



Evaluating and Improving Cybersecurity Capabilities of the Electricity Critical Infrastructure

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Outline

Electric Grid: Yesterday vs. Today

Development Approach

A Family of Cybersecurity Maturity Models

Model Architecture

- Domains
- Scaling
- Diagnostic Methodology

Using the Model

Relationship to NIST Cybersecurity Framework

CMU – SEI – CERT® Division



**Carnegie
Mellon
University**

Software Engineering Institute (SEI)

- Federally funded research and development center based at Carnegie Mellon University
- Basic and applied research in partnership with government and private organizations
- Helps organizations improve development, operation, and management of software-intensive and networked systems

CERT® Division – *Anticipating and solving our nation's cybersecurity challenges*

- Largest technical program at SEI
- Focused on internet security, digital investigation, secure systems, insider threat, operational resilience, vulnerability analysis, network situational awareness, and coordinated response

Cyber Risk and Resilience Management Team

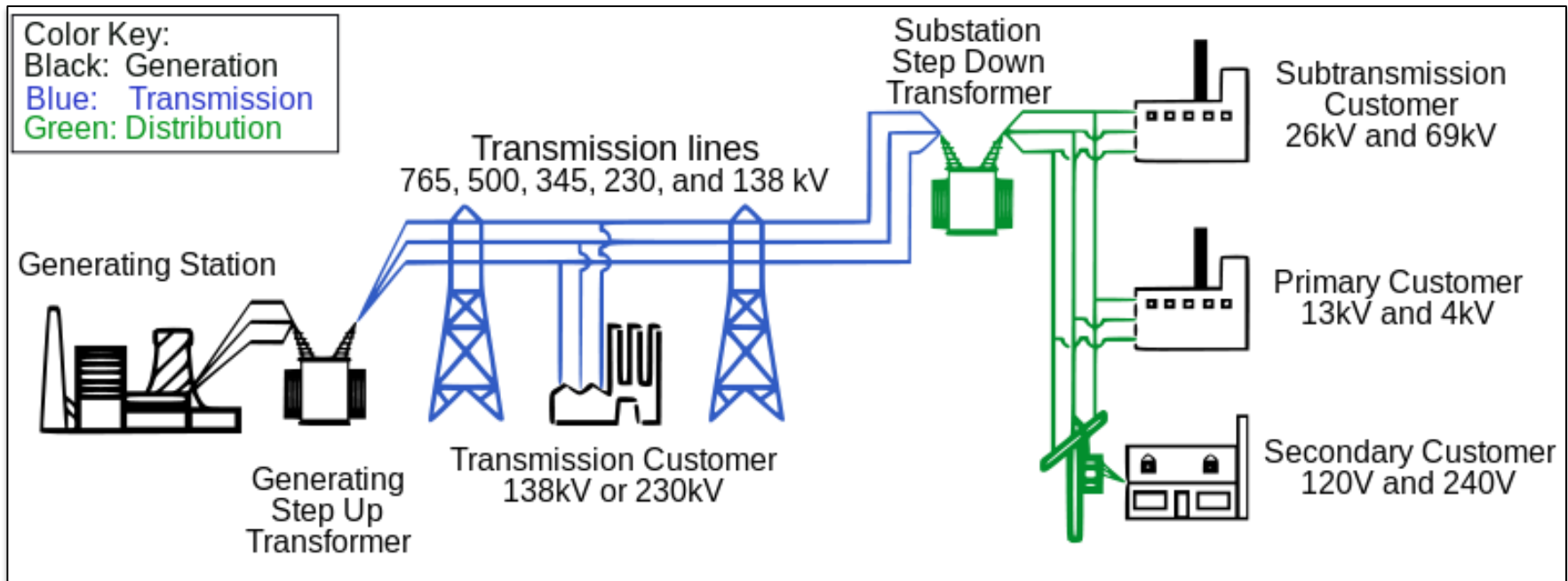
Engaged in

- Applied research
- Education & training
- Putting into practice
- Enabling our federal, state, and commercial partners

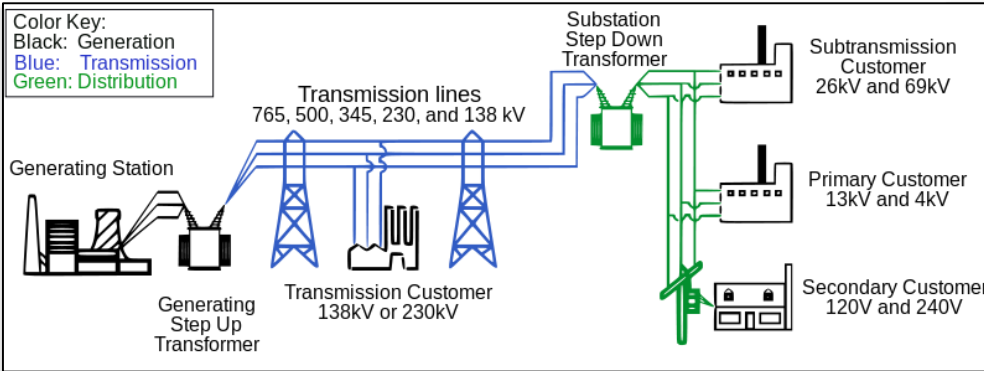
In areas dealing with

- Maturity models
- Operational resilience
- Resilience management
- Operation risk management
- Cybersecurity maturity models
- Integration of cybersecurity, business continuity, & disaster recovery

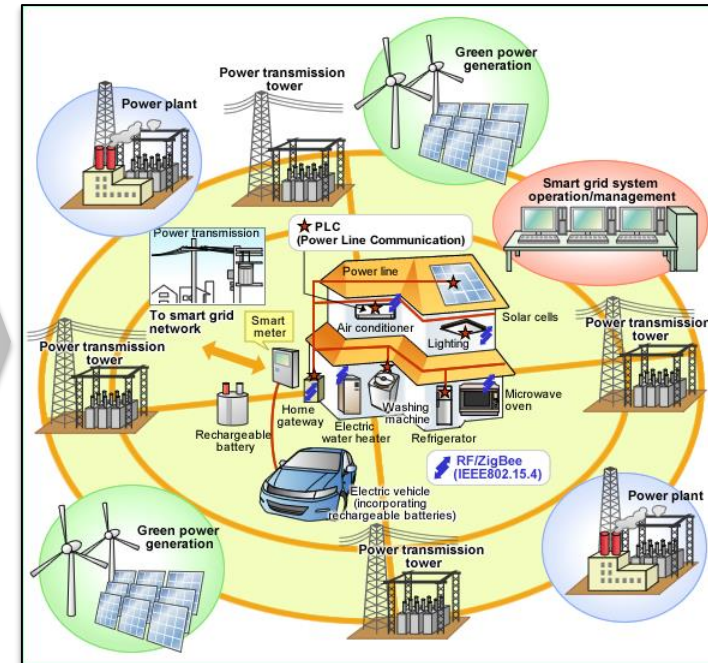
YESTERDAY: Legacy Electric Grid



TODAY: Smart Grid



Legacy Electrical Grid



Modern Smart Grid

INCREASED FUNCTIONALITY & EFFICIENCY

INCREASED OPERATIONAL RISK

Challenge from the White House



Challenge:

Develop capabilities to manage dynamic threats and understand cybersecurity posture of the grid

Strong Sponsorship & Collaboration

White House initiative

Led by Department of Energy

In partnership with DHS

In collaboration with energy sector
asset owners and operators

SEI model architect



Development Approach

Public-Private Partnership

Best Practices and existing cybersecurity resources

Review of cyber threats to the subsectors

Descriptive, Not Prescriptive

Fast-Paced Development

Pilot to Test, Validate, and Improve

The Approach: Maturity Model

An organized way to convey a path of experience, wisdom, perfection, or acculturation.

A Maturity Progression for Authentication

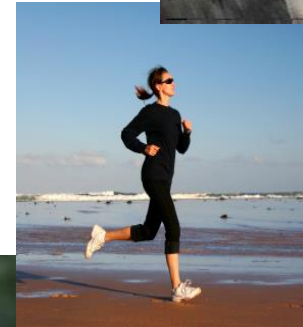
Three-factor authentication

Two-factor authentication

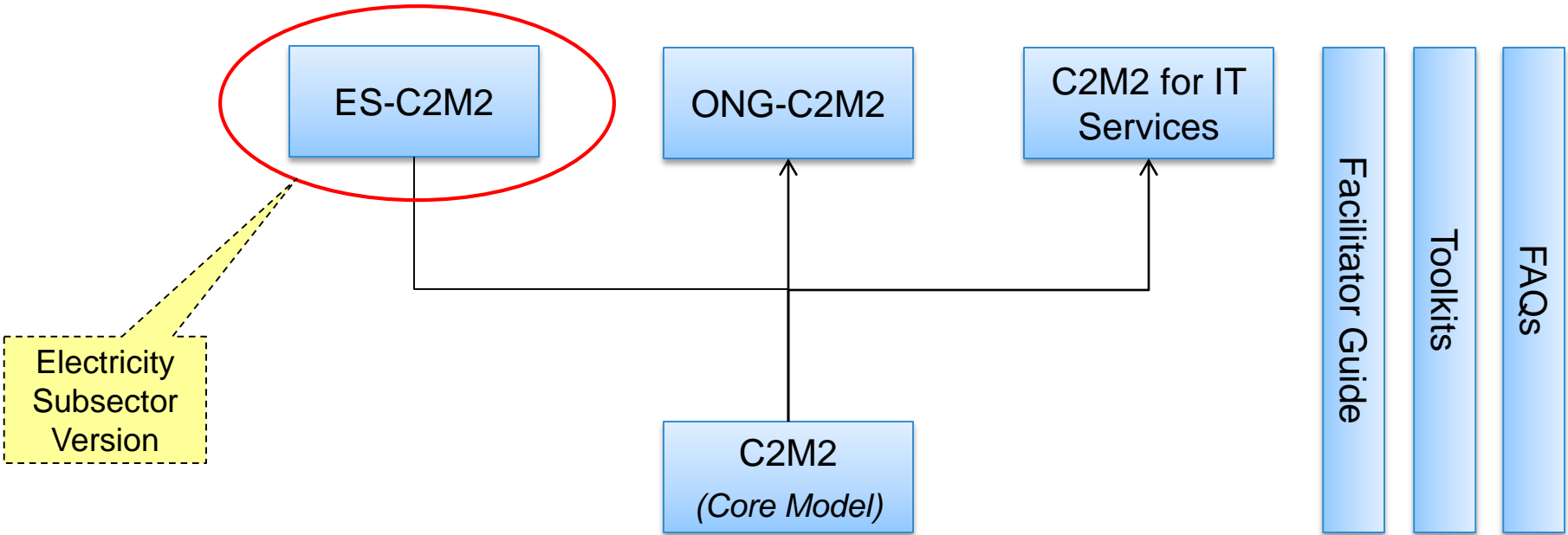
Addition of changing every 60 days

Use of strong passwords

Use of simple passwords`



A Family of Cybersecurity Maturity Models



Enabling Consistent Applicability to Complex Organizations

Electricity Subsector

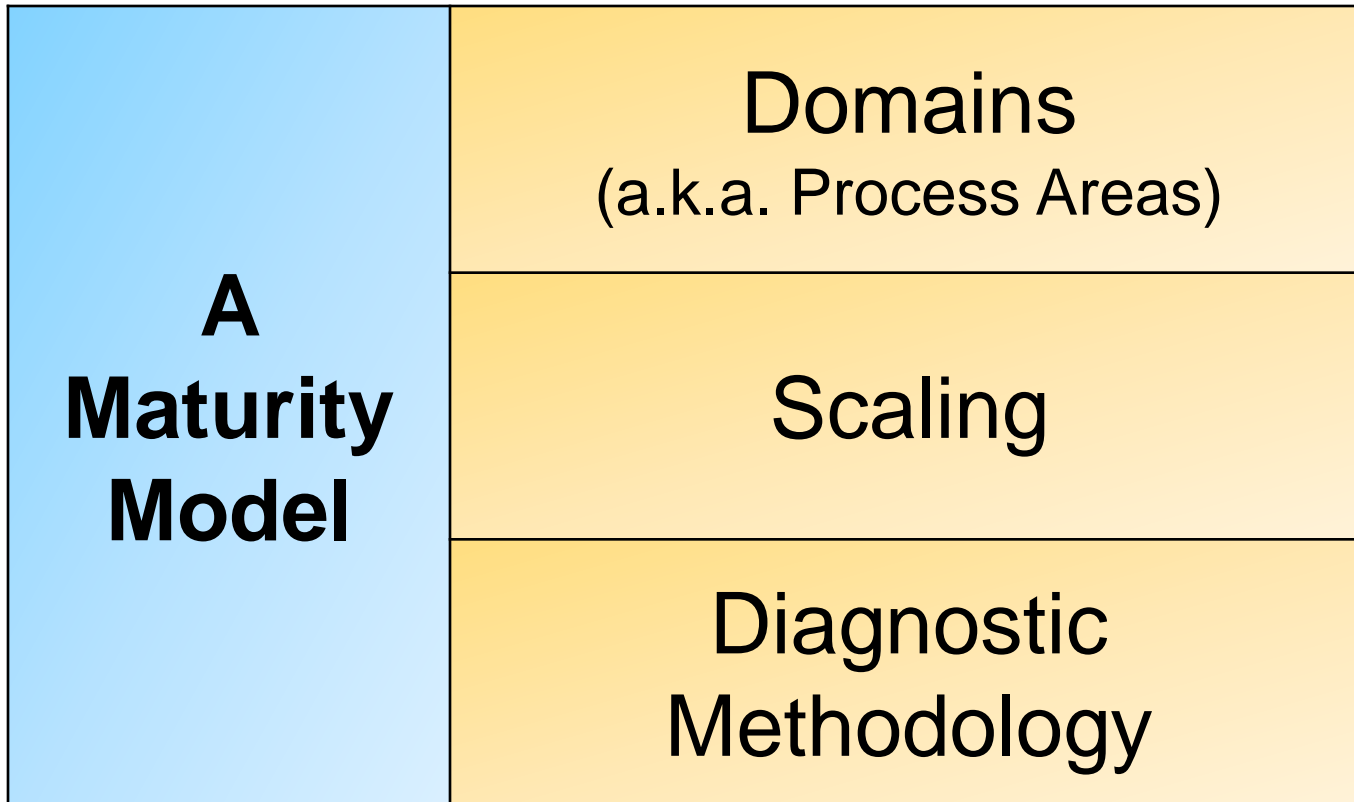
Electricity portion of the energy sector

Includes

- Generation
- Transmission
- Distribution
- Marketing



Model Architecture

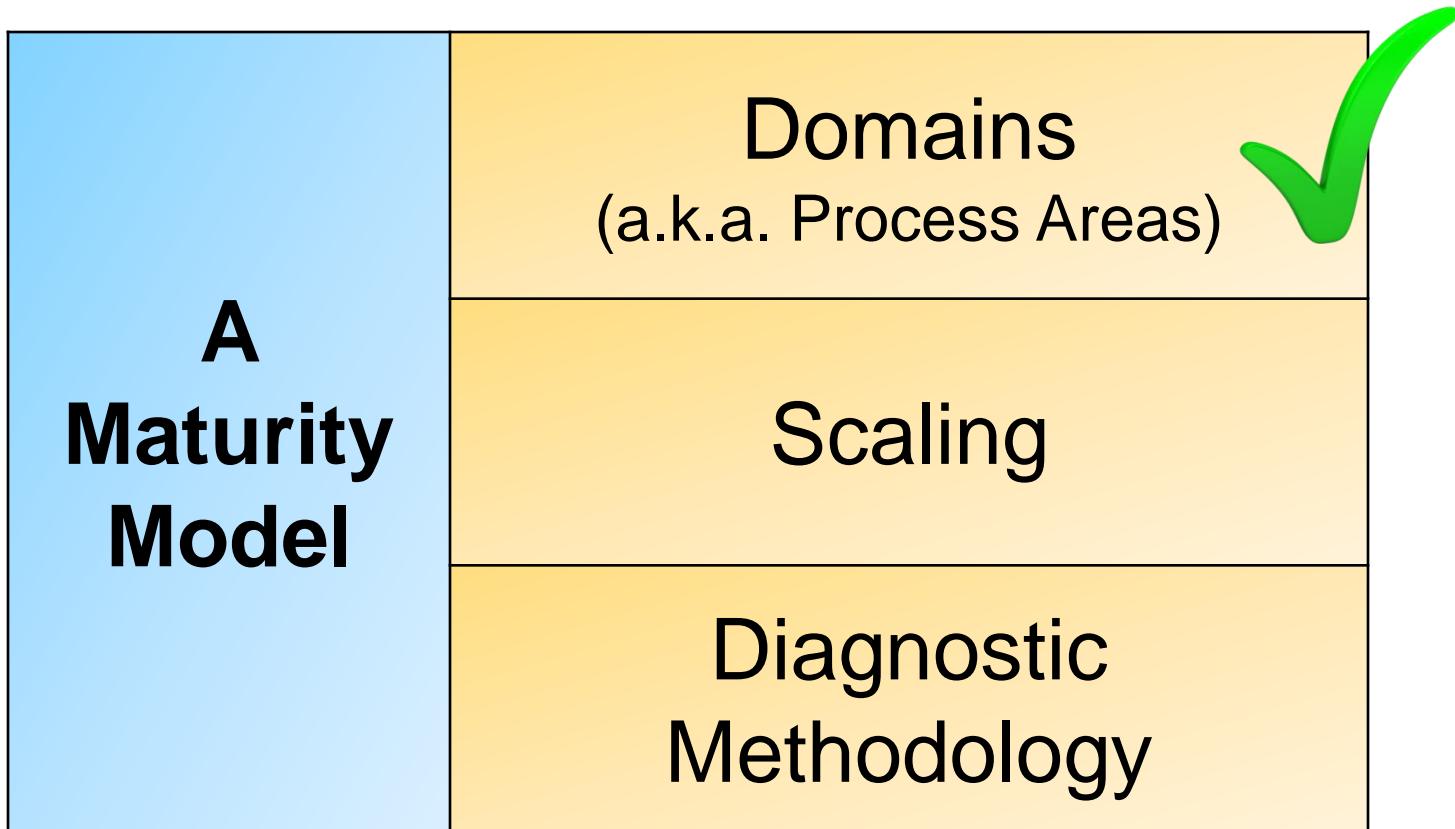


Domains that C2M2 Examines

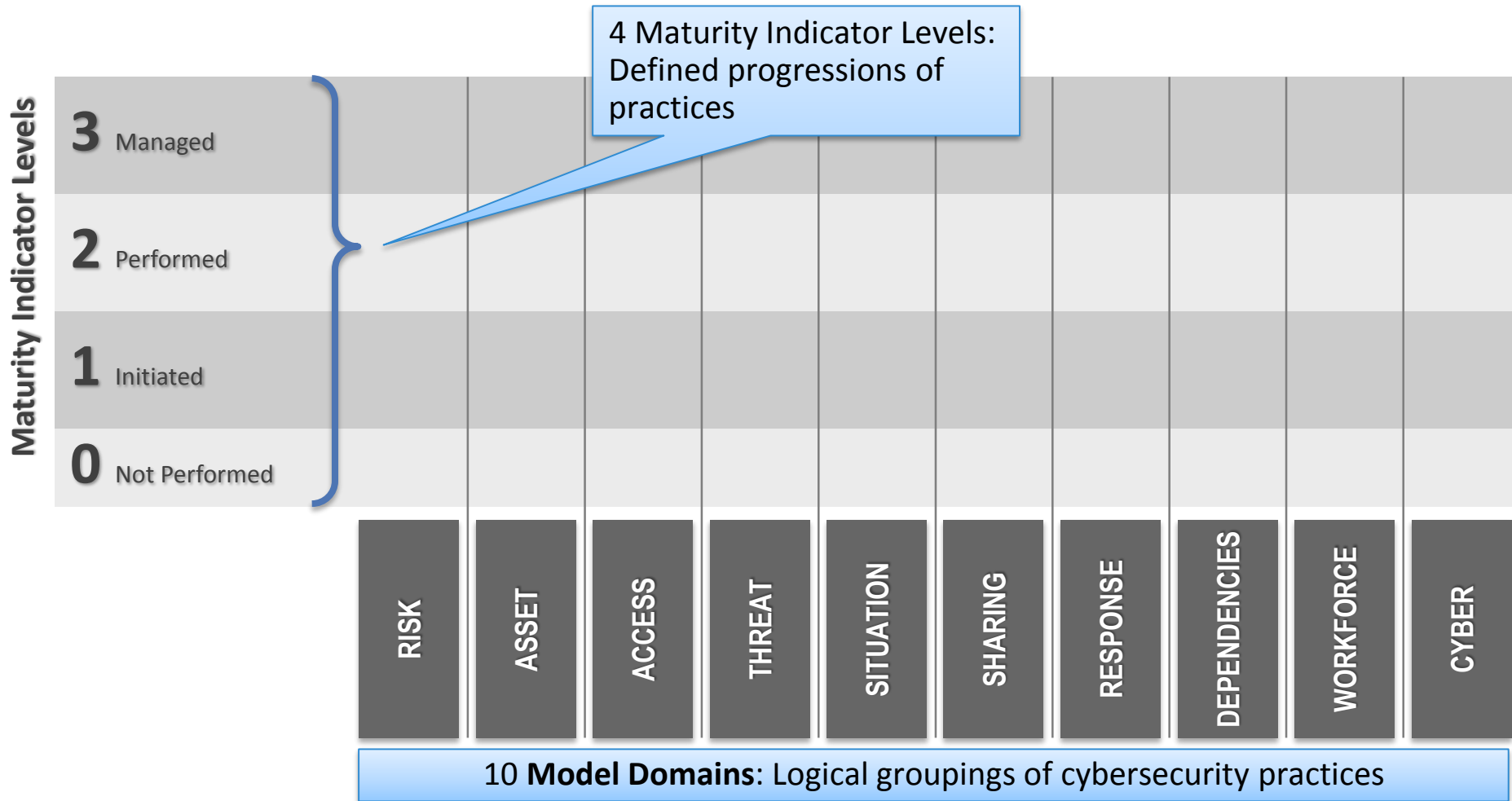


Domains are logical groupings of cybersecurity practices

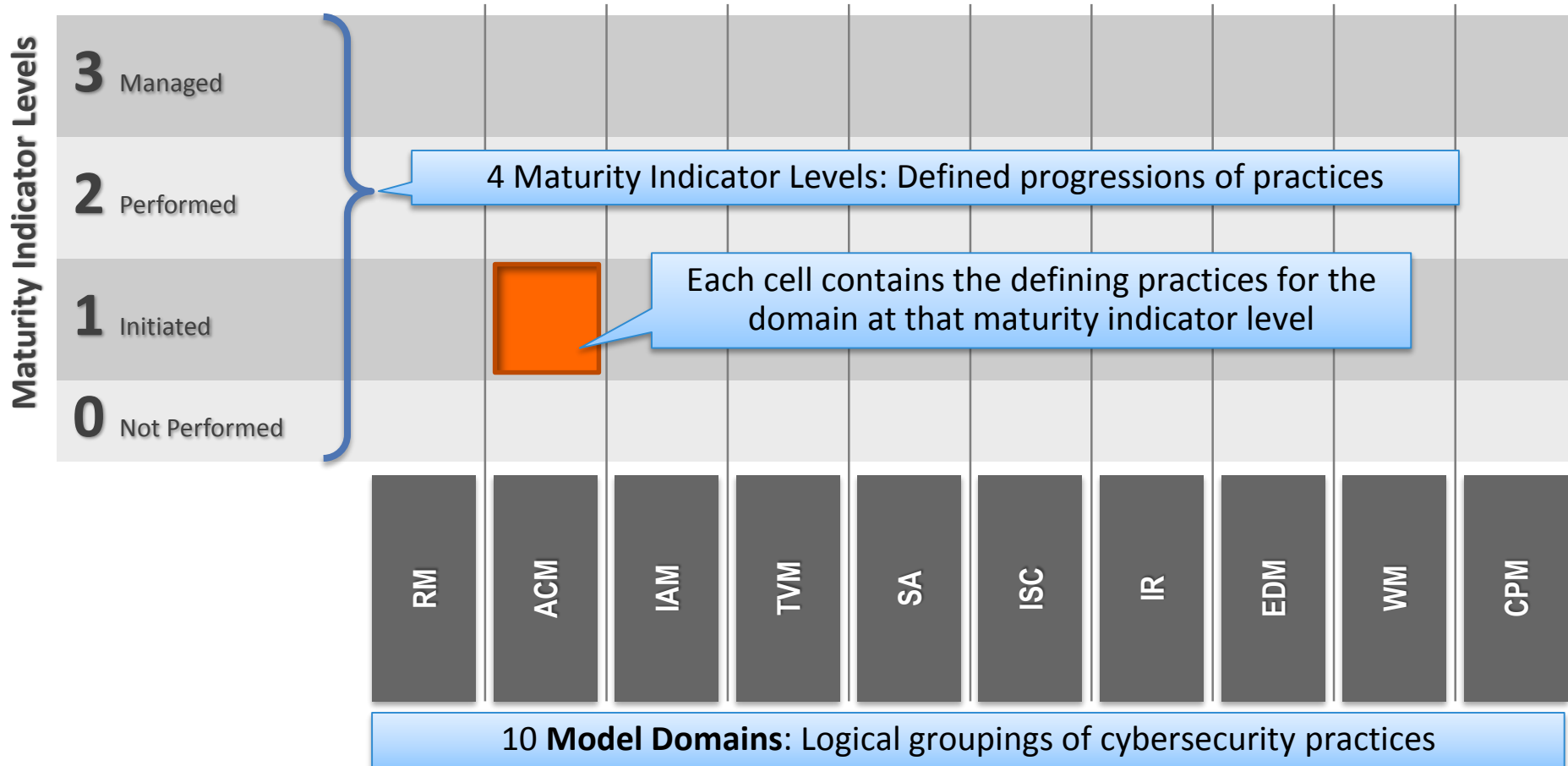
Model Architecture



C2M2 Structure



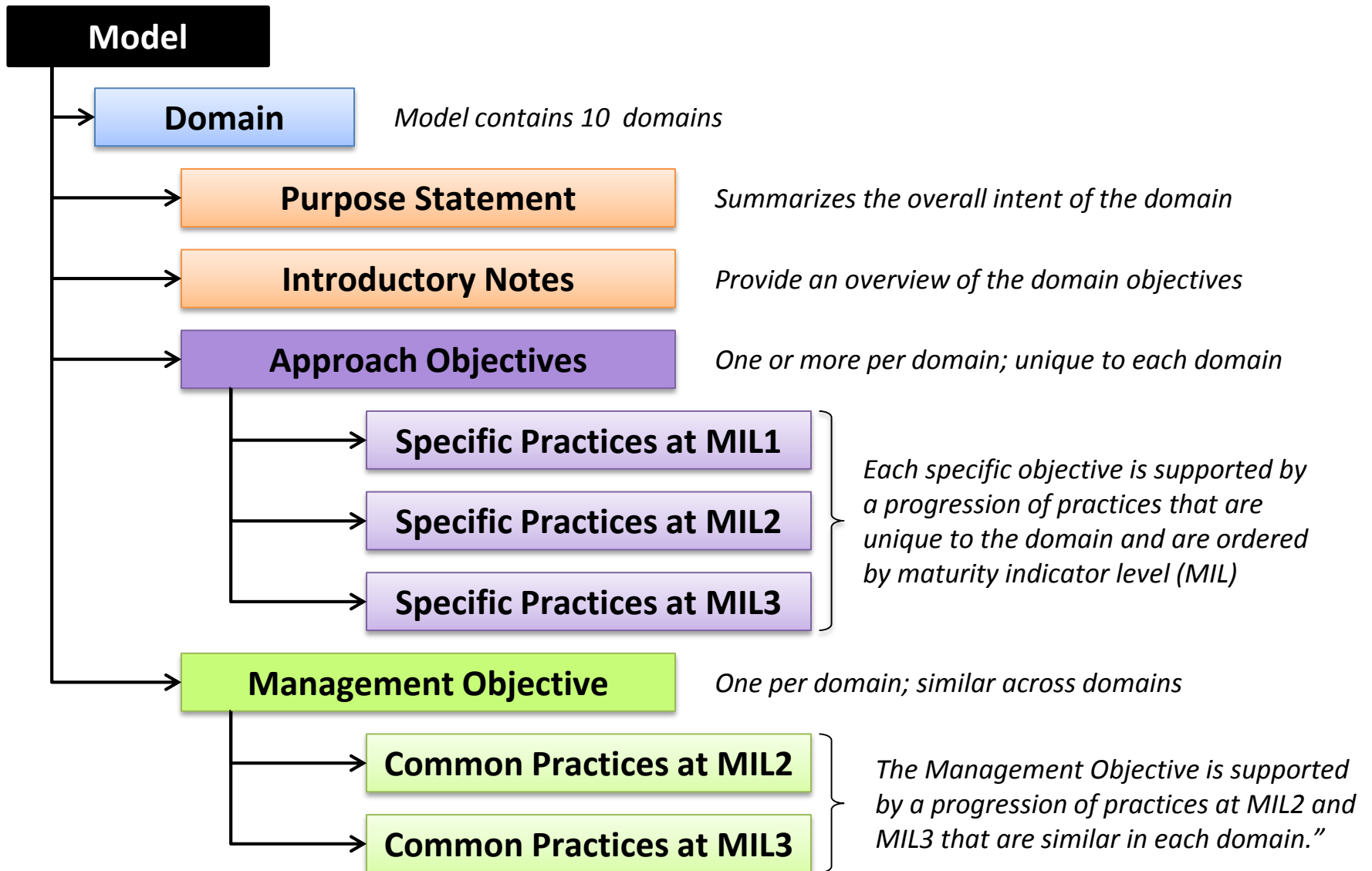
C2M2 Structure



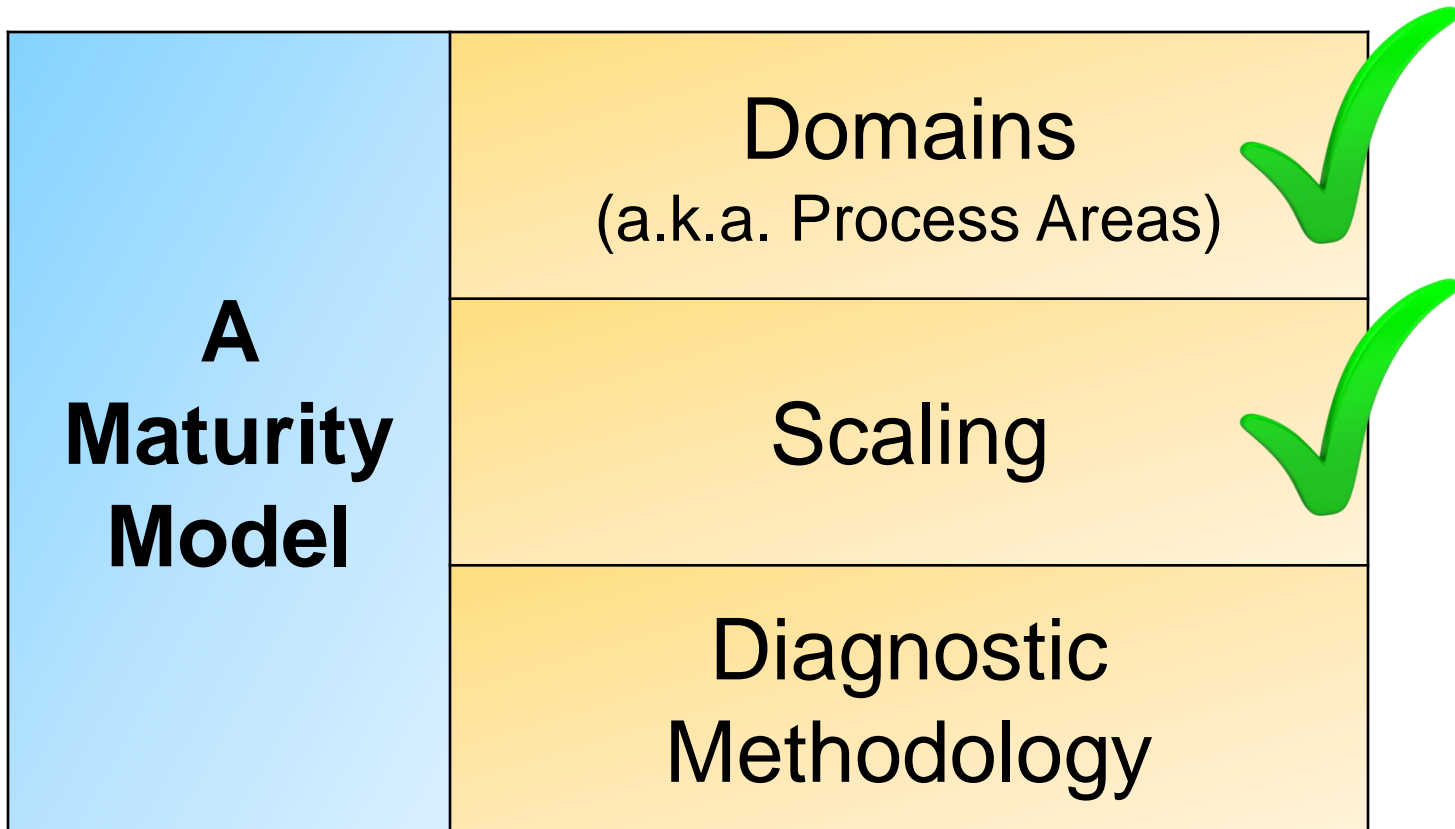
C2M2 Maturity Indicator Levels

Level	Name	Description
MIL0	Not Performed	<ul style="list-style-type: none">• MIL1 has not been achieved in the domain
MIL1	Initiated	<ul style="list-style-type: none">• Initial practices are performed, but may be ad hoc
MIL2	Performed	<ul style="list-style-type: none">• Practices are documented• Stakeholders are involved• Adequate resources are provided for the practices• Standards or guidelines are used to guide practice implementation• Practices are more complete or advanced than at MIL1
MIL3	Managed	<ul style="list-style-type: none">• Domain activities are guided by policy (or other directives)• Activities are periodically reviewed for conformance to policy• Responsibility and authority for practices are clearly assigned to personnel with adequate skills and knowledge• Practices are more complete or advanced than at MIL2

Domain Structure



Model Architecture



C2M2 Self-Evaluation

The C2M2 models are supported by a survey-based self-evaluation

An organization can use the survey (and associated scoring tool) to evaluate its implementation of the model practices

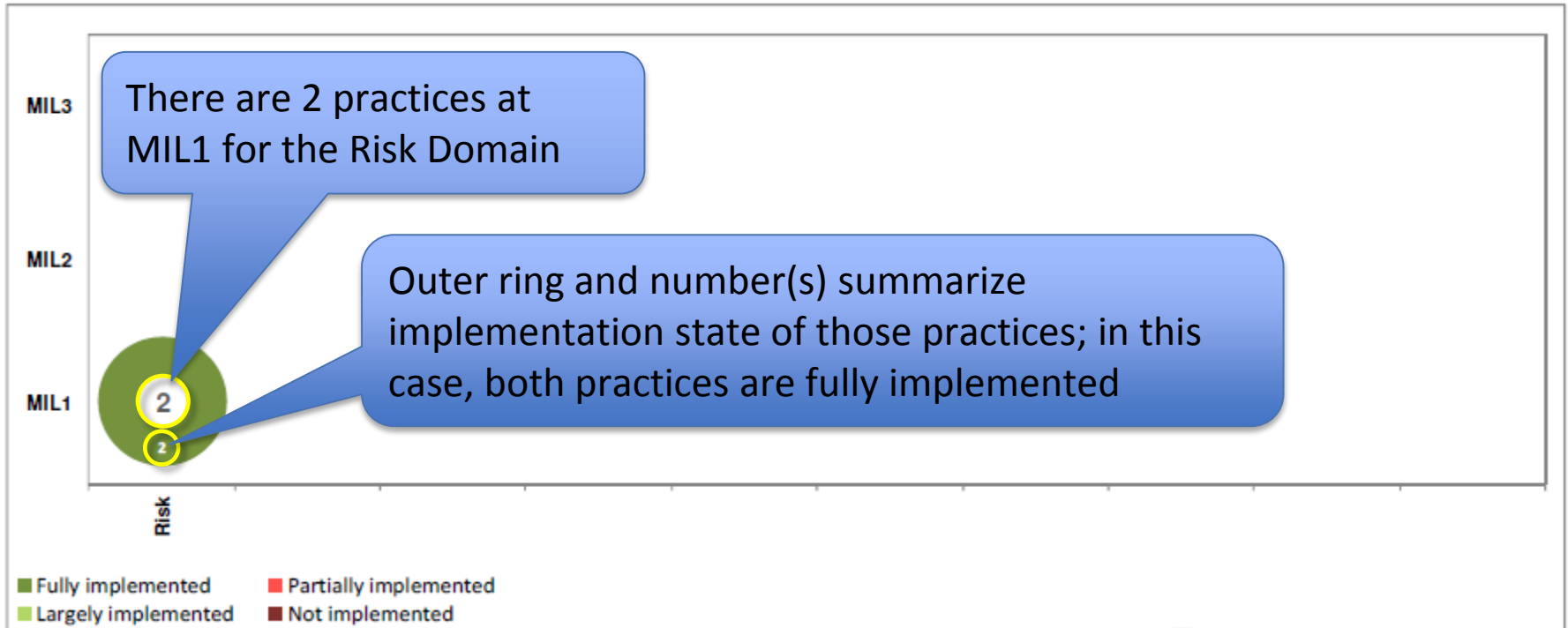
To complete the survey, an organization selects its level of implementation for the model practice from a 4-point answer scale



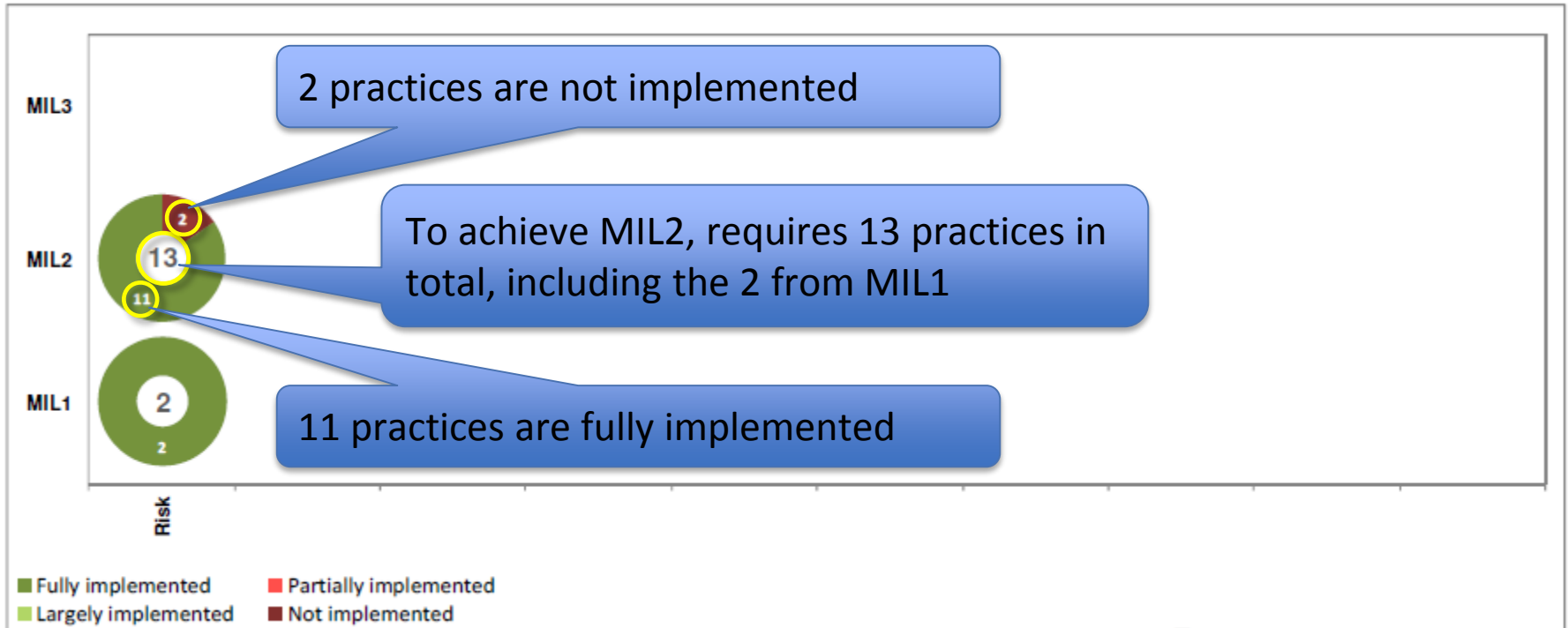
4-Point Answer Scale

4-point answer scale	The organization's performance of the practice described in the model is ...
Fully implemented	Complete
Largely implemented	Complete, but with a recognized opportunity for improvement
Partially implemented	Incomplete; there are multiple opportunities for improvement
Not implemented	Absent; the practice is not performed in the organization

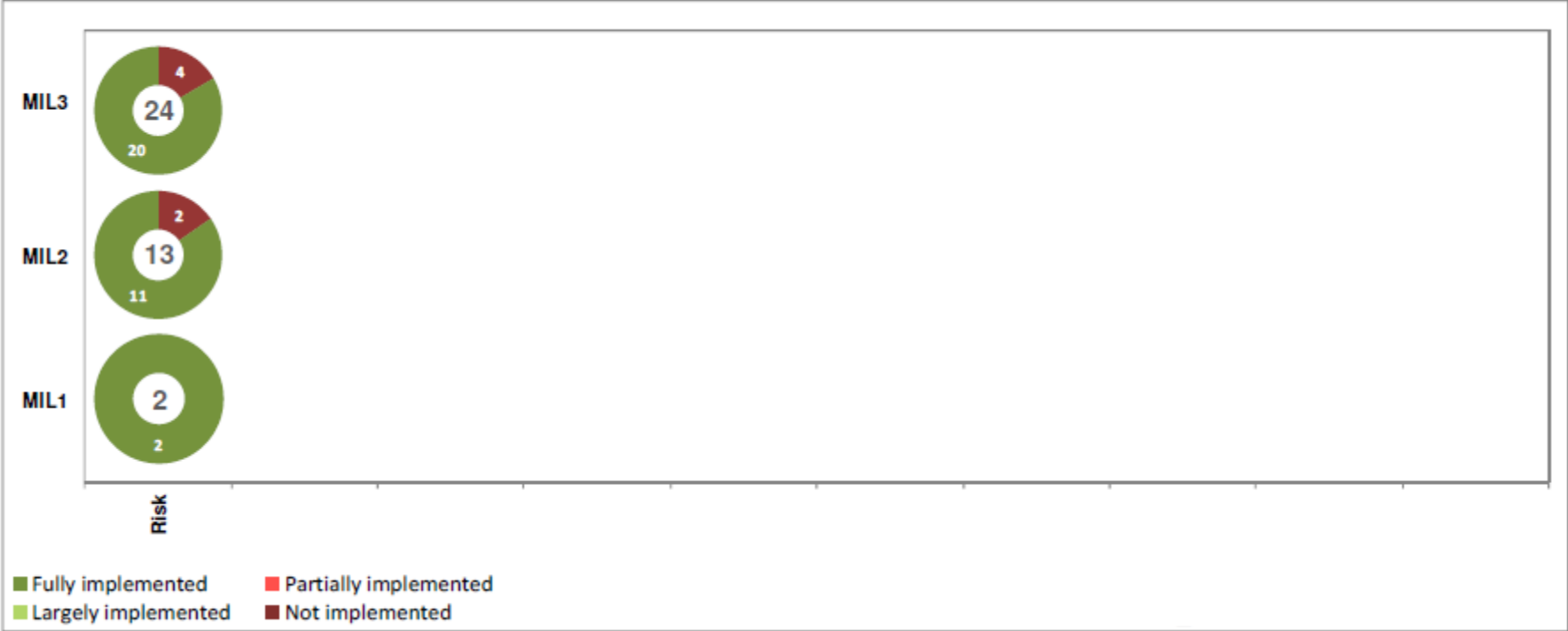
C2M2 Sample Summary Score



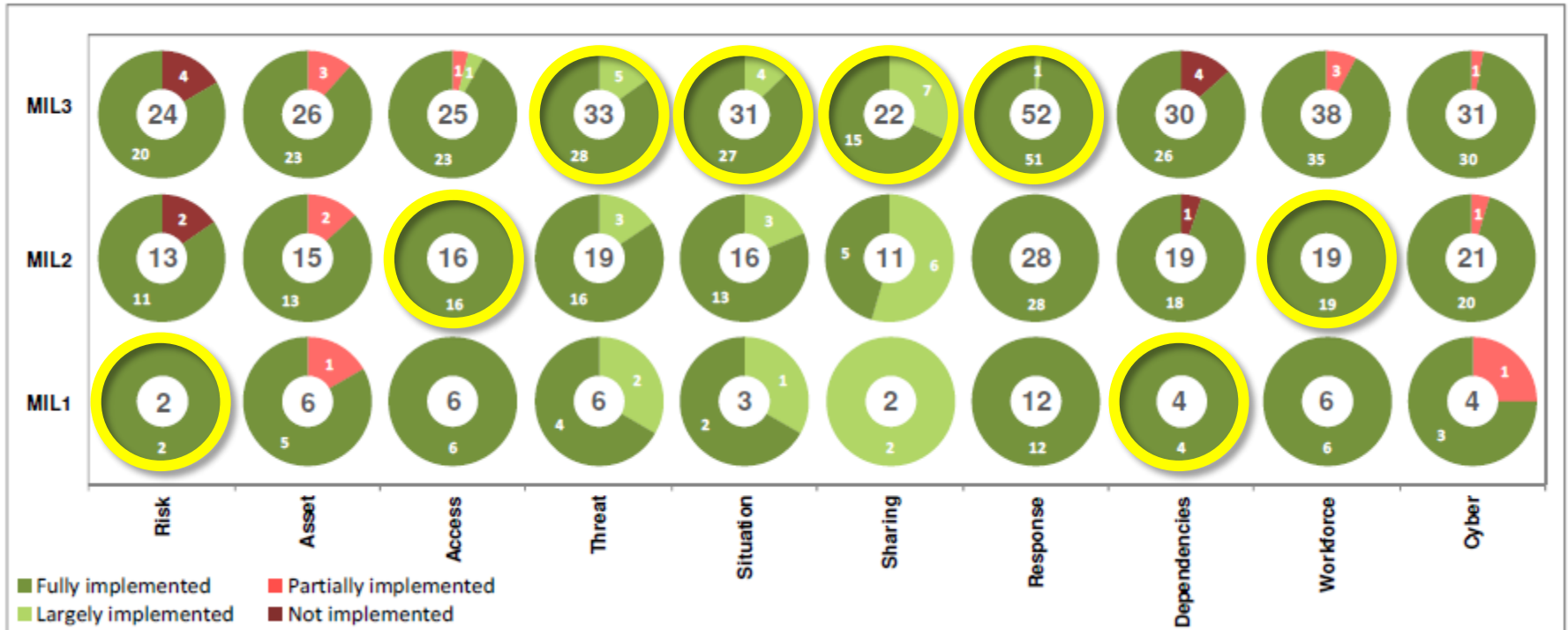
C2M2 Sample Summary Score



C2M2 Sample Summary Score



C2M2 Sample Summary Score



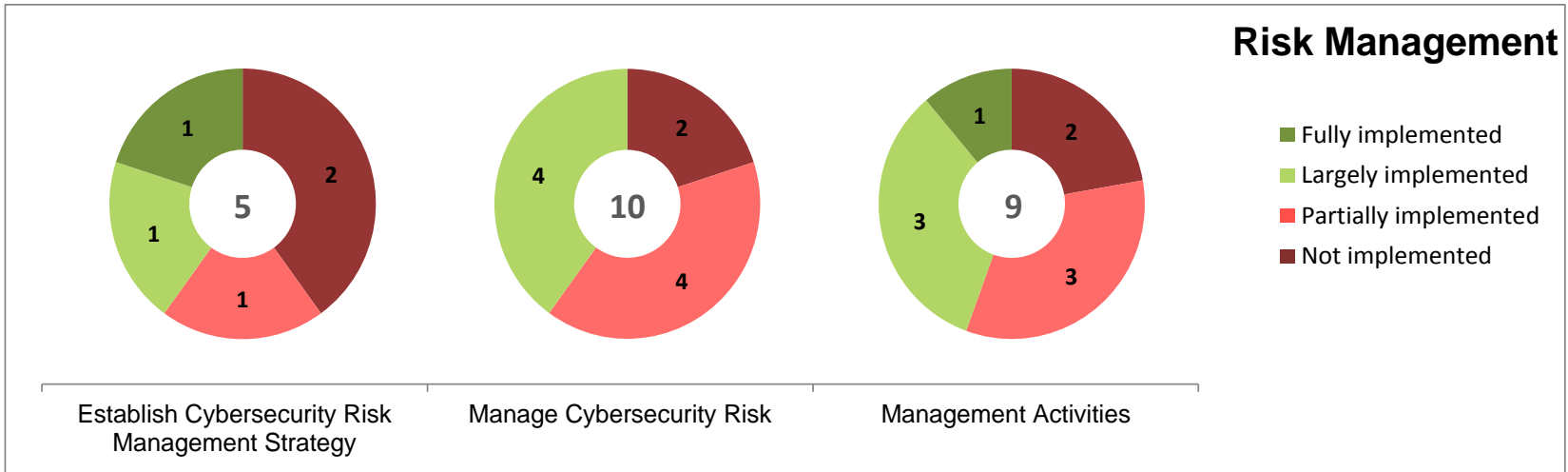
MIL Rating 1 0 2 3 3 3 3 1 2 0

C2M2 Sample Summary Score

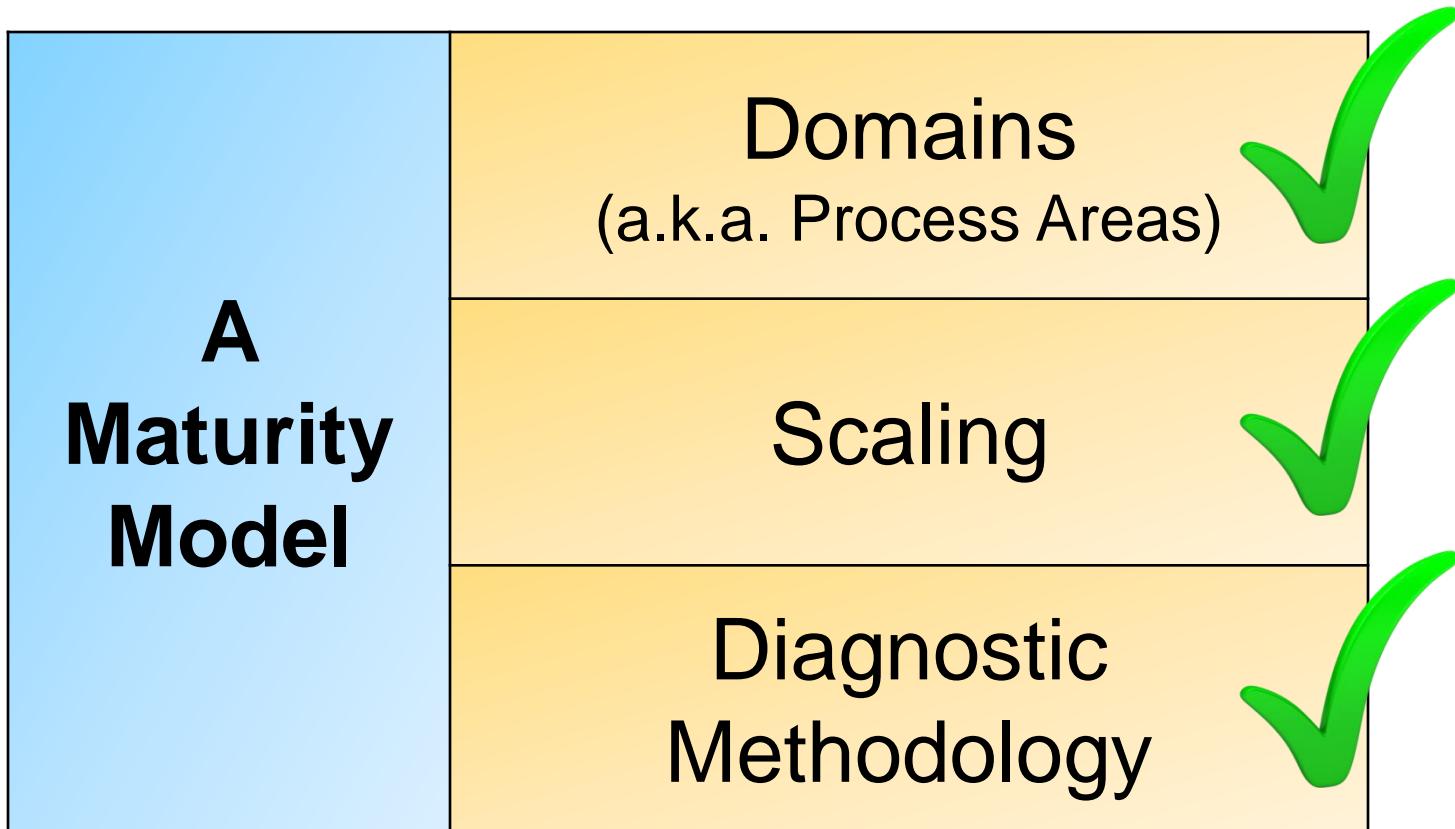
1. Establish Cybersecurity Risk Management Strategy			
MIL1		No practice at MIL1	
MIL2	a.	There is a documented cybersecurity risk management strategy	FI
	b.	The strategy provides an approach for risk prioritization, including consideration of impact	LI
MIL3	c.	Organizational risk criteria (tolerance for risk, risk response approaches) are defined	NI
	d.	The risk management strategy is periodically updated to reflect the current threat environment	PI
	e.	An organization-specific risk taxonomy is documented and is used in risk management activities	NI
2. Manage Cybersecurity Risk			
MIL1	a.	Cybersecurity risks are identified, at least in an ad hoc manner	PI
	b.	Identified risks are mitigated, accepted, tolerated, or transferred, at least in an ad hoc manner	LI
MIL2	c.	Risk assessments are performed to identify risks in accordance with the risk management strategy	LI
	d.	Identified risks are documented	LI
	e.	Identified risks are analyzed to prioritize response activities in accordance with the risk management strategy	LI
	f.	Identified risks are monitored in accordance with the risk management strategy	PI
	g.	Risk analysis is supported by network (IT and/or OT) architecture	PI
MIL3	h.	The risk management program defines and operates risk management policies and procedures that implement the risk management strategy	PI
	i.	A current cybersecurity architecture is used to support risk analysis	NI
	j.	A risk register (a structured repository of identified risks) is used to support risk management activities	NI

C2M2 Sample Summary Score

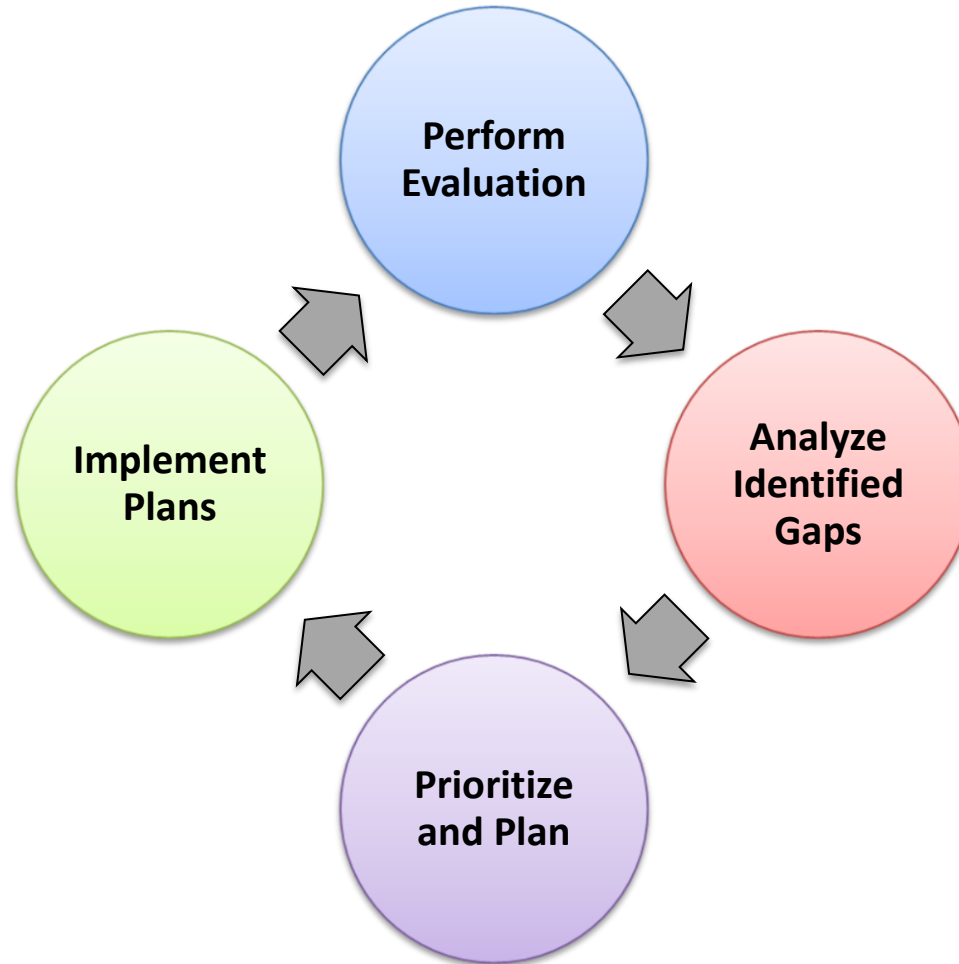
MIL1		MIL2												MIL3									
2a	2b	1a	1b	2c	2d	2e	2f	2g	3a	3b	3c	3d	1c	1d	1e	2h	2i	2j	3e	3f	3g	3h	3i






Model Architecture



Using the C2M2 Models



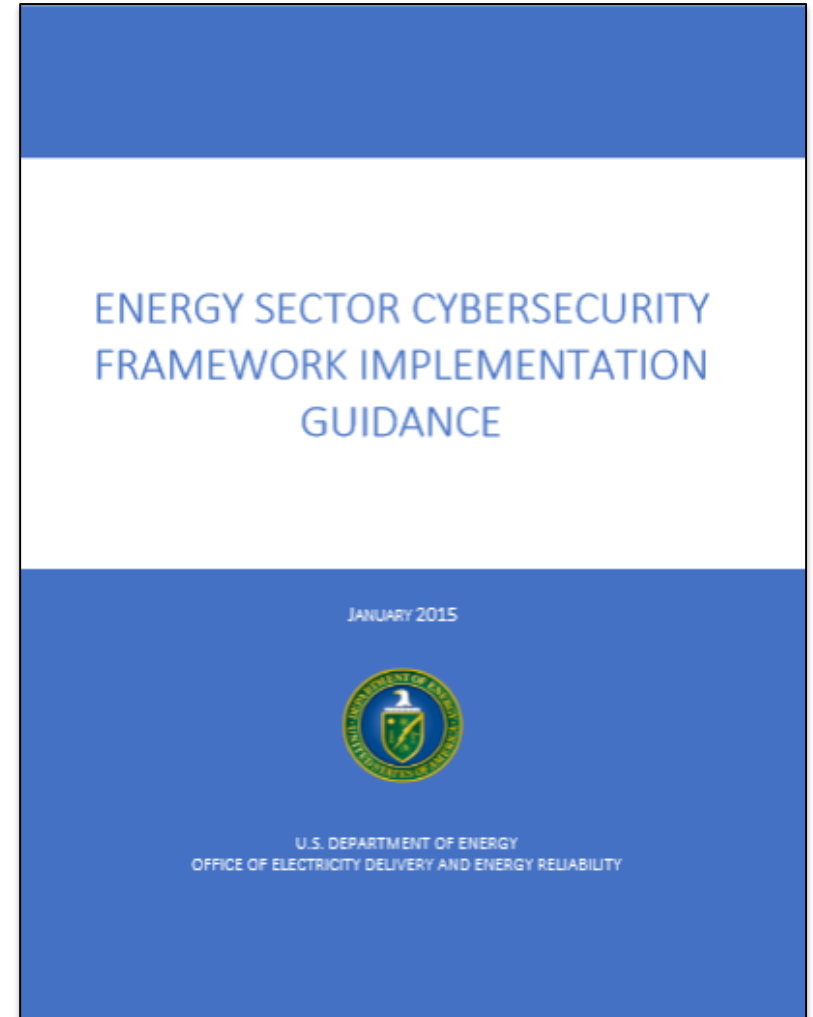
Recommended Process for Using Results

	Inputs	Activities	Outputs
Perform Evaluation 	<ol style="list-style-type: none"> 1. C2M2 Self-Evaluation 2. Policies and procedures 3. Understanding of cybersecurity program 	<ol style="list-style-type: none"> 1. Conduct C2M2 Self-Evaluation Workshop with appropriate attendees 	C2M2 Self-Evaluation Report
Analyze Identified Gaps 	<ol style="list-style-type: none"> 1. C2M2 Self-Evaluation Report 2. Organizational objectives 3. Impact to critical infrastructure 	<ol style="list-style-type: none"> 1. Analyze gaps in organization's context 2. Evaluate potential consequences from gaps 3. Determine which gaps need attention 	List of gaps and potential consequences
Prioritize and Plan 	<ol style="list-style-type: none"> 1. List of gaps and potential consequences 2. Organizational constraints 	<ol style="list-style-type: none"> 1. Identify actions to address gaps 2. Cost benefit analysis (CBA) on actions 3. Prioritize actions (CBA and consequences) 4. Plan to implement prioritize actions 	Prioritized implementation plan
Implement Plans	Prioritized implementation plan	<ol style="list-style-type: none"> 1. Track progress to plan 2. Re-evaluate periodically or in response to major change 	Project tracking data

Relationship to NIST Cybersecurity Framework

The U.S. Department of Energy (DOE) has developed guidance on using the NIST Cybersecurity Framework for the Energy Sector

DOE guidance highlights C2M2 models as an approach to using the NIST Cybersecurity Framework



CYBERSECURITY CAPABILITY MATURITY MODEL (C2M2) PROGRAM

- [Electricity Advisory Committee](#)
- [Technology Development](#)
- [Electricity Policy Coordination and Implementation](#)
- [DOE Grid Tech Team](#)
- [Energy Assurance](#)
- [Cybersecurity](#)
 - [NIST Framework](#)
 - [C2M2 Program](#)
 - [Cybersecurity Capability Maturity Model](#)
 - [ES-C2M2](#)
 - [ONG-C2M2](#)
 - [Cybersecurity Risk Management Process](#)
 - [Energy Delivery Systems Cybersecurity](#)



The Cybersecurity Capability Maturity Model (C2M2) program is a public-private partnership effort that was established as a result of the Administration's efforts to improve electricity subsector cybersecurity capabilities, and to understand the cybersecurity posture of the grid. The C2M2 helps organizations—regardless of size, type, or industry—evaluate, prioritize, and improve their own cybersecurity

- ### RELATED LINKS
- [Executive Order \(EO\) 13636 "Improving Critical Infrastructure Cybersecurity"](#)
 - [NIST Framework](#)
 - [Use of the NIST Cybersecurity Framework & DOE C2M2](#)
 - [Cybersecurity Capability Maturity Model \(C2M2\) Program](#)
 - [C2M2 Model](#)
 - [Electricity Subsector C2M2 Model](#)
 - [Podcast - Electricity Subsector C2M2 Model](#)
 - [Oil and Natural Gas Subsector C2M2 Model](#)

For More Information

DOE Cybersecurity Capability Maturity Model Program

- <http://energy.gov/oe/services/cybersecurity/cybersecurity-capability-maturity-model-c2m2-program>

ONG-C2M2

- <http://energy.gov/oe/cybersecurity-capability-maturity-model-c2m2-program/oil-and-natural-gas-subsector-cybersecurity>

ES-C2M2

- <http://energy.gov/oe/cybersecurity-capability-maturity-model-c2m2-program/electricity-subsector-cybersecurity>

Core C2M2

- <http://energy.gov/oe/cybersecurity-capability-maturity-model-c2m2-program/cybersecurity-capability-maturity-model-c2m2>

SEI Resilience Management Program

- <http://www.cert.org/resilience/>

Thank you for your attention...



Additional Material

Model Domains (1-2 of 10)

Domain	Description
Asset, Change, and Configuration Management (ACM)	<p>Manage the organization's operational technology (OT) and information technology (IT) assets, including both hardware and software, commensurate with the risk to critical infrastructure and organizational objectives, including activities to:</p> <ul style="list-style-type: none">• Identify, inventory, and prioritize assets,• Manage asset configurations, and• Manage changes to assets and to the asset inventory.
Workforce Management (WM)	<p>Establish and maintain plans, procedures, technologies, and controls to create a culture of cybersecurity and to ensure the ongoing suitability and competence of personnel, commensurate with the risk to critical infrastructure and organizational objectives.</p> <ul style="list-style-type: none">• Responsibilities• Workforce controls• Knowledge, skills, and abilities• Awareness

Model Domains (3-4 of 10)

Domain	Description
Identity and Access Management (IAM)	<p>Create and manage identities for entities that may be granted logical or physical access to the organization's assets. Control access to the organization's assets, commensurate with the risk to critical infrastructure and organizational objectives.</p> <ul style="list-style-type: none">• Identity management• Access management
Risk Management (RM)	<p>Establish, operate, and maintain a cybersecurity risk management and mitigation program to identify and manage cybersecurity risk to the organization and its related interconnected infrastructure and stakeholders.</p> <ul style="list-style-type: none">• Strategy• Sponsorship• Program

Model Domains (5-6 of 10)

Domain	Description
Supply Chain and External Dependencies Management (EDM)	<p>Establish and maintain controls to manage the cybersecurity risk associated with services and assets that are dependent on external entities, commensurate with the organization's business and security objectives.</p> <ul style="list-style-type: none">• Dependency identification• Risk management• Cybersecurity requirements
Threat and Vulnerability Management (TVM)	<p>Establish and maintain plans, procedures, and technologies to identify, analyze, and manage cybersecurity threats and vulnerabilities, commensurate with the risk to critical infrastructure and organizational objectives.</p> <ul style="list-style-type: none">• Threat management• Vulnerability management• Cybersecurity patch management• Assessments

Model Domains (7-8 of 10)

Domain	Description
Event and Incident Response, Continuity of Operations (IR)	<p>Establish and maintain plans, procedures, and technologies to detect, analyze, and respond to cybersecurity incidents and to sustain critical functions throughout a cyber event, commensurate with the risk to critical infrastructure and organizational objectives.</p> <ul style="list-style-type: none">• Detect events• Declare incidents• Respond to incidents• Manage continuity
Situational Awareness (SA)	<p>Establish and maintain activities and technologies to collect, analyze, alarm, present, and use power system and cybersecurity information, including status and summary information from the other model domains, to form a common operating picture, commensurate with the risk to critical infrastructure and organizational objectives.</p> <ul style="list-style-type: none">• Logging• Monitoring• Awareness

Model Domains (9-10 of 10)

Domain	Description
Information Sharing and Communications (ISC)	<p>Establish and maintain relationships with internal and external entities to share information, including threats and vulnerabilities, in order to reduce risks and increase operational resilience, commensurate with the risk to critical infrastructure and organizational objectives.</p> <ul style="list-style-type: none">• Communication• Analysis• Coordination
Cybersecurity Program Management (CPM)	<p>Establish and maintain a cybersecurity program that provides governance, strategic planning, and sponsorship for the organization's cybersecurity activities in a manner that aligns cybersecurity objectives with the organization's strategic objectives and the risk to critical infrastructure.</p> <ul style="list-style-type: none">• Strategy• Sponsorship• Program• Architecture

C2M2 Maturity Indicator Levels Example

Specific Characteristics for the ASSET domain	
MILO	
MIL1	<ol style="list-style-type: none">1. Asset inventory<ol style="list-style-type: none">a. There is an inventory of OT (operational technology) and IT (information technology) assets that are important to the delivery of the function <p>...</p>
MIL2	...
MIL3	<ol style="list-style-type: none">1. Asset inventory<ol style="list-style-type: none">a. The asset inventory is current and complete for assets of defined categories that are selected based on risk analysisb. Asset prioritization is informed by risk analysis <p>...</p>

Progress from one MIL to the next involves more complete or more advanced implementations of the core activities in the domain.

The organization is also expected to be performing additional activities at higher levels consistent with their risk strategy.

A Dual-Progression Model

The C2M2 is a dual progression model

Two things are progressing across the maturity indicator levels:

1. **Approach** – the completeness, thoroughness, or level of development/sophistication of the activity
2. **Management** – the extent to which the practices are ingrained/institutionalized in the organization's operations

Example of Dual Progression

Manage Cybersecurity Risk

Management Practices

- MIL1**
- a. Cybersecurity risks are identified
 - b. Identified risks are mitigated, accepted, tolerated, or transferred

1. Initial practices are performed but may be ad hoc

- MIL2**
- c. Risk assessments are performed to identify risks in accordance with the risk management strategy
 - d. Identified risks are documented
 - e. Identified risks are analyzed to prioritize response activities in accordance with the risk management strategy
 - f. Identified risks are monitored in accordance with the risk management strategy
 - g. A network (IT and/or OT) architecture is used to support risk analysis

1. Practices are documented
2. Stakeholders of the practice are identified and involved
3. Adequate resources are provided to support the process (people, funding, and tools)
4. Standards and/or guidelines have been identified to guide the implementation of the practices

- MIL3**
- a. The risk management program defines and operates risk management policies and procedures that implement the risk management strategy
 - b. A current cybersecurity architecture is used to support risk analysis
 - c. A risk register (a structured repository of identified risks) is used to support risk management

1. Activities are guided by policies (or other organizational directives) and governance
2. Activities are periodically reviewed to ensure they conform to policy
3. Responsibility and authority for performing the practice is clearly assigned to personnel
4. Personnel performing the practice have adequate skills and knowledge

4-Point Answer Scale – Fully Implemented

4-point answer scale	The organization's performance of the practice described in the model is ...
Fully implemented	Complete
Largely implemented	Incomplete; there are multiple opportunities for improvement
Partially implemented	Incomplete; there are multiple opportunities for improvement
Not implemented	Absent; the practice is not performed in the organization

The practice is performed as described in the model

4-Point Answer Scale – Largely Implemented

4-point answer scale	The organization's performance of the practice described in the model is ...
Fully implemented	Complete
Largely implemented	Complete, but with a recognized opportunity for improvement
Partially implemented	Incomplete
Not implemented	Absent

The practice is performed substantially as described in the model, but there is some recognized opportunity for improvement that is not material with respect to achieving model, organizational, or critical infrastructure objectives

4-Point Answer Scale – Partially Implemented

4-point answer scale	The organization's performance of the practice described in the model is ...
Fully implemented	Cor
Largely implemented	Cor
Partially implemented	Incomplete; there are multiple opportunities for improvement
Not implemented	Absent; the practice is not performed in the organization

The practice is performed substantially as described in the model, but there is some recognized opportunity for improvement that is not material with respect to achieving model, organizational, or critical infrastructure objectives

4-Point Answer Scale – Not Implemented

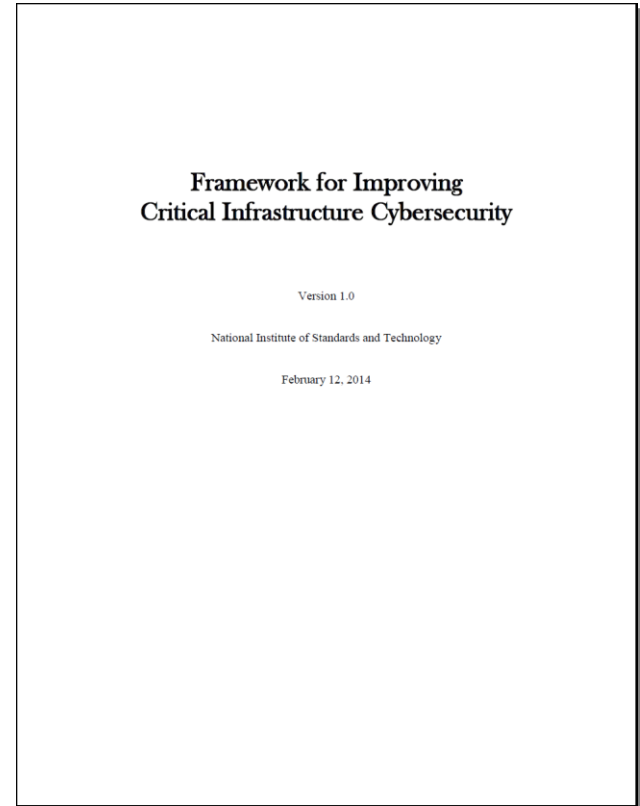
4-point answer scale	The organization's performance of the practice described in the model is ...
Fully implemented	Complete
Largely implemented	In progress; there are multiple opportunities for improvement
Partially implemented	In progress; there are multiple opportunities for improvement
Not implemented	Absent; the practice is not performed in the organization

The practice is not performed in the organization

NIST Cybersecurity Framework

The National Institute of Standards and Technology (NIST) released its *Framework for Improving Critical Infrastructure Cybersecurity* (Framework) in February 2014

The Framework enables organizations – regardless of size, degree of cybersecurity risk, or cybersecurity sophistication – to apply the principles and best practices of risk management to improving the security and resilience of critical infrastructure.



Elements of the Framework

The three main elements of the Framework are the **Core**, the **Implementation Tiers**, and the **Profile**.



The **Core** is a set of “cybersecurity activities, desired outcomes, and applicable informative references that are common across critical infrastructure sectors” within five “functions:” Identify, Protect, Detect, Respond, and Recover.

Tiers describe an organization’s approach to “cybersecurity risk and the processes in place to manage that risk,” ranging from Tier 1 (Partial) to Tier 4 (Adaptive).

Profiles align the Framework core elements with business requirements, risk tolerance, and organizational resources.