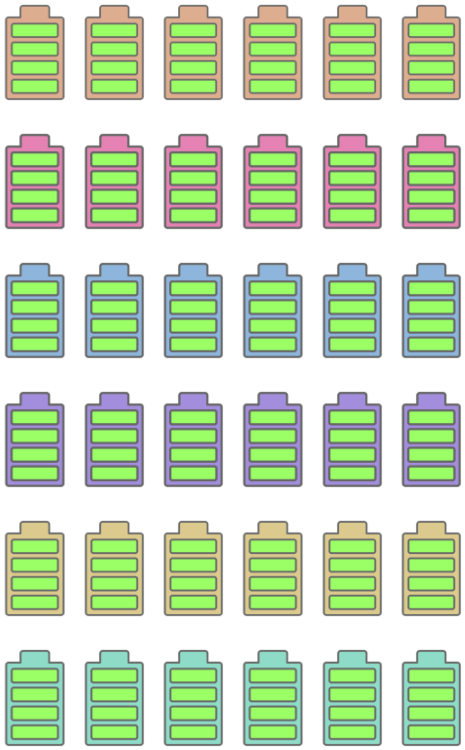
Nice to Have For Each Category

		Steps	Benefits	Effort
Level 5	4 5			
Level 4				
Level 3	3 4			
Level 2	2 3			
Level 1	1 2	Step Two	Benefit Two	Medium
		Step One	Benefit One	Low

Breakout: Exercise in Using Interoperability Criteria

An Example

- Various DER Storage Projects – Trying to install significant numbers of storage devices over three years to provide services to the grid.



- Criteria
  - Unambiguous resource identification and its management shall be described.
  - The requirements and mechanisms for auditing and for logging exchanges of information shall be described.
  - Compatible business processes and procedures shall exist across interface boundaries
  - Stakeholders shall actively identify and share lessons learned and best practices resulting from interoperability improvements.
  - Purchasers of connected technology shall specify interoperability performance language in relevant procurement contracts.

Breakouts

- One breakout per criteria.
- 60 minutes
- For each interoperability level increase for the various storage projects:
  - What issues might be corrected?
  - What standards are relevant?
  - Types of benefits that might accrue?
  - Types of actions to take?
  - The level of effort required? (H/M/L)
  - Procurement language that might help

What Else Could Happen in this Scenario?

- Several storage startups have decided to invest in various projects to try to install significant numbers of storage devices over three years to provide services to the grid.
- They will be using different devices from different vendors and installing them at multiple sites in different utility service territories. Some sites will have one type of device, others may have multiple.
- They have plans to offer spinning reserves by using the storage in generating mode and also to participate at different times by curtailing the charging. They may also offer voltage regulation and additional services.
- The storage units are being installed on a piecemeal basis from site to site and project to project.
- One day a supervisor at one site notices that the amount of electricity stored is less than planned.
- An engineer installed a new unit which arrived early and was installed ahead of schedule.
- The device did not show up on reports or dashboard.
- Procurement had been directed to purchase this specific device but had assumed some redundant technical (self identification/registration) language was not required and it was removed in a late review without the knowledge of the technical staff.
- On further investigation the new unit was found to be operating as part of the site and was storing energy on a load balanced basis with the other units, creating an unaccounted for capacity.
- The new unit was not registered and should not have been having energy delivered to it. The site has a resource identification module that provides unique identifiers to devices that register with it. The controller was registered in preparation for the unit arriving and had been interacting with the other systems at the storage farm.
- The device manufacturer is building devices that can be used in different situations. The storage company is buying units from different manufacturers to get them to work together. The controller was unable to log the transactions even though they were being performed so there were no records sent to the central information system.
- The controller should have had clearly defined rules not only for raising an error for a missing storage unit identifier but also for not including the storage unit into the system without creating auditable logs of the transactions.
- The lessons learned from this experience were discussed during the weekly operating meeting so that interoperability expectations for all undelivered units from multiple vendors could be shared within the team and at the next storage conference.

Breakout Plan

- 5 min – instructions and assemble groups
- 15 mins - Task 1:
  - Score your chosen criteria for the scenario – what level of interoperability has been ***achieved***
- 20 min – Task 2: identify additional issues that might exist at each level (1-5)
  - Internal factors (within control of the organizations and participants in the ecosystem)
  - External factors (e.g. vendor goes out of business, new regulations, etc.)
- 20 min – Task 3: identify common interoperability benefits from addressing these (Task 2) issues
  - Capability benefits
  - Ecosystem benefits
  - Procurement benefits
  - Integration benefits
  - Other
- 10 min – prepare flipchart for report out

- - - post breakout - - -

- 15 Min – report out

What can you expect to take away from each task?

- **Task 1** - familiarity with how criteria will be used. Preparation for Day 2.
- **Task 2** – shared experience of factors that impact interoperability, things you may not have considered.
- **Task 3** – benefits come in all shapes and sizes

An Example

A new unit which arrived early was installed but did not self register and was therefore not identified automatically. The supervisor noticed discrepancies in performance on her reports and dashboard. The site has a resource identification module that provides unique identifiers to devices that register with it. The unit was later registered in the system and a unique ID created manually.

7	C&E S&S O&P O I T ***Unambiguous resource identification and its management shall be described.***
Level 5	The ability to unambiguously identify resources can be demonstrated and the capabilities are regularly reviewed and improved.
Level 4	Resources are identified unambiguously and resource management requirements for resource identification are adopted by the whole community.
Level 3	Resources are identified unambiguously and resource management requirements exist to describe how resource identification shall be performed for the community.
Level 2	Resources are identified unambiguously but no documentation exists to describe how unambiguous resource identification and management shall be performed.
Level 1	Resource identification and management is ad hoc and little documentation exists to describe it.

An Example

The new unit was found to be storing energy on a load balanced basis with the other units thus creating an unaccounted for capacity discrepancy and it was not showing up on the supervisor's dashboard. The new unit was not registered/identified but the unit controller had been registered in preparation for the storage unit and had started interacting with the storage unit even though it did not have an ID.

17	C&E	S&S	O&P	O	I	T
	Compatible business processes and procedures shall exist across interface boundaries.					
Level 5	Interface messages that support the business processes are specified for the community and are consistent with the business context information model and processes are reviewed and improved as required.					
Level 4	Interface messages that support the business processes are specified for the community and are consistent with the business context information model.					
Level 3	Interface messages that support the business processes are specified by project and are consistent with the project's business context information model.					
Level 2	Interface messages that support the business processes are specified by some projects and are consistent with the project's business context information model where they exist.					
Level 1	Interface messages that support the business processes are not always consistent with the project's business context information model where they exist.					

An Example

The device manufacturer is building devices that can be used in different situations. The storage company is buying units from different manufacturers to get them to work together. The controller was unable to log transactions since there was no ID against which to record them, even though they were being performed, thus no records were sent to the information system. The controller should have had clearly defined rules not only for raising an error for a missing storage unit identifier but also for not including the storage unit into the system without creating auditable logs of the transactions.

9	C&E	S&S	O&P	O	I	T
	The requirements and mechanisms for auditing and for logging exchanges of information shall be described.					
Level 5	Auditing and logging requirements are aligned among community members and are regularly reviewed and updated as necessary.					
Level 4	Information logging and auditing of information exchanges are described for most deployments (based on community agreements with reference examples) and examples of audits are available.					
Level 3	Information logging and auditing of information exchanges are described for many deployments (based on community agreements) with documented examples available.					
Level 2	Information logging and auditing of information exchanges are described for some deployments (mostly project-centric).					
Level 1	No documentation exists to describe auditing and logging of information used in interface(s).					

An Example

The lessons learned from this experience were discussed during the weekly operating meeting so that interoperability expectations for all undelivered units from multiple vendors could be shared within the team and at the next storage conference.

27	C&E S&S O&P O I T ***Stakeholders shall actively identify and share lessons learned and best practices resulting from interoperability improvements.***
Level 5	Interoperability lessons learned have been included in future planning for continued improvement.
Level 4	Interoperability improvements exist and lessons learned have been shared.
Level 3	Interoperability improvements exist and lessons learned have been documented.
Level 2	Interoperability improvements have been measured, but lessons learned have not been documented.
Level 1	No documented evidence of interoperability improvements can be provided.

An Example

The procurement language was supposed to have some specific clauses such as the ability of devices to self-identify and register with the control system. Since procurement had been directed to purchase this specific device they had assumed this language was not required and it was removed in a late review without the knowledge of the technical staff.

32	C&E	S&S	O&P	O	I	T
	Purchasers of connected technology shall specify interoperability performance language in relevant procurement contracts.					
Level 5	Connected technology purchase requirements explicitly reference interoperability performance language that refers to open standards.					
Level 4	Connected technology purchase requirements reference community standards without customization.					
Level 3	Many connected technology purchase requirements reference community standards with customization in some cases.					
Level 2	Some connected technology purchase requirements reference community specifications or standards with customization in many cases.					
Level 1	No interoperability requirements were explicitly included in recent (12 months) procurement contracts.					

Any Questions?

Cheat Sheet

GRID MODERNIZATION LABORATORY

		Maturity Characteristics				
		7 Unambiguous resource identification and its management shall be described	9 The requirements and mechanisms for auditing and for logging exchanges of information shall be described	17 Compatible business processes and procedures shall exist across interface boundaries	27 Stakeholders shall actively identify and share lessons learned and best practices resulting from interoperability improvements	32 Purchasers of connected technology shall specify interoperability performance language in relevant procurement contracts
Maturity Level	Level 5 Optimizing					
	Level 4 Quantitatively Managed				●	
	Level 3 Defined			●	●	
	Level 2 Managed	●	●	●	●	●
	Level 1 Initial	●	●	●	●	●

Summary of Interoperability Benefits

GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy

- **Reduces integration cost:** Decreases costs to deploy and integrate new standards compliant technologies.
- **Reduces cost to operate:** Monitor equipment and operating conditions to reduce repair costs and extend equipment life.
- **Reduces capital IT cost:** Reduces investment uncertainty, extends the useful life of legacy infrastructure.
- **Reduces installation cost:** Reduces the need to modify existing systems to interoperate with new technology.
- **Reduces upgrade cost:** Ensures that today's technology can be interface with future technologies.
- **Better security management:** Reduces the number of different interfaces and permits the application of a single security framework.
- **More choice in products:** Select features not technologies, avoid technology "lock in," buy technology "off the shelf."
- **More price points and features:** Incentivizes innovation and facilitates customer trust of new technologies.