IEEE 1547-2018
and IEEE 1547a-2020

Opportunities, Adoption Methods & Stakeholder Coordination

Jose Cordova
Jens Boemer

Virtual Training on Bulk Power System Issues for State Energy Officials

June 22, 2021

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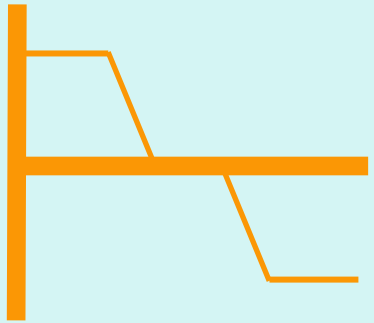
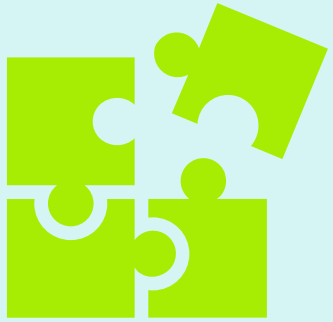
Steps to Unlock Benefits of Advanced DER

Grid Planning & Technical Interconnection Requirements
(e.g., IEEE 1547-2018)



Specify **DER** Performance and Functional **Capabilities**

- e.g., adopt IEEE Std 1547-2018



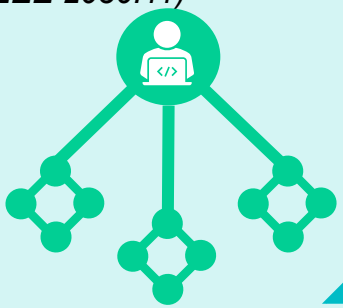
Update interconnection agreements

- e.g., allow for **utilization** of DER capabilities

Research, Development, Standardization
(e.g., DERMS, IEEE 2030.11)

Design architecture and deploy DER **communication infrastructure**

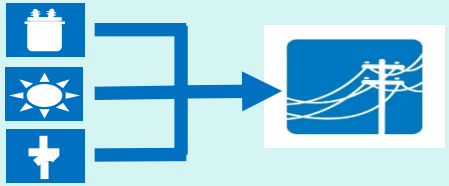
- e.g., start with utility-scale DER before integrating retail-scale DER



Specify DER Management System and select **DER Aggregations/ Group Management** Functions

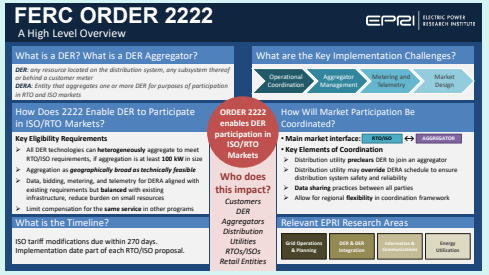
- e.g., codify messages to be exchanged across the T&D interface

Markets & Operations
(e.g. FERC Order 2222)



Design **market** and integrate DER into **grid operations**

- e.g., energy products, capacity products, re-dispatch, regulating reserves



**FERC Order 2222 Phase 1: Collaborative Forum, Gap Assessment, and Implementation Roadmap, https://www.epri.com/research/products/000000003002020167*

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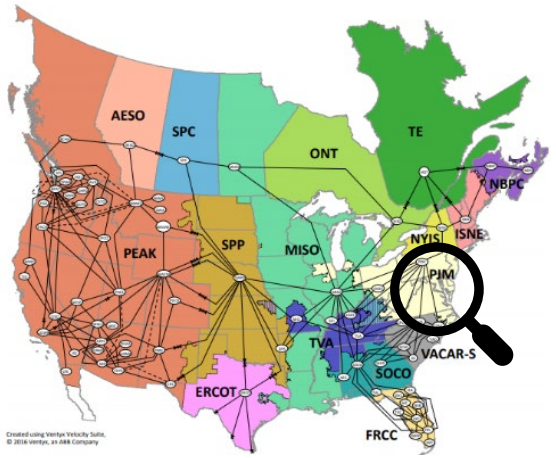
Potential Impacts of Aggregate DER on-Bulk Power System Reliability

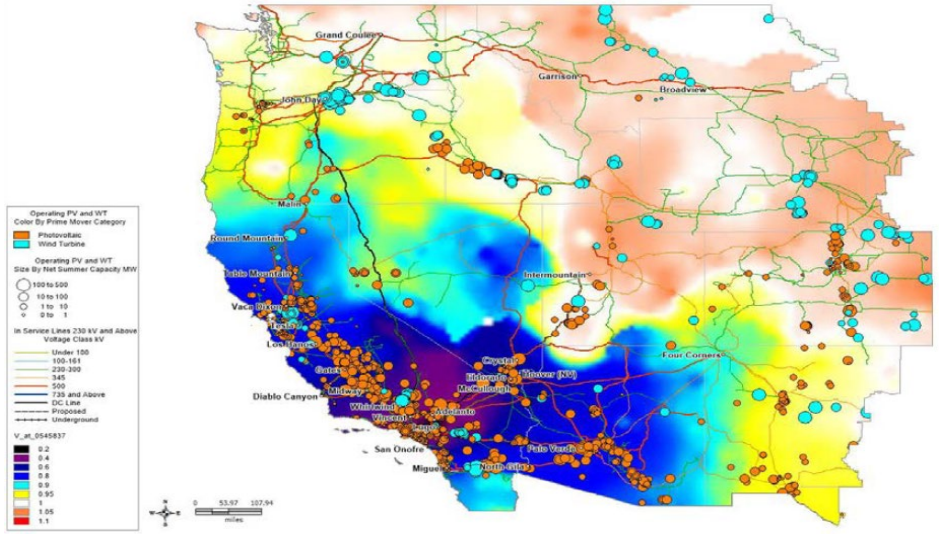
DER Frequency Ride-Through versus Tripping

- System frequency is defined by balance between load and generation
- Frequency is similar across entire interconnection
  - any DER exposed to large frequency deviations may trip simultaneously;
  - special concerns for system-split conditions
- Impact the same whether or not DER is on a high-penetration feeder
- NERC Reliability Coordinators
  - Colored entities in the map to the right



Source: NERC

DER Voltage Ride-Through versus Tripping



Source: SCE

- Transmission faults can depress distribution **voltage** over very large areas
- Sensitive voltage tripping (i.e., 1547-2003) can cause massive loss of DER generation
- Resulting BPS event may be greatly aggravated

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Role of IEEE Std 1547-2018

IEEE Std 1547-2018

DERs

- Defines and Standardizes "smart DERs" across the industry
- All DER not just inverter based!

TECHNICAL

- Technical basis for regulatory proceedings
- Can be flexibly adjusted to regional differences
- Widely-accepted by industry

VALUE

- Avoid lengthy discussions with stakeholders
- Avoid specifying technical requirements
- Account for regional differences (flexibility)
- Accelerate regulatory proceedings
- Mitigate technical risks

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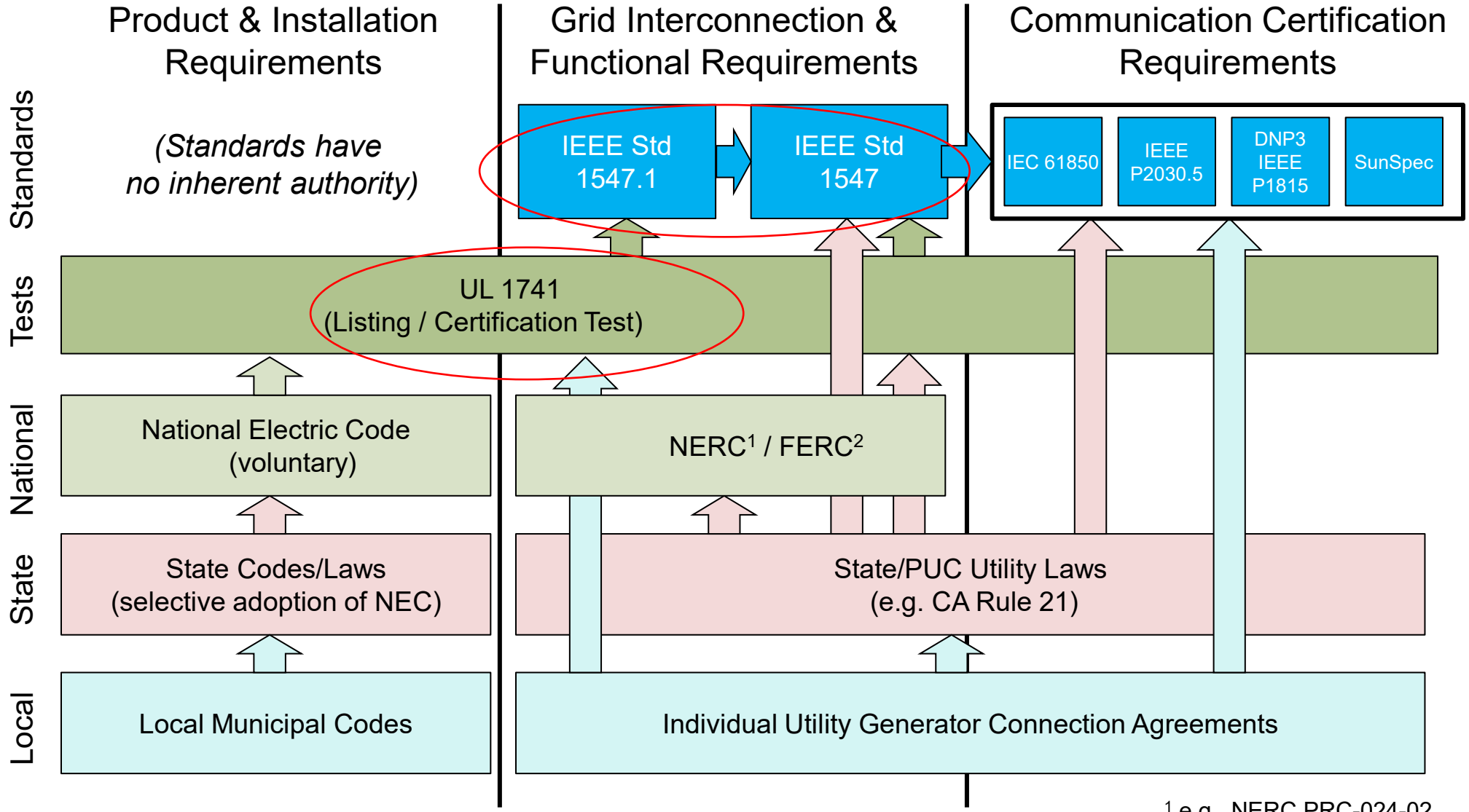
How IEEE 1547 Relates to Other Requirements



[1] e.g., NERC PRC-024-02,
[2] e.g., FERC Order No. 828

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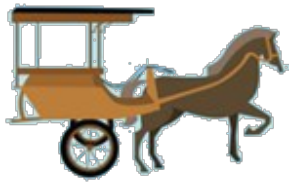
Capability versus Utilization

(Performance) Capability

- Functions
- Ranges of available settings



Examples

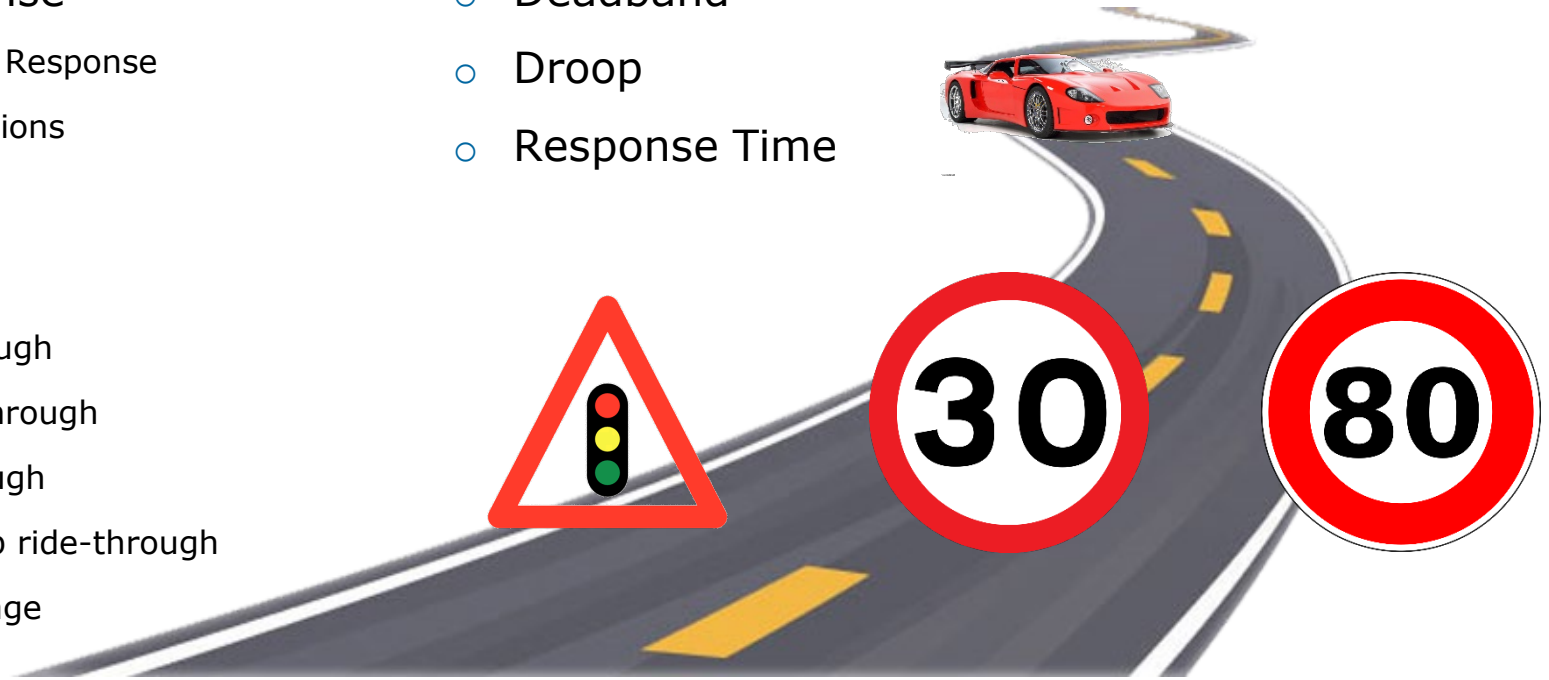
- Frequency Response
  - Frequency Droop Response
  - Ramp rate limitations
- Ride-Through
  - Voltage ride-through
  - Frequency ride-through
  - ROCOF ride-through
  - Phase angle jump ride-through
  - Consecutive voltage ride-through

Utilization of Capability

- Enable/disable functions
- Functional settings / configured parameters

Examples

- Deadband
- Droop
- Response Time



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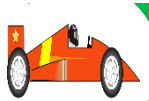
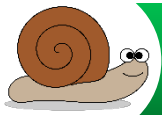
IEEE 1547-2018 Adoption Methods



General Reference

- Full adoption of standard by general reference
- Specification of
  - performance categories
    - normal category
    - abnormal category
  - functional settings (utility-required profiles)
  - standardized comms. protocols



Detailed Reference

- Full or partial adoption of std
- Clause-by-clause references
- Any additional requirements

EPRI's Generic TIIR Template

Benefit: *Consistency to standard*

Risk: *Fragmentation of requirements, certification challenges, additional costs*

Full Specification

- All on the left
- Clause-by-clause own language
- Any additional requirements

Benefit: *No need to buy standard*

Risk: *Inconsistencies to standard and fragmentation of requirements, certification challenges, additional costs*

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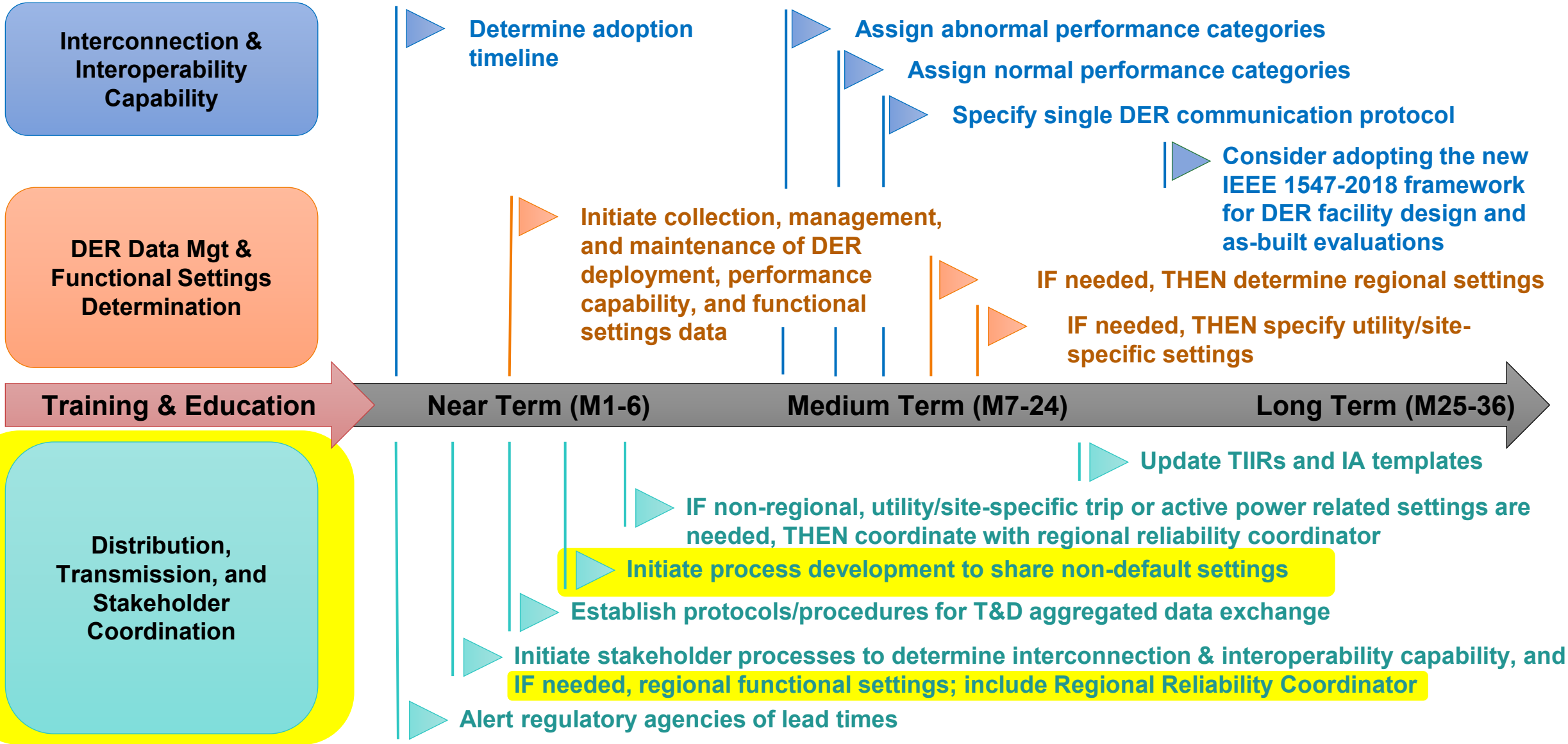
EPRI Recommended Steps for IEEE 1547-2018 Adoption



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Balancing Bulk & Distribution Grid Needs

Public EPRI-U Webinars
3002014545
3002014546
3002014547

Distribution Grid Side

- Short trip times
- Ride-through *with momentary cessation*
- Voltage rise concerns
- Islanding concerns
- Protection coordination
- Safety of line workers

Increasing need for T&D Coordination

Bulk System Side

- Long trip times
- Ride-through *without* momentary cessation
- Reactive power support
- Dynamic voltage support during abnormal voltage
- Frequency support

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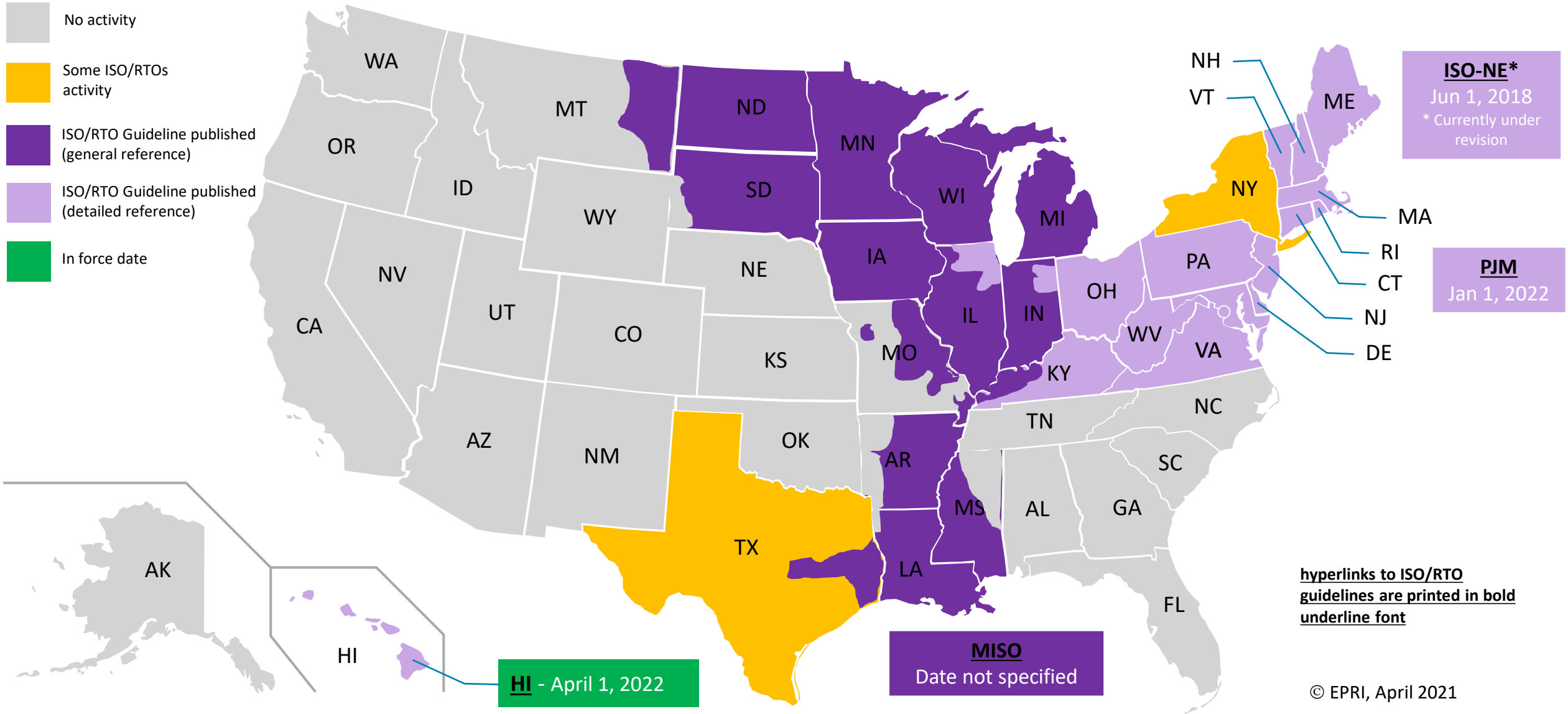
Adoption guidelines from Reliability Coordinators for IEEE Std 1547-2018



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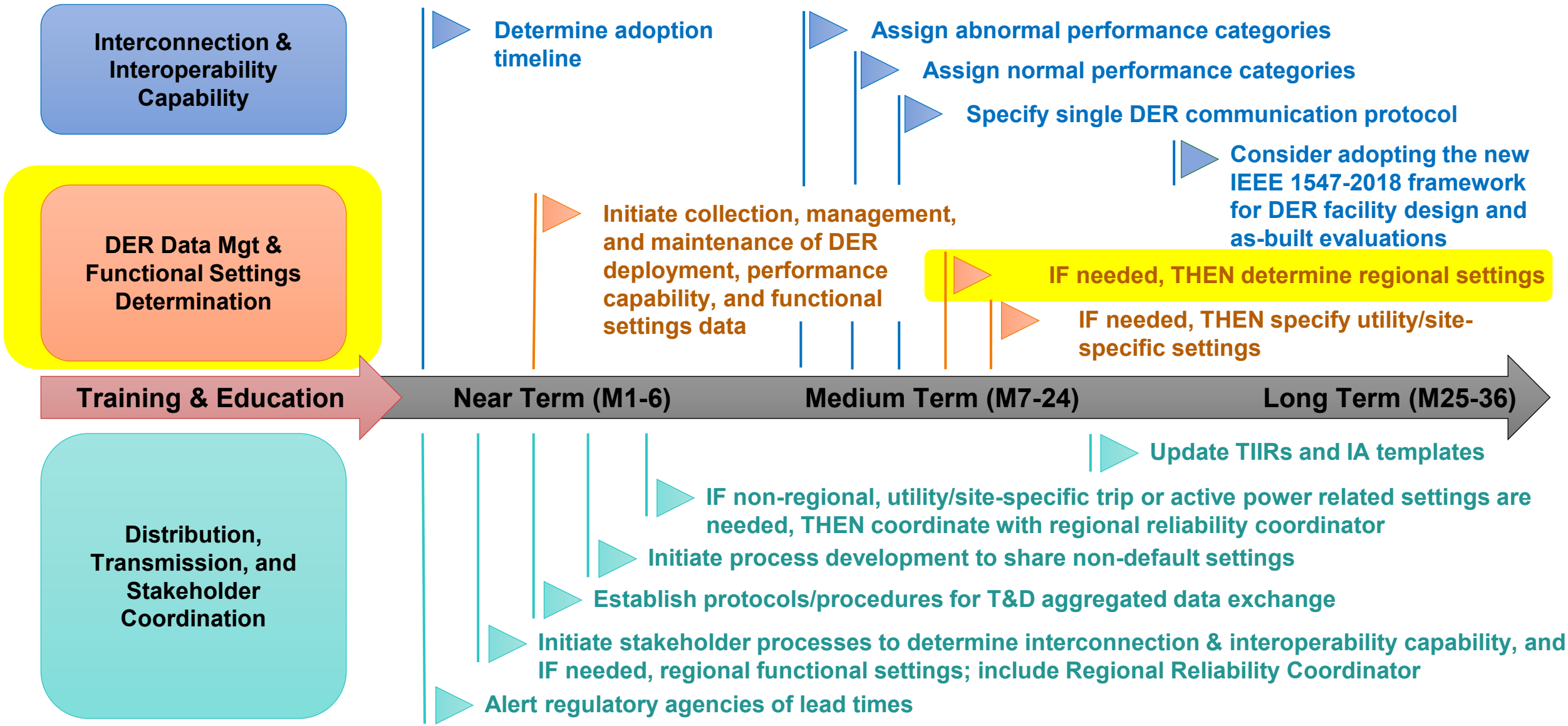
EPRI Recommended Steps for IEEE 1547-2018 Adoption



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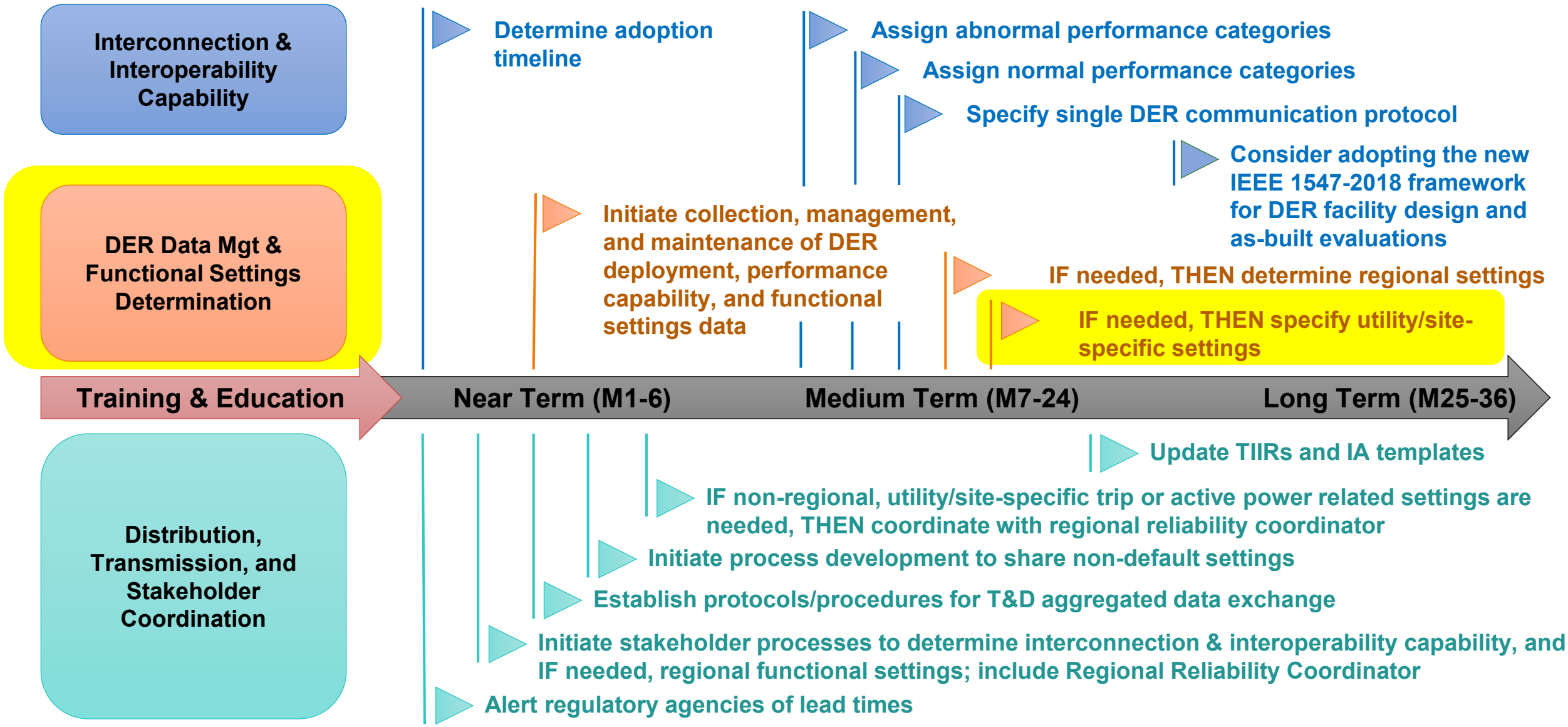
EPRI Recommended Steps for IEEE 1547-2018 Adoption



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Layers of Smart Inverter Settings with IEEE 1547-2018 Adoption

➢A **file format specification** was developed by a broad set of industry stakeholders and is publicly available at https://www.epri.com/research/products/000000003002020201

IA-URP
(site specific)

Utility-Required Profile (URP) for Specific Site
- Included in site-specific interconnection agreement (IA)
- May result from site-specific interconnection screenings

DU-URP
(distribution utility specific)

Utility-Required Profile for Distribution Service Area
- Included in interconnection agreement template
- Specific to Distribution Utility's practices, e.g., automatic re-closing, distribution circuit characteristics, operating practices

Regional-URP[1]
(state-wide or similar)

Utility-Required Profile for Region and/or ISO/RTO Reliability Region
- Consideration of distribution and bulk system impacts.
- May include some settings other than the SRD's default values

Adopted SRD[1] with Default Values
(state-wide or similar)

Source Requirements Document
- Preferably IEEE Std 1547-2018
- Otherwise: CAR21, HR14H, etc.

Database Scope

https://dersettings.epri.com/

[1] Based on decision by Authority Governing Interconnection Requirements (AGIR), may be a public utilities commission or similar

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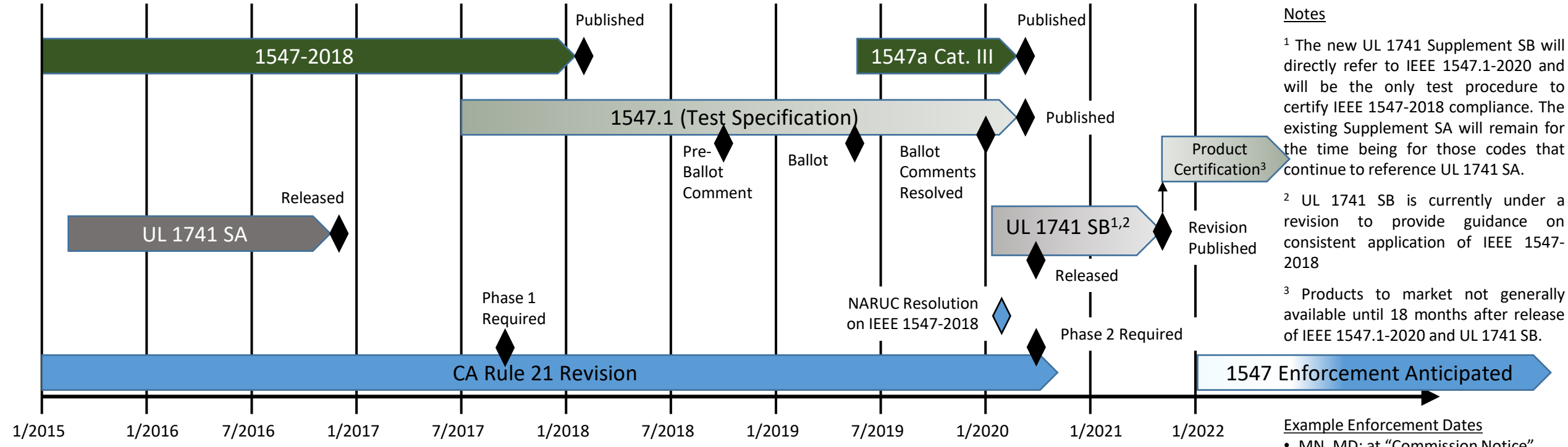
Timeline for Rollout of IEEE Std 1547™-2018 Compliant DER



Notes

[1] The new UL 1741 Supplement SB will directly refer to IEEE 1547.1-2020 and will be the only test procedure to certify IEEE 1547-2018 compliance. The existing Supplement SA will remain for the time being for those codes that continue to reference UL 1741 SA.

[2] UL 1741 SB is currently under a revision to provide guidance on consistent application of IEEE 1547-2018

[3] Products to market not generally available until 18 months after release of IEEE 1547.1-2020 and UL 1741 SB.

Example Enforcement Dates

- MN, MD: at "Commission Notice"
- CA: April 1, 2022

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See also: https://site.ieee.org/sagroups-scc21/standards/1547rev/

Adoption of CA Rule 21 and Hawai'ian Rule 14H by inverter certification per UL 1741 SA.

Stopgap solution for **adoption of parts of IEEE Std 1547-2018** by inverter certification per UL 1741 SA.

Full adoption of IEEE Std 1547™-2018 by inverter certification per UL 1741 SB

Question from **distribution** perspective:

Need to increase DER Integration?

Question from **transmission** perspective:

Need to address bulk system reliability?

The time to prepare for integration of IEEE 1547-2018 compliant inverters is now.

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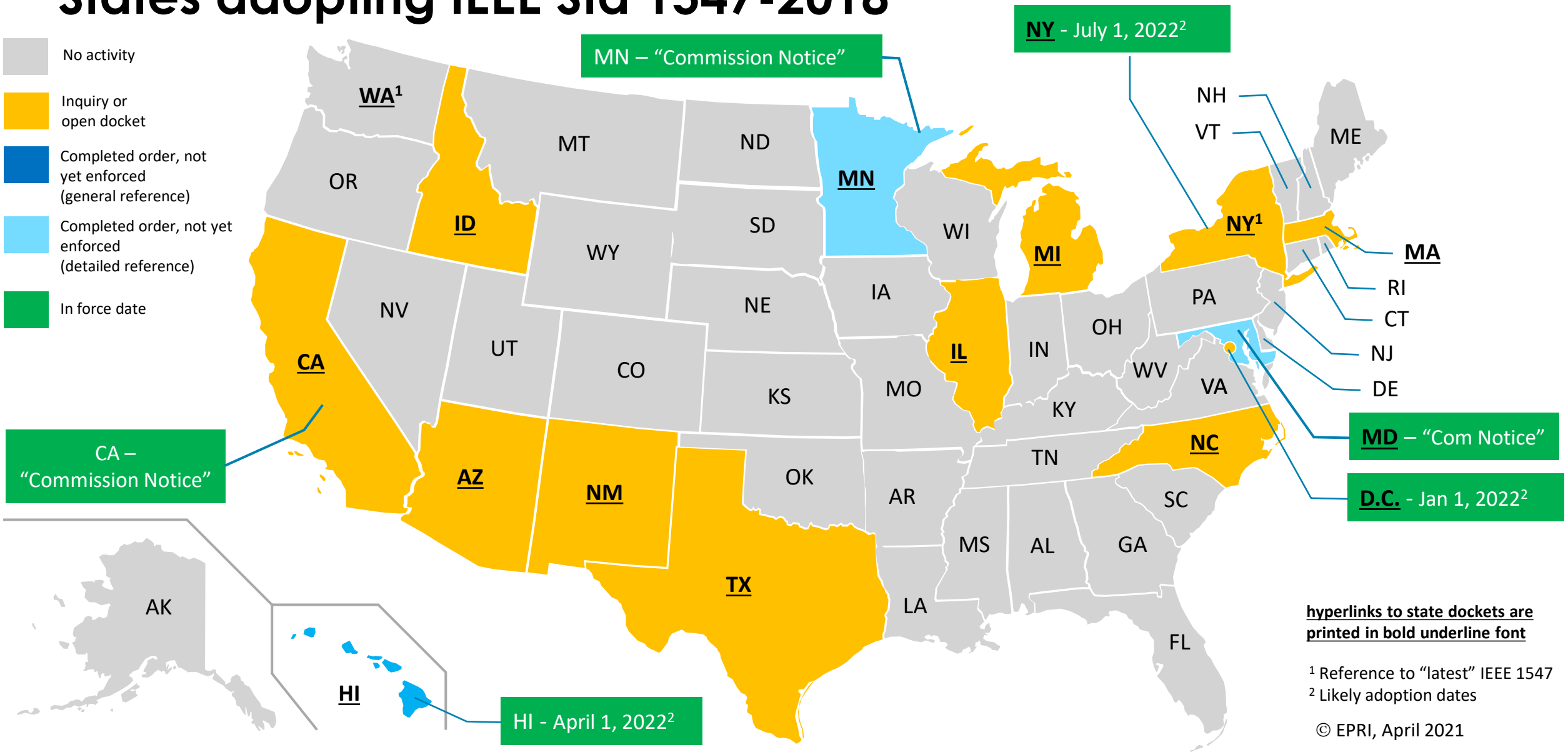
States adopting IEEE Std 1547-2018



hyperlinks to state dockets are printed in bold underline font

[1] Reference to "latest" IEEE 1547
[2] Likely adoption dates

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Q&A

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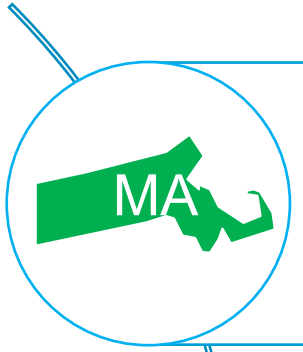
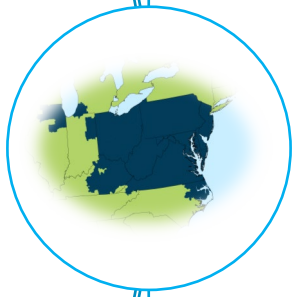
RTOs/ISOs Guidelines for IEEE Std 1547™-2018 Adoption



ISO New England – UL 1741 SA

June 1, 2018

- Coordination between ISO-NE and the MA's utilities in the Massachusetts Technical Standards Review Group
- Reference to UL 1741 SA as a stopgap to verify DER ride-through capability in the interim
  - Harmonization of voltage & frequency trip settings with IEEE Std 1547-2018 ranges of allowable settings (Link)



PJM Interconnection – UL 1741 SA/SB

Jan 1, 2022

- Initiation of formal stakeholder proceedings in 2019
- Published PJM *Guideline for Ride Through Performance of Distribution-Connected Generators* for voluntary DER ride-through in Oct 2019 (PJM Website)
- Established minimum ride-through requirements and trip time settings

Midcontinent Independent System Operator (MISO) – UL 1741 SB

date not specified

- MN PUC requested stakeholder process, see MISO's IEEE 1547 website
- Published the MISO Guideline for IEEE Std 1547-2018 Implementation (Link)
- Established the regional ride-through capabilities and trip time settings

See also NERC's Reliability Guideline
Bulk Power System Reliability Perspectives on the Adoption of IEEE 1547-2018 (March 2020)

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Publicly Available EPRI Resources on IEEE Std 1547-2018

EPRI Training Modules (EPRI-U)	Webinar	Quiz
1. *Overview on IEEE Std 1547-2018*, Dec. 2018	Public (*3002014545)*	Quiz 1
2. *DER Ride-through Performance Categories and Trip Settings*, Dec. 2018	Public (3002014546)	Quiz 2
3. *T+D Coordination for DER Ride-Through and Trip Requirements*, Dec. 2018	Public (3002014547)	N/A

https://www.epri.com/#/epri-u?lang=en-US

EPRI White Papers	Availability
5. *Fact Sheet*, May 2017	Public (3002011346)
6. *Minimum Requirements for DERs Ride-Through*, May 2015	Public (3002006203)
7. *Communications Interface and Interoperability*, Jul. 2017	Public (3002011591)
8. *Power Quality Considerations for DERs*, Dec. 2017	Public (3002010282)

https://www.epri.com/#/?lang=en-US

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Comparison of P2800 Initial Ballot Draft with IEEE 1547-2018

Legend: X Prohibited, √ Allowed by Mutual Agreement, ‡ Capability Required, (‡) Procedural Step Required as specified, Δ Test and Verification Defined

Function Set	Advanced Functions Capability	IEEE 1547-2018	IEEE P2800
General	Adjustability in Ranges of Allowable Settings	‡	‡
	Prioritization of Functions	‡	‡
Monitoring, Control, and Scheduling	Ramp Rate Control		
	Communication Interface	‡	‡
	Disable Permit Service (Remote Shut-Off, Remote Disconnect/Reconnect)	‡	‡
	Limit Active Power	‡	‡
	Monitor Key DER Data	‡	‡
	Remote Configurability	‡	‡
	Set Active Power		‡
	Scheduling Power Values and Models		√
Reactive Power & (Dynamic) Voltage Support	Constant Power Factor	‡	‡
	Voltage-Reactive Power (Volt-Var)	‡	‡
	Autonomously Adjustable Voltage Reference	‡	
	Capability at zero active power ("VArs at night")		‡
	Active Power-Reactive Power (Watt-Var)	‡	
	Constant Reactive Power	‡	‡
	Voltage-Active Power (Volt-Watt)	‡	
	Dynamic Voltage Support during VRT	√	‡
	Unbalanced Dynamic Voltage Support during VRT		‡

Function Set	Advanced Functions Capability	IEEE 1547-2018	IEEE P2800
Bulk System Reliability & Frequency Support	Frequency Ride-Through (FRT)	‡	‡
	Rate-of-Change-of-Frequency Ride-Through	‡	‡
	Voltage Ride-Through (VRT)	‡	‡
	Transient Overvoltage Ride-Through	‡	‡
	Consecutive Voltage Dip Ride-Through	‡	‡
	Voltage Phase Angle Jump Ride-Through	‡	‡
	Frequency-Watt	‡	‡
	Fast Frequency Response / Inertial Response	√	‡
	Return to Service (Enter Service)	‡	‡
	Black Start	√	√
Protection & Power Quality	Abnormal Frequency Trip	‡	√
	Abnormal Voltage Trip	‡	√
	Unintentional Islanding Detection and Trip	‡	√
	Limitation of DC Current Injection	‡	
	Limitation of Voltage Fluctuations	‡	‡
	Limitation of Current Distortion	‡	‡
	Limitation of Voltage Distortion		√
	Limitation of (Transient) Overvoltage	‡	‡
Test, Verification, Modeling & Measurements	Provision of Verified Models		(‡)
	Collection of Measurement Data	(‡)	(‡)
	Type Tests	(‡)	(‡)
	Production Tests	(‡)	
	Plant-Level Design Evaluation	(‡)	(‡)
	Commissioning Tests	(‡)	(‡)
	Model Validation		(‡)
	Performance Monitoring		(‡)
	Periodic Tests	(‡)	(‡)
	Periodic Verification	(‡)	(‡)

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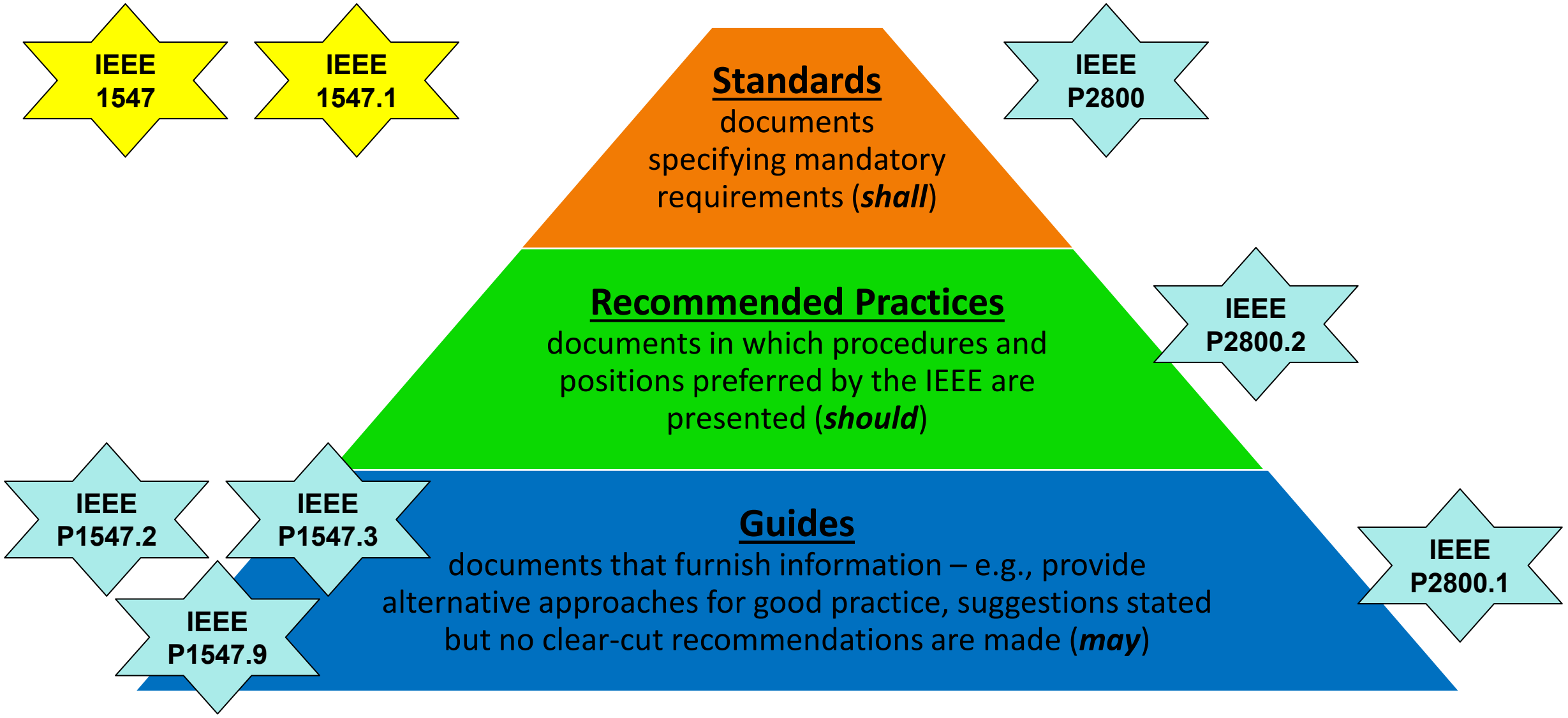
IEEE Standards Classification and Consensus Building



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