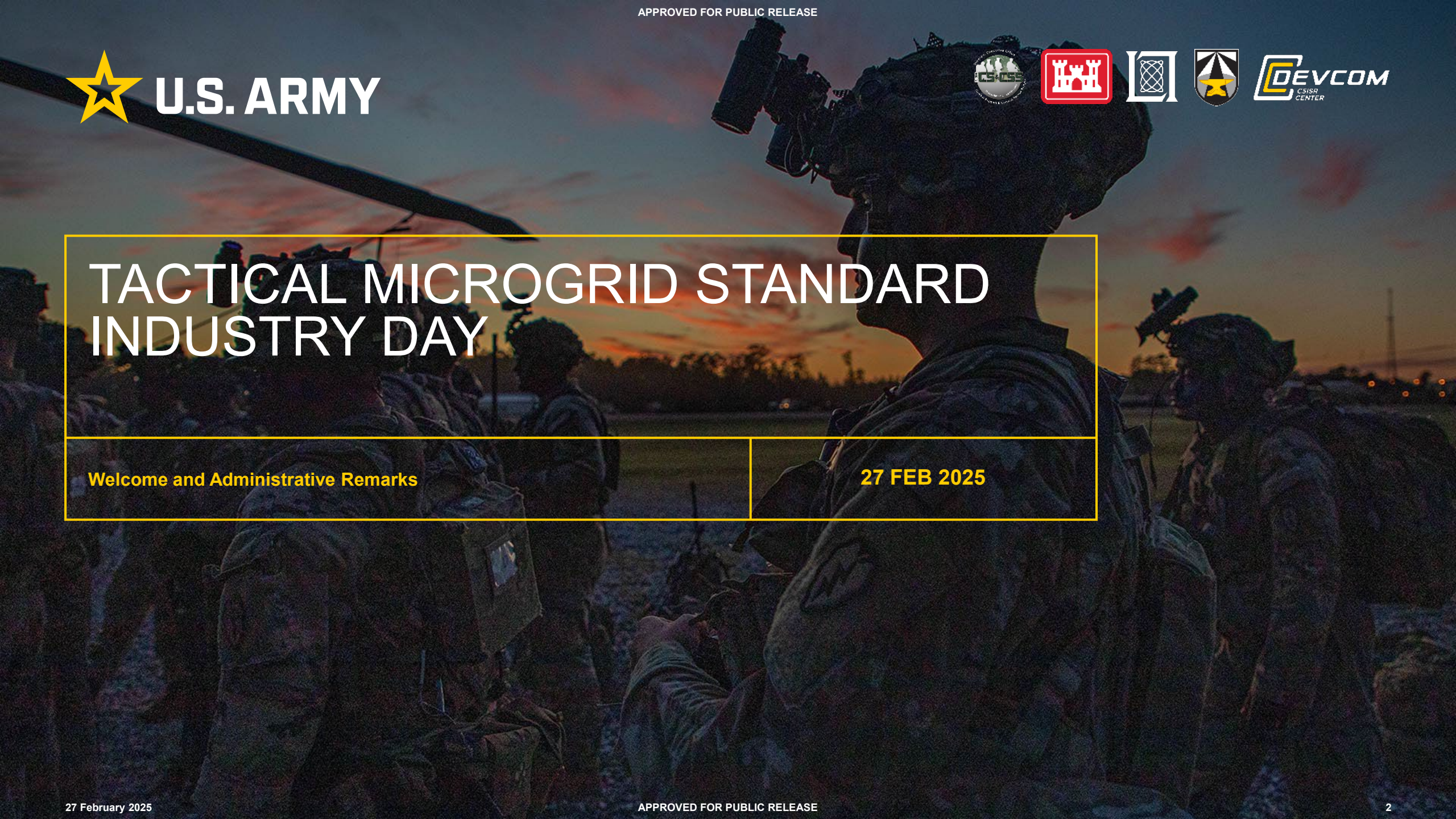
Industry Day



U.S. ARMY

TACTICAL MICROGRID STANDARD INDUSTRY DAY

Welcome and Administrative Remarks	27 FEB 2025

INDUSTRY DAY GUIDELINES

- Questions are welcome
  - In person - try to use a microphone so online participants can hear
  - Virtual participants – please use the raise hand feature or the chat. We will monitor the teams meeting for questions.
- Full day planned; we will try to stay on schedule. Depending on timing we may defer questions until later
- There will be opportunities over lunch, poster session, and Q&A session to ask questions and discuss in smaller groups
- Limited amount of food and drink available for purchase in cafeteria
- No Photography inside or outside of facility

TMS INDUSTRY DAY IS INTENDED TO:

- Provide a general introduction to TMS
- Provide forum for general feedback and comments on TMS
- Provide forum for non-proprietary questions on TMS
- Provide opportunity for Industry, DoD, Government, and Academia to meet and find ways to collaborate
- Encourage standard adoption to grow the TMS ecosystem

TMS TGP INDUSTRY DAY IS NOT INTENDED TO:

- Provide any information on procurement or acquisition
- Provide any information of PM timelines or schedule
- Provide detailed technical information
- Solicit information on specific product developments
- Solicit proprietary information from any vendor

This is NOT a solicitation for procurement or acquisition

AGENDA

Agenda Item	Time (EST)
Welcome and Administrative Brief	**0900-0930**
Government Organization Introductions	0930-1000
TMS Executive Overview	1000-1030
Break	1030-1040
Overview on APAN and how to participate in TMS community	1040-1055
TMS Governance Participation	1055-1105
TMS Technical Overview	1105-1200
Admin Remarks	1200-1205
Lunch	1205-1330
Poster Session (Start will overlap lunch)	1300-1400
Hardware Demonstration	1400-1505
Break	1505-1515
Compliance Overview	1515-1600
TMS Q&A Panel and Concluding Remarks	1600-1630

TMS INDUSTRY DAY REGISTRATIONS

280+ Attendees

- 135+ In Person

180+ Industry Attendees

- 95+ Companies

40+ DoD Representative

- Army, Navy, Air Force, DIU

3+ Government Organizations

- NASA, Department of Energy, Idaho National Labs

15+ Academia Attendees

- University of Saint Thomas, University of Texas at Austin, Naval Postgraduate School, MIT-Lincoln Laboratory, West Point, Arizona State University, Michigan Tech, Johns Hopkins

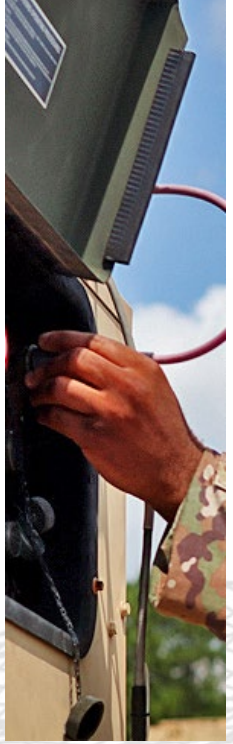
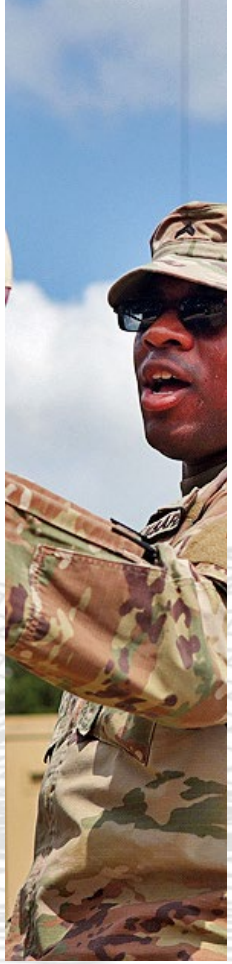
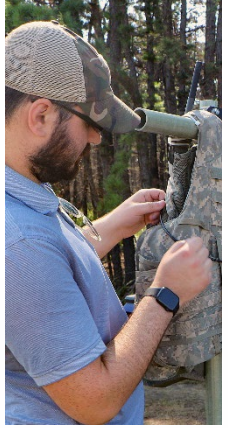
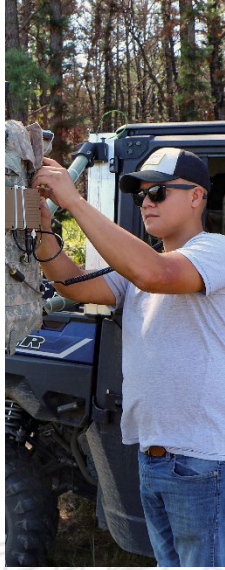
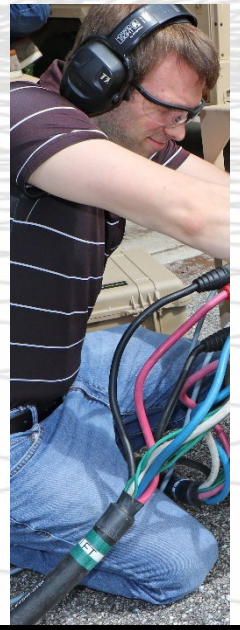
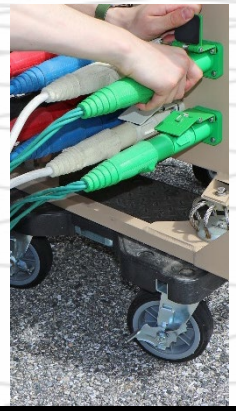
TMS INDUSTRY DAY – INDUSTRY

- Ace Electronics Defense Systems
- Aegis Power Systems, Inc.
- Airrow inc
- Amentum
- AmplifiedSpace
- Applied Research Associates
- Arkel International /Aed Stratecon
- Arkel International, LLC
- ATSE LLC
- BAE Systems
- Baker Engineering
- Belcan Government Solutions
- BETA Technologies
- BWR Innovations
- CACI
- Caterpillar
- Chariot Defense
- City Light & Power
- Control Systems, Inc.
- Crane A&E
- Crane Aerospace & Electronics
- Cummins Power Generation
- Defience Systems
- DEIF Inc.
- Delta Development Team INC
- Dewey Electronics
- DRS
- DRS Land Electronics
- Eaton
- Ecoethic Solar LLC
- Energetics Technology Center
- Epirus Inc.
- ETC / Gloria Patri Group
- FederatedDesigns
- FEWSS Project
- FinalSec, LLC
- FirstEnergy
- Galley Power Inc,
- General Technical Services LLC
- GLSV
- GM Defense
- Go Electric Inc., Saft
- Gravitics
- Great Lakes Sound and Vibration
- HDT
- HII
- HUBER+SUHNER INC
- Hyperion Technology Group
- I2T
- JDI Integrations, LLC
- Lema
- LEMA Defense
- Leonardo DRS
- Lex Products
- LiquidPiston Inc.
- Mesodyne
- Mission Ready Resources Co
- MITRE
- Moser Energy Systems
- NetApp US Public Sector
- NetApp USPS
- Northrop Grumman
- Object Computing, Inc.
- OPEX SYSTEMS LLC
- Parsons
- PC Krause and Associates
- PD POWER SYSTEMS
- Pillar Innovations
- Precision Combustion Inc.
- RCT Systems
- RDA Technical Services
- Real-Time Innovations, Inc.
- Rebel Systems
- REGENT Craft, Inc.
- Resilient Energy & Infrastructure
- Resilient Power Works LLC
- RMF Engineering, Inc.
- Safire Technology Group, Inc.
- Schneider Electric
- SEL
- Serco
- Siemens
- Silopanna, LLC
- Spectrum Research Corporation
- SYNCRIS
- TechFlow, Inc.
- TMST Consultants
- Twin Oaks Computing, Inc.
- Wandering Trails Inc
- Wenzlau Engineering
- XENDEE

DEVCOM C5ISR CENTER

U.S. ARMY DEVCOM
C5ISR CENTER

OVERVIEW | 25 SEPTEMBER 2025

U.S. ARMY

WHO WE ARE

C5ISR CENTER DIRECTOR

- Research and Technology Integration Directorate
  - Soldier & Platform Mission Equipment
  - Spectrum Dominance and Intelligence
  - Advanced Technology
- Engineering and Systems Integration Directorate
  - Systems Integration
  - Networks and Communications
  - Readiness Engineering

3,000+ TEAMMATES

- ~2,000 CIVILIANS
- ~28 MILITARY
- ~1,000 CONTRACTORS

WORKFORCE FOOTPRINT

APG: 75% FORT BELVOIR: 24% OTHER LOCATIONS: 1%

WE ARE

- SCIENTISTS
- ENGINEERS
- CODERS
- RESEARCHERS
- DOCTORS
- BUSINESS PROFESSIONALS

HIGHLY EDUCATED

- 39% BACHELOR'S DEGREE
- 41% MASTER'S DEGREE
- 5% PHD

WHAT WE DO

The Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR) Center is a key enabler in delivering information dominance to our Warfighters.

RESEARCH AND TECHNOLOGY INTEGRATION (RTI) DIRECTORATE

SOLDIER & PLATFORM MISSION EQUIPMENT
Integrates sensors, positioning, navigation, and timing for decision dominance.

SPECTRUM DOMINANCE AND INTELLIGENCE
Helps Warfighters better comprehend their space and detect threats across the spectrum.

ADVANCED TECHNOLOGY
Focuses on early S&T investments to achieve the greatest benefit for the Army.

ENGINEERING AND SYSTEMS INTEGRATION (ESI) DIRECTORATE

SYSTEMS INTEGRATION
Lab and field-based risk reduction & prototyping and platform integration.

NETWORKS AND COMMUNICATIONS
Communicates data and information across a robust tactical network to the tactical edge.

READINESS ENGINEERING
Addresses the operational readiness needs of Army C5ISR systems.

ARMY MODERNIZATION PRIORITIES

- Long Range Precision Fires
- Next Generation Combat Vehicles
- Future Vertical Lift
- Network
- Air Missile Defense
- Soldier Lethality
- Contested Logistics

CORE COMPETENCIES

INFORMATION PROCESSING & ANALYSIS

- Data Collection, Analysis and Processing
- Software Architecture
- Artificial Intelligence
- Systems Modeling
- Virtual Prototyping

RADIO FREQUENCY

- RF Photonics
- Antennas
- Software Defined Radio
- Waveforms
- ATR Algorithm Development

CYBER

- Information Security Oversight
- Cyber Operations, Resilience, and Defense
- Cyberspace Effects
- Cyber System Engineering

NETWORKING

- NetOps, Applications and Management
- Network Architecture Design, Engineering, Integration
- Network Modeling and Performance Analysis
- Satellite/High-Altitude Networks
- Terrestrial Networks

ELECTRO-OPTIC INFRARED

- Lasers
- Photodiode Growth and Characterization
- Focal Plane Array Characterization
- EO/IR System Level Test and Evaluation
- Microelectronics for Imaging Systems

POWER & ENERGY

- Operational Energy
- Power and Energy Sustainment
- Energy Storage
- Power Generation, Management and Distribution
- Thermal Management

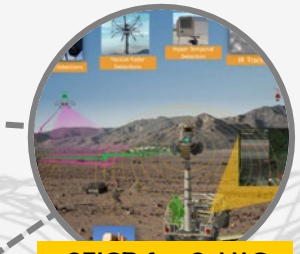
MISSION FOCUS AREAS


Next Generation Command and Control


Commander's Decision Aids


Uncooled Infrared

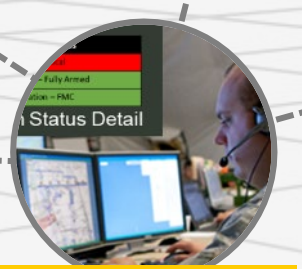

Advanced Targeting


C5ISR for C-UAS


EW/Counter ISR


Vehicle/Air Protection


Unified Data Reference Architecture



Predictive Logistics


Signals Intelligence


Operational Energy


CJSIL

Tactical Microgrid Standard (TMS)

Description:

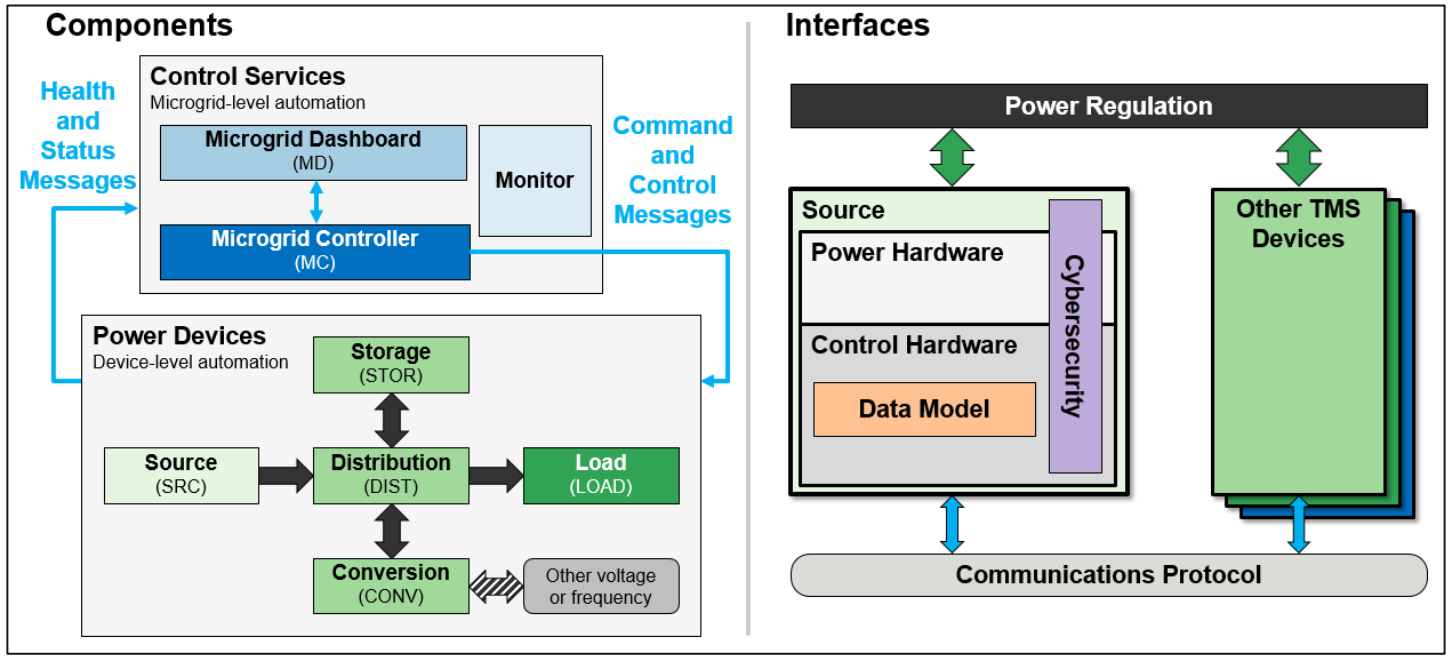
TMS supports more robust power for the Warfighter by standardizing the communications and controls architecture across power systems. The TMS will allow for vendor-agnostic microgrids and enables future power systems to easily integrate into existing microgrids. TMS will be entered into the Defense Standardization Program for MIL-STD approval and will aid in the future procurement of open power systems.

Capabilities:

- Standardized power system data and communications
- Enables Power System Interoperability
- Enables fuel efficient, resilient, and adaptable tactical microgrids.

Energy Focus

- Reduce equipment and transportation requirements
- Reduce fuel usage and reduce emissions
- Reduced need for fuel resupply
- Increased Power and Energy Resilience



Secure Tactical Power

Description:

The objective of the Secure Tactical Power is to show the military utility of "Universal Battlefield Power" by demonstrating a highly mobile, cybersecure, and lightweight fast-forming vehicle hybrid power system using a variety of vehicles, integration of AC (static ground generation) with DC microgrid with energy storage, and a tactical vehicle charging station.

Capabilities:

TMS Complaint Control, Vehicle Microgrid, Advanced Lightweight Inverter, Tactical Charging Station, Battlefield Energy Storage, Integration with legacy AMMPS Generators, AC / DC Microgrid Interoperability, Power Management Dashboard

Energy Focus

- Reduce equipment and transportation requirements
- Reduce fuel usage and reduce emissions
- Reduced need for fuel resupply
- Increased Power and Energy Resilience

TACTICAL MICROGRID STANDARD

Government Organization Introductions

PROJECT MANAGER EXPEDITIONARY ENERGY & SUSTAINMENT SYSTEMS (PM E2S2)

POWER PORTFOLIO

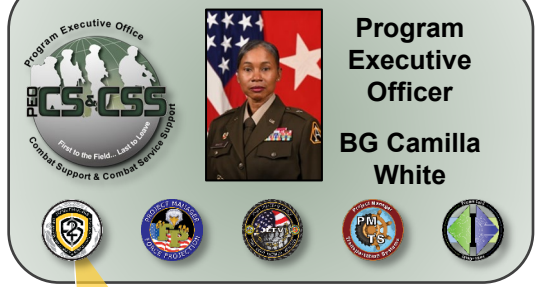
<5kW Small Tactical Electric Power (STEP)

120kW AMMPS MicroGrid

Power Distribution Illumination Systems Electrical (PDISE)

5-60kW Advanced Medium Mobile Power Sources (AMMPS)

500kW Large Tactical Power System (LTPS)



TMS INTEREST AND ACTIVITIES

- PM E2S2 is the Lead Standardization Activity for DoD tactical electric power
- TMS is a critical enabler for us to field standard interoperable systems
- E2S2 spearheaded publishing of the TMS standard (MIL-STD 3071)
- Portfolio Relevance
  - TMS is being designed into the STEP family of systems
  - All future systems will be required to be TMS-compliant
  - R&D efforts are underway to create a TMS-compliant AMMPS and AMMPS Microgrid controller
- Currently exercising a TMS Campaign Plan at the behest of senior Army Acquisition leadership

U.S. Army ERDC CERL

U.S. Army DEVCOM Ground Vehicle Systems Center

MIT LINCOLN LABORATORY

DOD FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTER

MIT Campus, Cambridge, MA
Education and Research. Open consulting and start ups.
FY23: 17k employees, $0.8B research

MIT Lincoln Laboratory, Lexington, MA
Applied R&D. Strict conflict of interest policy.
FY23: 4k employees, $1.4B research

Technology in Support of National Security

System architecture engineering **Long-term technology development** **System prototyping and demonstration**

- Biotechnology and Human Systems
- Air, Missile, and Maritime Defense Technology
- Homeland Protection
- Air Traffic Control
- Communication Systems
- Cyber Security
- Advanced Technology
- Space Systems and Technology
- ISR Systems and Technology
- Tactical Systems
- Engineering

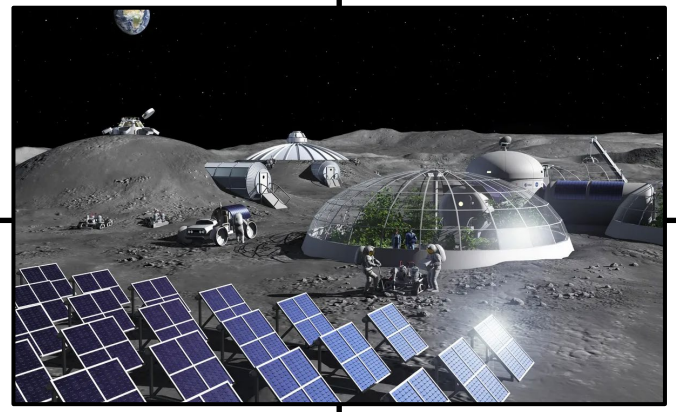
NASA Glenn Research Center – Power Systems

Autonomous Power Control Project

- Develops the controls needed to manage power for a variety of space applications including Gateway, Lunar/Martian surface, and Mars Transit Vehicle

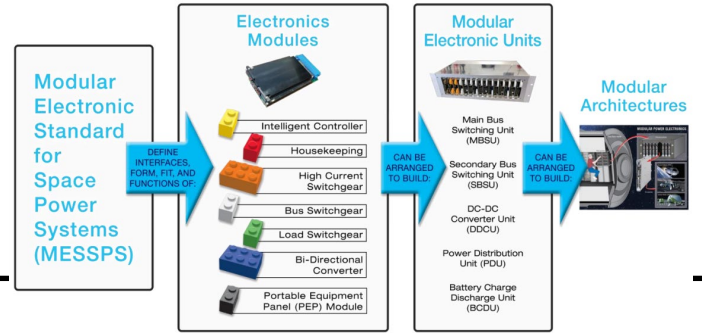
Future space missions and systems require power systems that:

- Increase the reliability, resilience and autonomy of a space-based electric power system (EPS)
- Contain effective control strategies to achieve system-level autonomy and interoperability



Advanced Modular Power Systems Project

- Aims to minimize maintenance operations, improve power system availability, and reduce the number of unique spare parts
- Standardizes the power system at the electronics module level, automating power management and distribution functions



NASA Implementation of TMS

- Provides a common interface standard for space power systems, linking APC, EIO, and AMPS
- Reduces overhead of integration with multiple vendors

Key Benefits:

- Provides seamless integration and interoperability for evolving, distributed power systems
- Enables plug-n-play capability
- Provides a basis for device discovery and ad-hoc control

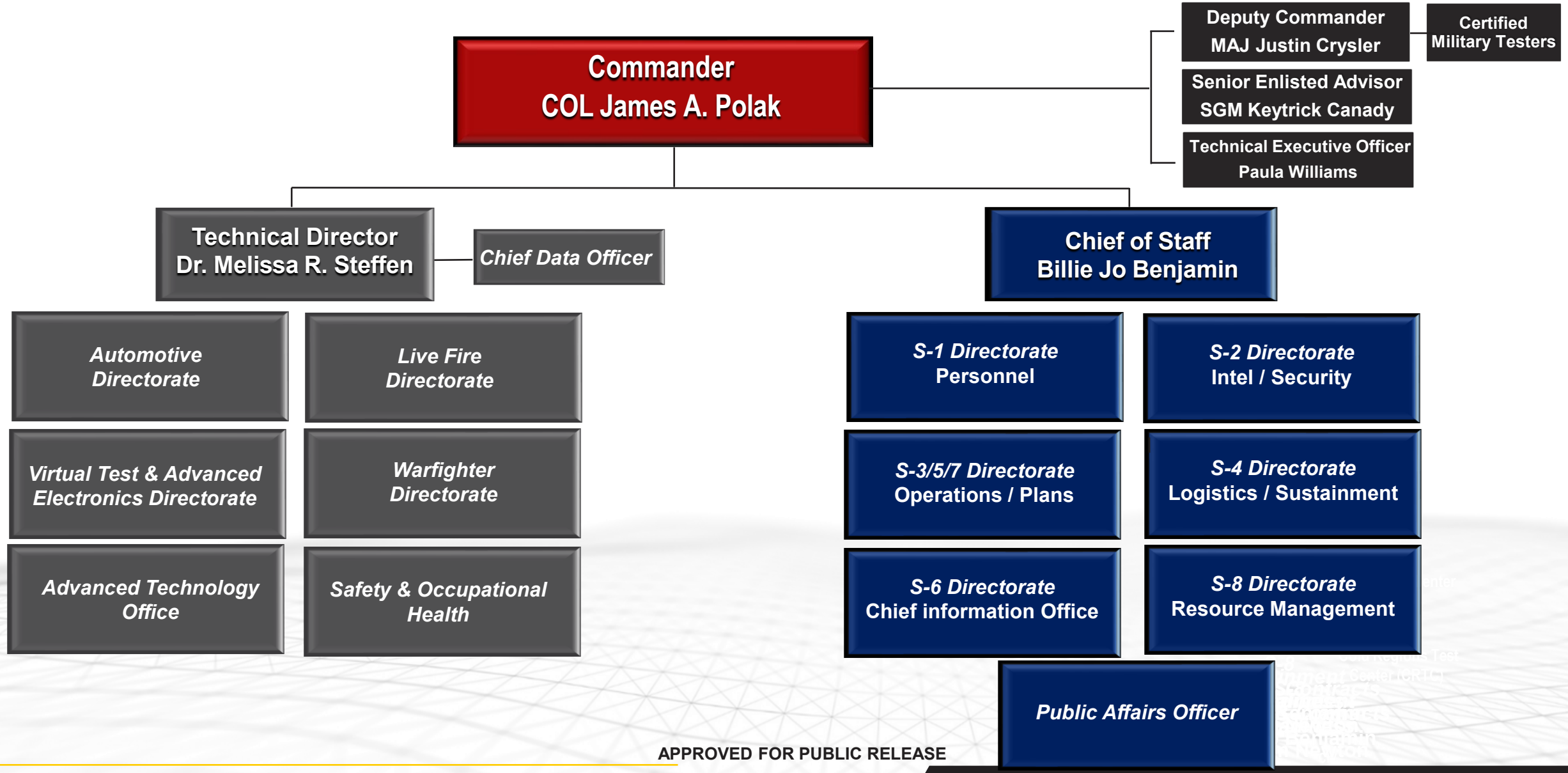
Earth Independent Operations

- Mars missions will see unavoidable comms delays of up to 20 minutes each way
- This project develops the set of technologies needed to ensure that crew can safely respond to on-board situations
- Using advanced signal processing and AI/ML this project aims to identify unknown failure modes in the electric power system

U.S. ARMY ABERDEEN TEST CENTER (ATC) OVERVIEW

- **Mission:** ATC plans and conducts test efforts, analyzes, and reports the results of developmental tests, production tests, and other tests in assigned test functions areas to support authorized customers within the Department of Defense (DoD), and outside DoD, including domestic and foreign governments, and nongovernmental organizations.
- **U.S. Army Aberdeen Test Center Core Mission Areas:**
  - Ground Vehicles: manned, unmanned, autonomous
  - Ballistic Lethality: weapons, ammunition
  - System Vulnerability: Title 10 Live Fire
  - Soldier Systems: protective equipment, eyewear
  - Transportability
  - Power Generation Systems
- **Our Product is Information! Ensuring systems are safe, effective and reliable**

ATC COMMAND STRUCTURE



APPROVED FOR PUBLIC RELEASE

POWER SYSTEMS AND ELECTRONICS BRANCH

Generator Test Facility

Generators, Networked Power, Microgrids, Smart Grids

Simulated Solar for Photovoltaic Panels

Smart Power Distribution Systems

POWER SYSTEMS AND ELECTRONICS BRANCH

- Current ATC support for DoD Power and Energy Community
- 40 test stations accommodate generators up to 200+ kW
- Higher capacity generator testing (800 kW or greater) can be accomplished
- Power & energy instrumentation, load simulators, and a central test control, data monitoring, and analysis facility

Warfighter Portable Power (<900W)

Small/Medium Power

Grid Power (Megawatt+)

OUTPUT POWER RANGE

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TACTICAL MICROGRID STANDARD

TMS Executive Overview

How We Will Distribute Power Through Phased Operations

FMTV w/ power interface

MicroGrid

JLTV
with power interface

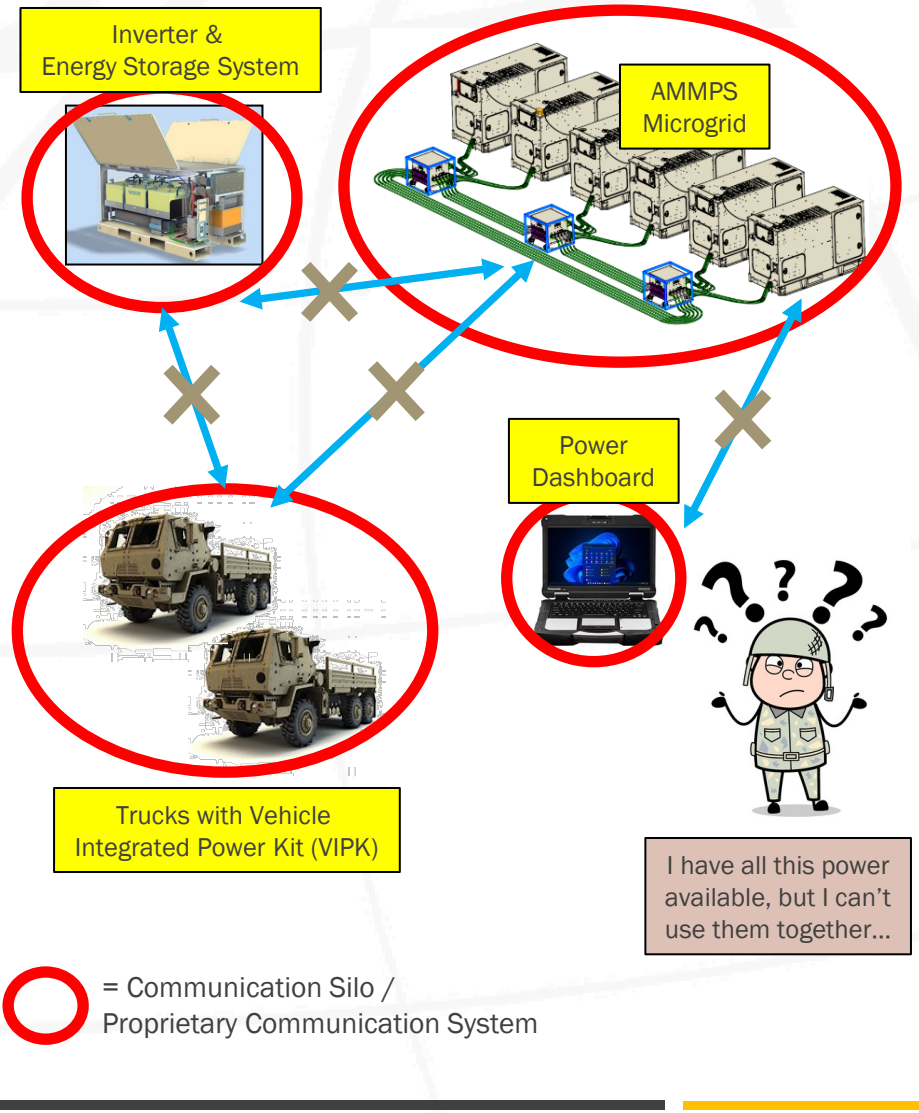
Energy Storage

TOPICS

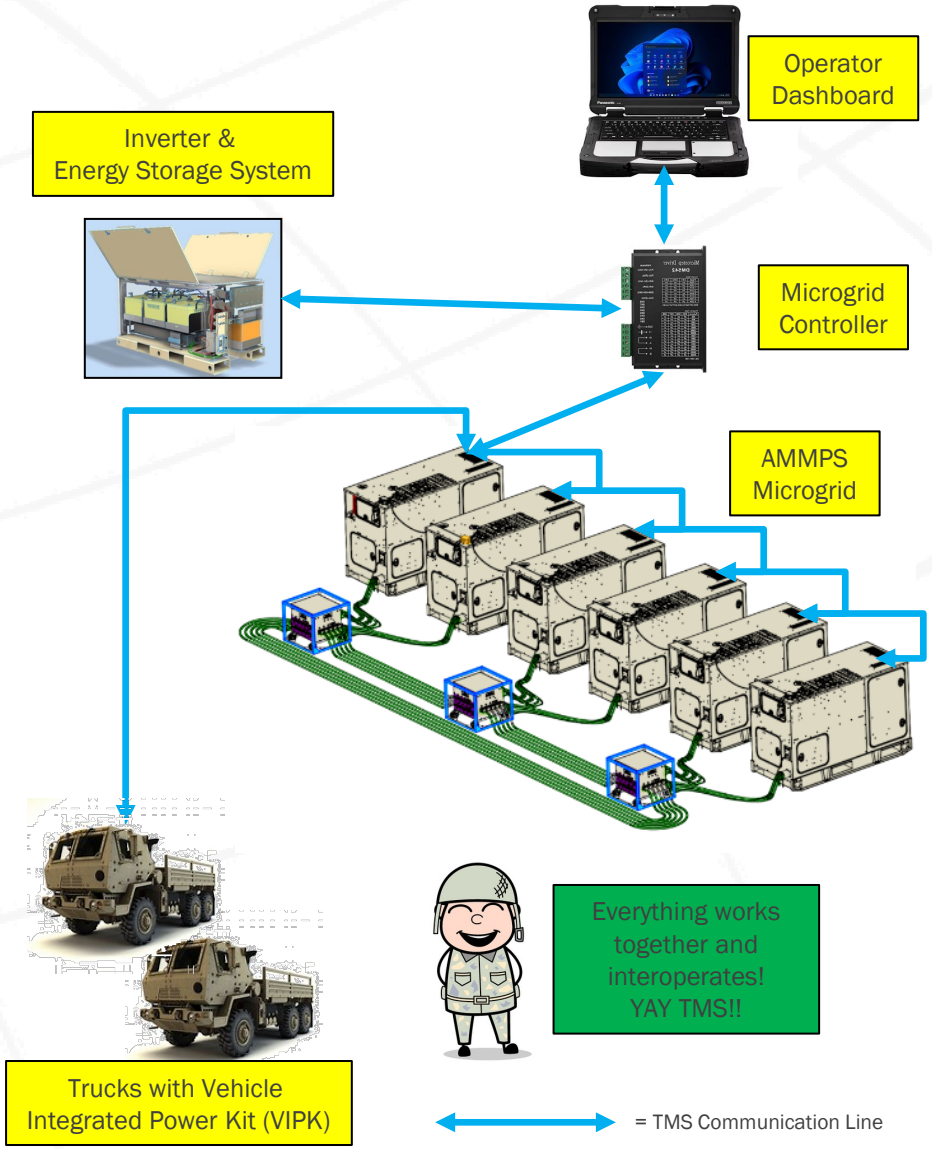
1. Why Power Standardization?
2. MIL-STD 3071 Overview
3. Maintaining The Bus
4. Common Language
5. Over the Wire
6. Vendor Experience
7. Putting it all together
8. TMS Tools
9. Stay Plugged In

WHY STANDARDIZATION?

Vendor Lock / Proprietary Communication Grid



TMS Enabled Grid



INTEROPERABILITY DRIVES RESILIENCE

APPROVED FOR PUBLIC RELEASE

TMS CONTRIBUTORS AND STAKEHOLDERS

Combat Capabilities Development Command C5ISR Center

US Army Construction Engineering Research Laboratory

MIT Lincoln Laboratory

Project Manager Expeditionary Energy & Sustainment Systems (PM E2S2)

Operational Energy Capability Improvement Fund (OECIF)

MIL-STD 3071

INTEROPERABLE
- Vendor Agnostic
- Plug and Play

RESILIENT
- Optimization & Redundancy
- Comms Loss Resilient

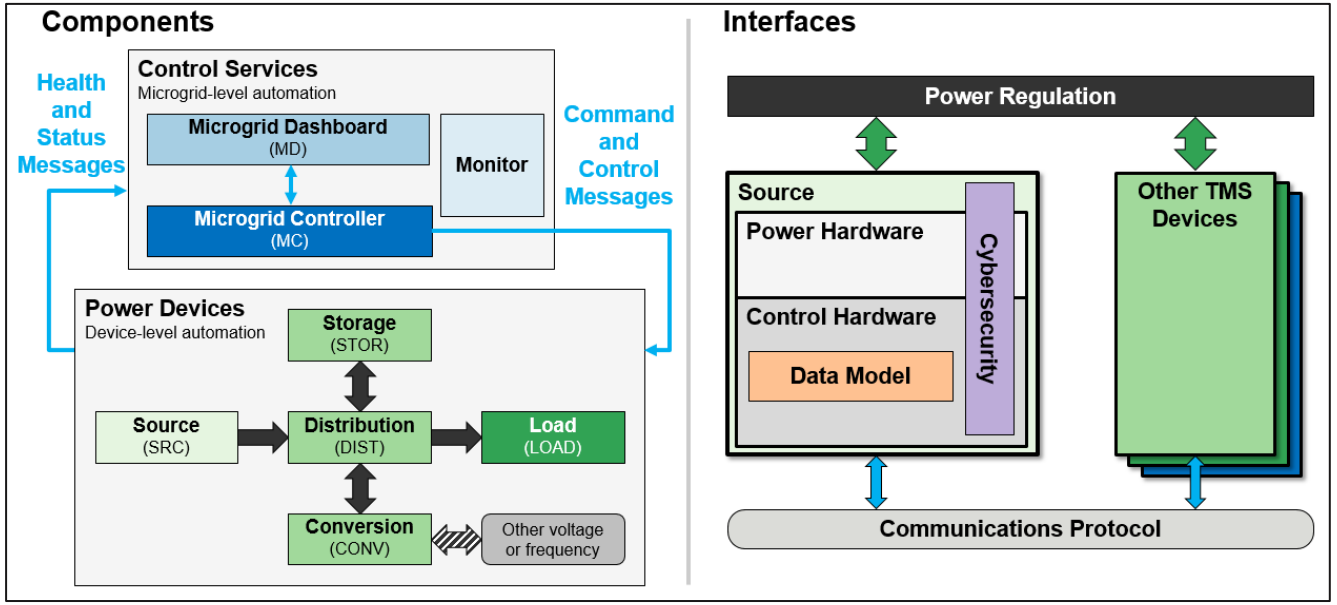
SCALABLE
- Dynamically Adapts
- AC & DC power components

PROCUREABLE
- Cybersecure
- Development Toolkit (Industry Adoption)
- Proven prototypes

TACTICAL MICROGRID STANDARD (TMS)

DESCRIPTION

TMS supports more robust power for the Warfighter by standardizing the communications and controls architecture across power systems. The TMS will allow for vendor-agnostic microgrids and enables future power systems to easily integrate into existing microgrids. TMS will be entered into the Defense Standardization Program for MIL-STD approval and will aid in the future procurement of open power systems.



CAPABILITIES

- Standardized power system data and communications
- Enables Power System Interoperability
- Enables fuel efficient, resilient, and adaptable tactical microgrids.

ENERGY FOCUS

- Reduce equipment and transportation requirements
- Reduce fuel usage and reduce emissions
- Reduced need for fuel resupply
- Increased Power and Energy Resilience

TMS LUNCH AND LEARN

KEY LEARNING POINTS

- **MIL-STD 3071 is also known as Tactical Microgrid Standard (TMS)**
- **TMS enables interoperability of power components with complementary power physics**

EXAMPLE ELECTRICAL CONSIDERATIONS

Power Quality

Electrical Response

LOAD SHARING

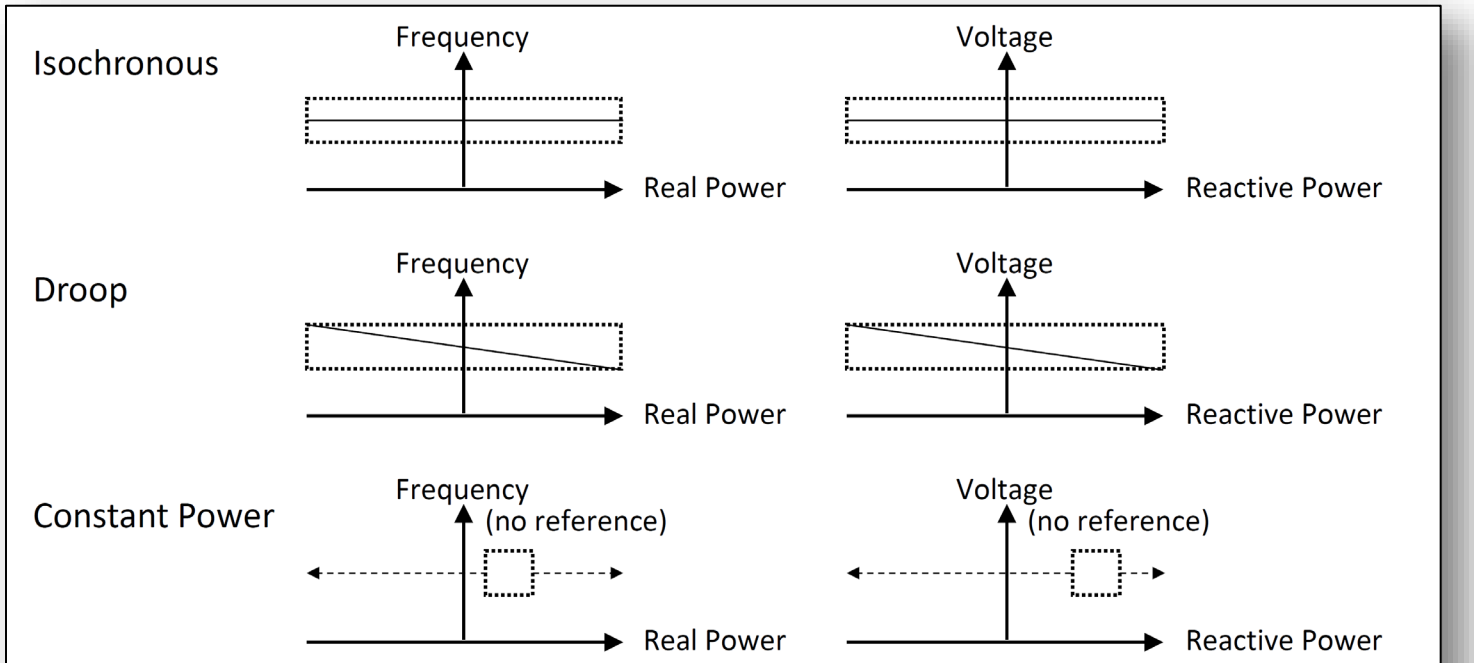


Figure B.38: Example AC Load Sharing Types

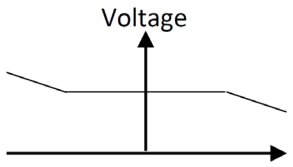


Figure B.46: Example Multi-Segment DC Load Sharing

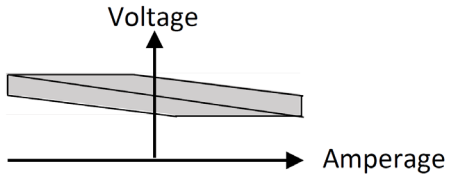


Figure B.47: Example DC Load Sharing Region

MIL-STD 3071 applies to both AC & DC power components

TMS LUNCH AND LEARN

KEY LEARNING POINTS

- MIL-STD 3071 is also known as Tactical Microgrid Standard (TMS)
- TMS enables interoperability of power components with complementary power physics
- **TMS establishes electrical data to facilitate successful power physics of load sharing**

THE NEED FOR MIDDLEWARE

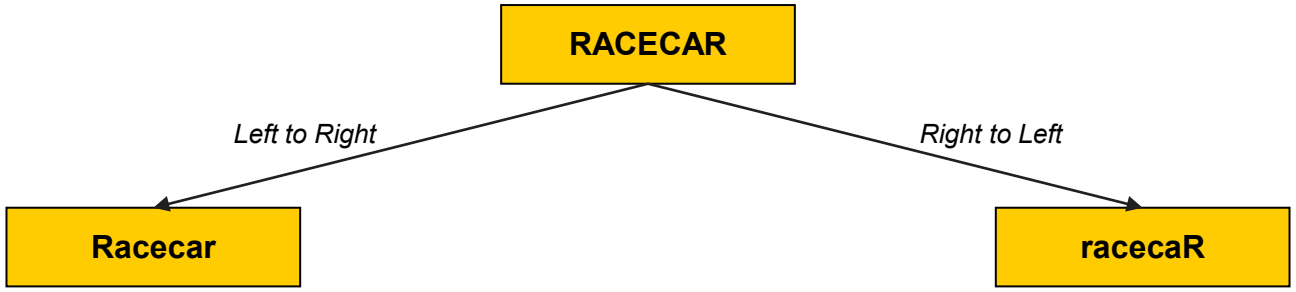
Over The Wire

Participant Management

ENDIANNESS

RACECAR

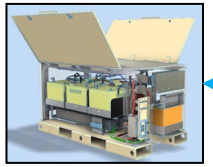
ENDIANNESS (CONT'D)



PARTICIPANT MANAGEMENT

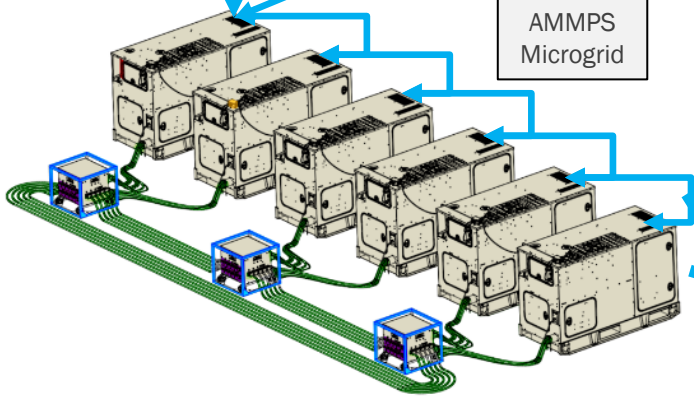
Operator Dashboard

Inverter & Energy Storage System



Microgrid Controller

AMMPS Microgrid



If a new vehicle wants to join the microgrid, what history should it be aware of?

How about for a microgrid controller?

PARTICIPANT MANAGEMENT (CONT'D)

Table A.5: High-level definitions of QoS Profiles.

QoS Profile	Durability	Reliability	History	Deadline	Priority
PublishLast	Transient	Reliable	1	Infinite	Normal
Command	Volatile	Reliable	1	Infinite	Normal
Response	Volatile	Reliable	1	Infinite	Normal
Reply	Volatile	Reliable	128	Infinite	Normal
Continuous	Volatile	Best effort	1	2 s	Normal
Medium	Volatile	Best effort	1	3 s	Normal
Slow	Volatile	Best effort	1	20 s	Normal
Rare	Volatile	Best effort	1	2000 s	Normal

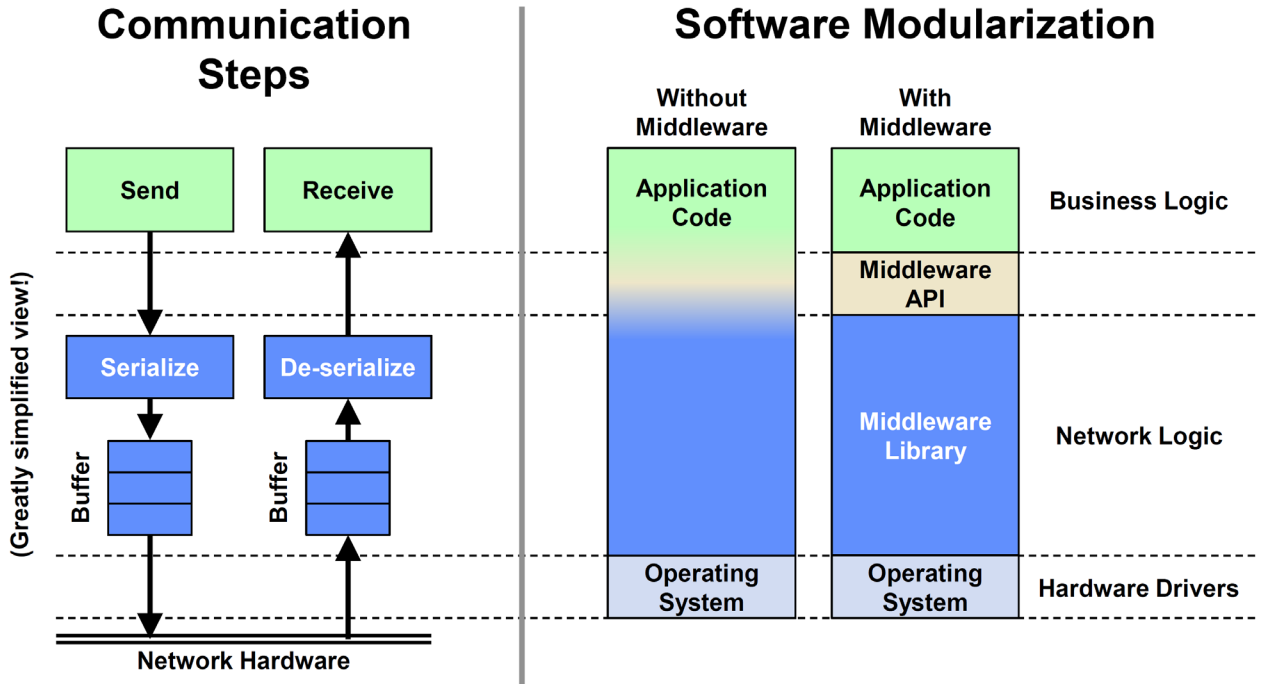
TMS standardizes behavior to handle participants joining, leaving, and transmitting data on the network.

OMG-DDS: OVERVIEW

- Object Management Group – Data-Distribution Service
- International Standard Middleware
- Programming Language Agnostic
  - IDL Compiler Code Generates Language Specific Bindings
  - Vendor Supported Languages: c, C++, Java, C#, python, Typescript, etc.

“Data Centric” Publish-Subscriber (No Central Broker)

- Devices **send** data by **publishing** it
- Devices **receive** data by **subscribing** to it

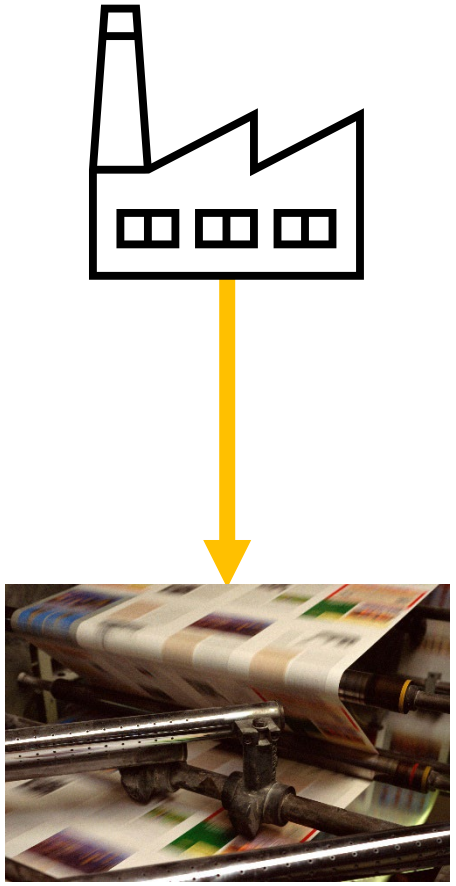


TMS LUNCH AND LEARN

KEY LEARNING POINTS

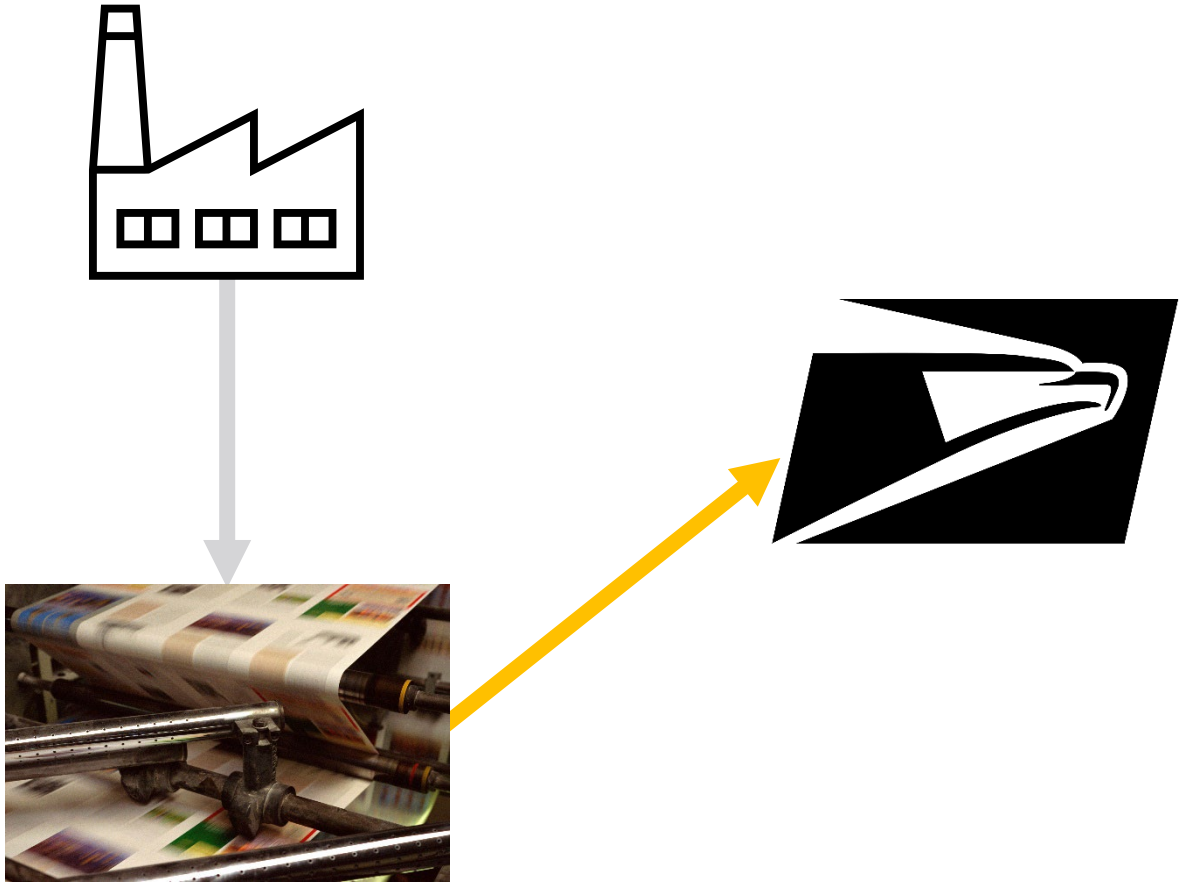
- MIL-STD 3071 is also known as Tactical Microgrid Standard (TMS)
- TMS enables interoperability of power components with complementary power physics
- TMS establishes electrical data to facilitate successful power physics of load sharing
- **TMS uses DDS, an industry standard protocol, to handle data over the wire and participants**

PUB/SUB: NON-TECHNICAL



1. Newspaper is printed for pickup

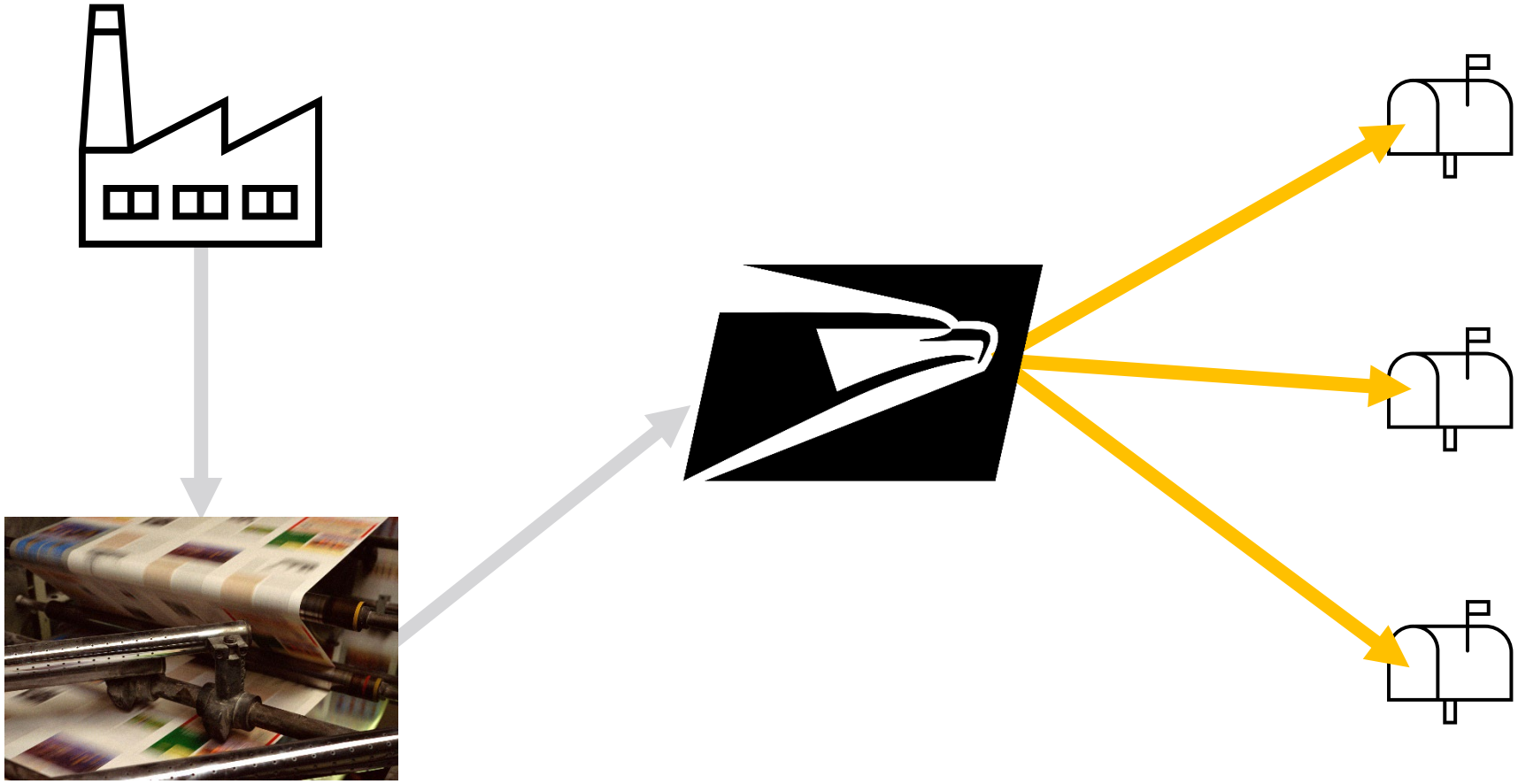
PUB/SUB: NON-TECHNICAL



1. Newspaper is printed for pickup

2. Post Office picks up the mail

PUB/SUB: NON-TECHNICAL

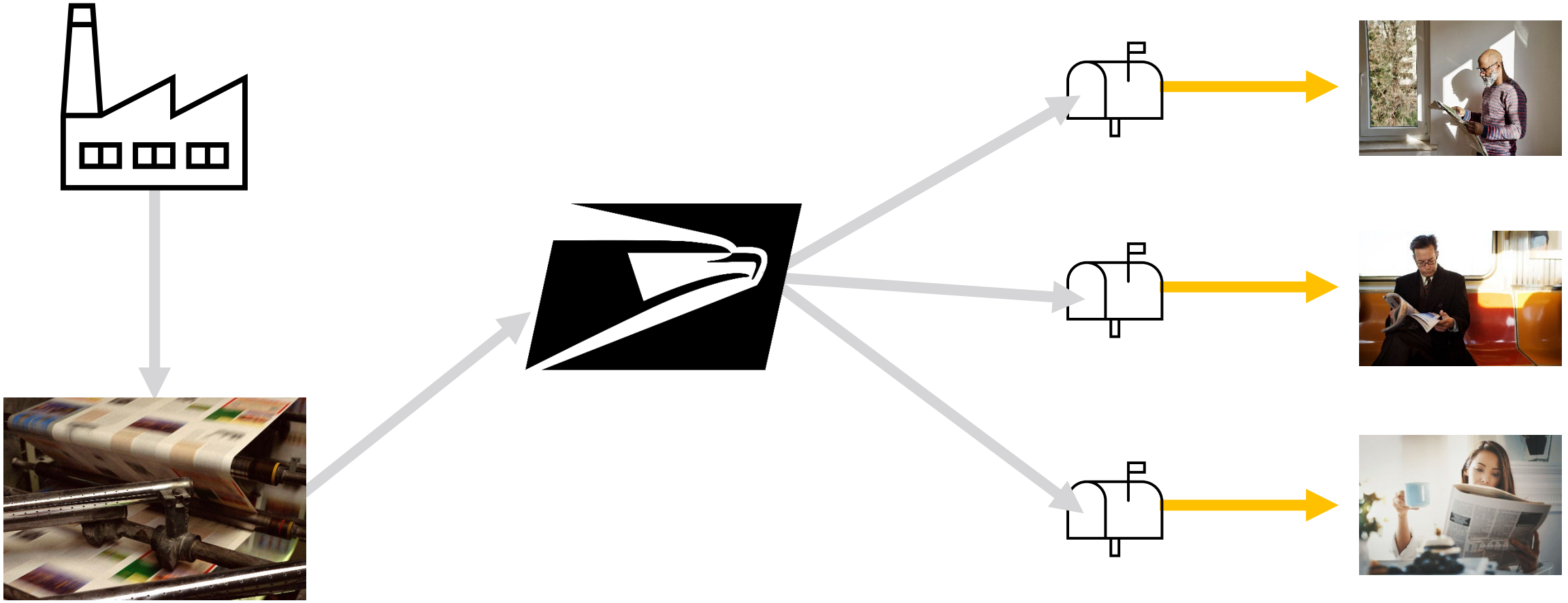


1. Newspaper is printed for pickup

2. Post Office picks up the mail

3. Mail delivered to you

PUB/SUB: NON-TECHNICAL



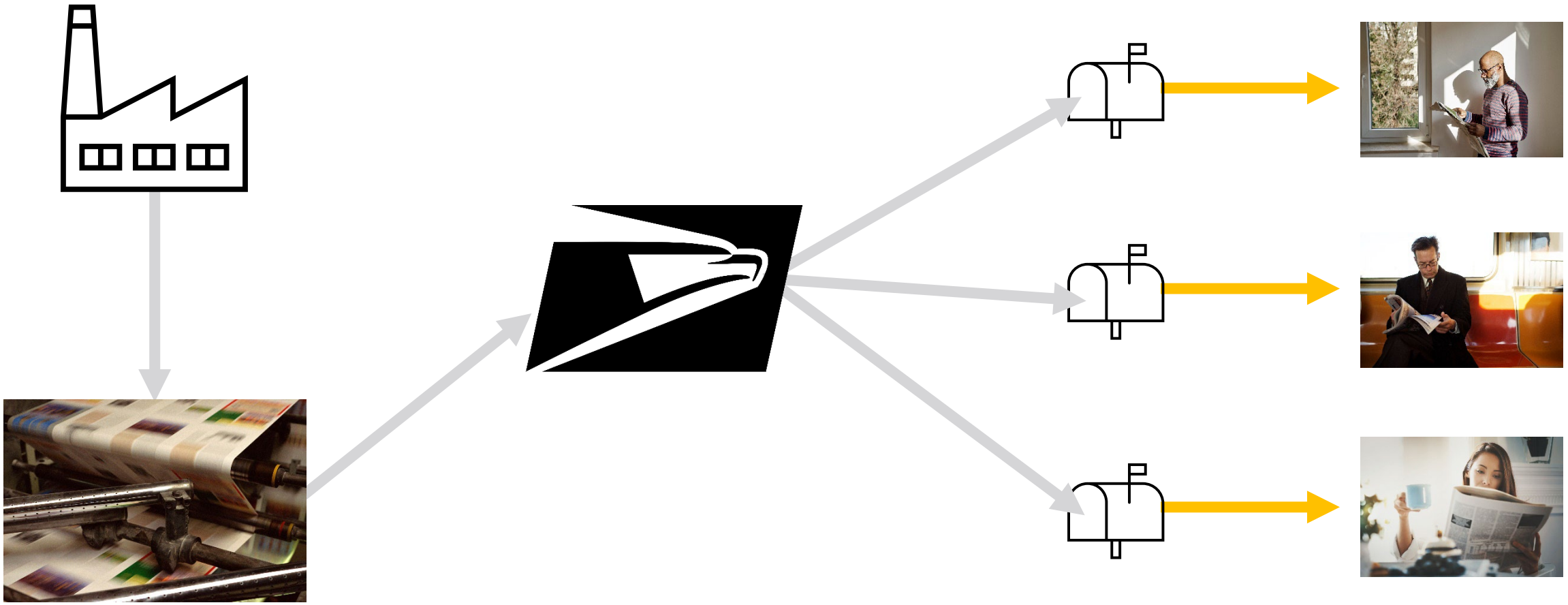
1. Newspaper is printed for pickup

2. Post Office picks up the mail

3. Mail delivered to you

4. You read the newspaper

PUB/SUB: NON-TECHNICAL



1. Device A Populates Data

2. Published by DDS Middleware

3. Middleware receives subscribed data

4. Device B actions on data

TMS LUNCH AND LEARN

KEY LEARNING POINTS

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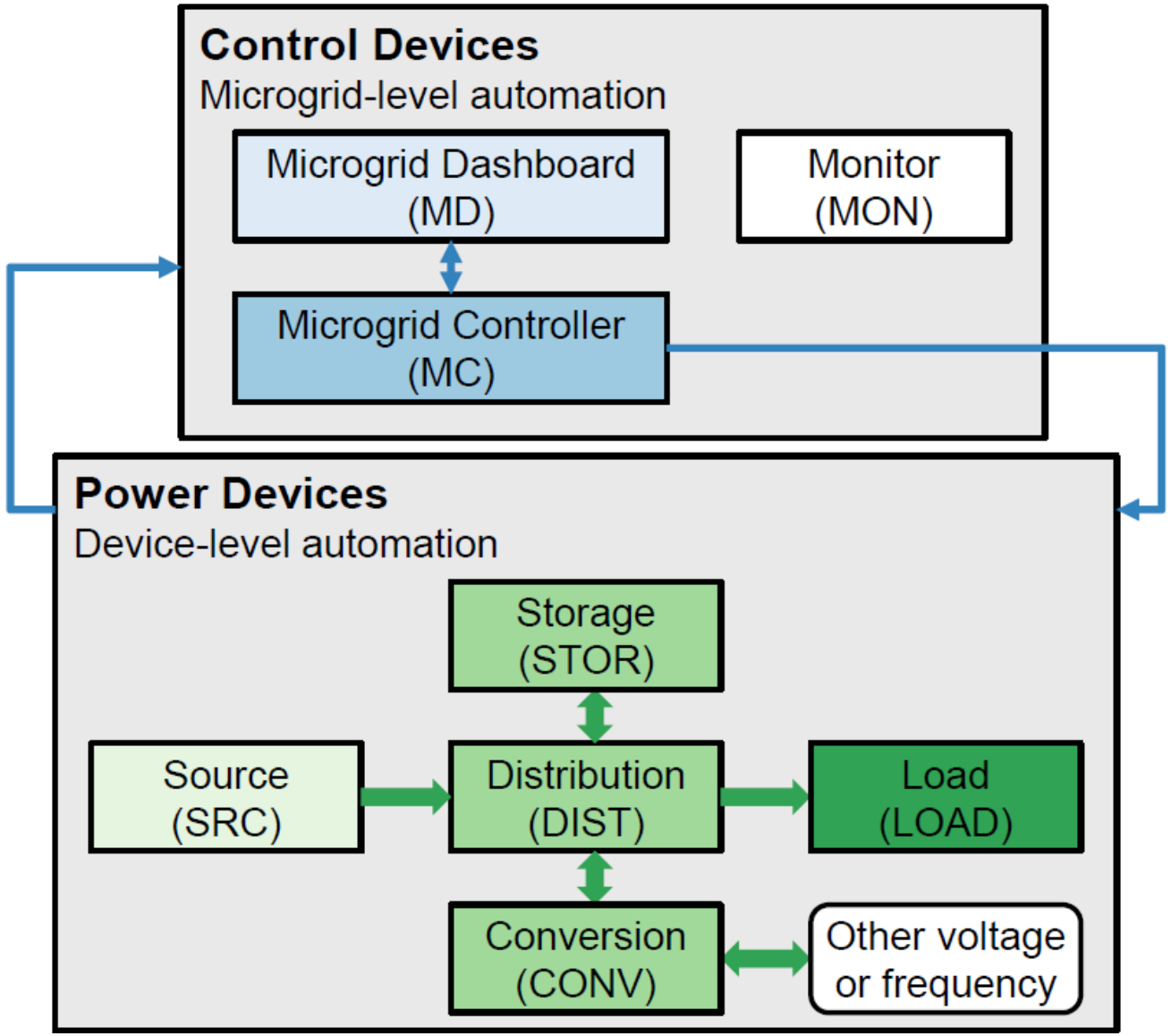
- TMS establishes electrical data to facilitate successful power physics of load sharing
- TMS uses DDS, an industry standard protocol, to handle data over the wire and participants
- **Data is sent using a Publish/Subscribe Architecture**

MIL-STD 3071: DEVICE ROLES



TOPIC USAGE

Topics are a standard data format with specific information described in each

- **Required.** Implemented by all TMS devices.
- **Conditional.** Implemented by TMS devices that meet the specified condition.
- **Optional.** Not required by TMS but may be required by acquisition documents or customers.

Table B.2: Overview of Topic Usage.

Topic	Usage	Section
AcLoadSharingRequest	Optional	B.21.1
AcLoadSharingState	Conditional on HAS_AC_PORTS	B.21.1
AcMeasurementUpdate	Conditional on HAS_AC_METERS	B.18.1
AcSummaryMeasurementUpdate	Conditional on HAS_AC_SUMMARY_METERS	B.18.1
ActiveDiagnosticState	Required	B.12.1
ActiveMicrogridControllerState	Required	B.13.1
AuthorizationToEnergizeReply	Conditional on SUPPORTS_REQUEST	B.24.1
AuthorizationToEnergizeRequest	Optional	B.24.1
AuthorizationToEnergizeResult	Optional	B.24.1
ClockState	Optional	B.23.1
ControlHardwareUpdate	Optional	B.8.1
ControlParameterRequest	Optional	B.14.1
ControlParameterState	Conditional on HAS_CONTROL_PARAMETERS	B.14.1
DcLoadSharingRequest	Optional	B.22.1
DcLoadSharingState	Conditional on HAS_DC_PORTS	B.22.1
DcMeasurementUpdate	Conditional on HAS_DC_METERS	B.19.1
DcSummaryMeasurementUpdate	Conditional on HAS_DC_SUMMARY_METERS	B.19.1
DeviceIcon	Optional	B.7.1
DeviceInfo	Required	B.5.1
DiscoveredPowerConnectionState	Optional	B.20.1
EnergyStartStopRequest	Optional	B.16.1
EnergyStartStopState	Required	B.16.1
GroundingCircuitRequest	Optional	B.15.1
GroundingCircuitState	Conditional on HAS_DEVICE_GROUND_PORTS	B.15.1
Heartbeat	Required	B.4.1
IdentityNicknameRequest	Optional	B.6.1
IdentityNicknameState	Conditional on SUPPORTS_REQUEST	B.6.1
MetricParameterState	Optional	B.14.1
MicrogridPowerConnectionState	Optional	B.20.1
OperatorIntentRequest	Optional	B.11.1
OperatorIntentState	Conditional on SUPPORTS_REQUEST	B.11.1
OperatorPowerConnectionState	Optional	B.20.1
PowerHardwareUpdate	Optional	B.9.1
PowerPortState	Required	B.17.1
PowerSwitchRequest	Optional	B.17.1
Reply	Required	B.22.1
StorageUpdate	Required	B.10.1

HEARTBEAT EXAMPLE

B.4.2.1 `tms::Heartbeat`

PURPOSE: Periodic indication of device availability.

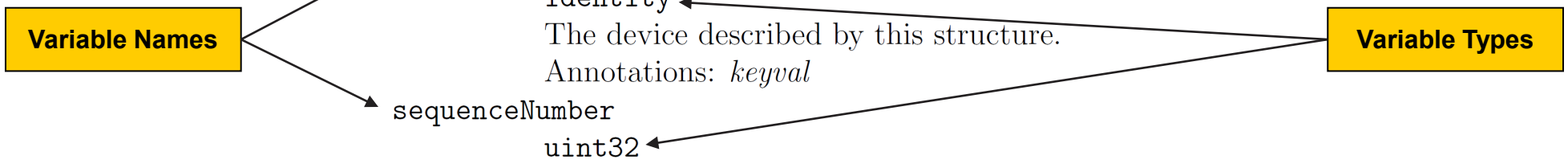
TOPIC USAGE: Heartbeat

EXTENSIBILITY: extensibility(APPENDABLE)

PATTERN: Structure

ATTRIBUTES:

Name	Type and Description
`deviceId`	`Identity` The device described by this structure. Annotations: *keyval*
`sequenceNumber`	`uint32` A counter that starts at 0 and increments by 1 for each new heartbeat.



DESCRIPTION:

Network communications generally provides a low-level indication whether two devices are connected. The periodic update of `Heartbeat` with an incrementing `sequenceNumber` confirms availability of the application software.

LATE JOINER SOLUTION

Table B.14: Timing of the Heartbeat topics.

Topic	Data Trigger	Rate Class	Burst Size	QoS Profile
Heartbeat	Periodic 1 s	1 s	1	Medium

Table A.5: High-level definitions of QoS Profiles.

QoS Profile	Durability	Reliability	History	Deadline	Priority
PublishLast	Transient	Reliable	1	Infinite	Normal
Command	Volatile	Reliable	1	Infinite	Normal
Response	Volatile	Reliable	1	Infinite	Normal
Reply	Volatile	Reliable	128	Infinite	Normal
Continuous	Volatile	Best effort	1	2 s	Normal
Medium	Volatile	Best effort	1	3 s	Normal
Slow	Volatile	Best effort	1	20 s	Normal
Rare	Volatile	Best effort	1	2000 s	Normal

TOPIC PUBLISH/SUBSCRIBE BY ROLE

P – Publish
S – Subscribe

Table 3.1: Overview of All Data Model Topics.

Topic	Participants: MD	MC	SRC	STOR	DIST	LOAD	CONV	Section
Heartbeat	P, S	P, S	P, S	P, S	P, S	P, S	P, S	3.3
DeviceAnnouncement	P, S	P, S	P, S	P, S	P, S	P, S	P, S	3.4
DeviceIcon	S	P	P	P	P	P	P	3.6
FingerprintNickname	P, S	P	P	P	P	P	P	3.5
FingerprintNicknameRequest	P, S	S	S	S	S	S	S	3.5
OperatorConnectionList	P	S						3.22
DiscoveredConnectionList		S	P	P	P	P	P	3.5
MicrogridConnectionList	S	P						3.22
ActiveDiagnostics	S	P, S	P	P	P	P	P	3.11
DeviceClockStatus	P, S	P, S	P	P	P	P	P	3.26
StandardConfigMaster	S	S	P	P	P	P	P	3.12
DevicePowerMeasurementList	S	S	P	P	P	P	P	3.20

Standardized Data Underpin Interoperability

PUB/SUB: NON-TECHNICAL

Microgrid Controller

DDS Middleware

Generator

Energy Storage

Distribution

1. Device Publishes Data

2. Send to DDS Middleware

3. DDS sends data to Subscriber

4. Subscriber actions on data

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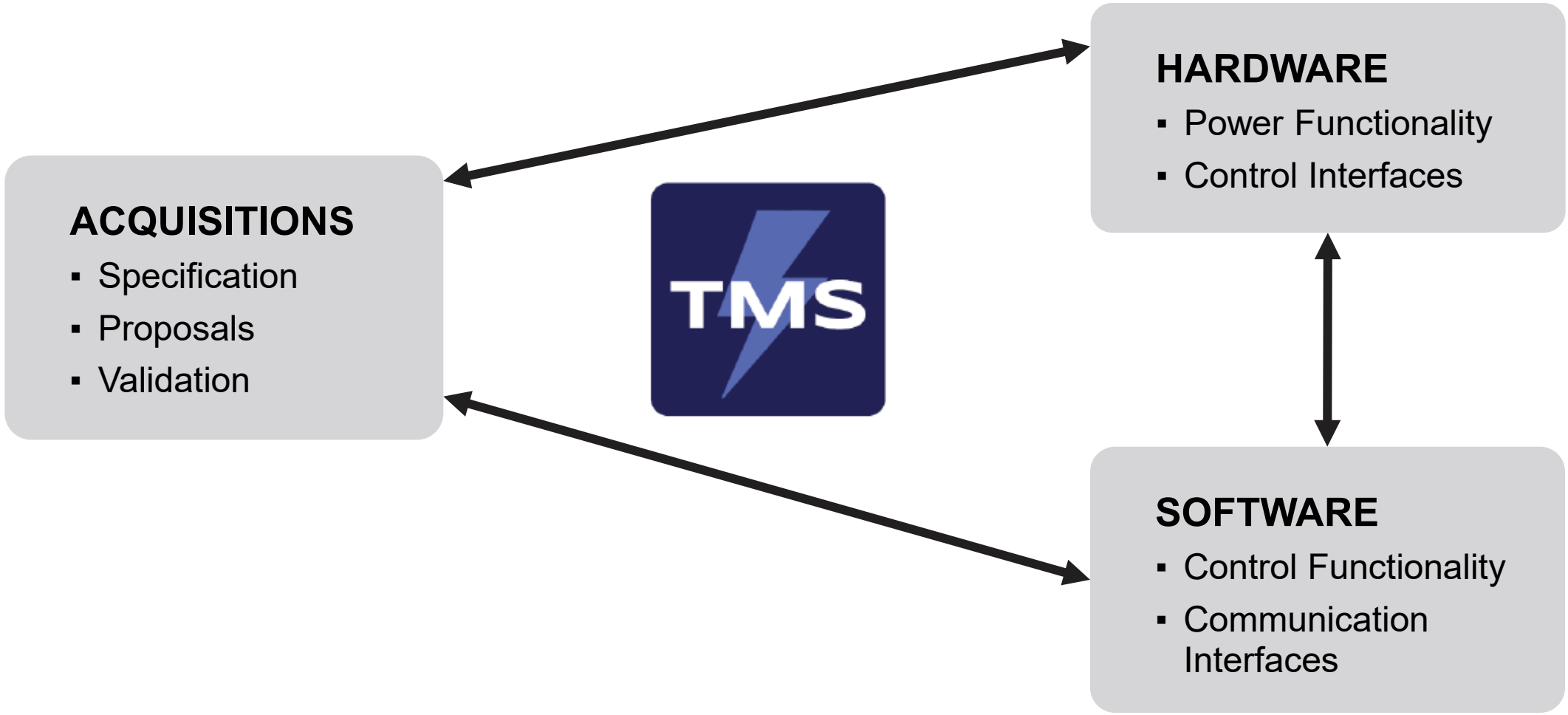
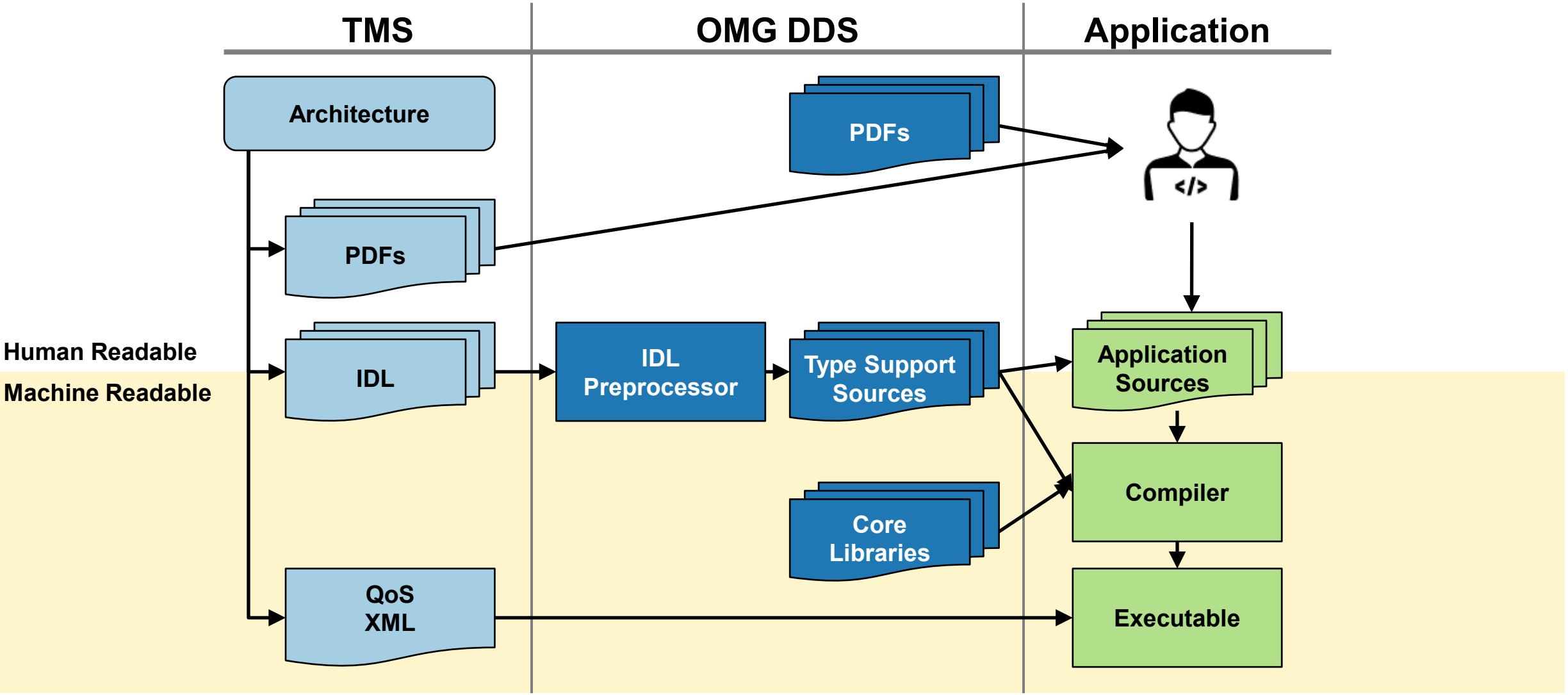
- Data is sent using a Publish/Subscribe Architecture
- **TMS data exchange is done through populating “Topics”**

TMS INVOLVES MULTI-DISCIPLINARY TEAMS



TMS SOFTWARE INTEGRATION



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- Data is sent using a Publish/Subscribe Architecture
- TMS data exchange is done through populating “Topics”
- **Vendors are provided MIL-STD which includes IDL**
- **Vendors must choose DDS middleware library and ingest MIL-STD IDL**

BREAK

Agenda Item	Time (EST)
Welcome and Administrative Brief	0900-0930
Government Organization Introductions	0930-1000
TMS Executive Overview	1000-1030
Break	**1030-1040**
Overview on APAN and how to participate in TMS community	1040-1055
TMS Governance Participation	1055-1105
TMS Technical Overview	1105-1200
Admin Remarks	1200-1205
Lunch	1205-1330
Poster Session (Start will overlap lunch)	1300-1400
Hardware Demonstration	1400-1505
Break	1505-1515
Compliance Overview	1515-1600
TMS Q&A Panel and Concluding Remarks	1600-1630

TMS

TACTICAL MICROGRID STANDARD

Community Involvement

OVERVIEW OF APAN AND HOW TO PARTICIPATE IN TMS COMMUNITY

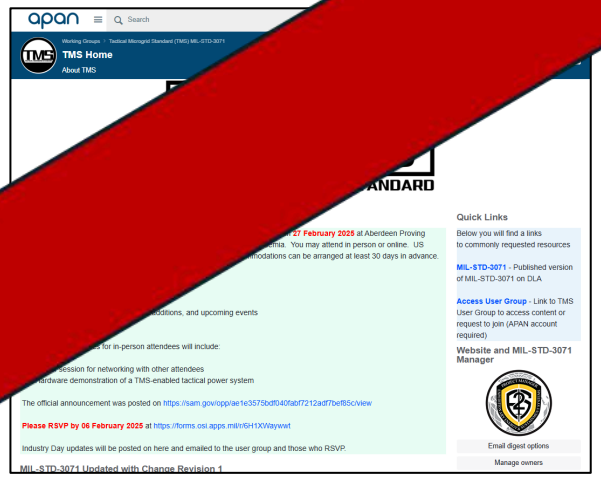
Agenda

1. How TMS team connects with you
2. How you can connect with the TMS team
3. Summary / Q&A

OVERVIEW OF APAN

TMS Site on APAN

- Connects the Government and the public for information sharing/dissemination on MIL-STD-3071, the Tactical Microgrid Standard (TMS).
- Used as a single entry point to the Tactical Microgrid Standard ecosphere
- Public, vendors, partners, other services, and industry will come to get the latest information they will need
- TMS Subsites:
  - Public facing site
  - User group site



What is APAN?

- All Partners A
- US De se (DOD) information sh
- tional and nontraditional mission
- web-based community spaces and tools to t their mission objectives

Why APAN?

- Equal access to all interested partners
- Accredited to host DoD information
- Free to all

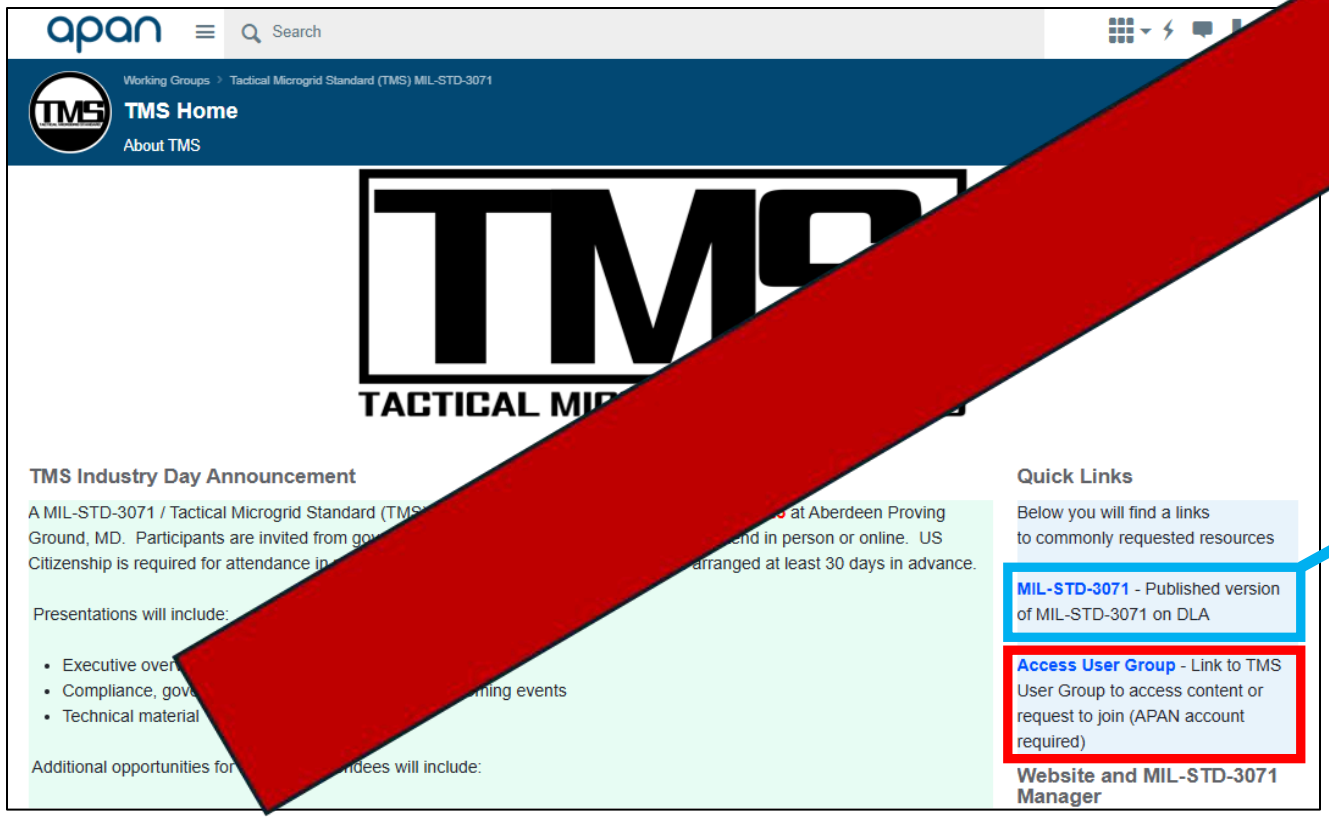
apan.org

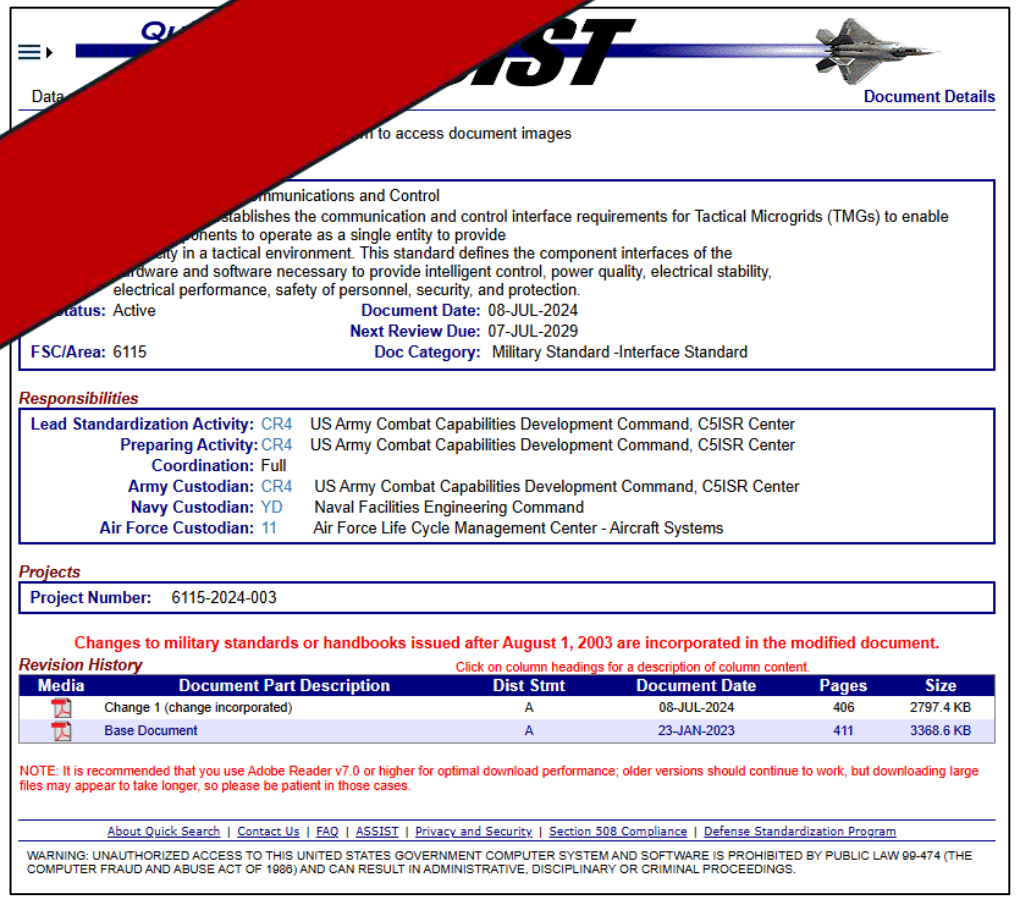
https://go.mil/TMS

OVERVIEW OF APAN

TMS Public Facing Site

- General Information
- Link to latest published version of TMS
- Link to access TMS User Group





https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=285095

OVERVIEW OF APAN

TMS User Group Site

- Obtaining access
  - With APAN Account – request access
  - Without account – create account / request access
    - Accounts are free
    - Please use company email for verification purpose
  - TMS Team will receive request and will typicall
    within 1 business day

find a links
monly requested resources

MIL-STD-3071 - Published version of MIL-STD-3071 on DLA

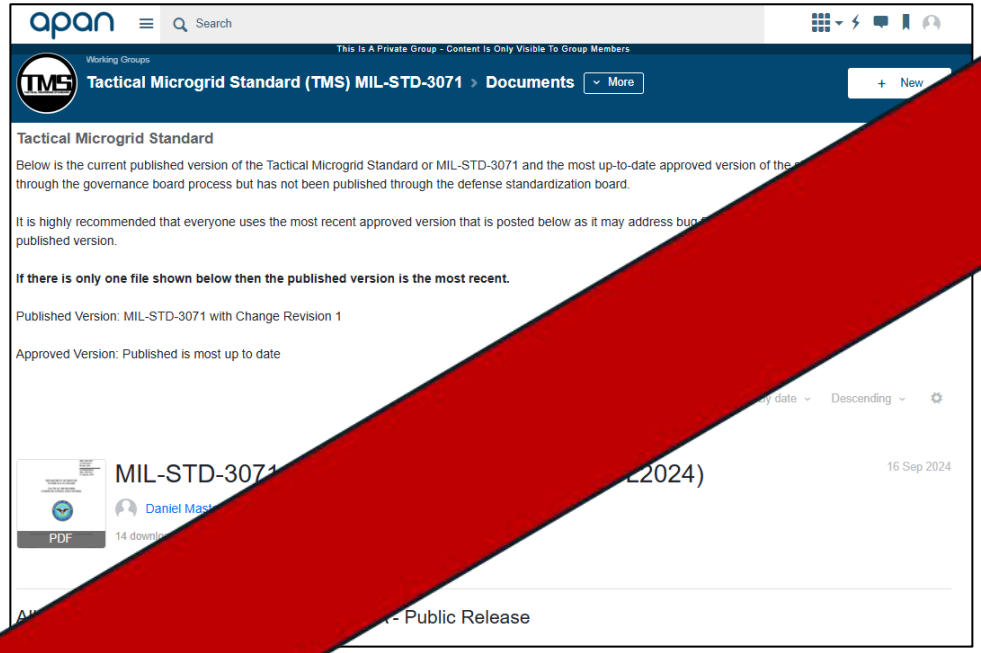
Newest TMS Version - Newest Approved but not Published Version

Contact Us - Request Technical Assistance / Submit Bug Report

OVERVIEW OF APAN

TMS User Group Site Sections

- **Documents**
- Development Tools
- FAQ
- **Contact Us**
- Announcements
  - Upcoming events
  - Public Comment Periods
  - **Mirrored on SAM.gov**



– Document Section

ents

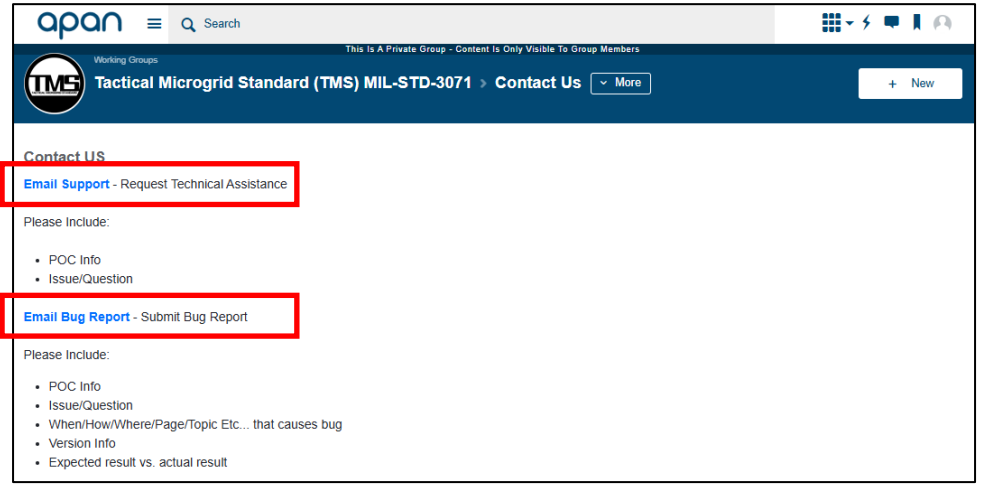
Current Published Version

- DLA ASSIST

- Current Approved Version
  - Includes Governance Board approved changes – not yet published

RT EMAIL:

usarm ss.mbx.tms-support@army.mil

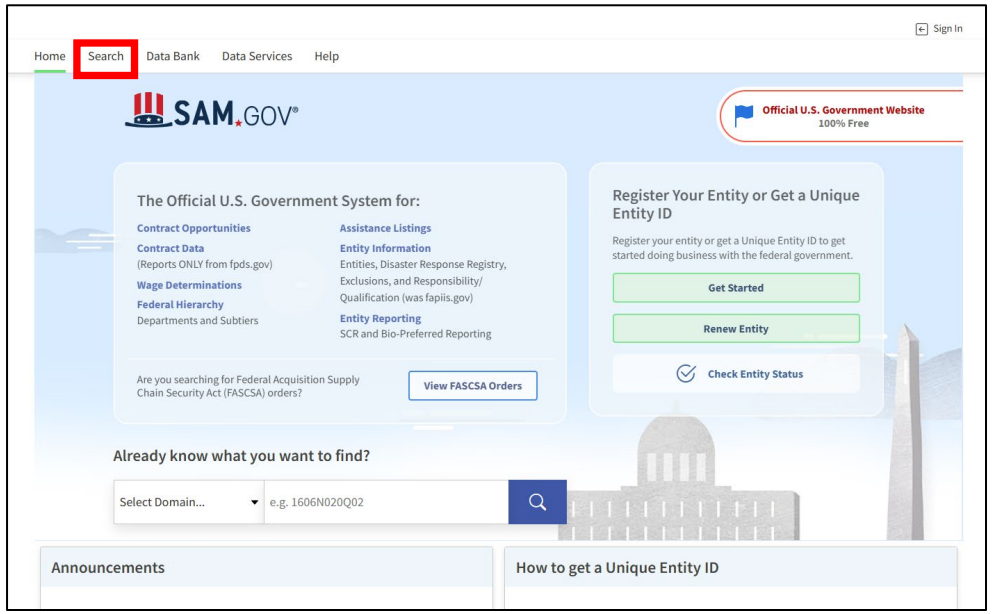


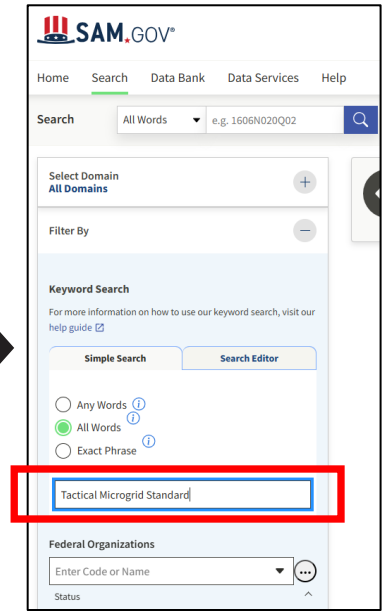
TMS User Group – Contact Us Section

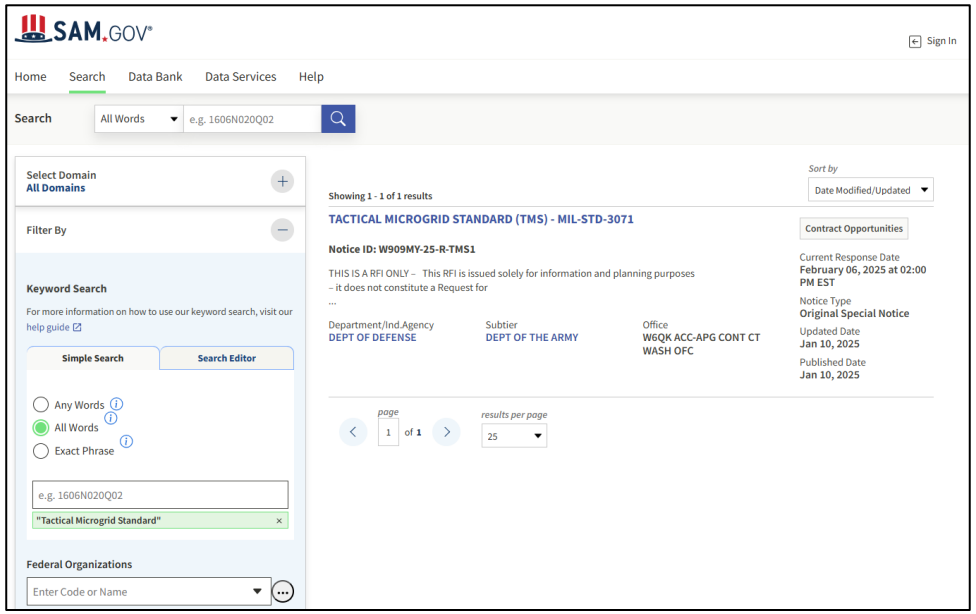
OVERVIEW OF SAM.GOV

SAM.gov

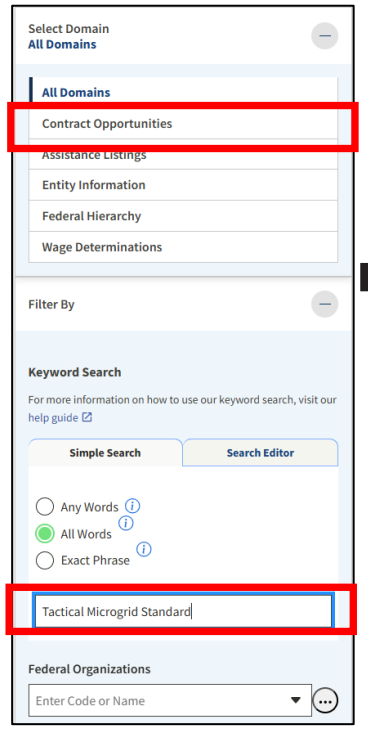
- Open and free to all
- Search “Tactical Microgrid Standard”
- Typically will see: “Contract Opportunity Type: Special Notice”
- Will be used to:
  - Announce major updates to standard
    - Directions on how to comment will be provided
  - Upcoming TMS related events

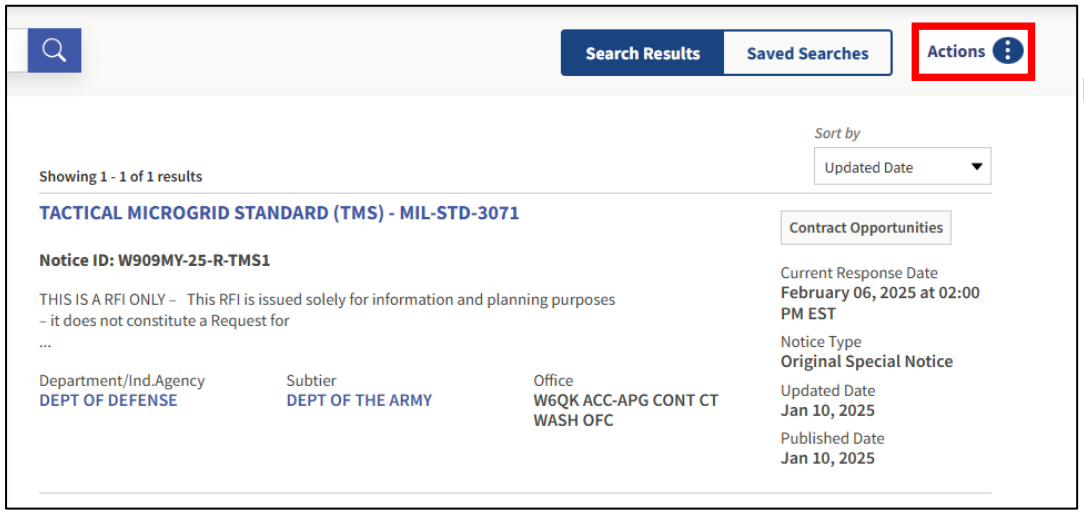


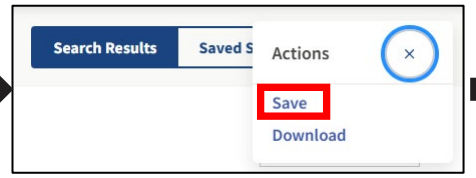


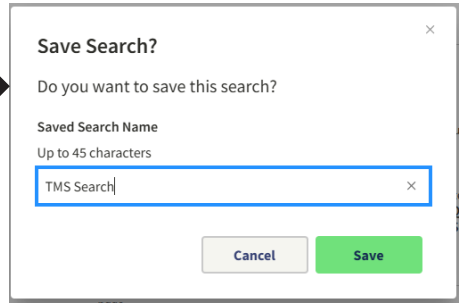


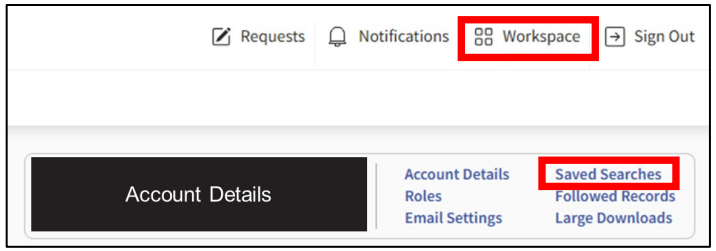
OVERVIEW OF SAM.GOV











SAM.gov – Automatic Notifications

- Must be signed-in
- Set up search parameters
- Save search & name
- User Workspace
- Set to notify

SUMMARY – Q&A

We have received many good suggestions for how to help the TMS community

1. TMS vendor directory (on APAN or elsewhere)
2. TMS integration activities / **Plugfest** (multi-vendor / government)
3. TMS training events (webinars or workshops)
4. TMS issue tracker (semi-public)
5. TMS testing activities (outside of DoD acquisition)
6. TMS certification marks and data sheet formats (for commercial use)
7. Additional TMS Industry Days

- We need your input on where to focus to assist you the most

Your input & feedback is critical (end of event survey)

TMS Team Ready to Support

- Reach out for assistance

Stay Connected

- Monitor APAN
- Set up automatic SAM.gov notifications
- Report bugs and suggest changes

Governance

DEFENSE STANDARDIZATION PROGRAM

- Defense Standardization Program (DSP) provides the policy framework and standardization management process to promote interoperability using a modular open systems approach (MOSA)
  - https://www.cto.mil/sea/dsp/
  - https://www.dsp.dla.mil/
  - https://assist.dla.mil
- Joint Standardization Boards (JSBs) provide a DoD-wide forum for achieving common, mutually satisfactory standardization solutions
- Mobile Electric Power Systems (MEPS)
  - Fulfilled by Project Manager Expeditionary Energy & Sustainment Systems, Project Manager Mobile Electric Power Systems
  - Established by DoDI 4120.11, future revision to explicitly require TMS

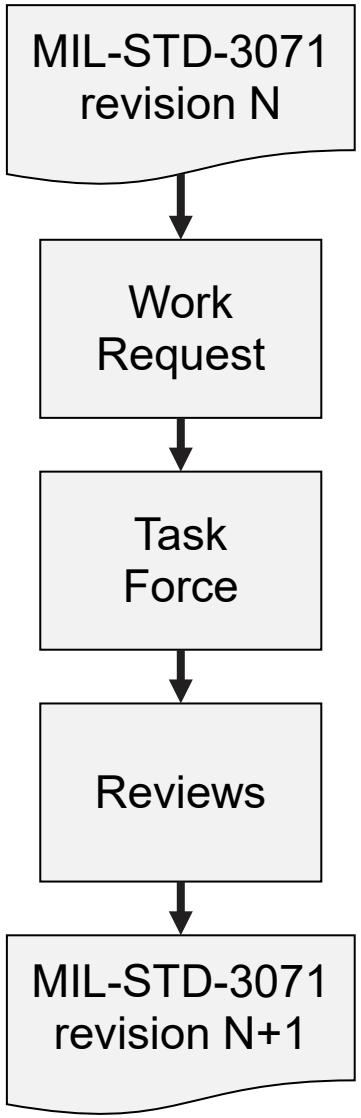
DSP

MEPS JSB

TMS
TACTICAL MICROGRID STANDARD

TMS GOVERNANCE PROCESS

- TMS Governing Board
  - Steering body that charters task forces and enforces due process
  - Members represent core stakeholders
- Works Request
  - Submitted by one or more stakeholders to define required scope and purpose, initiate a call for participation, and track progress
- Task Forces
  - Allow wide participation by all stakeholders
  - Revision Task Force (RTF) for editorial changes and minor issues
  - Proposal Task Force (PTF) for larger enhancements
- Reviews
  - Technical, editorial, and governance within TMS
  - Submitted to DSP for final publication



WORK REQUEST 2025-1:
DDS SECURITY PROPOSAL TASK FORCE (PTF)

- Add to Appendix C
  - How DDS Security integrates with the TMS data model
  - Sufficient detail for implementation and benchmarking
  - Baseline settings for common applications
  - Requirements for hardware support such as secure key storage and real-time clocks
- Out of scope
  - Provisioning system including key management
  - Authorization user interfaces

Improve cybersecurity. Supports hardware selection.
Will not be required by TMS in the near future. May be required by acquisitions.

WORK REQUEST 2025-2:
REVISION TASK FORCE (RTF)

- ~20 editorial issues
- ~15 minor technical issues on subjects such as the following
  - Changes
    - B.12: Publish Diagnostic Trouble Codes about other devices
    - B.16: Indicate which EnergyStartStop states can be requested
    - A.6.3, B.6, B.7: Improved nickname and icon support for platforms
  - Additions
    - Add ability to represent non-TMS devices
    - Support administrative URLs
    - Publish backup battery state (for booting control hardware)
    - Improve type extensibility using DDS-Xtypes

Improve clarity, backwards compatibility, and existing features in MIL-STD-3071.

CALL FOR PARTICIPATION

- We will announce calls for participation in the coming weeks
  - To join the DDS Security PTF
  - To join the Revision Task Force
- Please join the APAN community to stay informed
  - Task force announcements
  - Draft review announcements

APAN Community Links

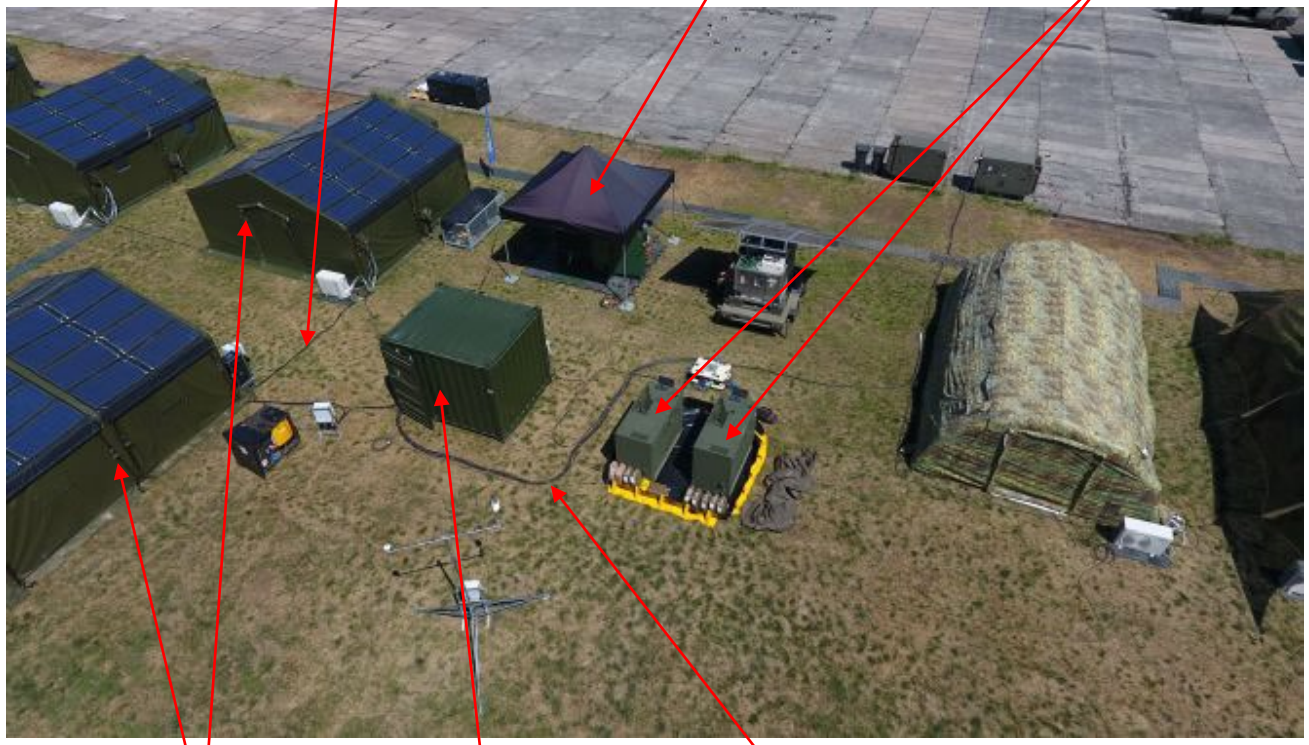
https://go.mil/TMS

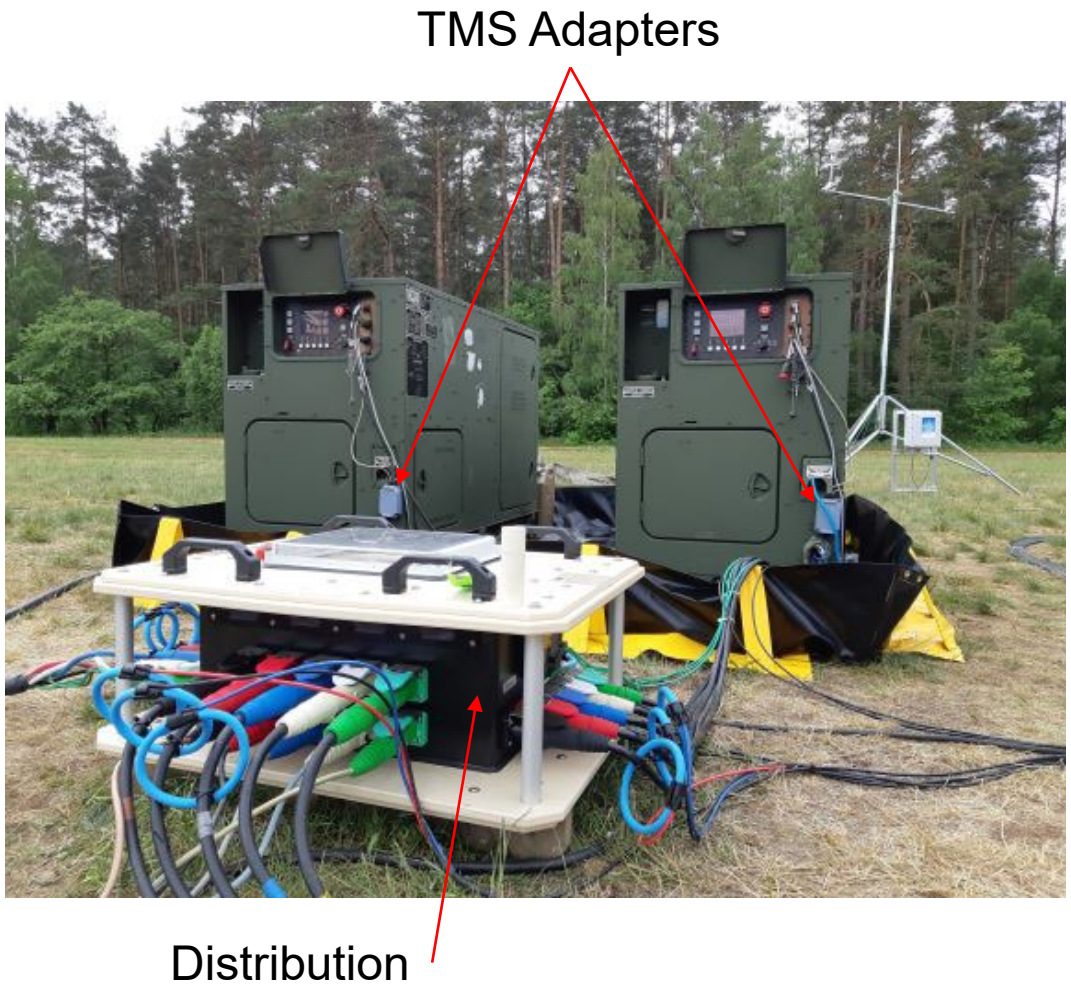
Technical Overview

NEXT SECTION

- Background
- TMS Architecture Concepts
- Example Device Behaviors
- Communications Layer
- TMS Tools
- Conclusion

WHAT IS A MICROGRID?

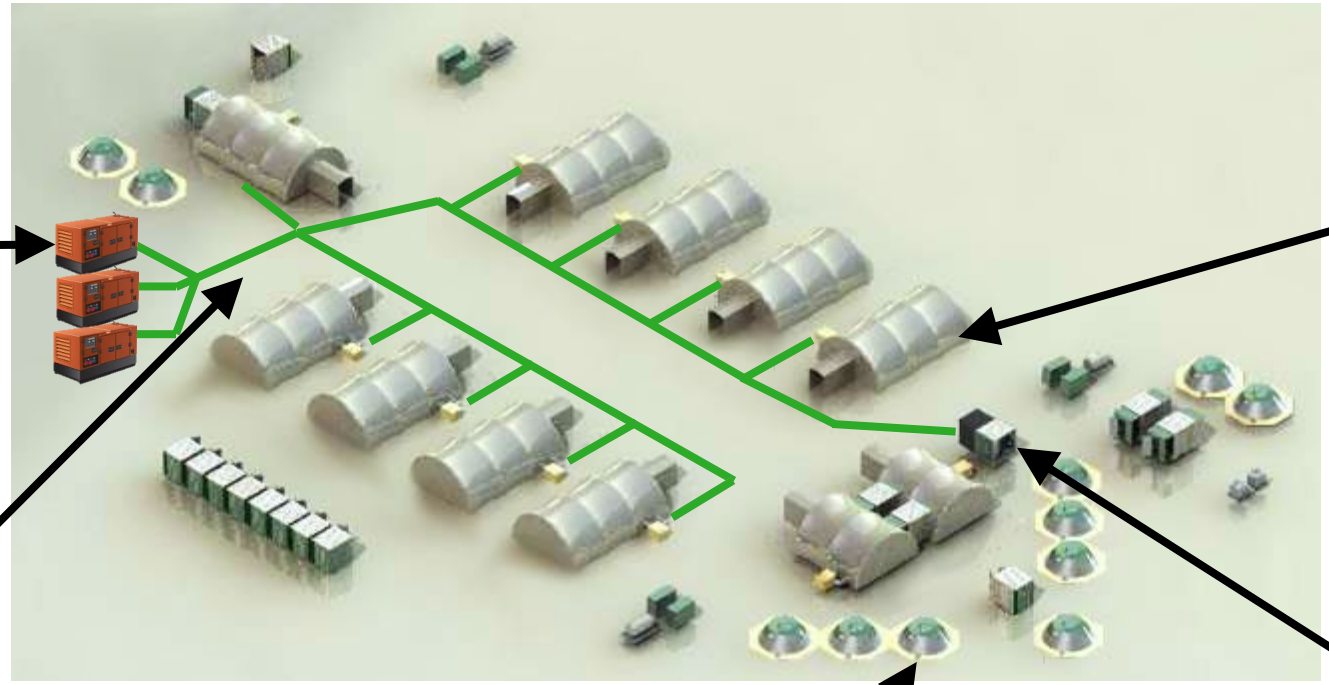




ON-SITE POWER EXAMPLE

120-person Base Camp

Diesel Generator



Portable Shelter

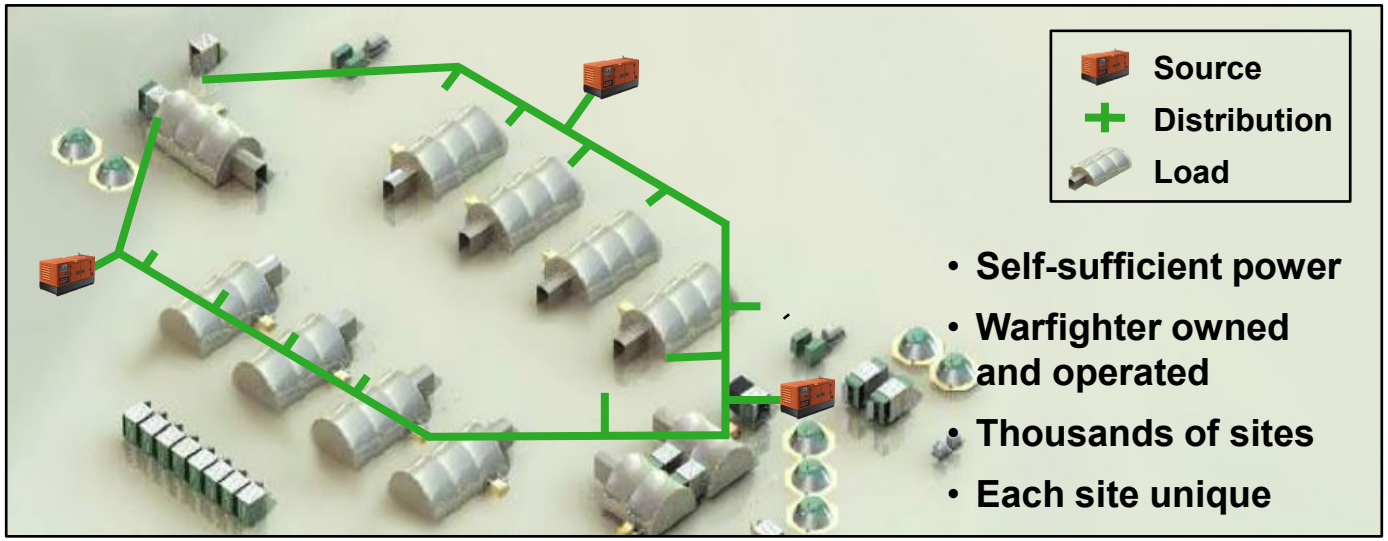
Power Distribution

Fuel Storage

Food Storage

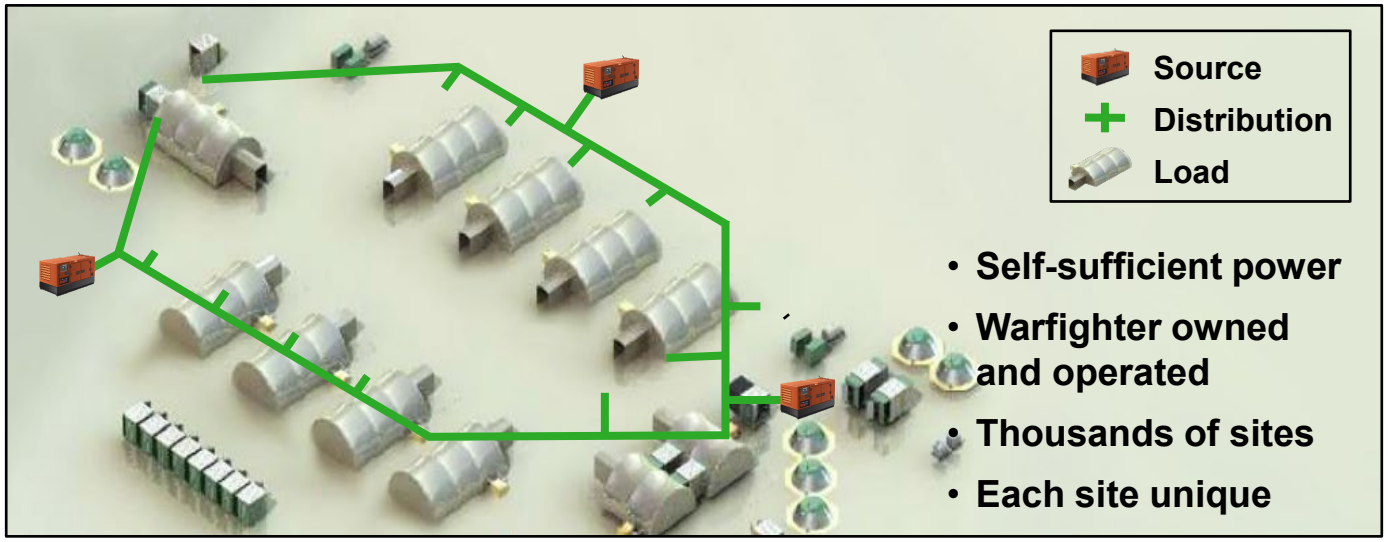
TACTICAL POWER OPERATING CONTEXT

Example Forward Operating Base (FOB)

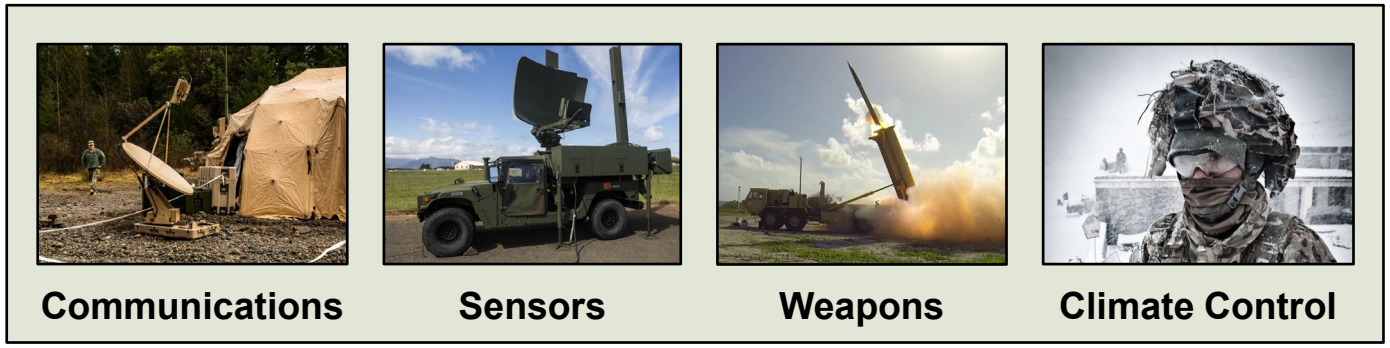


TACTICAL POWER OPERATING CONTEXT

Example Forward Operating Base (FOB)

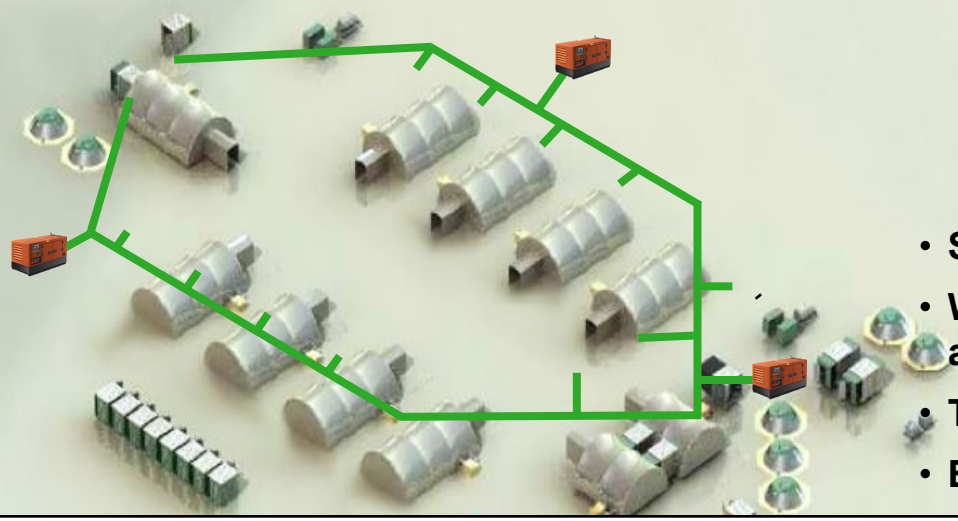


Example FOB Mission Systems



TACTICAL POWER OPERATING CONTEXT

Example Forward Operating Base (FOB)



- Self-sufficient power
- Warfighter owned and operated
- Thousands of sites
- Each site unique

Example FOB Mission Systems


Communications


Sensors

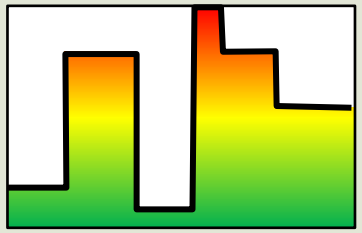

Weapons


Climate Control

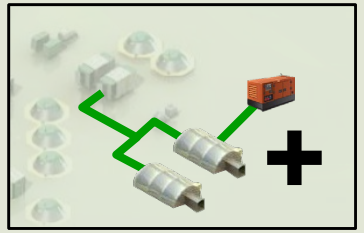
Operational Challenges


Rapid Deployment


Limited Training

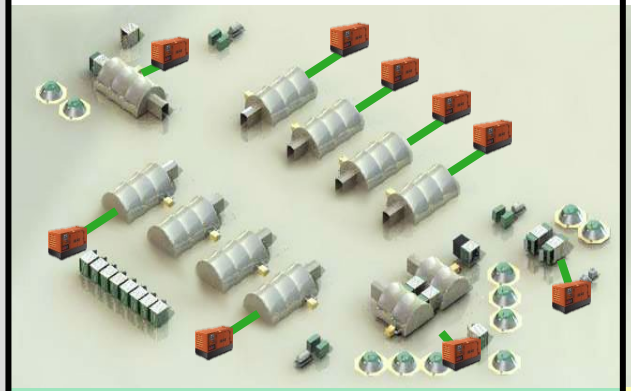
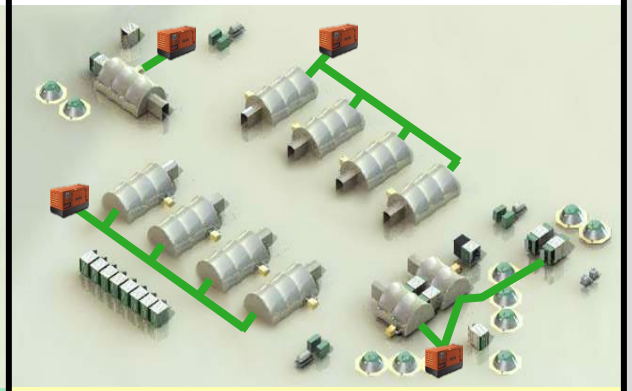

Dynamic Loads


Equipment Failures

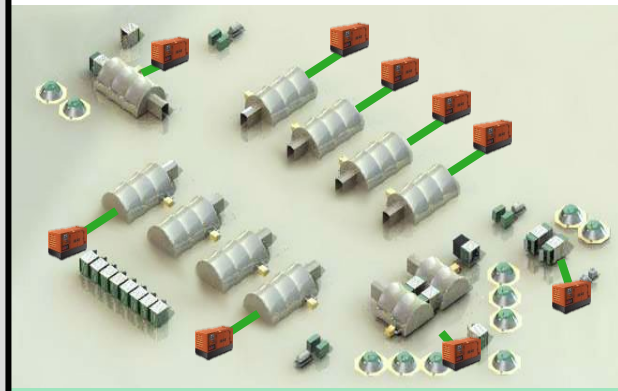
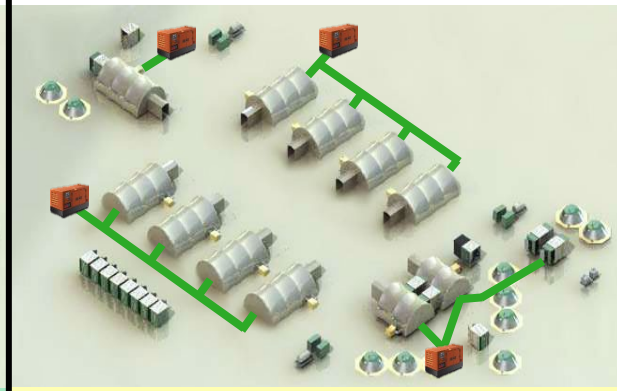
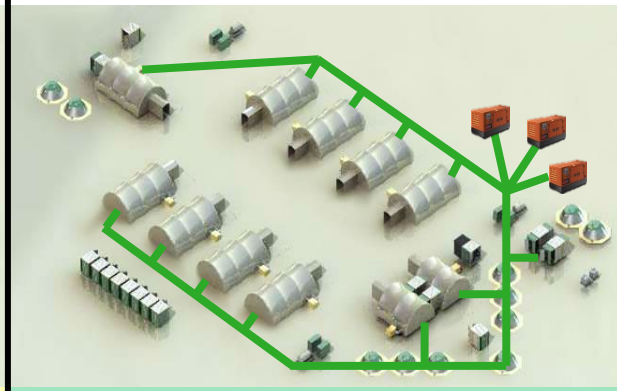
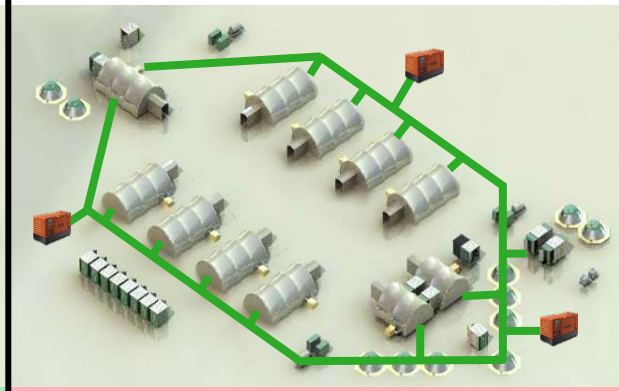

Organic Growth


New Tech Insertion

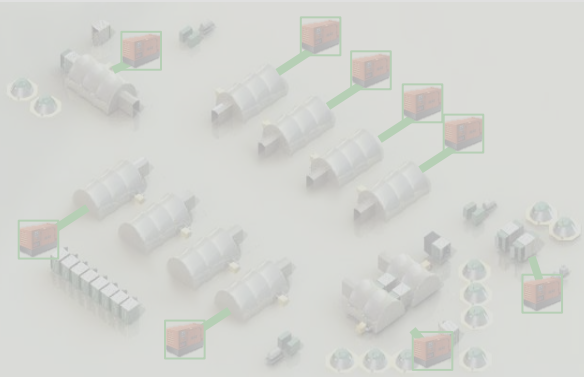
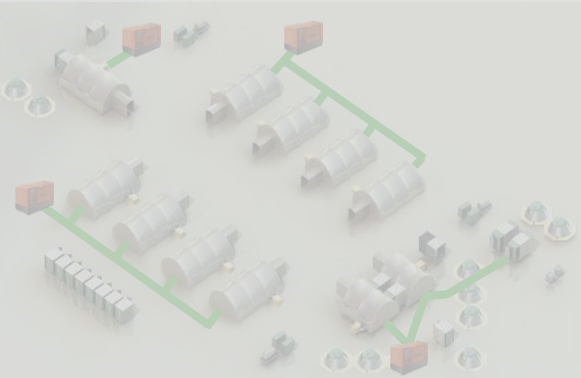
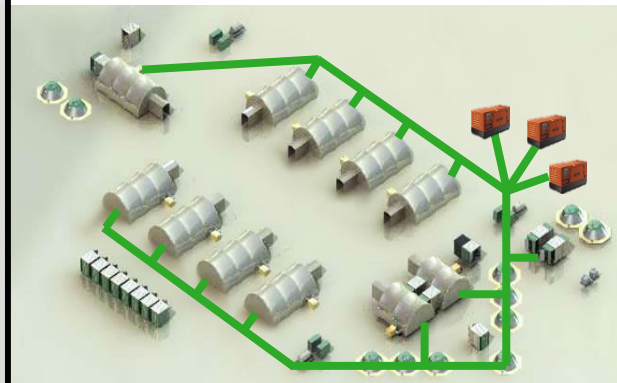
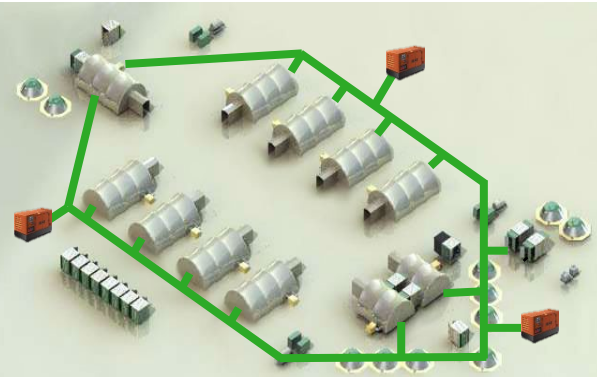
ON-SITE POWER ARCHITECTURE OPTIONS BEFORE TMS

Spot Generation	Consolidated Generation
	
• Simple setup	• Complex setup
• Inefficient	• Efficient
• Fragile generation	• Fragile generation
• Minimal distribution	• Fragile distribution
• Extensible, modular	• Extensible, modular
Typical DoD Approach	**Limited DoD Use**

ON-SITE POWER ARCHITECTURE OPTIONS BEFORE TMS

Spot Generation	Consolidated Generation	Central Microgrid	Distributed Microgrid
			
• Simple setup	• Complex setup	• Simple setup	• Very complex setup
• Inefficient	• Efficient	• Efficient	• Efficient
• Fragile generation	• Fragile generation	• Backup generation	• Spread out generation
• Minimal distribution	• Fragile distribution	• Fragile distribution	• Backup distribution
• Extensible, modular	• Extensible, modular	• Proprietary vendor lock	• Proprietary vendor lock
Typical DoD Approach	**Limited DoD Use**	**Early DoD Adoption**	**Emerging DoD Use**

ON-SITE POWER ARCHITECTURE OPTIONS BEFORE TMS

Spot Generation	Consolidated Generation	Central Microgrid	Distributed Microgrid
			
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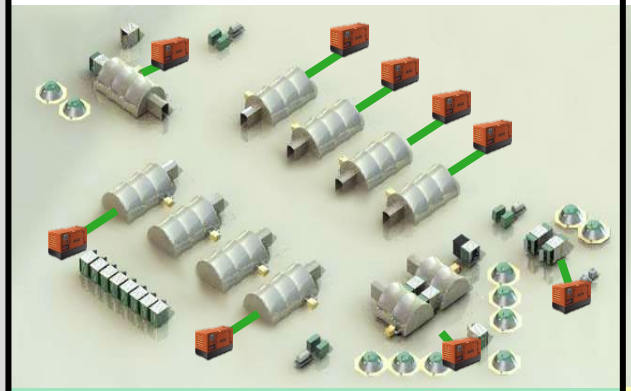
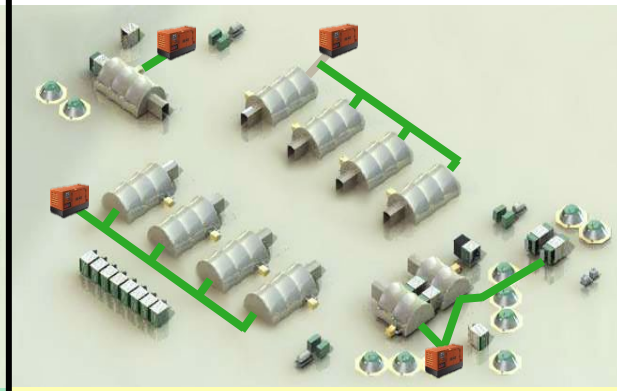
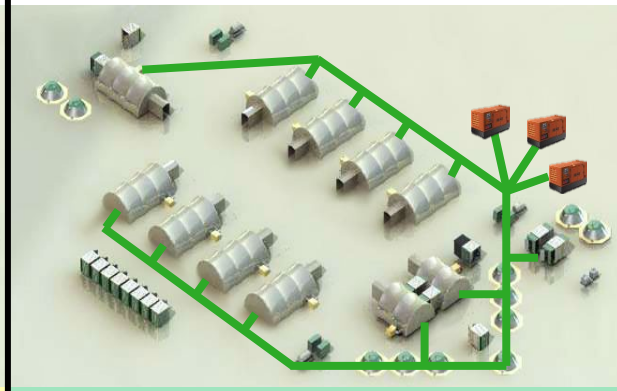
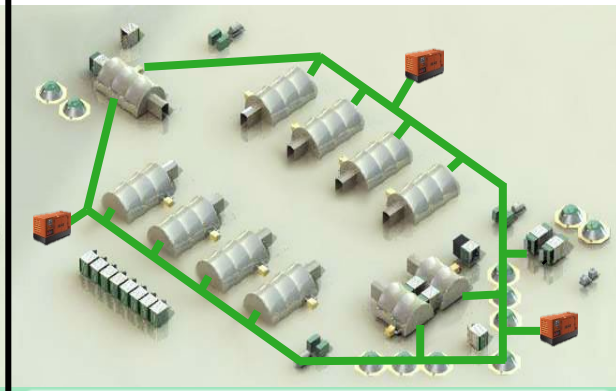
Typical DoD Approach	Limited DoD Use	Early DoD Adoption	Emerging DoD Use

Opportunities for improvement

ON-SITE POWER ARCHITECTURE OPTIONS WITH TMS

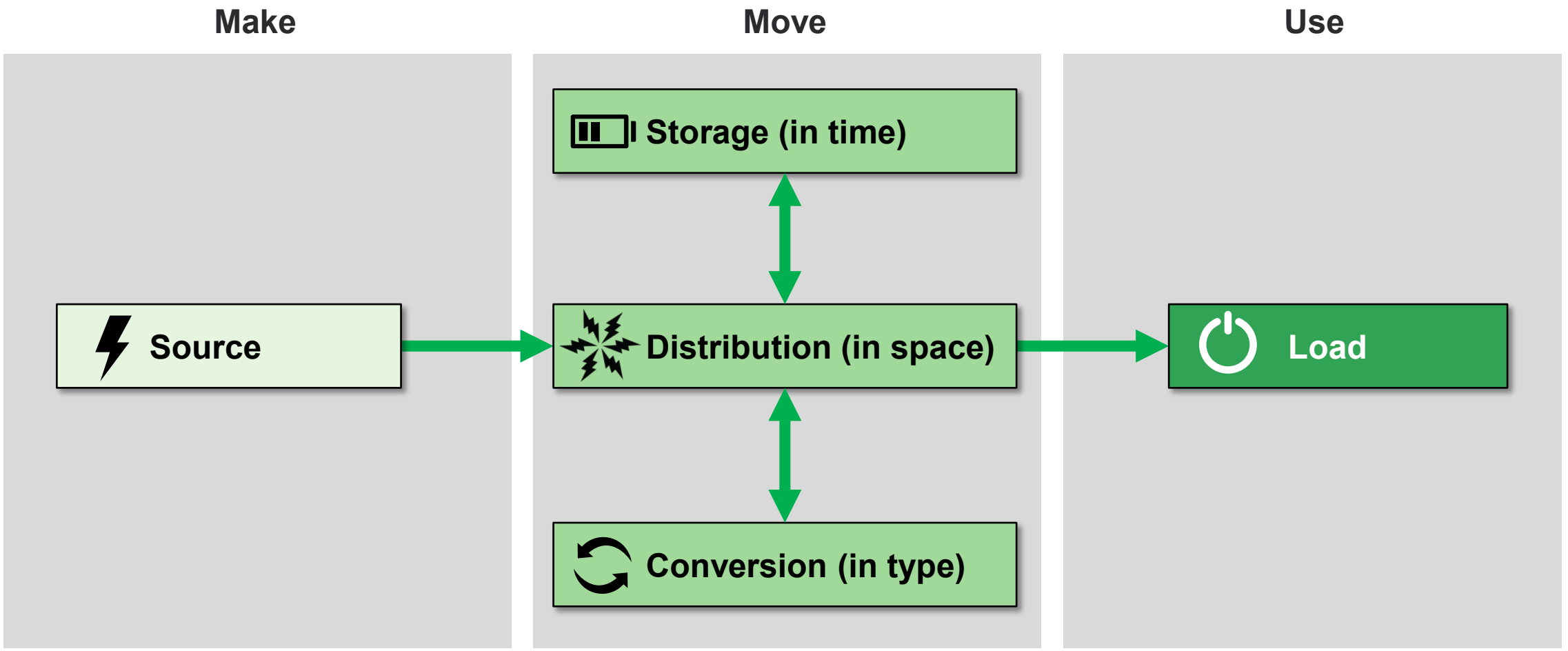
Spot Generation	Consolidated Generation	Central Microgrid	Distributed Microgrid
			
• Simple setup	• Complex setup	• Simple setup	• Simple Setup
• Inefficient	• Efficient	• Efficient	• Efficient
• Fragile generation	• Fragile generation	• Backup generation	• Resilient generation
• Minimal distribution	• Fragile distribution	• Fragile distribution	• Resilient distribution
• Extensible, modular	• Extensible, modular	• Extensible, modular	• Extensible, modular
Typical DoD Approach	**Limited DoD Use**	**Early DoD Adoption**	**Emerging DoD Use**

Improvements

NEXT SECTION

- Background
- TMS Architecture Concepts
- Example TMS Implementation
- Example Device Behaviors
- Communications Layer
- TMS Tools
- Conclusion

MICROGRID SYSTEM COMPONENTS



MICROGRID SYSTEM INTERFACES

Interface	COTS Status	TMS Objectives
Power	Adequate	Leverage existing standards
User	Adequate	Leverage existing standards
Cybersecurity	Growing risk	Lay strong foundation, upgrade over time
Communications	Not interoperable	New standard
Control	Not interoperable	New standard

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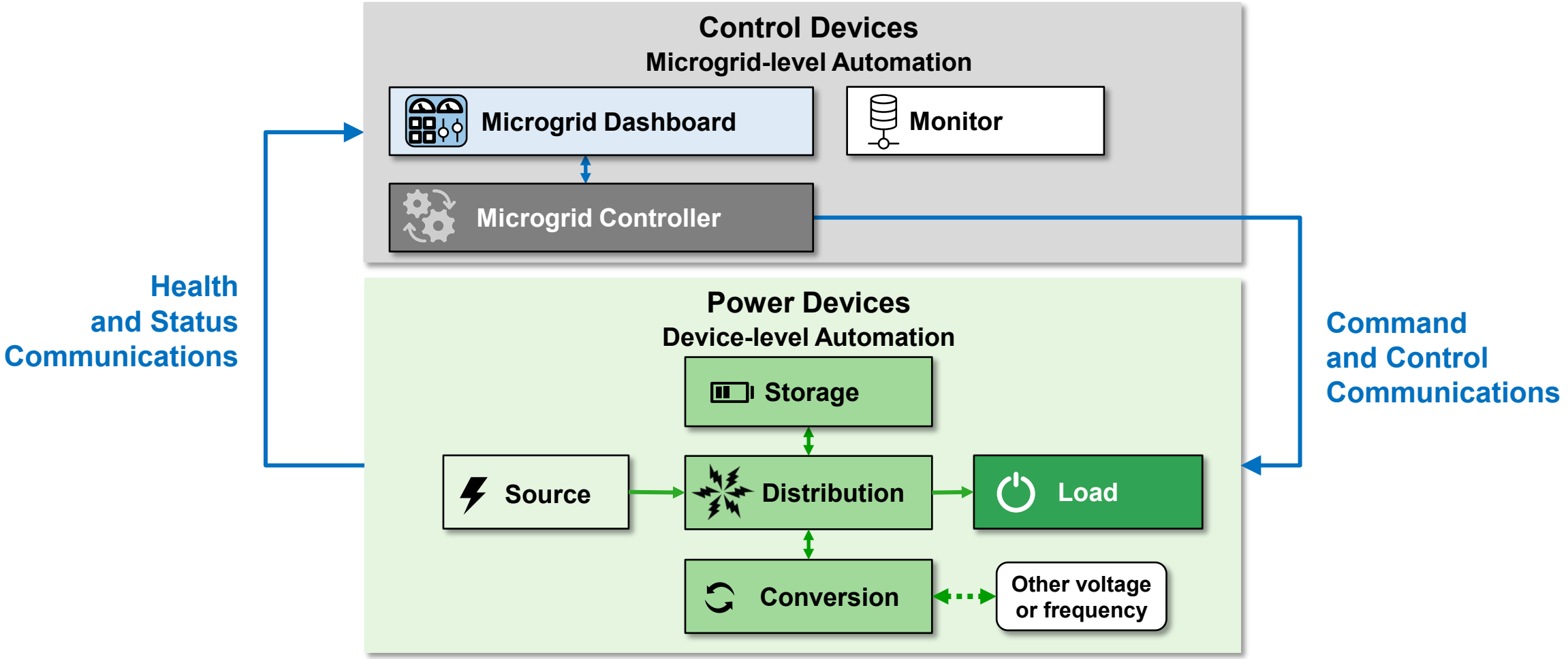
TMS Focus

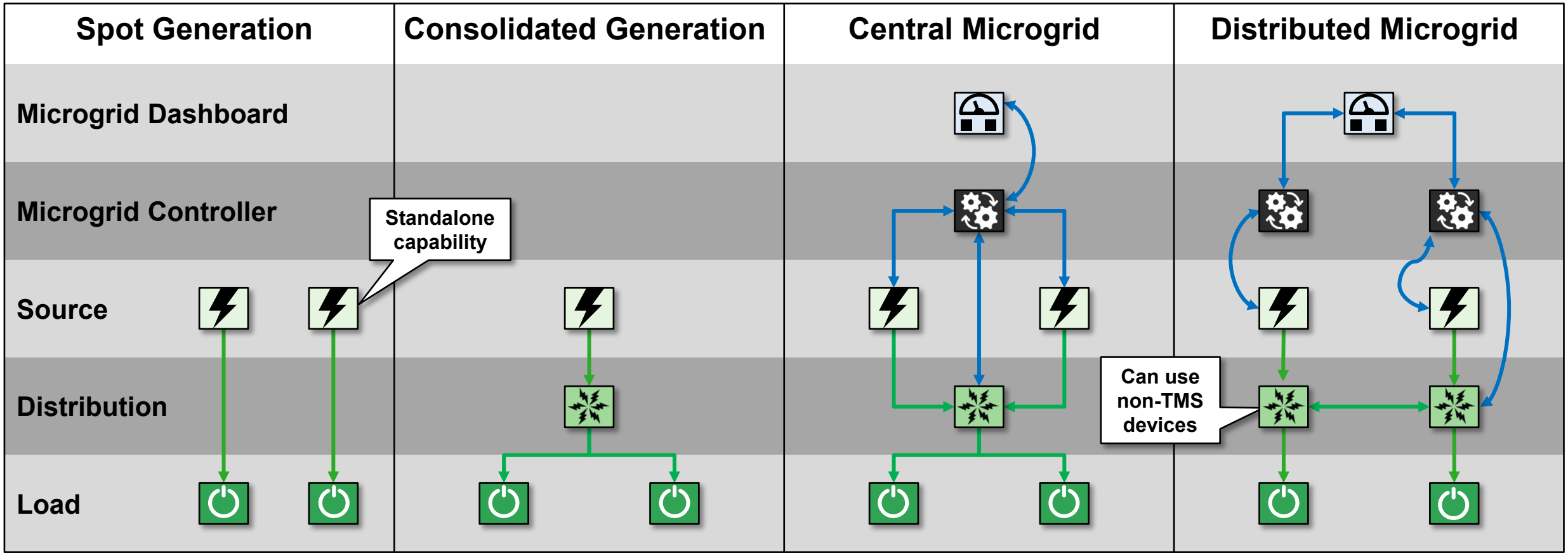
TMS ARCHITECTURE OVERVIEW



KEY FEATURES OF TMS

- Assemble devices to meet mission needs
- Automatic discovery
- Hierarchical control
- Resilient control
- Integrated cybersecurity
- Room for industry innovation

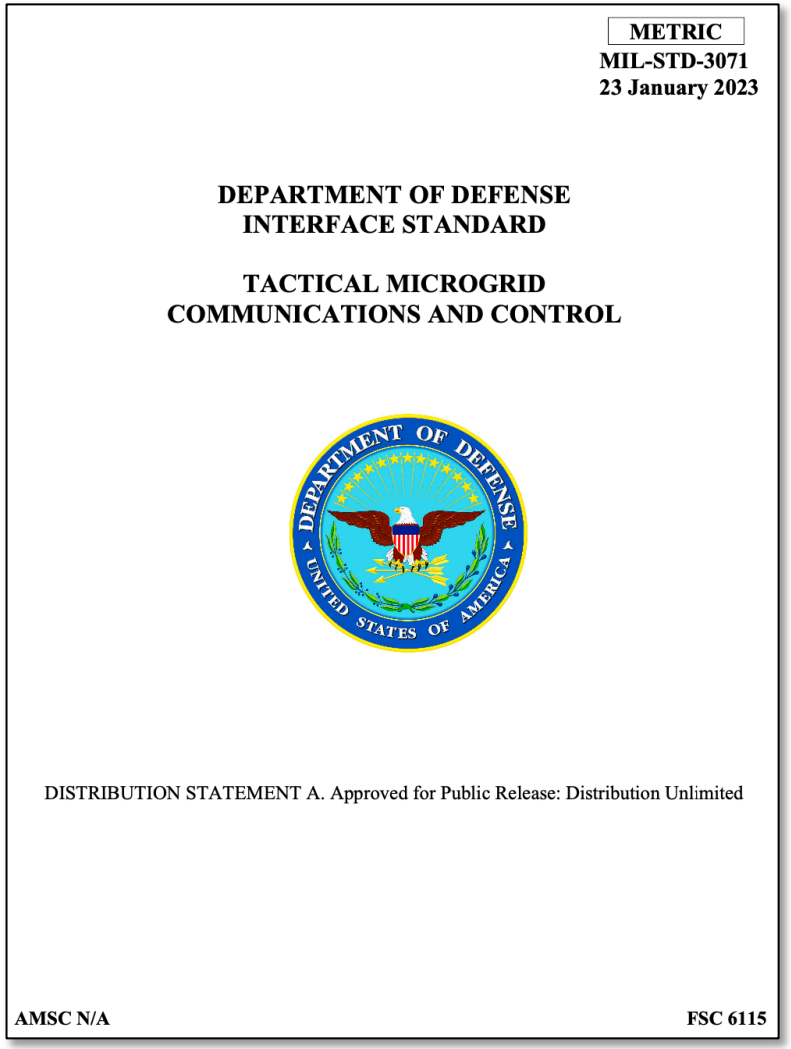
ASSEMBLE DEVICES TO MEET MISSION NEEDS



Typical DoD Approach | **Limited DoD Use** | **Early DoD Adoption** | **Emerging DoD Use**

Power
Communication

MIL-STD-3071: TACTICAL MICROGRID STANDARD (TMS)



METRIC
MIL-STD-3071
23 January 2023

DEPARTMENT OF DEFENSE
INTERFACE STANDARD

TACTICAL MICROGRID
COMMUNICATIONS AND CONTROL

DISTRIBUTION STATEMENT A. Approved for Public Release: Distribution Unlimited

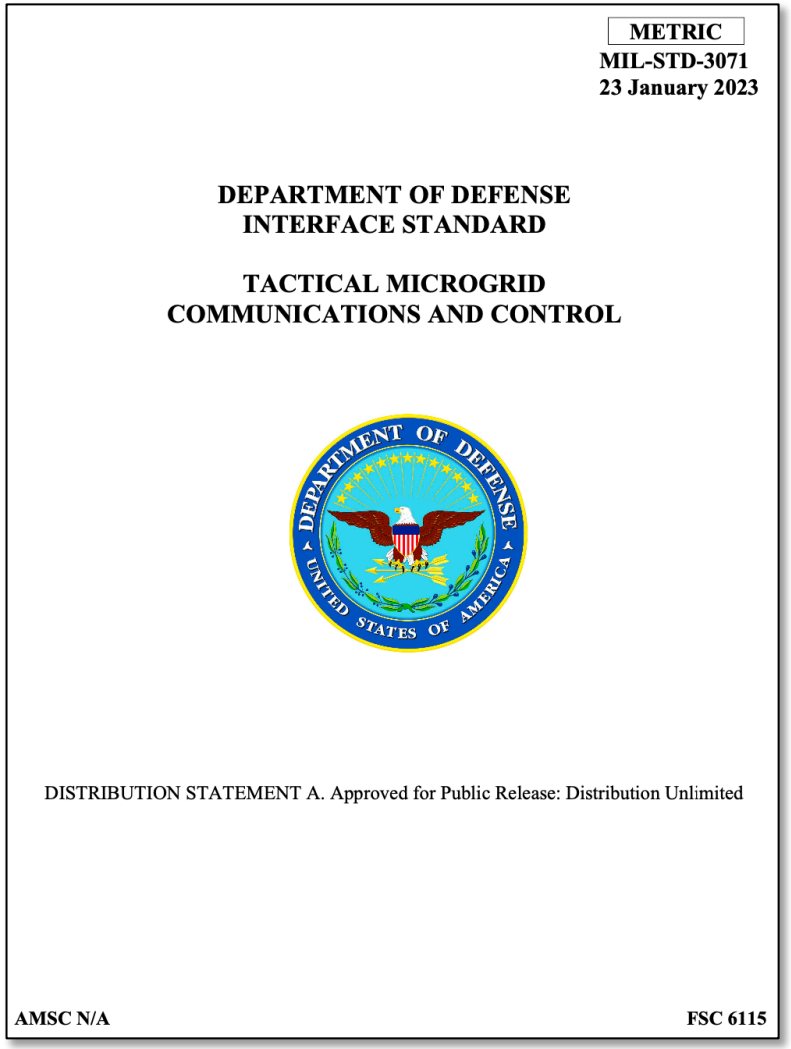
AMSC N/A FSC 6115

Download at quicksearch.dla.mil

Document Organization

- Scope and Purpose
- Definitions
- General Requirements
- Detailed Requirements
- Appendix (Data Model)
- Machine-Readable Attachments
  - Data Model (IDL)
  - Quality of Service settings (XML)

MIL-STD-3071: TACTICAL MICROGRID STANDARD (TMS)



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TACTICAL MICROGRID
COMMUNICATIONS AND CONTROL

DISTRIBUTION STATEMENT A. Approved for Public Release: Distribution Unlimited

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Architected to Meet DoD Needs

DoD Need	TMS
Full Functionality	Y
Mission Integration	Y
Open Interfaces	Y
Rapid Deployment	Y
Battle Hardened	Y
Simple User Interaction	Y

- Recognition:

R&D 100 Award
2019

NATO Interoperability Demo
2019

Published & Required for Selected Acquisitions
2023

Joint Capability Technology Demo
2023

NEXT SECTION

- Background
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- Example Device Behaviors
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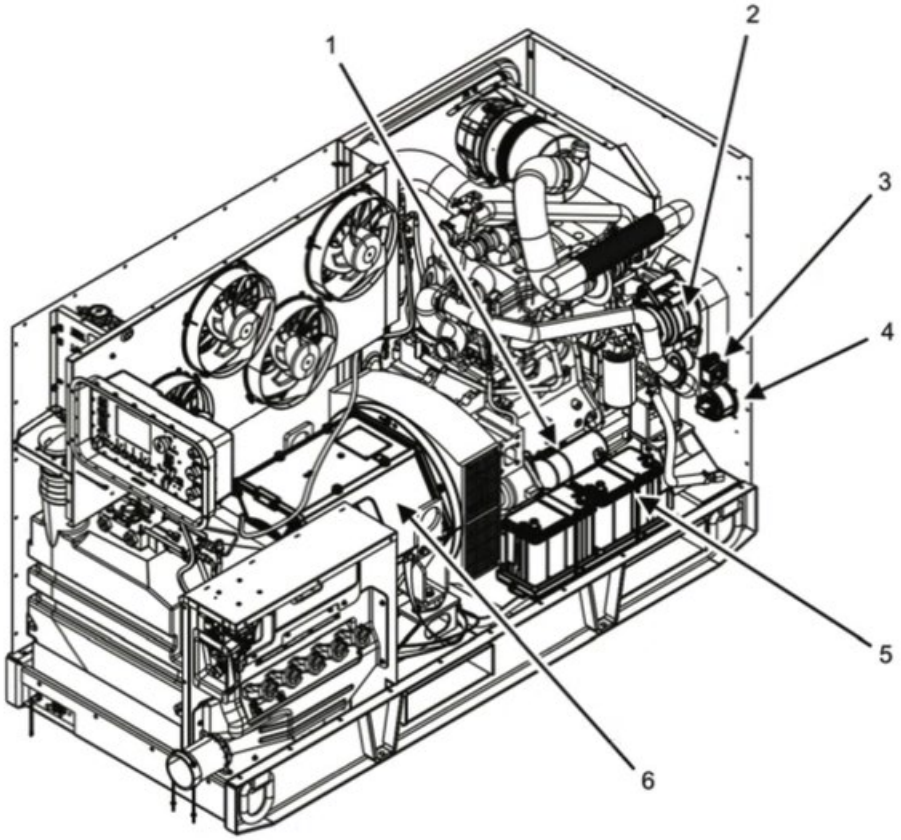
- TMS Tools
- Conclusion

EXAMPLE TMS INTEGRATION

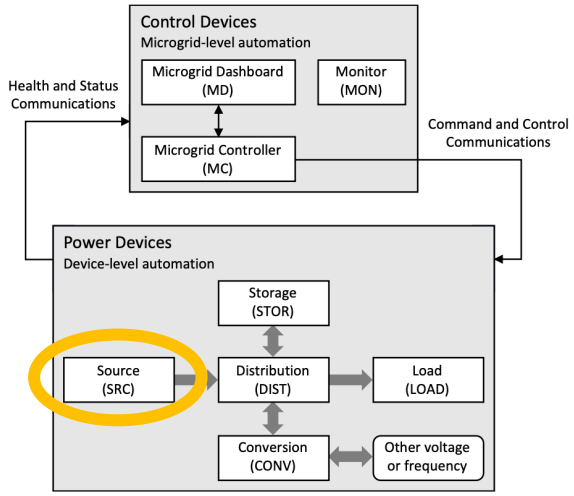
- Scope and purpose
  - Quick intro of how MIL-STD-3071 fits with power hardware
  - Informational only, not comprehensive or normative
  - Selected details and figures are for illustration purposes only
- Example scenario
  - Manufacturer or system integrator has a 60 kW genset product
  - Wants to add TMS support
- Walk through key implementation steps with example results
  - Requirements – describe customer needs in TMS terms
  - Design – map TMS interfaces to product
  - Design Review – validate integration approach
  - Testing – verify implementation



See Army TM 9-6115-753-10 (Distro A)

EXAMPLE REQUIREMENTS

- Activity: Select appropriate TMS device role(s)
  - See MIL-STD-3071 Section A.6
- Results:
  - A genset makes electricity, so it fits the SRC device role
  - Integrated microgrid controllers or distribution panels would add MC or DIST device roles. Such multi-function products are outside the scope of this example.



See MIL-STD-3071 Figure A.1: TMS Device Roles

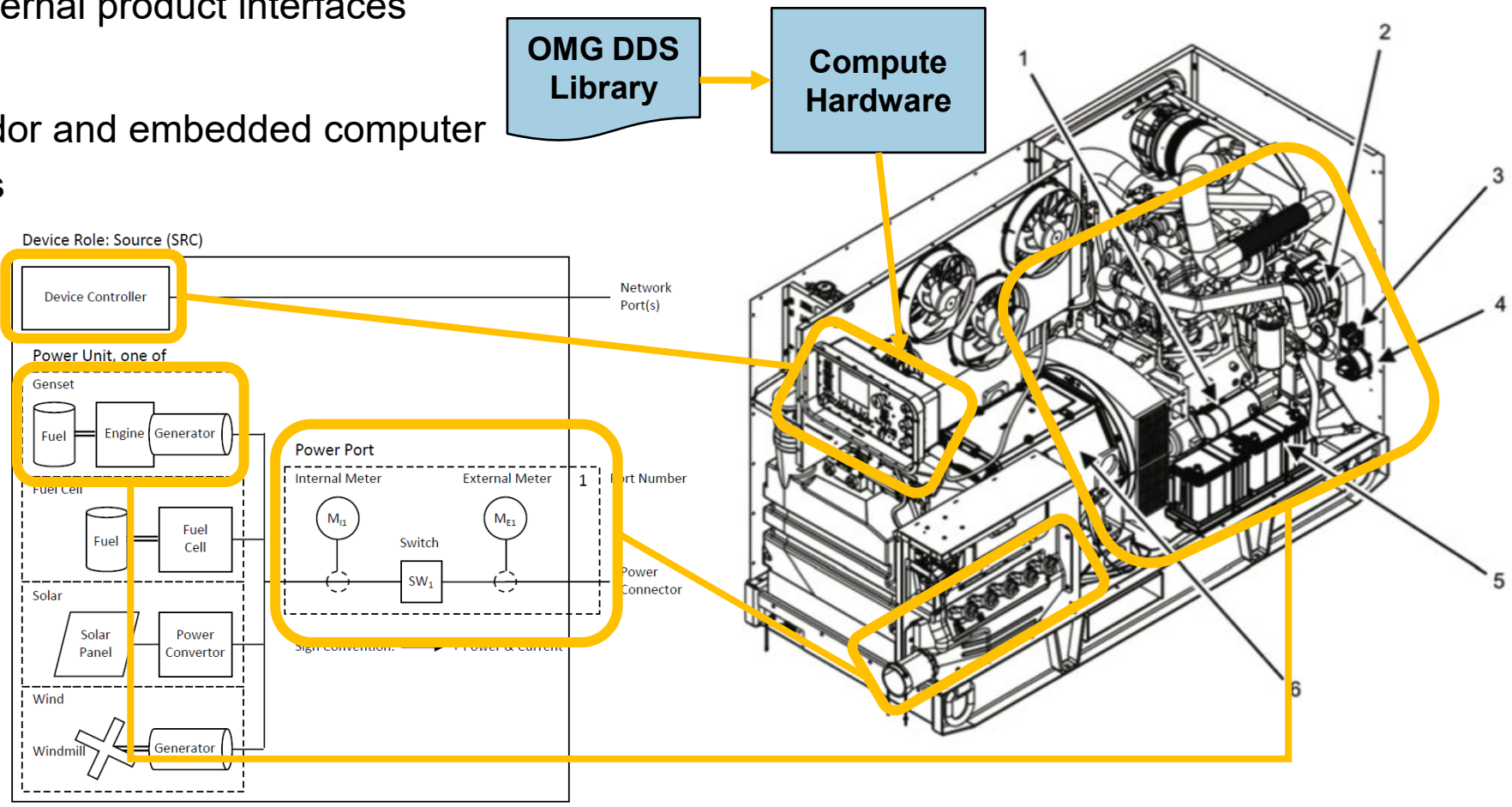
- Activity: Select appropriate TMS topics
  - See MIL-STD-3071 Section B
- Results
  - Topics required for all TMS SRC devices
  - Conditional topics
    - AC=yes, DC=no, …
  - Optional topics
    - Include load sharing, skip AuthorizationToEnergize, …

Topic	Usage	Selection
AcLoadSharingRequest	Optional	Y
AcLoadSharingState	Conditional on HAS_AC_PORTS	Y
AcMeasurementUpdate	Conditional on HAS_AC_METERS	Y
AcSummaryMeasurementUpdate	Conditional on HAS_AC_SUMMARY_METERS	N
ActiveDiagnosticState	Required	Y
ActiveMicrogridControllerState	Required	Y
AuthorizationToEnergizeReply	Conditional on SUPPORTS_REQUEST	N
AuthorizationToEnergizeRequest	Optional	N
AuthorizationToEnergizeResult	Optional	

See MIL-STD-3071 Table B.2: Overview of Topic Usage.

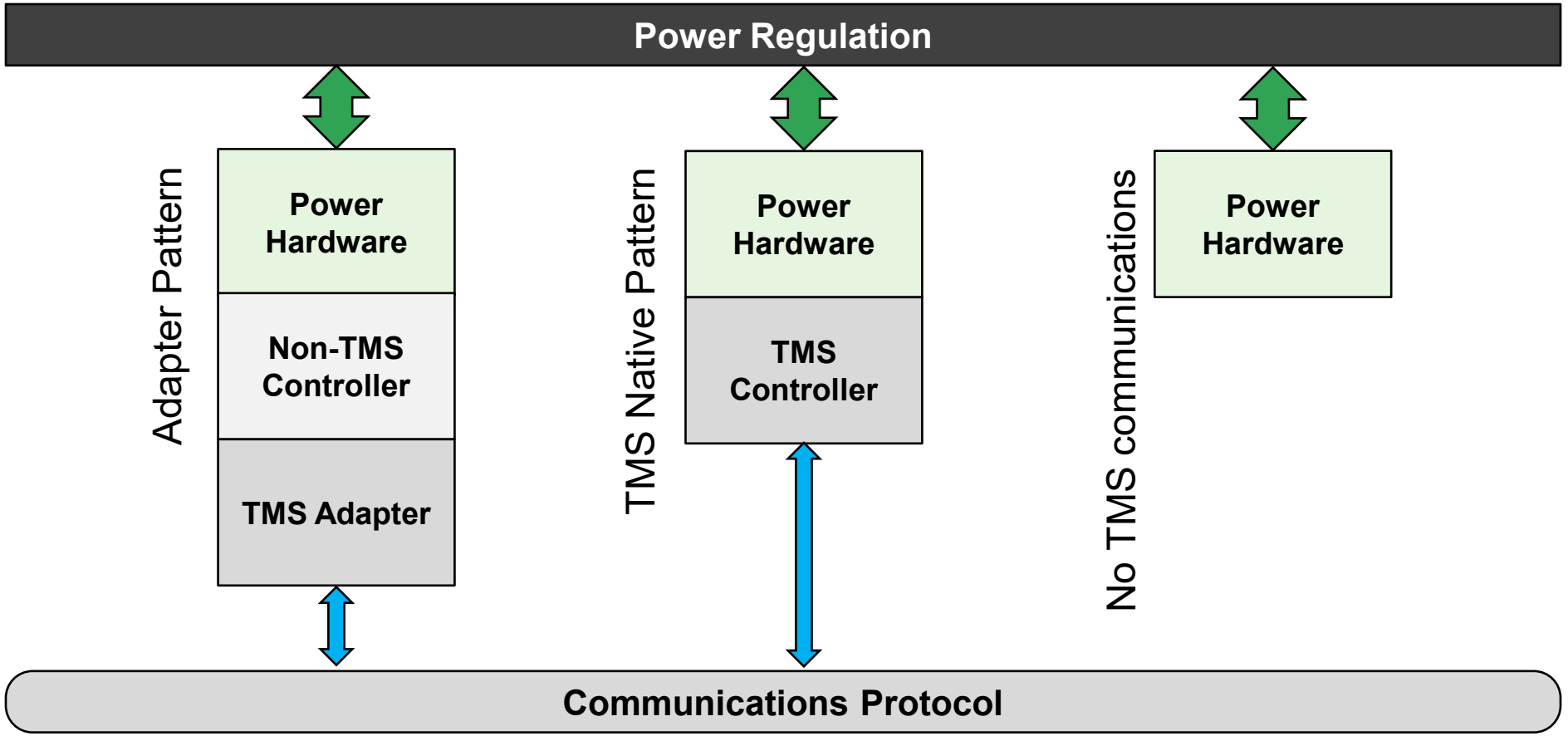
EXAMPLE DESIGN

- Activity: connect TMS to internal product interfaces
- Results:
  - Selected OMG DDS vendor and embedded computer
  - Hardware block diagrams
  - Software architecture



See MIL-STD-3071 Section B.1.2.3

DESIGN OPTION:
TMS INTEROPERABILITY IMPLEMENTATION PATTERNS



EXAMPLE DESIGN REVIEW

- Activity
  - Present design artifacts from previous activities
  - Deep dive into technical details with the review team
- Results
  - Authorization to build

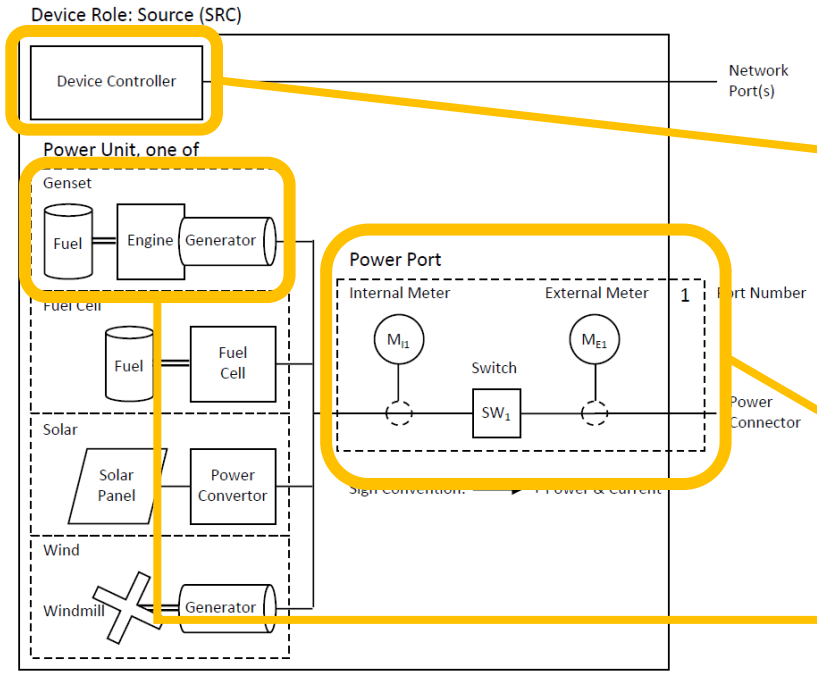
Example review of selected DeviceInfo values – tabular (shown) or JSON

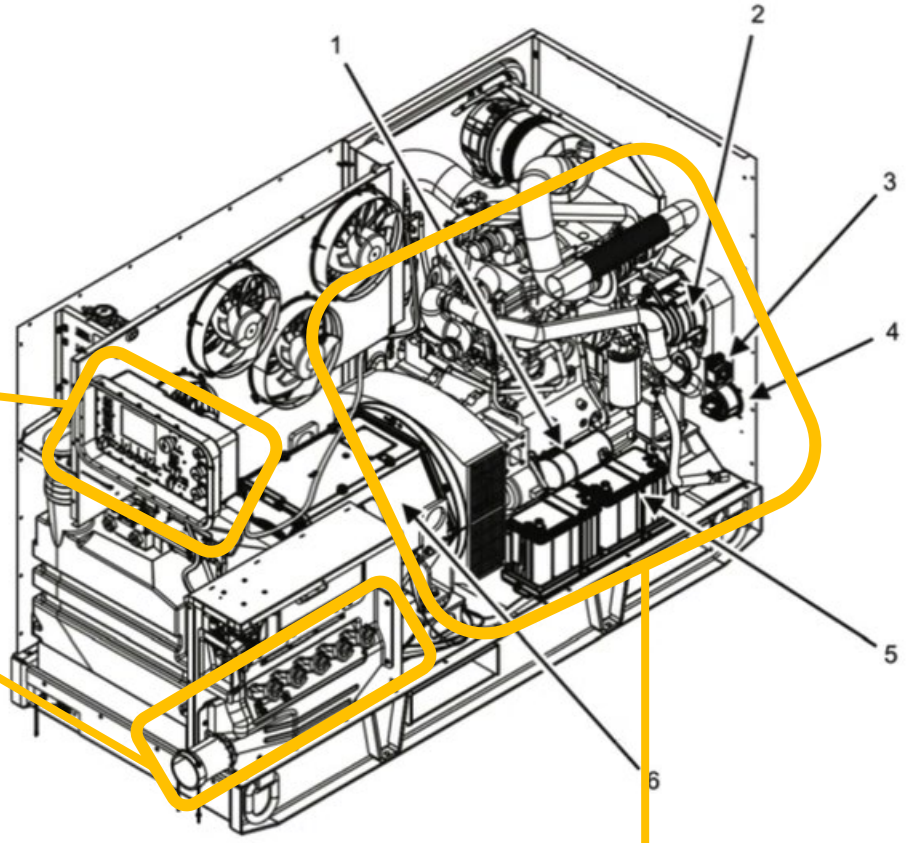
TMS Attribute	Product Value	Explanation
DeviceInfo.role	ROLE_SOURCE	Genset
TopicInfo.publishedConditionalTopics	Filled in	Results of previous activity
PowerHardwareInfo.generator	Filled in	SRC role
PowerHardwareInfo.energyStorage	Not filled in	Not STOR role
PowerDeviceInfo.powerPorts	1	Single 3-phase output
PowerDeviceInfo.source	Filled in	SRC role
LoadSharingInfo.maxRealPower	60,000	Rated for 60 kW
…	…	…

See MIL-STD-3071 Section B.5

EXAMPLE TESTING

- Activities
  - TMS network traffic compliance
  - Buzz out connections between TMS topics and hardware I/O
  - Check device control logic
- Results
  - All systems nominal





See MIL-STD-3071 Section B.1.2.3

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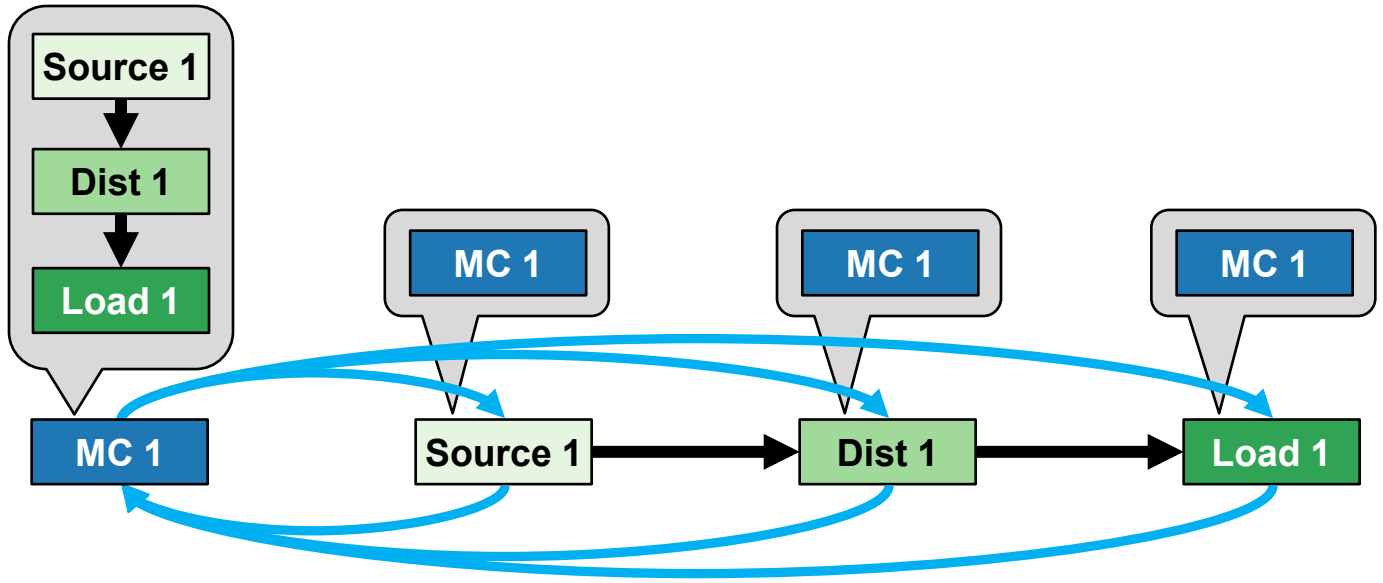
DISCOVERY

- All devices announces identity, type, and ratings.
- Enables rapid, ad-hoc deployment.
- Can happen in any order.

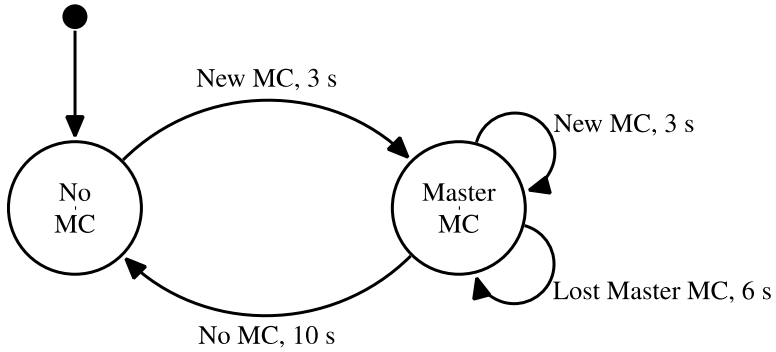


Power connections:

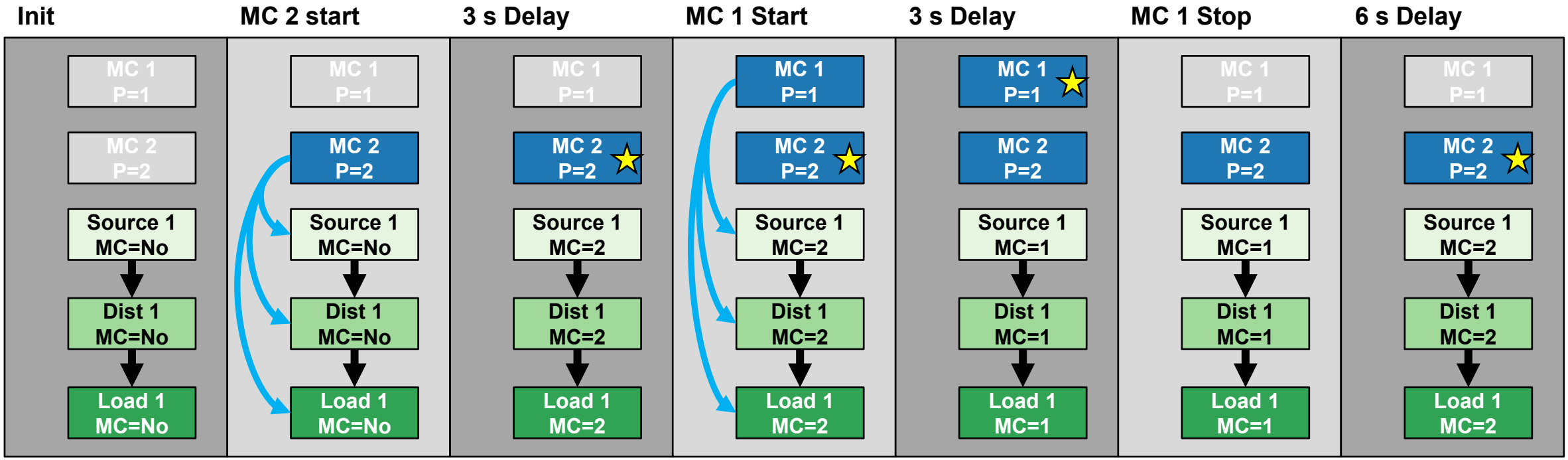
- **Smart cables**
- **Power correlation**
- **Manual entry**

MICROGRID CONTROLLER PRIORITY

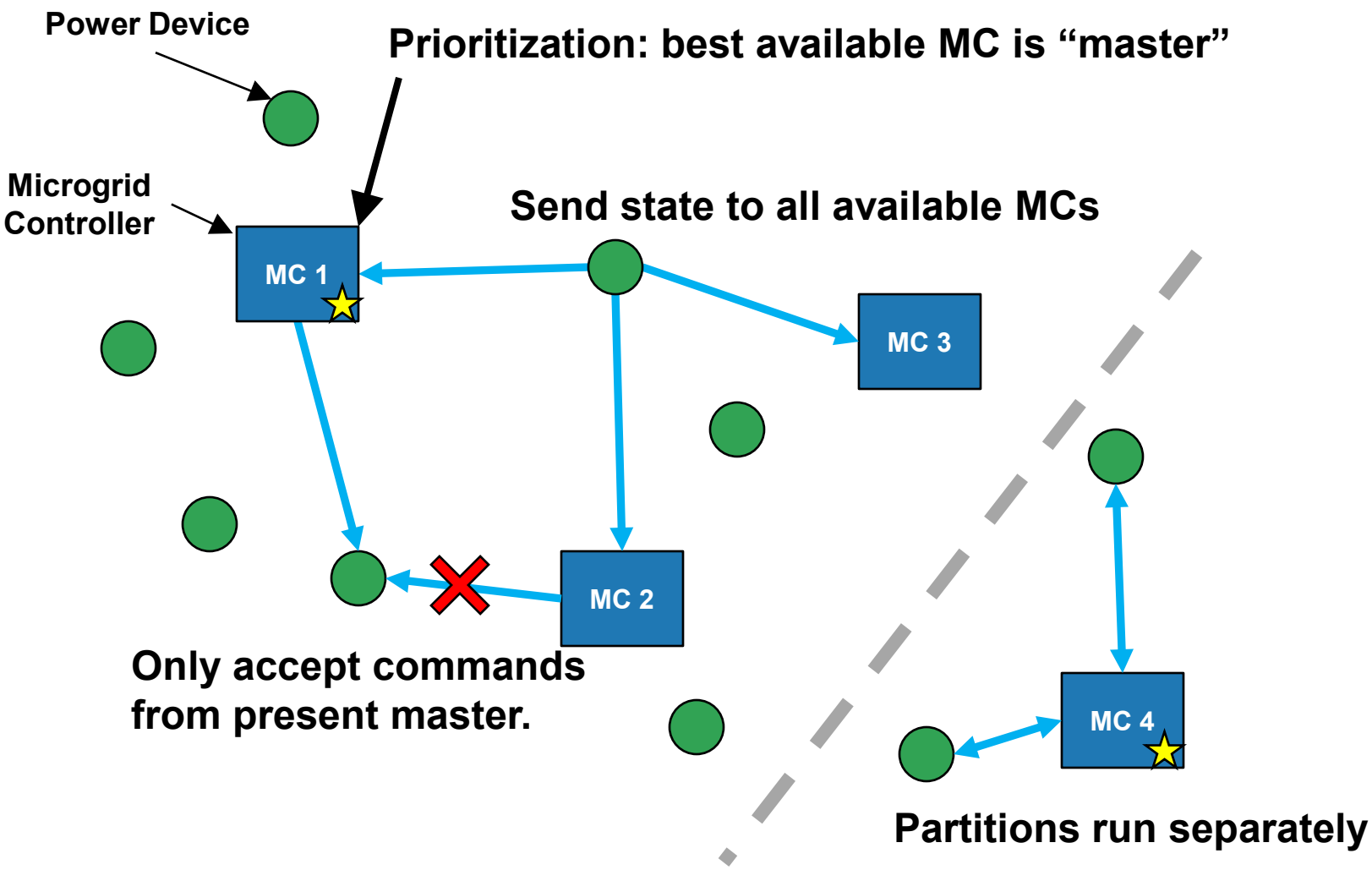
- Highest priority active MC gains control.
- All devices run same MC selection algorithm.



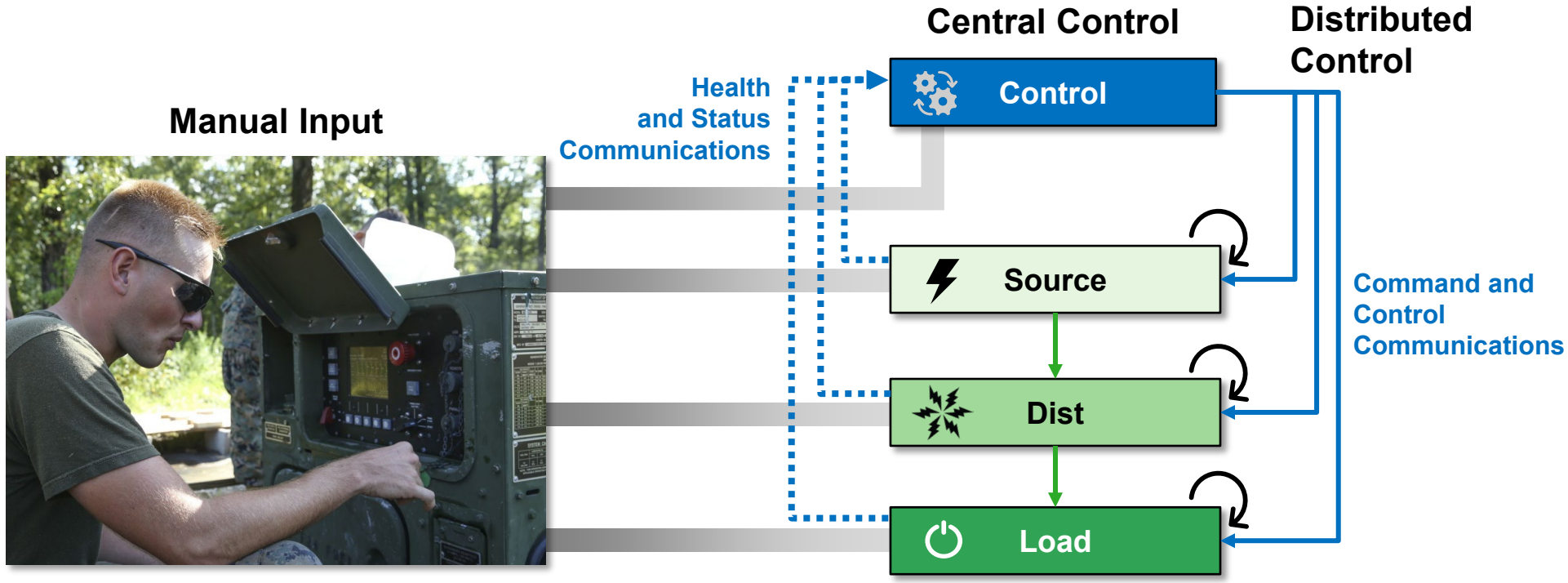
Example Sequence:



SUMMARY OF CONSENSUS APPROACH



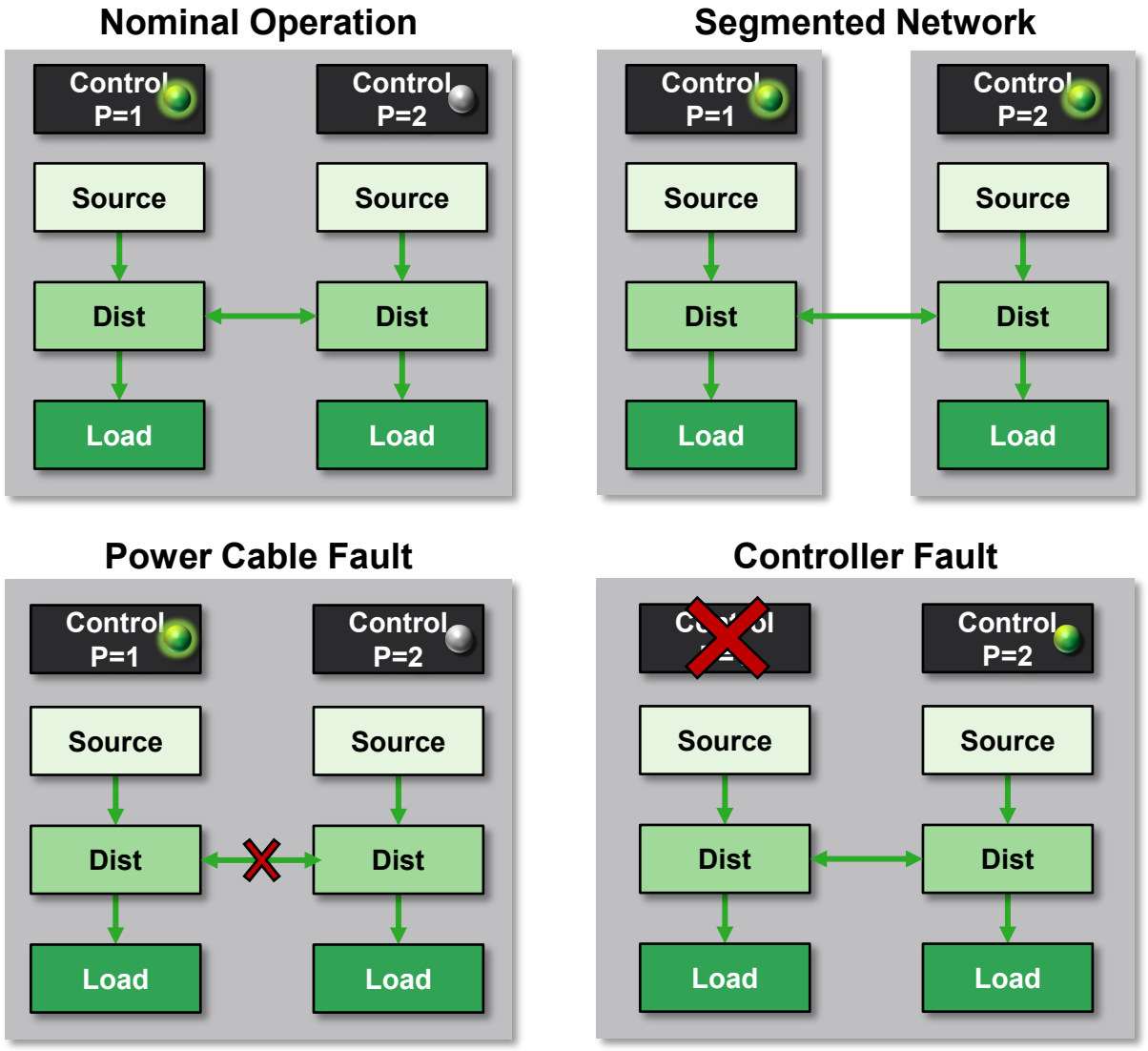
HIERARCHICAL CONTROL



The operator has positive control over individual devices and the whole system

Power
Communication input
Communication output
Control

RESILIENT CONTROL



- Operational Capabilities
- Robust against faults
- Supports Integrated Fight-Through Power
- Distributed control always operational
- Centralized control
  - Segments to handle network faults
  - Dispatches to handle hardware faults

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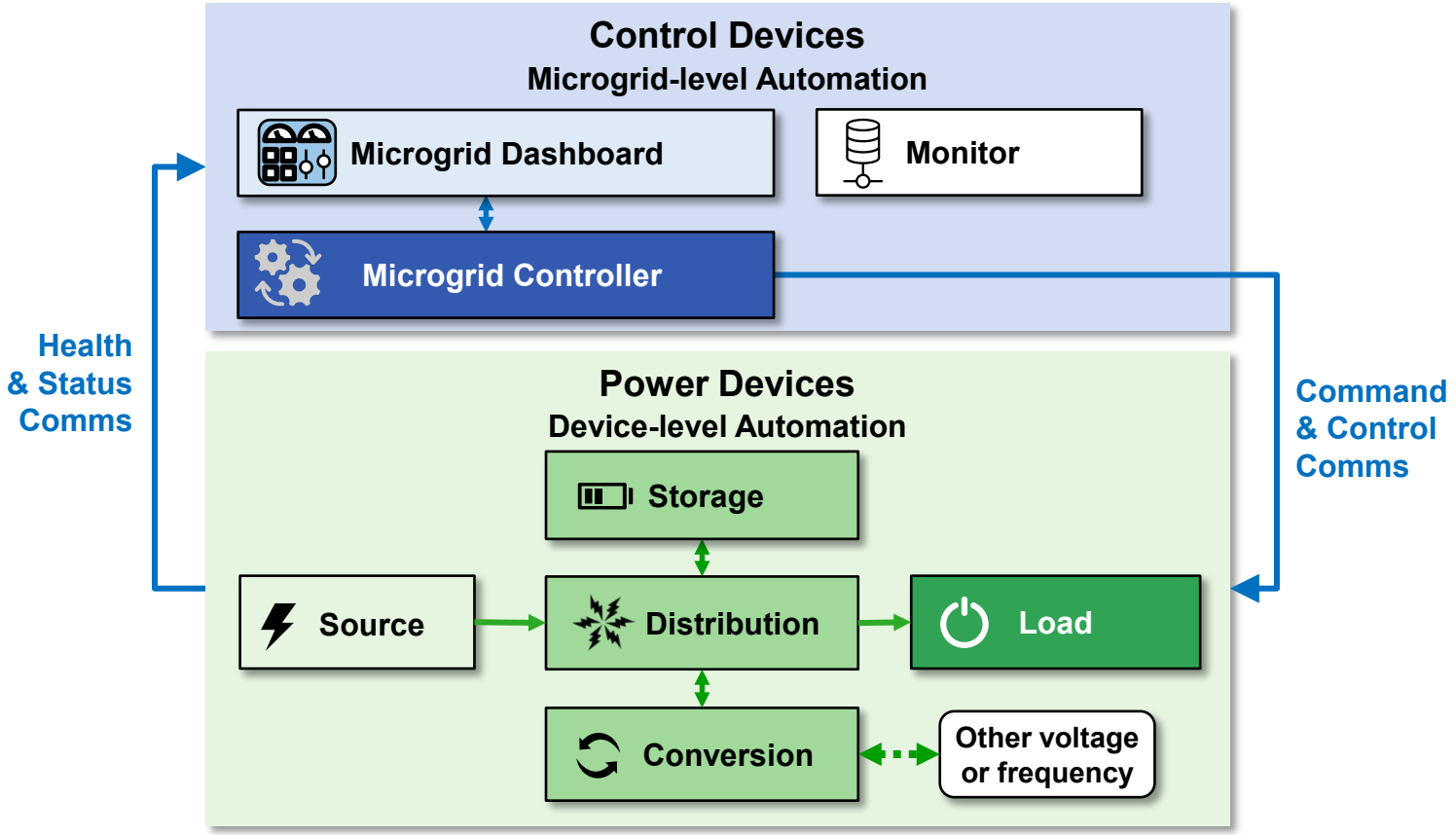
COTS COMMUNICATIONS

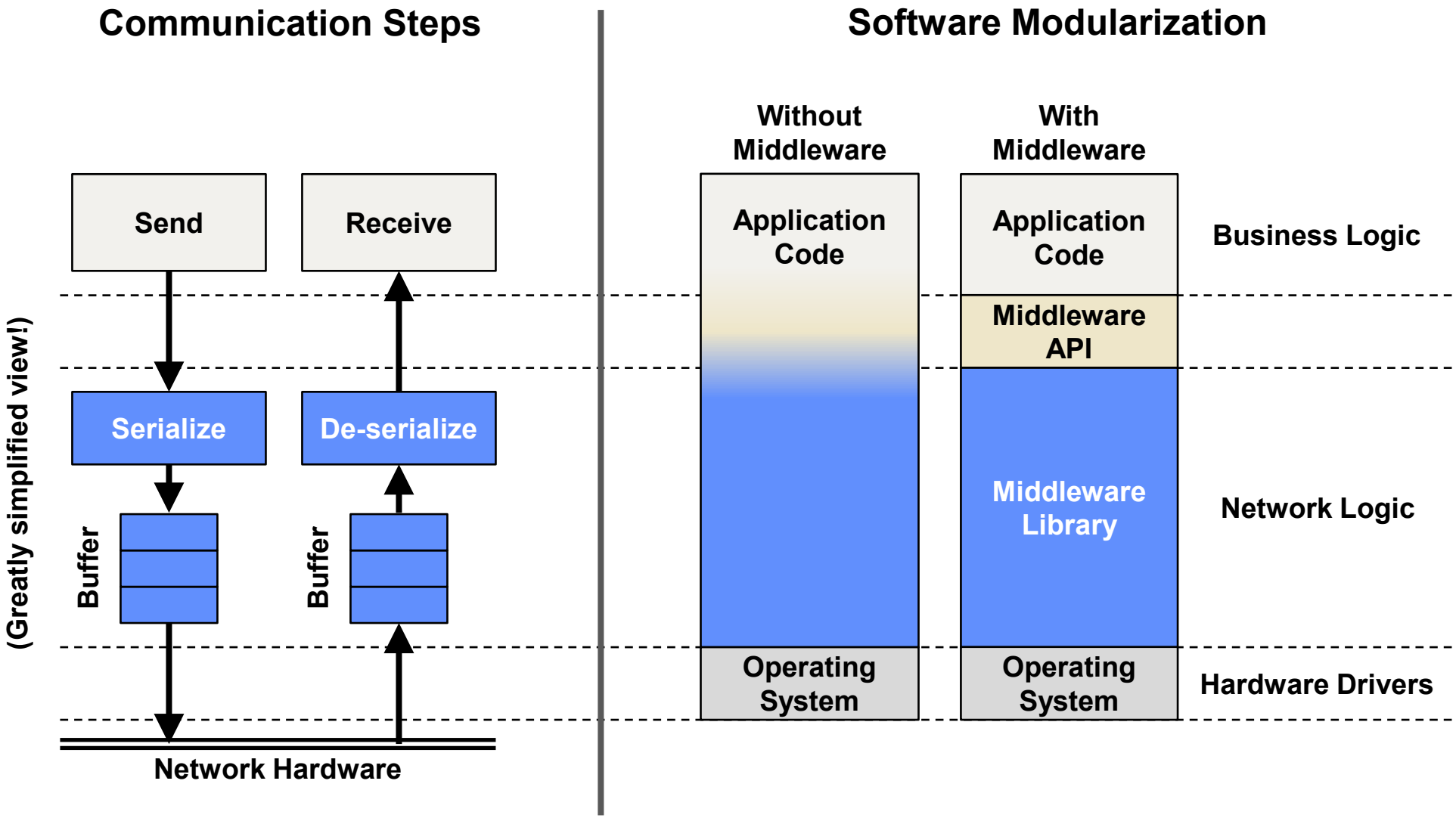


Object Management Group (OMG) Data Distribution Service (DDS)

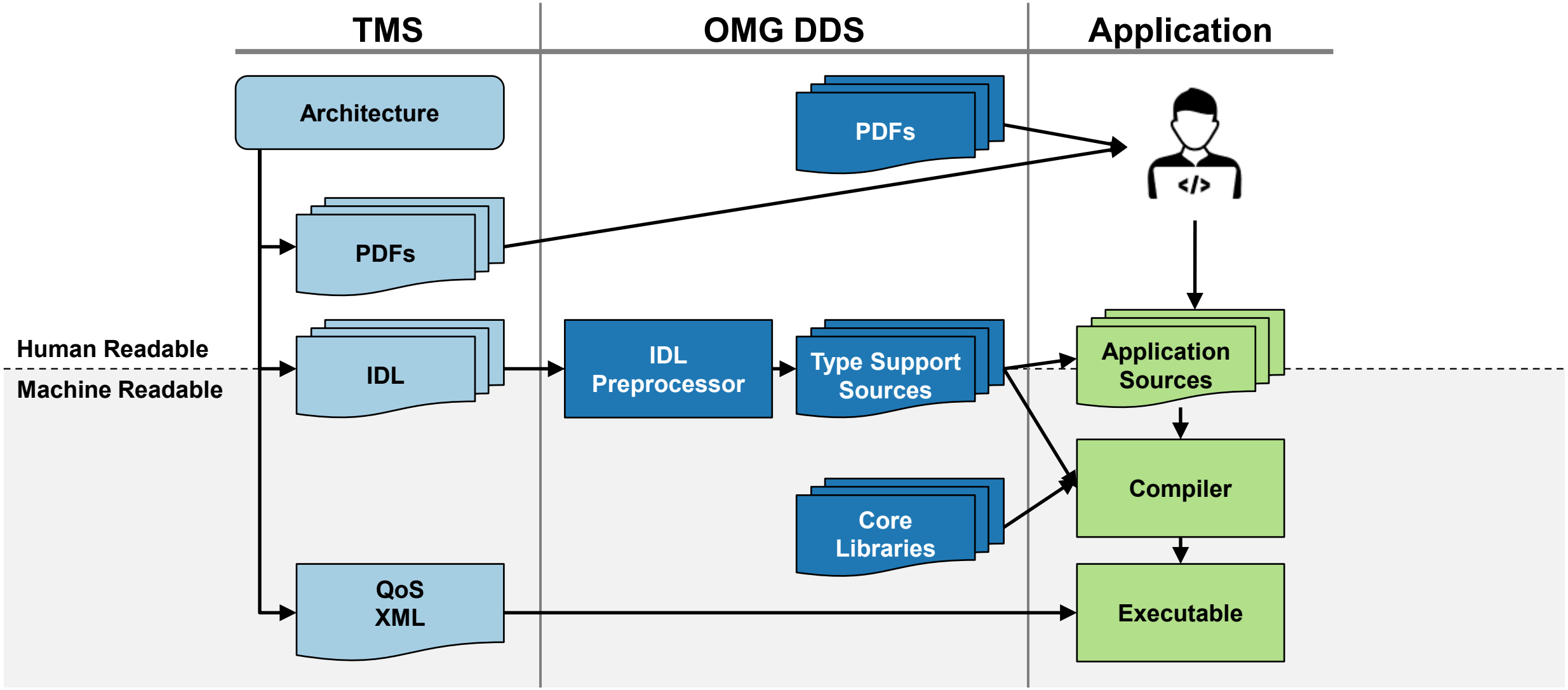
- **Technology Features**
  - **Ethernet with UDP/IP**
  - **Peer-to-peer publish/subscribe**
  - **High performance**
  - **Cybersecurity**
- **Ecosystem Features**
  - **Stable growth**
  - **Open platform**

TMS specifies how to use OMG DDS for microgrids

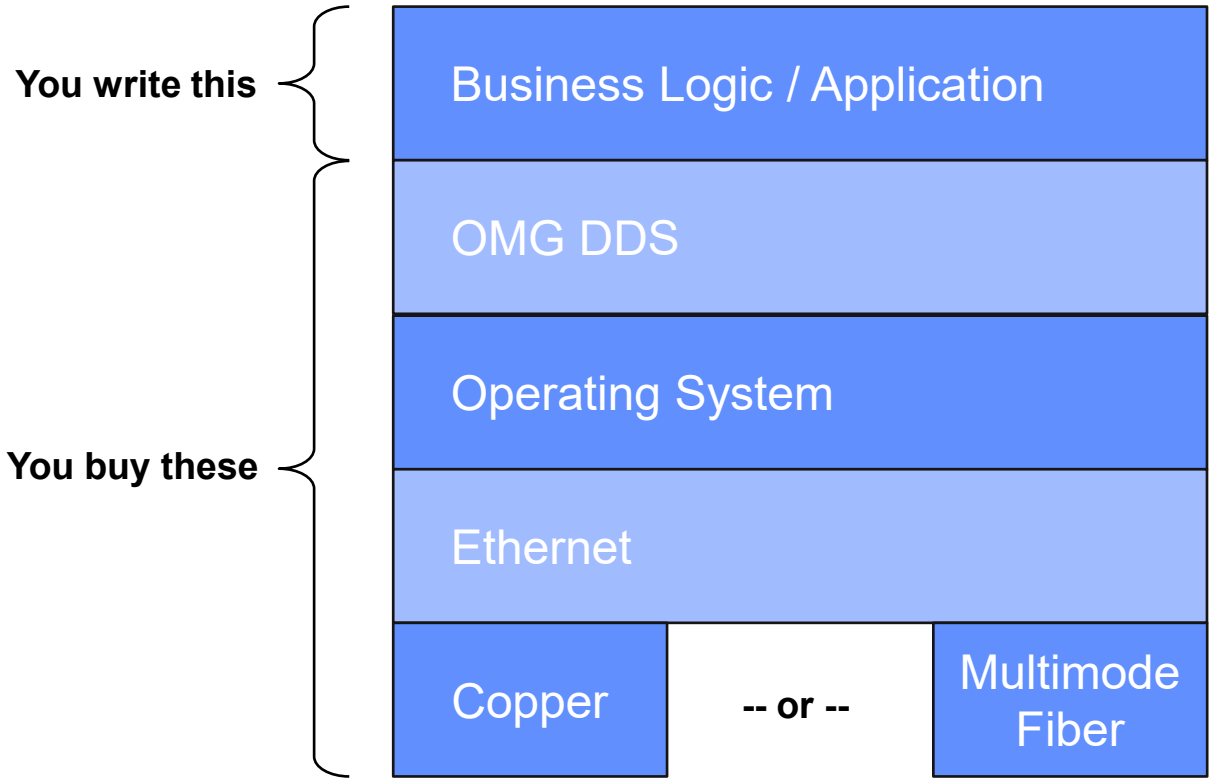
ILLUSTRATION OF MIDDLEWARE CONCEPT



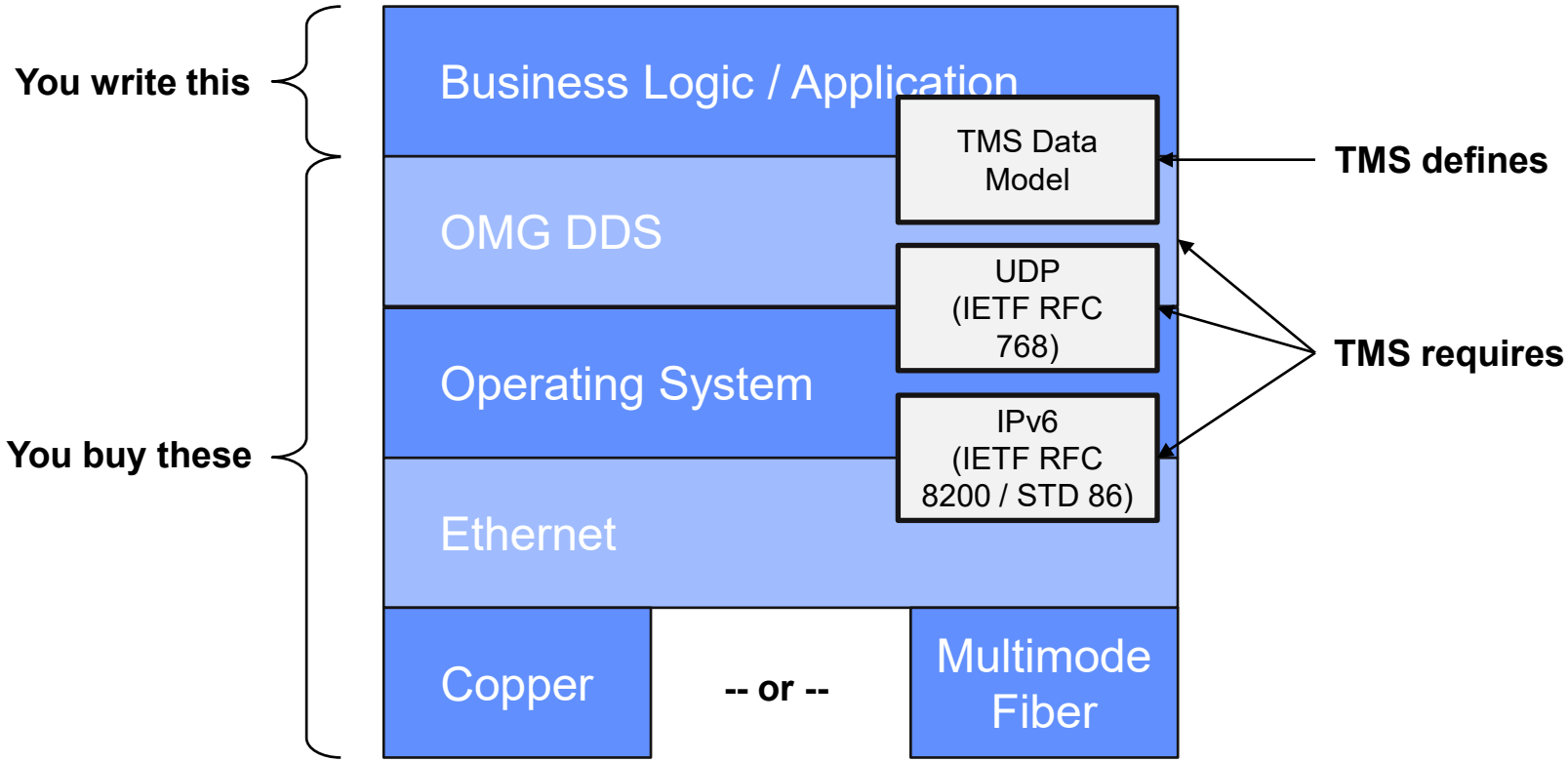
TMS SOFTWARE INTEGRATION



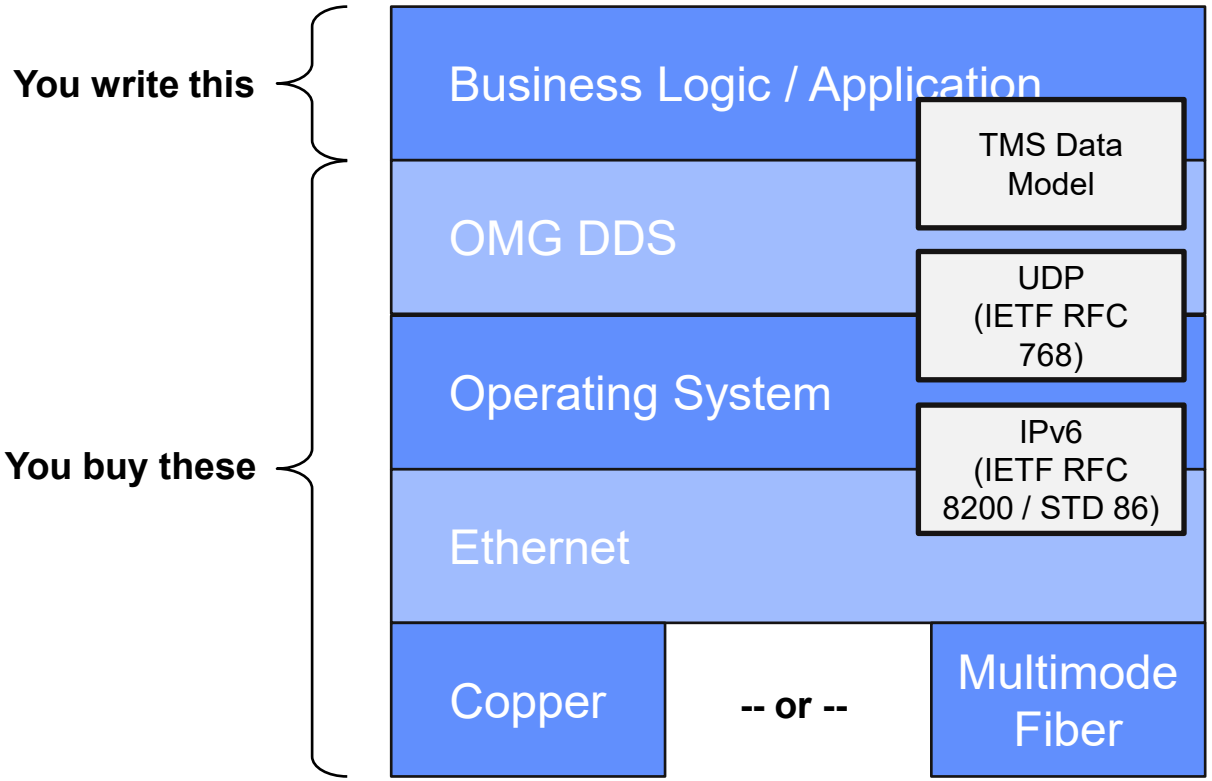
TMS NETWORK STACK



TMS NETWORK STACK INTERFACES



TMS NETWORK STACK REASONS



IPv6: No manual configuration or central server required for address assignment.

https://www.gao.gov/assets/gao-20-402.pdf
https://media.defense.gov/2014/Dec/01/2001713445/-1/-1/1/DODIG-2015-044.pdf

- Cheaper
- More widely available
- Cat6 rated for 100 m @ 1 Gbps

- Immune to EMI
- Good for long runs
- Patchable with primitive tools

Have considered wifi or cell

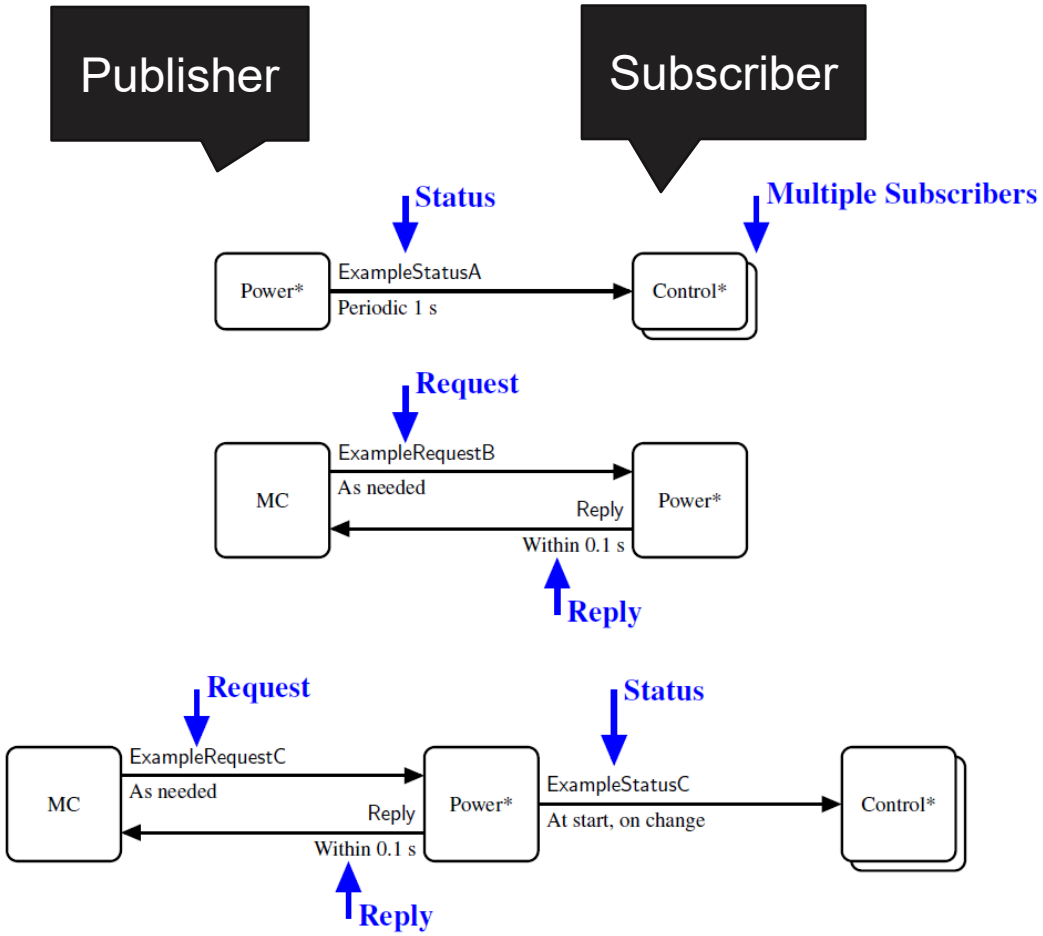
- **Prone to interference, jamming, latency, and/or eavesdropping**
- **➔ recommending against DoD use**

Have considered power line communications

- **Prone to RF interference**
- **Does not work when power switches open**
- **Poor interoperability between vendors**
- **➔ recommending against general use**

DATA FLOW PATTERNS

- Data sent over Topics
  - Each topic has exactly one data structure that is allowed on it.
  - Each topic has Quality of Service parameters, expected publishing rates defined and allowed data types.
- Interaction Patterns
  - Request/Reply
    - Configuration Change
  - Continuous Publish
    - Power measurements
  - Event driven
    - Join the network/boot up announcement and device information
  - On change
    - Engine/battery status



Common building blocks and patterns

TOPIC PUBLISH/SUBSCRIBE BY ROLE

Topic	Participants: MD	MC	SRC	STOR	DIST	LOAD	CONV	Section
AcLoadSharingRequest		P	S	S			S	B.21.1
AcLoadSharingState	S	S	P	P			P	B.21.1
AcMeasurementUpdate	S	S	P	P	P	P	P	B.18.1
AcSummaryMeasurementUpdate		S	P	P	P	P	P	B.18.1
ActiveDiagnosticState	S	P S	P	P	P	P	P	B.12.1
ActiveMicrogridControllerState	S	S	P	P	P	P	P	B.13.1
AuthorizationToEnergizeReply	P S		S	S	S		S	B.24.1
AuthorizationToEnergizeRequest	S		P	P	P		P	B.24.1
AuthorizationToEnergizeResult	S	S	P	P	P		P	B.24.1
ClockState	P S	P S	P	P	P	P	P	B.23.1
ControlHardwareUpdate	P S	P S	P	P	P	P	P	B.8.1
ControlParameterRequest		P	S	S	S	S	S	B.14.1
ControlParameterState	S	S	P	P	P	P	P	B.14.1
DcLoadSharingRequest		P	S	S			S	B.22.1
DcLoadSharingState	S	S	P	P			P	B.22.1
DcMeasurementUpdate	S	S	P	P	P	P	P	B.19.1
DcSummaryMeasurementUpdate		S	P	P	P	P	P	B.19.1
DeviceIcon	P S	P	P	P	P	P	P	B.7.1

Subset of Table B.1: Overview of Topic Participants – see MIL-STD-3071

P – Publish
S – Subscribe

NEXT SECTION

- Background
- TMS Architecture Concepts
- Example Device Behaviors
- Communications Layer
- **TMS Tools**
- **Conclusion**

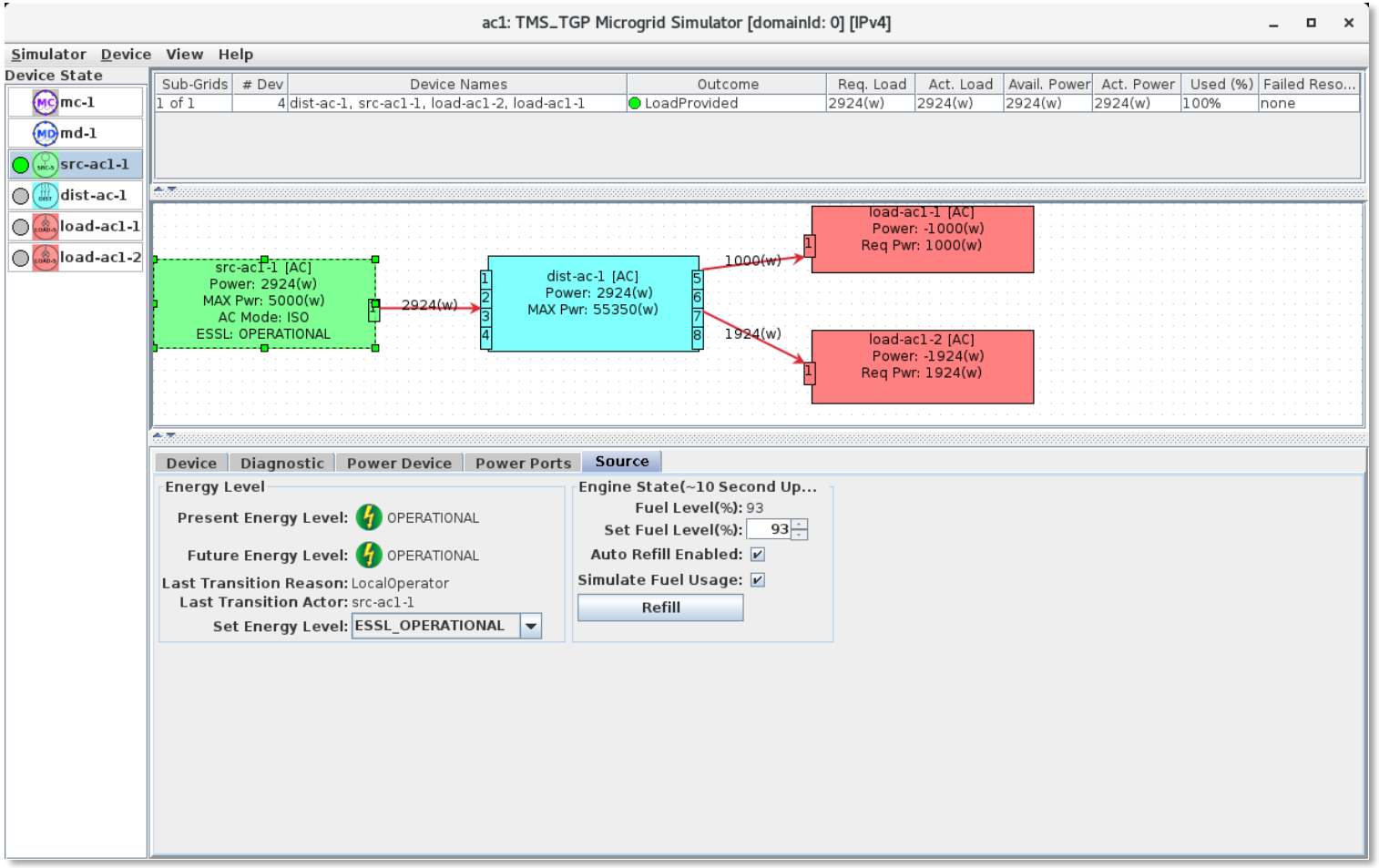
TMS TOOLS OVERVIEW

TMS Tools are *Distribution Statement C*: Distribution authorized to U.S. Government agencies and their contractors

- Available Tools
  - TMS Microgrid Simulator
    - Publish and subscribe TMS traffic for virtual devices
  - TMS Topic Monitor
    - Diagnostics tool for observing TMS traffic
  - TMS Test Stand
    - Compliance checks for TMS traffic
- Upcoming Tools
  - TMS Bandwidth Calculator
    - Calculate TMS traffic statistics for selected devices

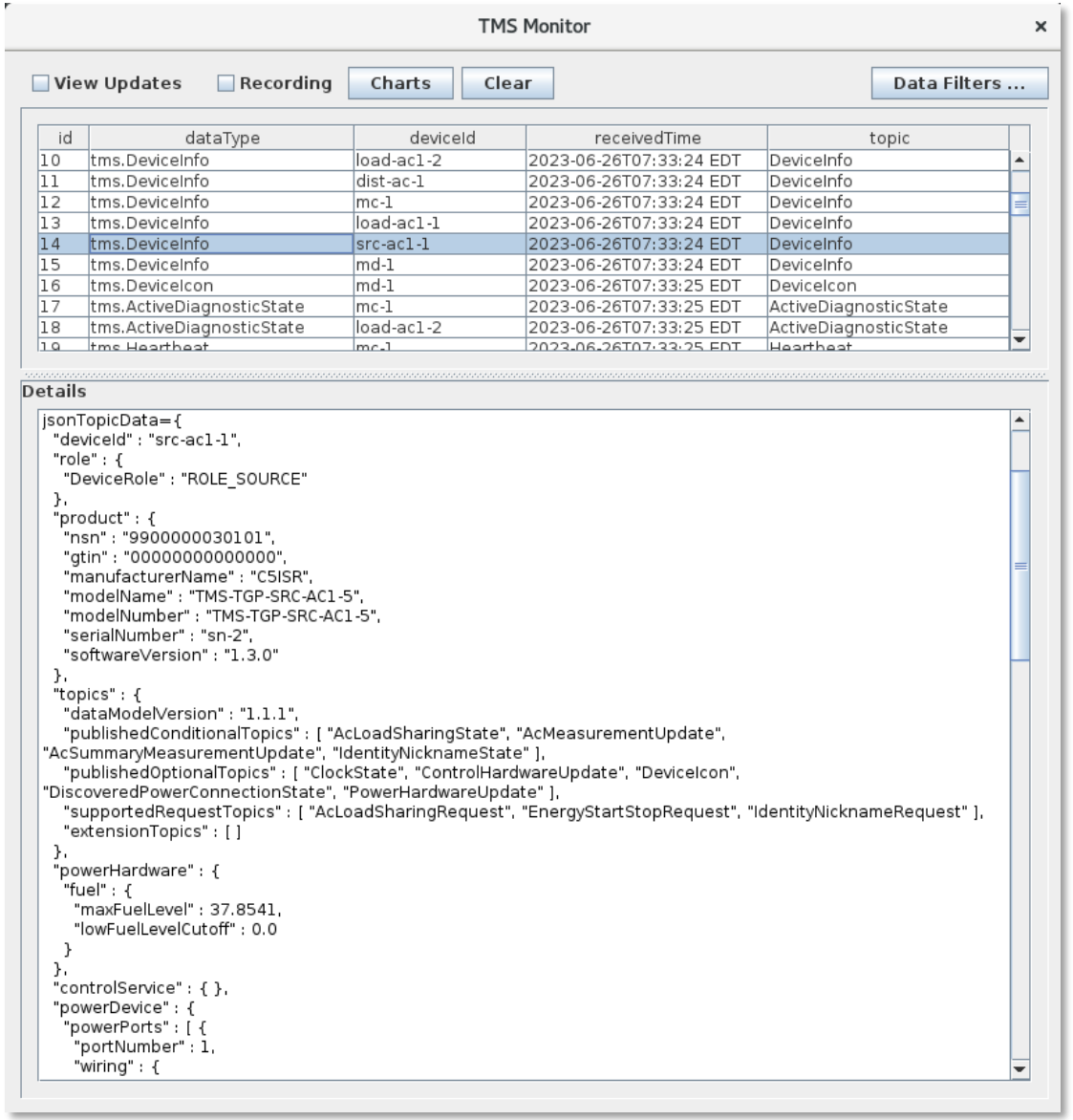
TMS MICROGRID SIMULATOR

- GUI Microgrid Simulator
- Supports all TMS device roles
- Supports all TMS Topics
- Numerous pre-built and user-defined grids
- Approximates grid power flows
  - Power Measurements
  - Load Sharing
- Simulated MC publishes all TMS requests for remote control
- Sunny and rainy-day testing with values out of range
- Simulate device states
  - Power measurements
  - Fuel level
  - State of charge
  - Active diagnostics



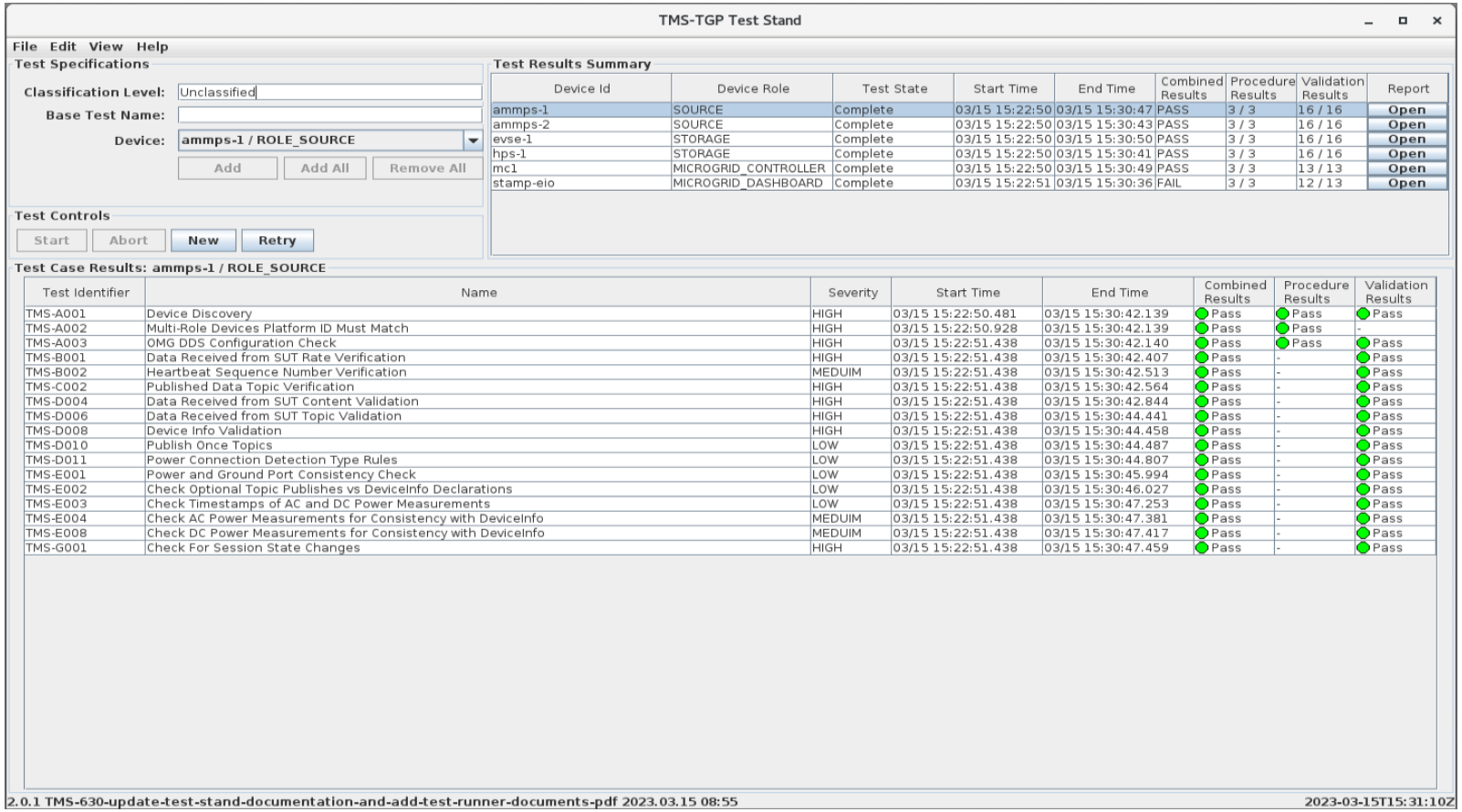
TMS TOPIC MONITOR

- GUI display of published TMS Topics
- Implements “MONITOR” Device Role
- Subscribes to all published topics
- Displays topic data in JSON format
- Basic topic data filters
- Line charts for numeric fields
- Ability to save to JSON files



TMS TEST STAND

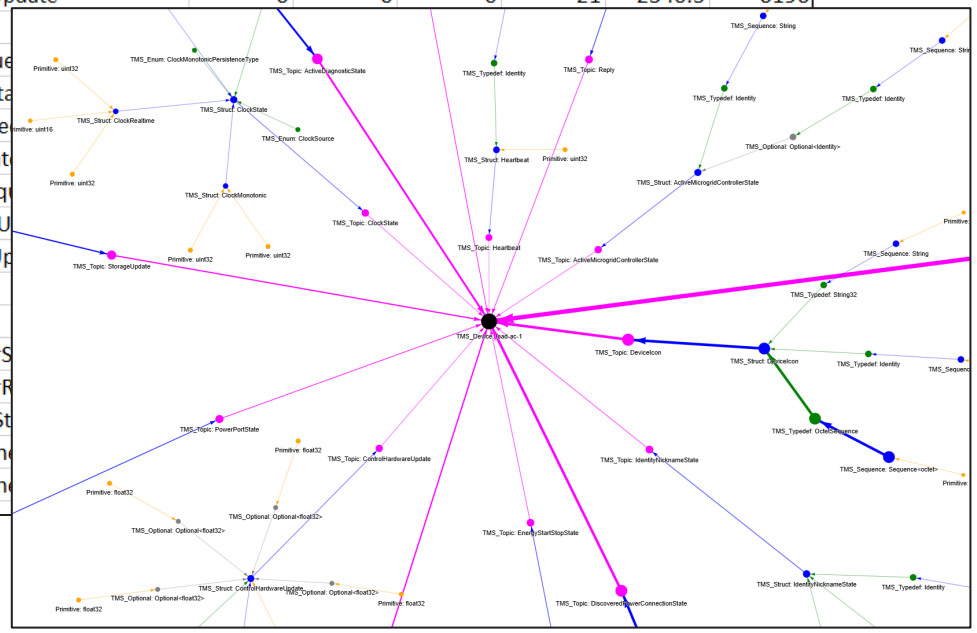
- Verifies device compliance to MIL-STD-3071
- Recording and persistence of TMS topic data for the duration of testing
- Generates .docx reports
- Real time plots of most TMS metrics and measurements



TMS BANDWIDTH CALCULATOR

- Reads DeviceInfo JSON from other TMS Tools
- Calculates TMS network bandwidth statistics
  - Per device and microgrid total
  - Publish and subscribe
  - Device-specific data sizes
  - Timing such as periodic and as-needed
  - Unicast and multicast traffic patterns
  - Optional OMG DDS Security overhead
- Outputs spreadsheets, machine-readable files, and visualizations
- Currently in pre-release development
  - Please direct requests to Daniel Herring, dherring@ll.mit.edu

	A	B	C	D	E	F	G
1	name	min_in	mean_in	max_in	min_out	mean_out	max_out
2	Heartbeat	0	0	0	9	24.5	40
3	DeviceInfo	0	0	0	0	110076	2773970
4	DeviceIcon	0	0	0	0	16429	32844
5	IdentityNicknameState	0	0	0	0	61	108
6	IdentityNicknameRequest	0	142	236	0	69	116
7	OperatorPowerConnectionState	0	0	0	0	6549.5	24840
8	DiscoveredPowerConnectionState	0	0	0	0	6549.5	24840
9	MicrogridPowerConnectionState	0	0	0	0	6549.5	24840
10	ActiveDiagnosticState	0	0	0	0	1692.5	4908
11	ClockState	0	0	0	0	56.5	72
12	ActiveMicrogridControllerState	0	0	0	0	30.75	72
13	AcMeasurementUpdate	0	0	0	21	2340.5	6196
14	PowerPortState						
15	PowerSwitchReque						
16	EnergyStartStopSta						
17	EnergyStartStopRe						
18	AcLoadSharingStat						
19	AcLoadSharingReq						
20	ControlHardwareU						
21	PowerHardwareUp						
22	StorageUpdate						
23	Reply						
24	ControlParameterS						
25	ControlParameterR						
26	MetricParameterSt						
27	AuthorizationToEn						
28	AuthorizationToEn						



NEXT SECTION

- Background
- TMS Architecture Concepts
- Example Device Behaviors
- Communications Layer
- TMS Tools
- Conclusion

ADMIN REMARKS

On Base Food Options?

- Subway – Building 6007
- Subway – Express
- Tropical Smoothie – Post Exchange
- Eat Like a Greek – Brewner Lanes Bowling Alley (BLDG 2342)
- First Sergeants BBQ – AA Recreation Center (BLDG 3326)

Off Base Food Options?

Poster Session?

Demonstration?

TMS Team Availability?

Virtual Participants? - Return at 1515 for Compliance Overview

Agenda Item	Time (EST)
Welcome and Administrative Brief	0900-0930
Government Organization Introductions	0930-1000
TMS Executive Overview	1000-1030
Break	1030-1040
Overview on APAN and how to participate in TMS community	1040-1055
TMS Governance Participation	1055-1105
TMS Technical Overview	1105-1200
Admin Remarks	**1200-1205**
Lunch	**1205-1330**
Poster Session (Start will overlap lunch)	**1300-1400**
Hardware Demonstration	**1400-1505**
Break	1505-1515
Compliance Overview	1515-1600
TMS Q&A Panel and Concluding Remarks	1600-1630

DEMONSTRATIONS

Demo Stop	Title	Location
A	NASA	Multifunction Room
B	TMS Dashboard and Monitor	Room 101
C	AC Microgrid	Parking Lot South Side
D	Vehicle Microgrid	Parking Lot North Side

	1	2	3	4
1400				
1405	A	B		
1410			C	D
1415				
1420	B	A		
1425			D	C
1430				
1435				
1440	C	D		
1445			A	B
1450				
1455	D	C		
1500			B	A
1505				

BREAK

Agenda Item	Time (EST)
Welcome and Administrative Brief	0900-0930
Government Organization Introductions	0930-1000
TMS Executive Overview	1000-1030
Break	1030-1040
Overview on APAN and how to participate in TMS community	1040-1055
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TMS Technical Overview	1105-1200
Admin Remarks	1200-1205
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Break	**1505-1515**
Compliance Overview	1515-1600
TMS Q&A Panel and Concluding Remarks	1600-1630

TMS

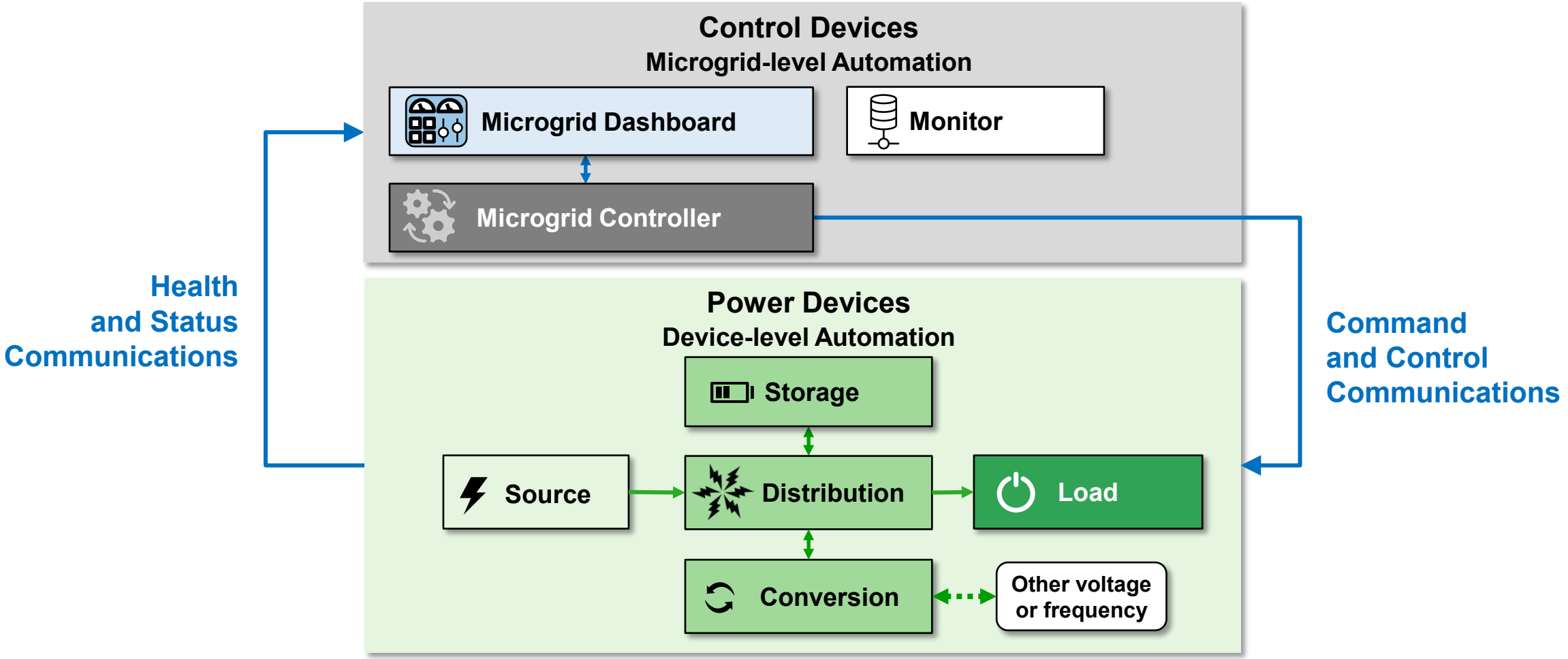
TACTICAL MICROGRID STANDARD

Compliance Overview

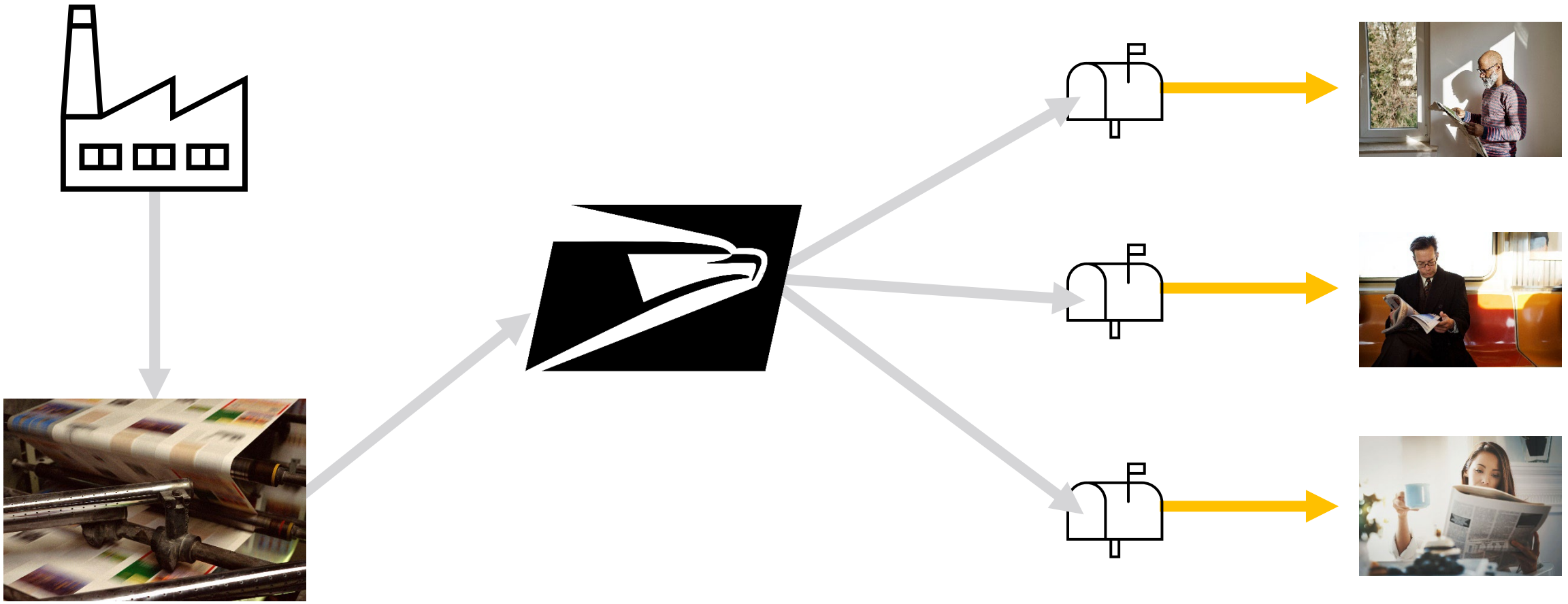
TMS COMPLIANCE OVERVIEW

- TMS Refresher
- Compliance High Level Definition
- Compliance Ecosystem
- TMS Compliance Test Overview
- Example

TMS ARCHITECTURE OVERVIEW



PUB/SUB: NON-TECHNICAL



1. Device A Populates Data

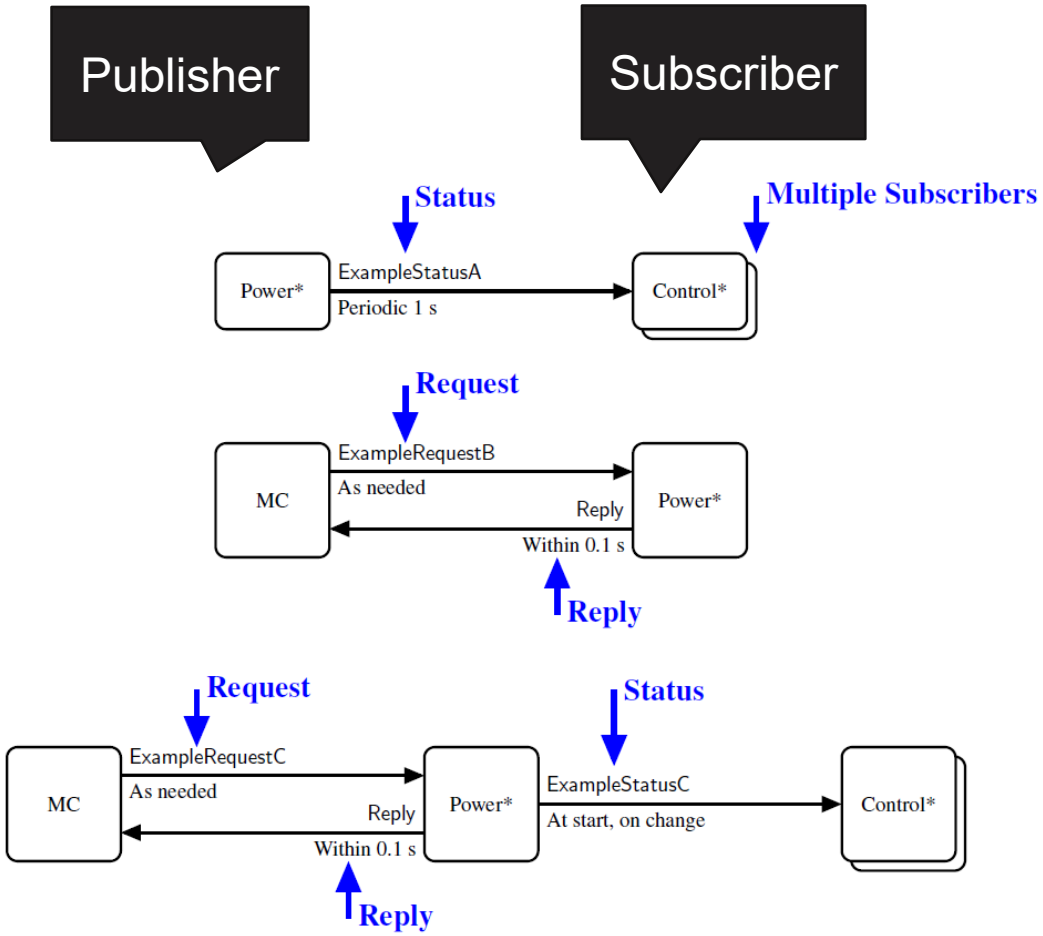
2. Published by DDS Middleware

3. Middleware receives subscribed data

4. Device B actions on data

DATA FLOW PATTERNS

- Data sent over Topics
  - Each topic has exactly one data structure that is allowed on it.
  - Each topic has Quality of Service parameters, expected publishing rates defined and allowed data types.
- Interaction Patterns
  - Request/Reply
    - Configuration Change
  - Continuous Publish
    - Power measurements
  - Event driven
    - Join the network/boot up announcement and device information
  - On change
    - Engine/battery status



Common building blocks and patterns

TOPIC PUBLISH/SUBSCRIBE BY ROLE

P – Publish
S – Subscribe

Table 3.1: Overview of All Data Model Topics.

Topic	Participants: MD	MC	SRC	STOR	DIST	LOAD	CONV	Section
Heartbeat	P S	P S	P S	P S	P S	P S	P S	3.3
DeviceAnnouncement	P S	P S	P S	P S	P S	P S	P S	3.4
DeviceIcon	S	P	P	P	P	P	P	3.6
FingerprintNickname	P S	P	P	P	P	P	P	3.5
FingerprintNicknameRequest	P S	S	S	S	S	S	S	3.5
OperatorConnectionList	P	S						3.22
DiscoveredConnectionList		S	P	P	P	P	P	3.5
MicrogridConnectionList	S	P						3.22
ActiveDiagnostics	S	P S	P	P	P	P	P	3.11
DeviceClockStatus	P S	P S	P	P	P	P	P	3.26
StandardConfigMaster	S	S	P	P	P	P	P	3.12
DevicePowerMeasurementList	S	S	P	P	P	P	P	3.20

Standardized Data Underpin Interoperability

TOPIC REQUIRED BY ROLE

Table B.2: Overview of Topic Usage.

Topic	Usage	Section
AcLoadSharingRequest	Optional	B.21.1
AcLoadSharingState	Conditional on HAS_AC_PORTS	B.21.1
AcMeasurementUpdate	Conditional on HAS_AC_METERS	B.18.1
AcSummaryMeasurementUpdate	Conditional on HAS_AC_SUMMARY_METERS	B.18.1
ActiveDiagnosticState	Required	B.12.1
ActiveMicrogridControllerState	Required	B.13.1
AuthorizationToEnergizeReply	Conditional on SUPPORTS_REQUEST	B.24.1
AuthorizationToEnergizeRequest	Optional	B.24.1
AuthorizationToEnergizeResult	Optional	B.24.1
ClockState	Optional	B.23.1
ControlHardwareUpdate	Optional	B.8.1
ControlParameterRequest	Optional	B.14.1
ControlParameterState	Conditional on HAS_CONTROL_PARAMETERS	B.14.1
DcLoadSharingRequest	Optional	B.22.1
DcLoadSharingState	Conditional on HAS_DC_PORTS	B.22.1
DcMeasurementUpdate	Conditional on HAS_DC_METERS	B.19.1
DcSummaryMeasurementUpdate	Conditional on HAS_DC_SUMMARY_METERS	B.19.1
DeviceIcon	Optional	B.7.1
DeviceInfo	Required	B.5.1
DiscoveredPowerConnectionState	Optional	B.20.1
EnergyStartStopRequest	Optional	B.16.1
EnergyStartStopState	Required	B.16.1

TEST CATEGORIES

- TMS-AXXX - Discovery and OMG DDS configurations
- TMS-BXXX - Topic publications rates and timing
- TMS-CXXX - Topic subscriptions and publications match role requirements
- TMS-DXXX - Data validation (values within allowed ranges)
- TMS-EXXX - Cross topic published data consistency
- TMS-FXXX - Published data validation against independent measurements
- TMS-GXXX - Behaviors, Stability and Security validation
- TMS-HXXX - Safety and other requirements

COMPLIANCE DEFINITIONS

- Compliant
  - Implements all **Required** Topics

- Compatible
  - Implements most topics needed for interoperability

- Conformant
  - Monitoring capability Only

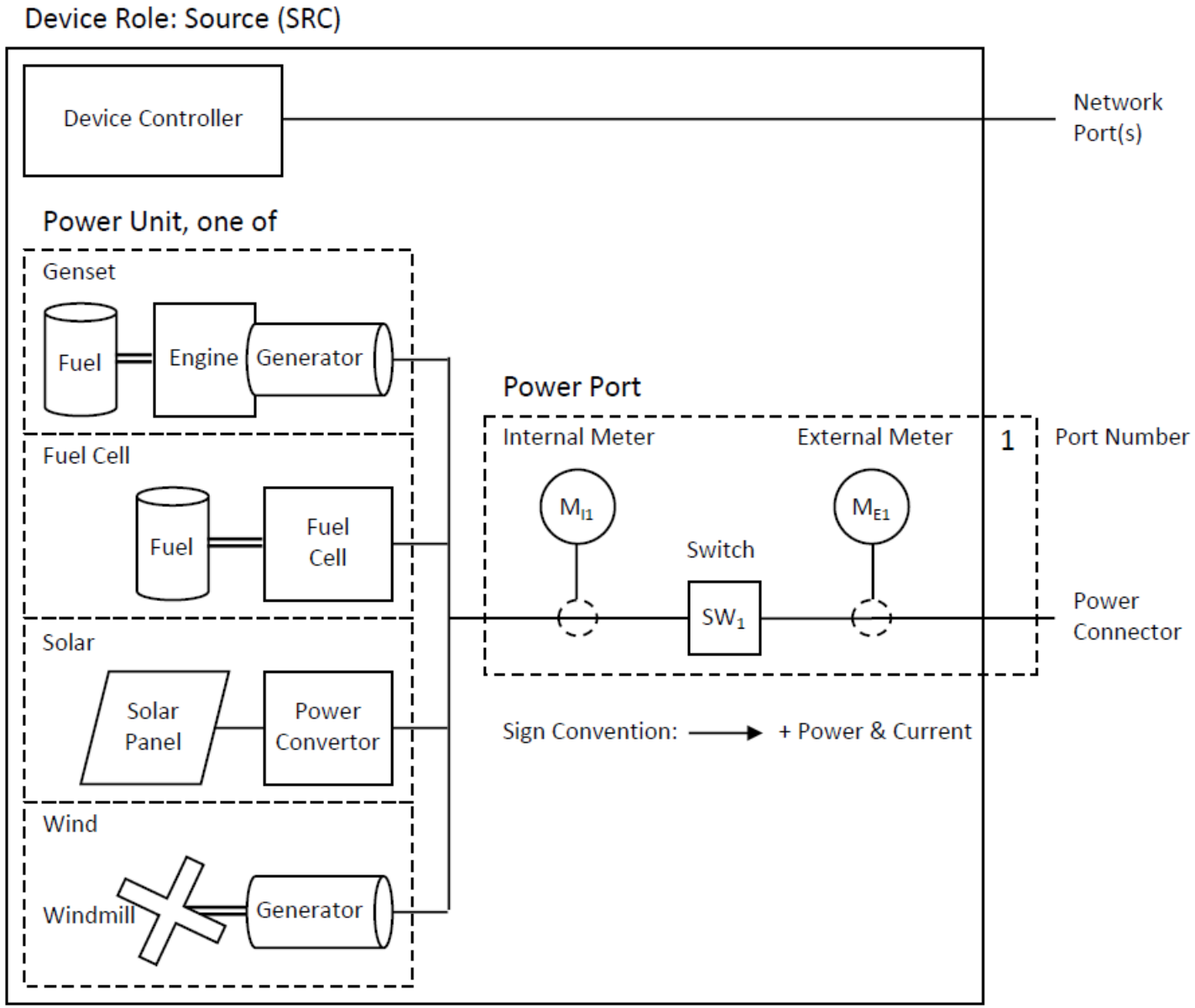
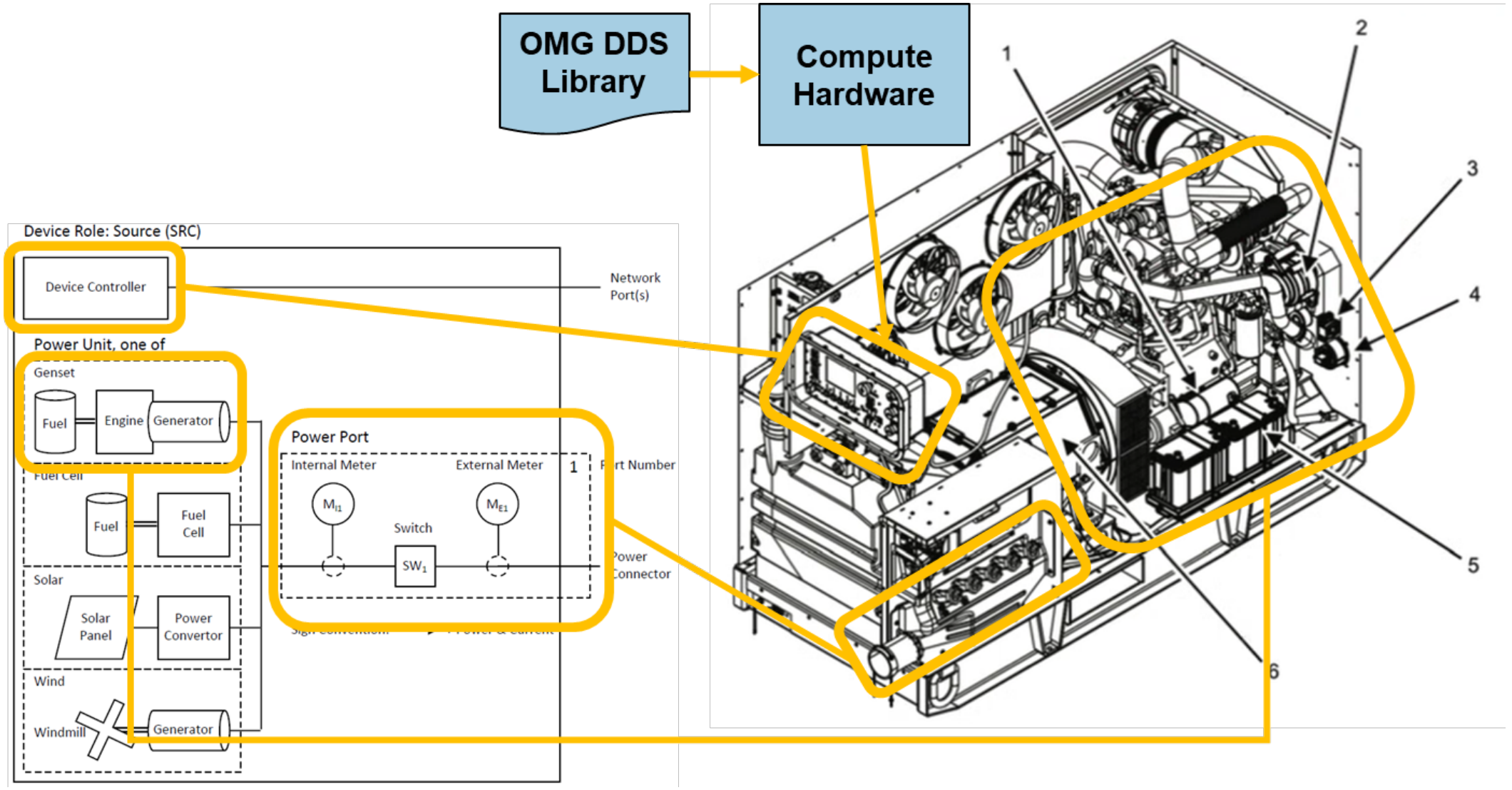


Figure B.6: Schematic diagram of the Source device role.

EXAMPLE DESIGN



TAILORING REQUIRED TOPICS

Table B.2: Overview of Topic Usage.

Topic	Usage	Section
AcLoadSharingRequest	Optional	B.21.1
AcLoadSharingState	Conditional on HAS_AC_PORTS	B.21.1
AcMeasurementUpdate	Conditional on HAS_AC_METERS	B.18.1

TAILORING REQUIRED TOPICS

Table B.2: Overview of Topic Usage.

Topic	Usage	Section
AcLoadSharingRequest	Optional	B.21.1
AcLoadSharingState	Conditional on HAS_AC_PORTS	B.21.1
AcMeasurementUpdate	Conditional on HAS_AC_METERS	B.18.1

Table B.98: Data types of the AC Load Sharing topics.

Topic	Data Type
AcLoadSharingState	`tms::ac::LoadSharingState`
AcLoadSharingRequest	`tms::ac::LoadSharingRequest`
Reply	`tms::Reply`

TAILORING REQUIRED TOPICS

Table B.2: Overview of Topic Usage.

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Topic	Data Type
AcLoadSharingState	`tms::ac::LoadSharingState`
AcLoadSharingRequest	`tms::ac::LoadSharingRequest`
Reply	`tms::Reply`

B.21.2.1 `tms::ac::LoadSharingState`

PURPOSE: Report the present value of the load sharing parameters for alternating current devices.

TOPIC USAGE: AcLoadSharingState

EXTENSIBILITY: extensibility(APPENDABLE)

PATTERN: Structure

ATTRIBUTES:

Name	Type and Description
`deviceId`	`tms::Identity` The device described by this structure. Annotations: *keyval*
`config`	`tms::ConfigId` Configuration that these values belong to.
`parameters`	`LoadSharingParameterSequence` LoadSharingParameters for each power port that supports AC load sharing.

TAILORING REQUIRED TOPICS

Table B.2: Overview of Topic Usage.

Topic	Usage	Section
AcLoadSharingRequest	Optional	B.21.1
AcLoadSharingState	Conditional on HAS_AC_PORTS	B.21.1
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B.21.2.1 `tms::ac::LoadSharingState`

PURPOSE: Report the present value of the load sharing parameters for alternating current devices.

TOPIC USAGE: AcLoadSharingState

EXTENSIBILITY: extensibility(APPENDABLE)

PATTERN: Structure

ATTRIBUTES:

Name	Type and Description
`deviceId`	`tms::Identity` The device described by this structure. Annotations: *keyval*
`config`	`tms::ConfigId` Configuration that these values belong to.
`parameters`	`LoadSharingParameterSequence` LoadSharingParameters for each power port that supports AC load sharing.

B.21.2.6 `tms.ac::LoadSharingParameterSequence`

PURPOSE: A sequence of AC LoadSharingParameters.

EXTENSIBILITY: extensibility(APPENDABLE)

PATTERN: Typedef

ORIGINAL TYPE: `sequence<LoadSharingParameters,1,MAX_PORTS>`

B.21.2.7 tms::ac::LoadSharingParameters

PURPOSE: Load sharing parameters for AC power ports.

TOPIC USAGE: Nested

EXTENSIBILITY: extensibility(APPENDABLE)

PATTERN: Structure

ATTRIBUTES:

Name	Type and Description
portNumber	tms::PowerPortNumber The power port number.
referenceFrequency	tms::ControlCurve Desired frequency as a function of output real power. Zero points disables frequency regulation and enables bounded or constant real power regulation. One point is invalid. Two points with the same frequency enables constant frequency (isochronous) regulation. Two or more points with different frequencies enables droop frequency regulation. Annotations: *units*=watt, hertz (W, Hz)
referenceVoltage	tms::ControlCurve Desired voltage as a function of output reactive power. Zero points disables voltage regulation and enables bounded or constant reactive power regulation. One point is invalid. Two points with the same voltage enables constant voltage regulation. Two or more points with different voltages enables droop voltage regulation. Annotations: *units*=volt ampere reactive, volt (var, V)
minRealPower	float32 Minimum desired real power output. May limit the device's ability to regulate frequency. Annotations: *units*=watt (W)
maxRealPower	float32 Maximum desired real power output. May limit the device's ability to regulate frequency. Annotations: *units*=watt (W)
minFrequency	float32 Minimum desired voltage output. May limit the device's ability to regulate real

MIL-STD 3071: GENERATOR EXAMPLE

Hello,
I'm a **TMS SRC** device
you can call me **Gen_1**
from **Company A**
with **60kW** max output.
with **x, y, z** optional parameters

Control* , **Power***

Device Info

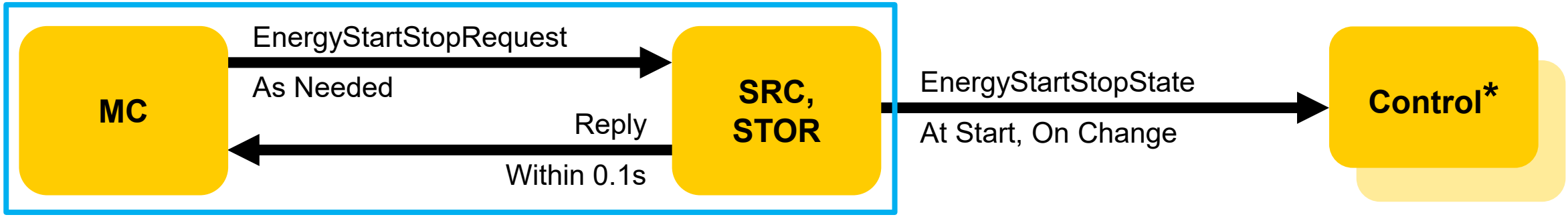
At Start

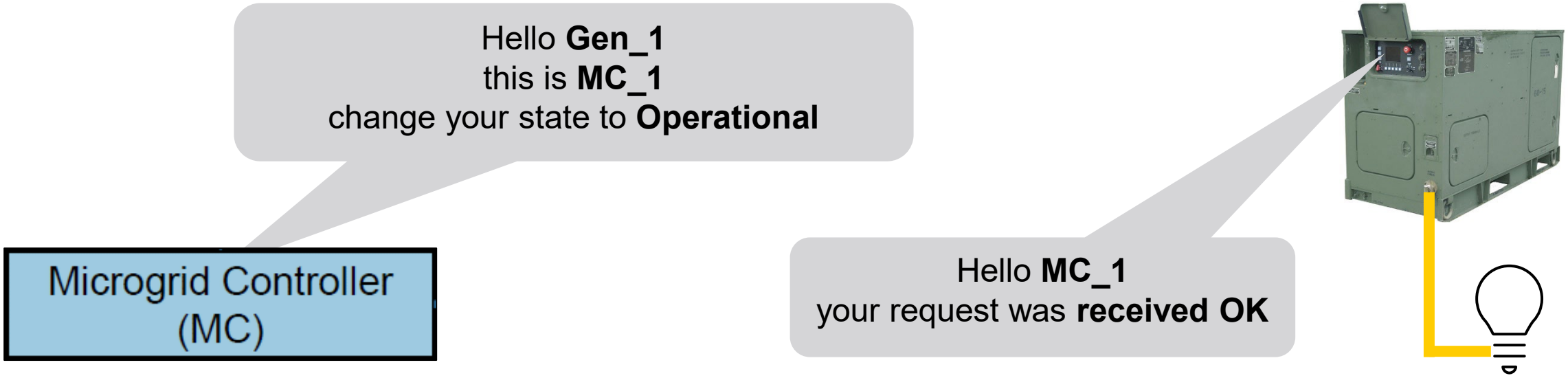
Control* , **Power***

Figure B.13: Device Announcement Data Flow

MIL-STD 3071: GENERATOR EXAMPLE

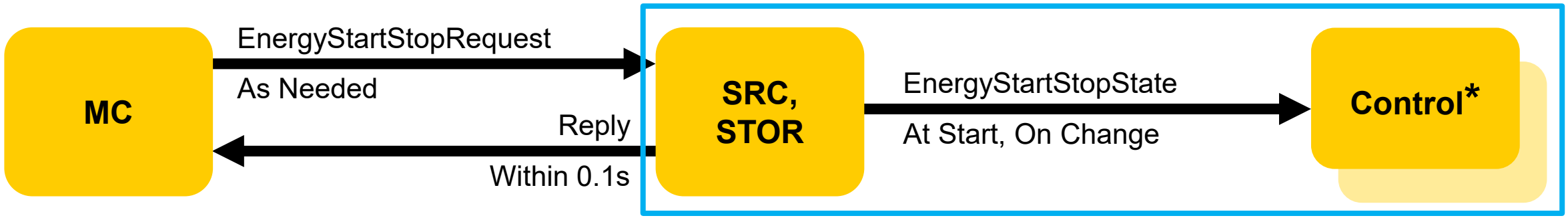
Figure B.26: Source and Storage Start / Stop Data Flow

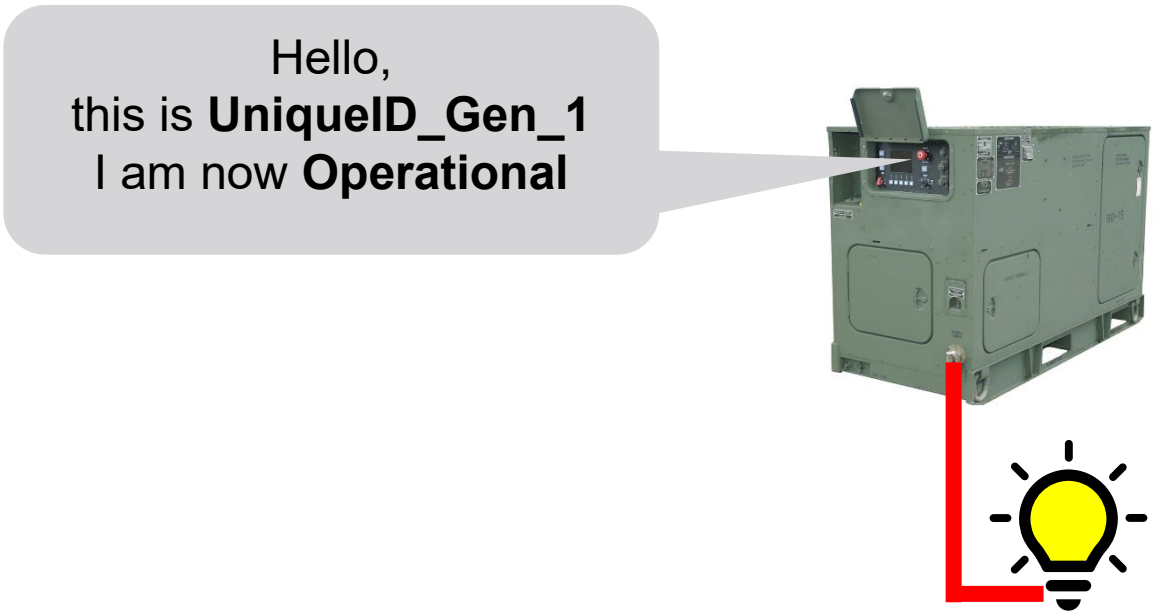




MIL-STD 3071: GENERATOR EXAMPLE

Figure B.26: Source and Storage Start / Stop Data Flow





COMPLIANCE DEFINITIONS

- Compliant
  - Implements all **Required** Topics
  - Use Table B.2 to determine “Required”
  - Tests are tailored to system/functionality

- Conformant
  - Monitoring capability Only
  - Likely using most applicable “..State” topics
  - Tests are tailored to system/functionality

DOCUMENTING COMPLIANCE TESTING

When a system is (Compliant, Compatible, or Conformant), documentation will include:

- Power Physics capabilities (multi-mode system will have multiple entries)
- TMS Devices (single, multi-mode, and platform will be captured)
- TMS version compliance tested
- TMS Compliant, Compatible, or Conformant
- TMS Device Type
- PoR only
  - Tested to work with:
    - Fielded Program of Record Equipment

TMS COMPLIANCE TESTING ECOSYSTEM

- ATEC
  - –TMS Test Authority for Program of Record
  - –Geared to validate TMS implementation as part of acquisition activities
  - –ATEC Testing leads to **TMS Certified**

- C5ISR Center
  - –TMS Independent Verification
  - –Geared to work with vendors in implementing TMS / validate their implementation (prior to any PoR activities)
  - –C5ISR Center Testing leads to **TMS Independent Verification**

U.S. ARMY

TACTICAL MICROGRID STANDARD (TMS) TESTING

27 FEBRUARY 2025

Warfighter | Daniel Torrecampo and Ryan Shih

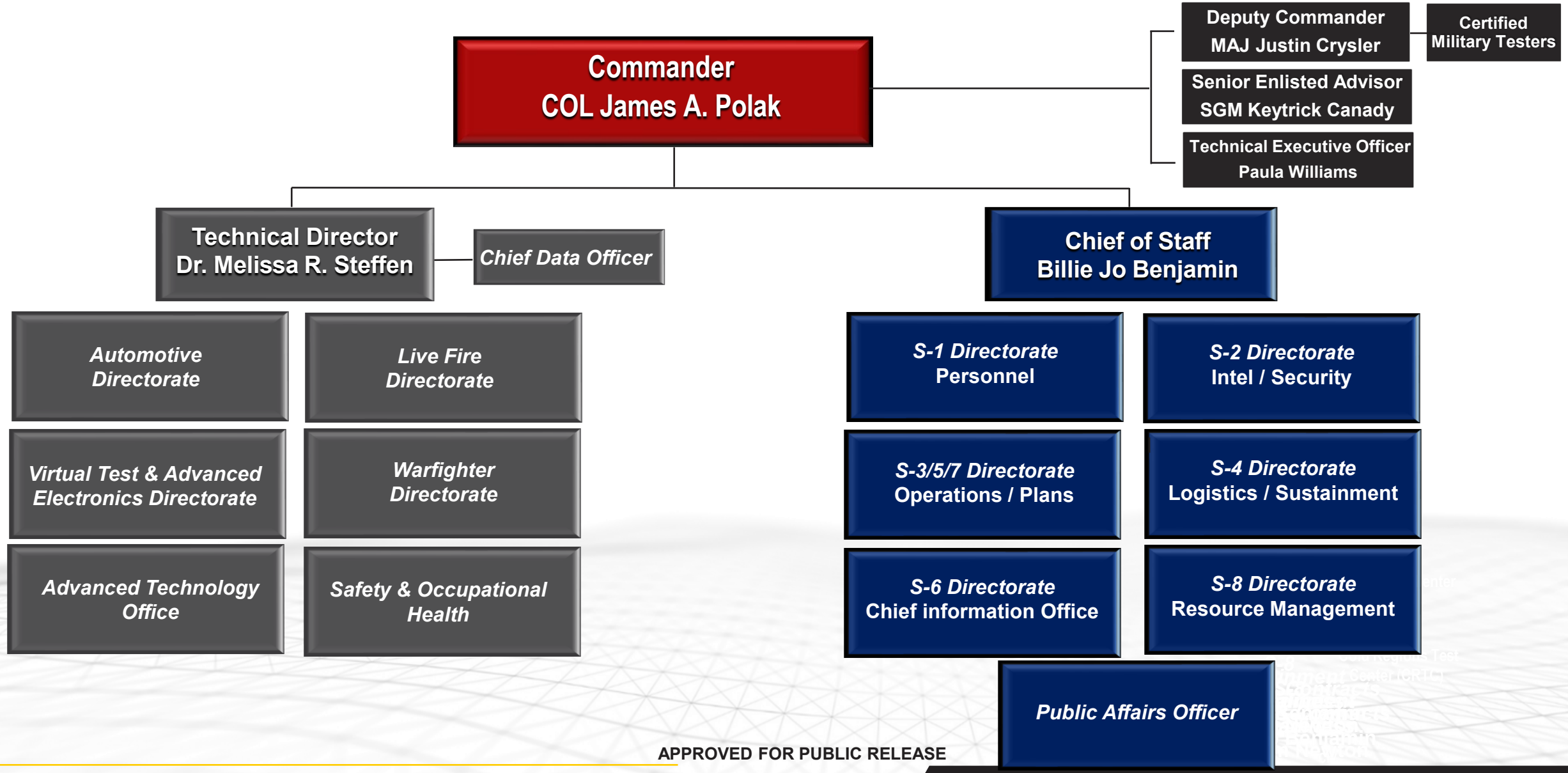
AGENDA

No.	Topic
1	ATEC, ATC Overview
2	Data acquisition with ADMAS
3	Data transformation to Test Runner
4	TMS Test Bed Configuration
5	Integration with Test Infrastructure
6	TMS MIL-STD Compliance Tests

U.S. ARMY ABERDEEN TEST CENTER (ATC) OVERVIEW

- **Mission:** ATC plans and conducts test efforts, analyzes, and reports the results of developmental tests, production tests, and other tests in assigned test functions areas to support authorized customers within the Department of Defense (DoD), and outside DoD, including domestic and foreign governments, and nongovernmental organizations.
- **U.S. Army Aberdeen Test Center Core Mission Areas:**
  - Ground Vehicles: manned, unmanned, autonomous
  - Ballistic Lethality: weapons, ammunition
  - System Vulnerability: Title 10 Live Fire
  - Soldier Systems: protective equipment, eyewear
  - Transportability
  - Power Generation Systems
- **Our Product is Information! Ensuring systems are safe, effective and reliable**

ATC COMMAND STRUCTURE



POWER SYSTEMS AND ELECTRONICS BRANCH

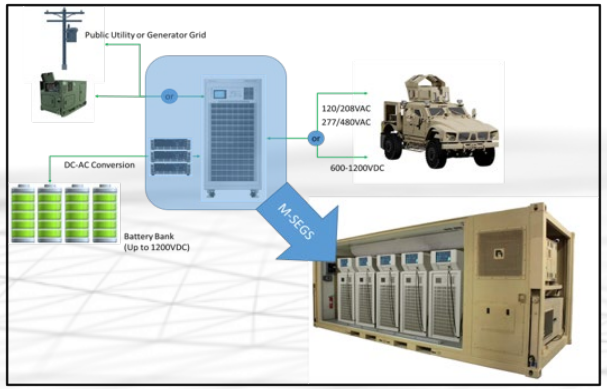
Generator Test Facility

Generators, Networked Power, Microgrids, Smart Grids

Simulated Solar for Photovoltaic Panels

Smart Power Distribution Systems

POWER SYSTEMS AND ELECTRONICS BRANCH



Invest in modular scalable electrical grid simulators for:

- Energy Storage/Battery Simulation
- Electric Vehicle (EV) Subcomponent Modeling and HITL testing
- Remote vehicle charging stations (reconfigurable to all EV output voltages, AC/DC power, and charging connector standards).
- Capability can be leveraged by other ATEC/CCDC test facilities

POWER SYSTEMS AND ELECTRONICS BRANCH

- Current ATC support for DoD Power and Energy Community
- 40 test stations accommodate generators up to 200+ kW
- Higher capacity generator testing (800 kW or greater) can be accomplished
- Power & energy instrumentation, load simulators, and a central test control, data monitoring, and analysis facility

Warfighter Portable Power (<900W)

Small/Medium Power

Grid Power (Megawatt+)

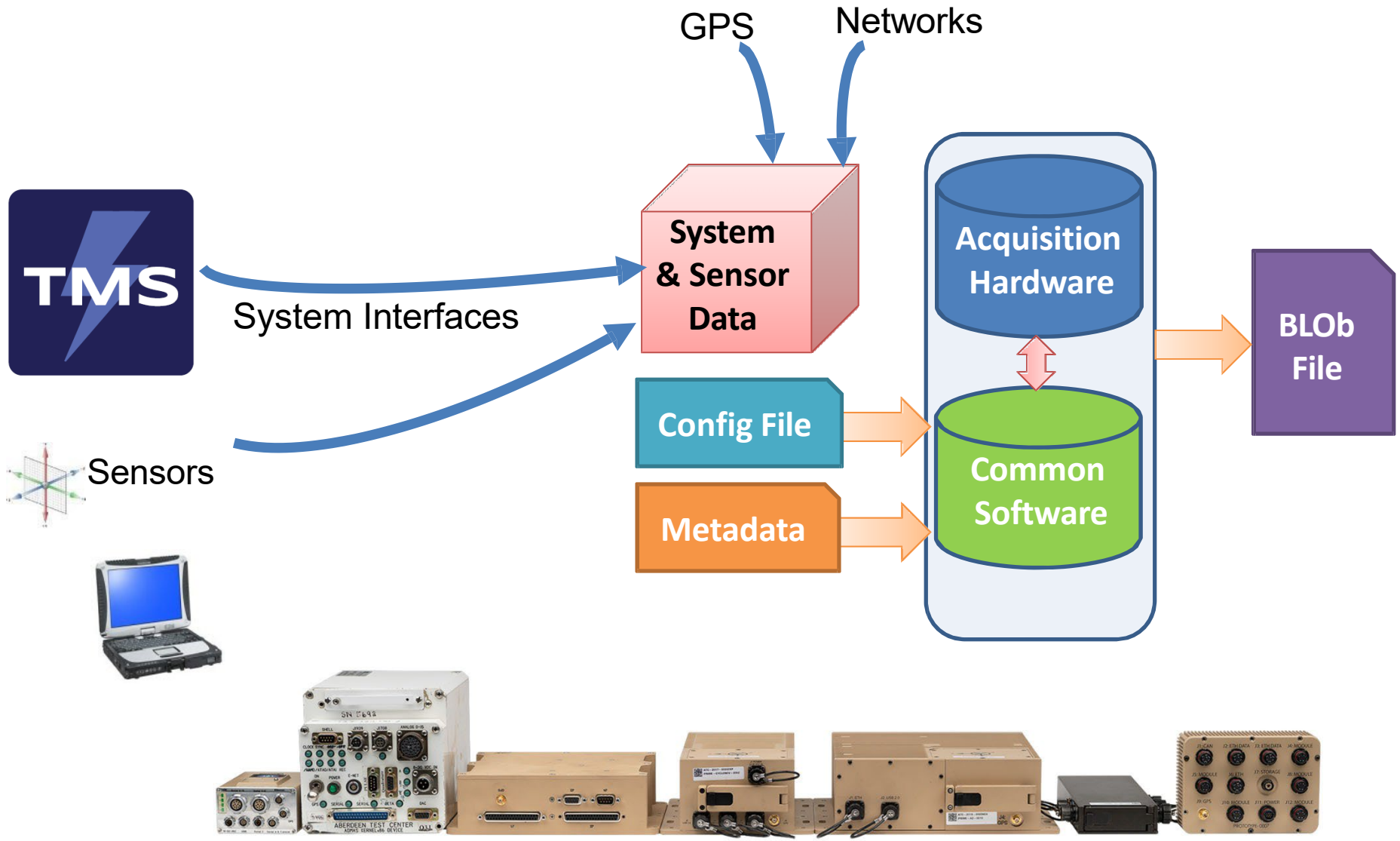
OUTPUT POWER RANGE

APPROVED FOR PUBLIC RELEASE

ADVANCED **D**ISTRIBUTED **M**ODULAR **A**CQUISITION **S**YSTEM (ADMAS)

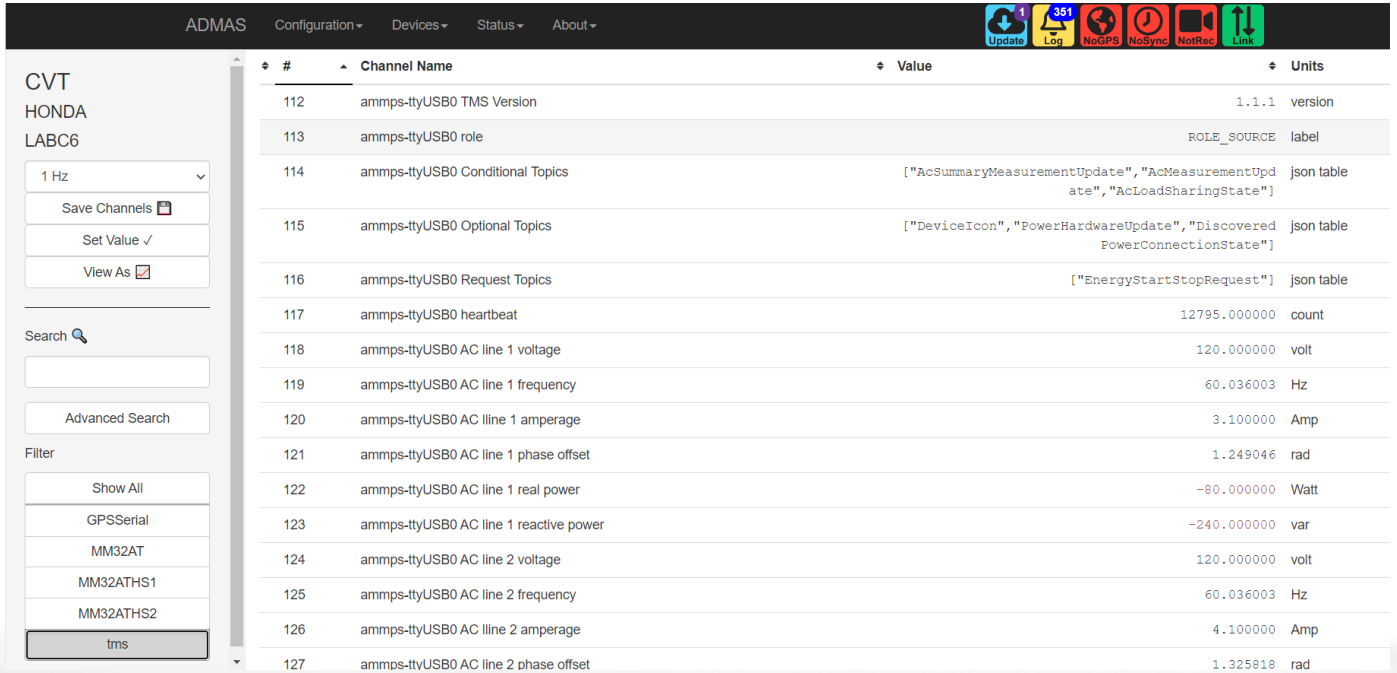
- Family of instrumentation developed and maintained by US Army Aberdeen Test Center (ATC)
- ADMAS instrumentation records data from sources such as vehicle data buses, networks, audio/video equipment and appended sensors
- Flexible enough to collect any data type and record into a common data format
- Hardware is rugged: designed to survive shock, vibration, and operate at extended temperature ranges (-40 to 85c)
- All ADMAS run the same core software and provide the same user interfaces, file formats etc. allowing them to be used interchangeably based on test requirements
- Fully Government owned technology

ADMAS DATA ACQUISITION

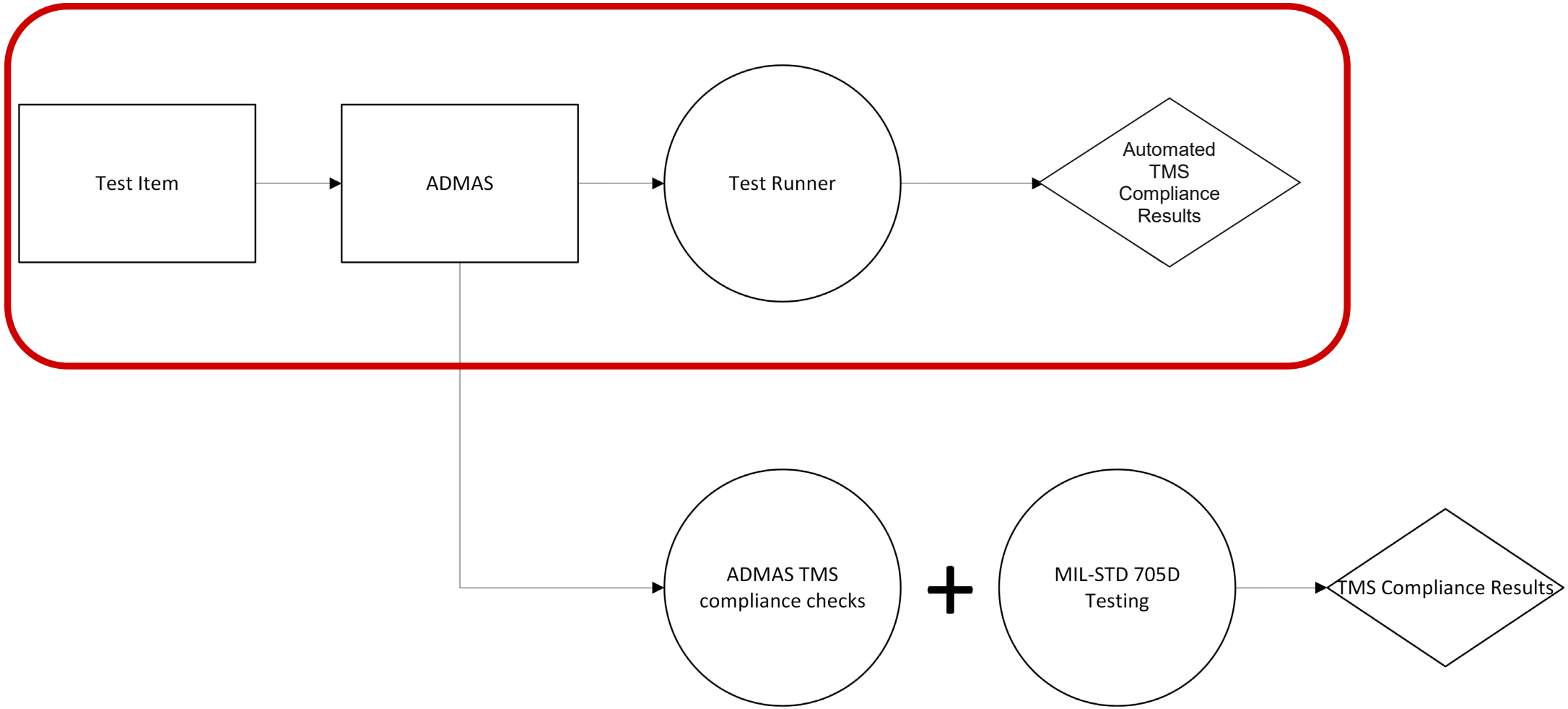


TMS SOFTWARE INTEGRATION WITH ADMAS

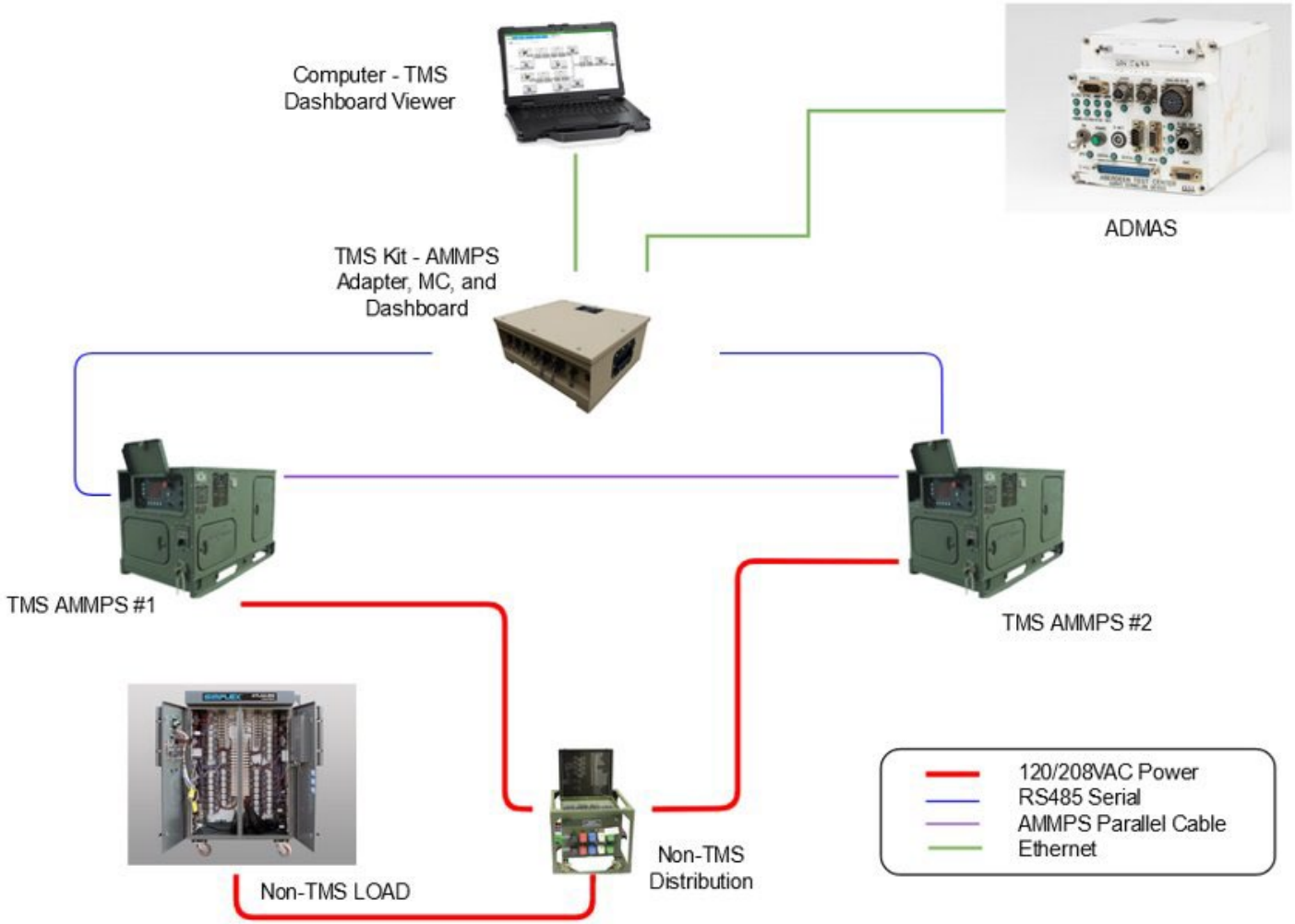
- Utilized Interface Definition Language(IDL) and Quality of Service(QoS) defined in MILSTD
- COTS DDS Middleware
- ADMAS is designed as a recorder only
- Subscribes to all TMS topics
- Stored locally on ADMAS in blob file along with metadata
- Designed to scale up for long duration tests with saved session information such as *deviceinfo* and matched publishers info
- TMS messages can be displayed real-time or post-test



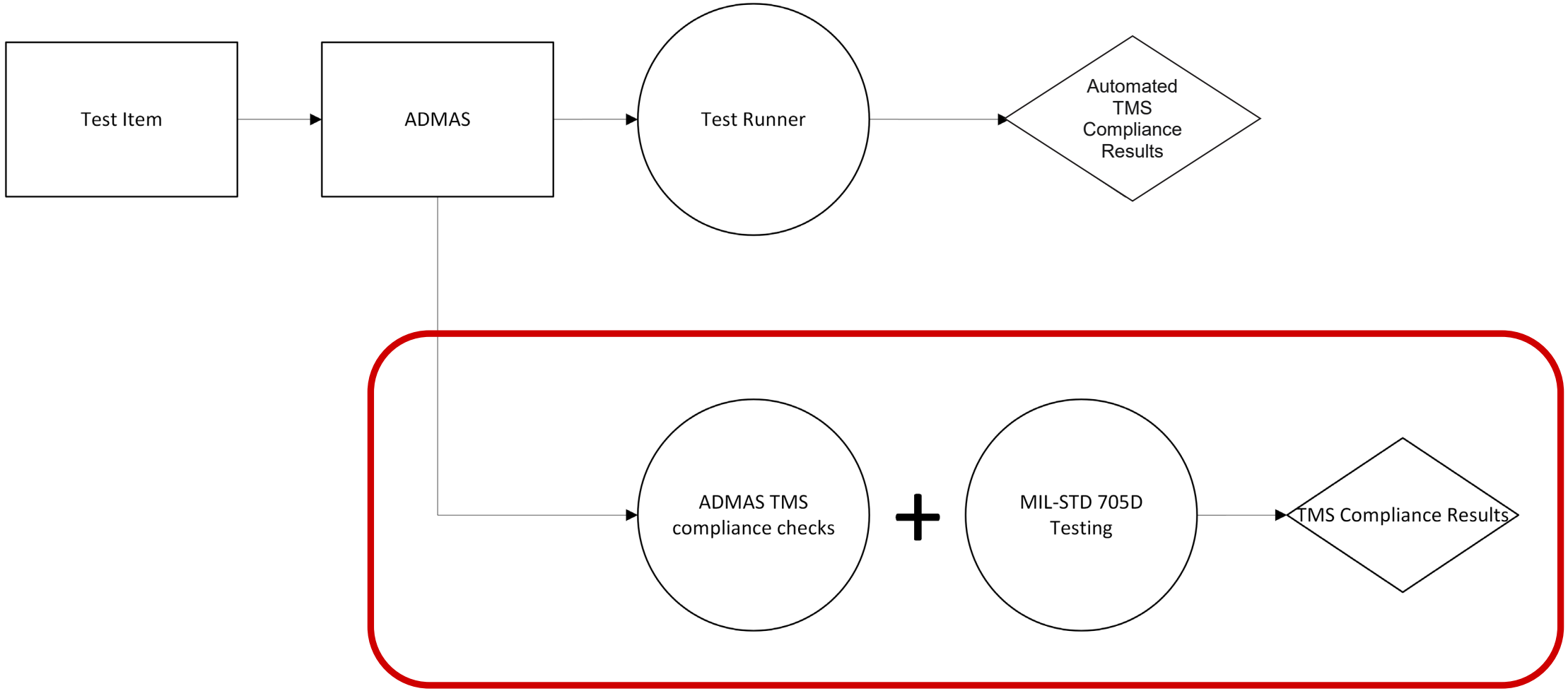
DATA TRANSFORMATION INTO TEST RUNNER



EXAMPLE TMS TEST BED



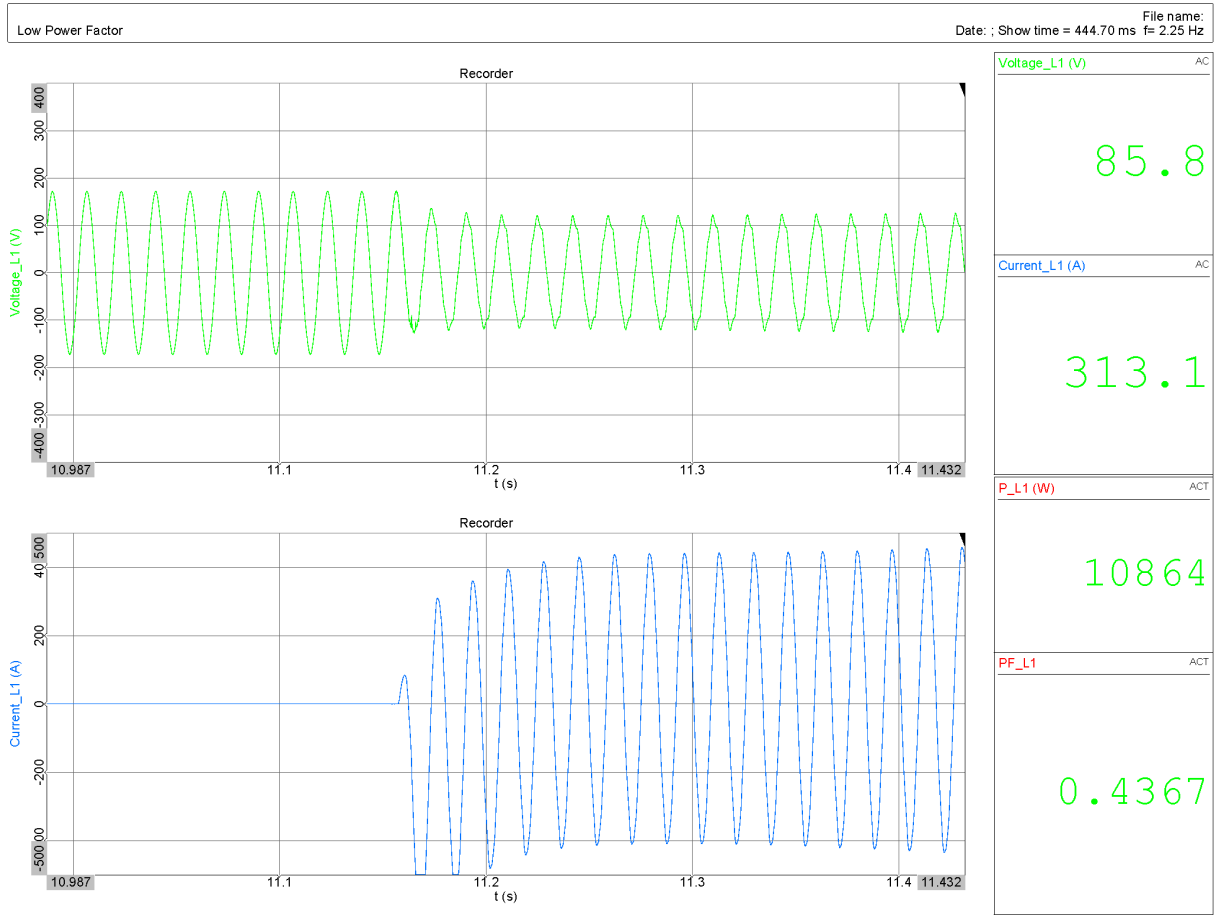
ADDITIONAL TMS COMPLIANCE TESTS



TMS COMPLIANCE TESTS

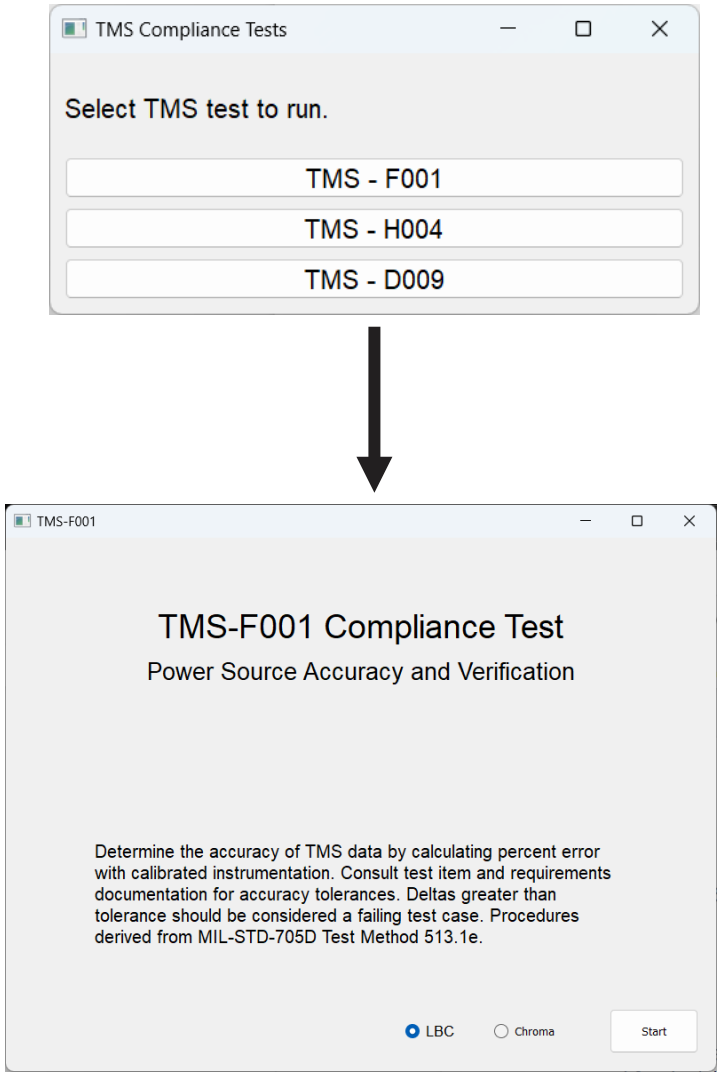
- Contains a set of tests, checks, validation procedures and processes for verification and validation of a device against TMS.

- Includes:
  - DDS and TMS network compliance
  - Device information accuracy checks
  - Device behavior checks
  - Grid operation checks



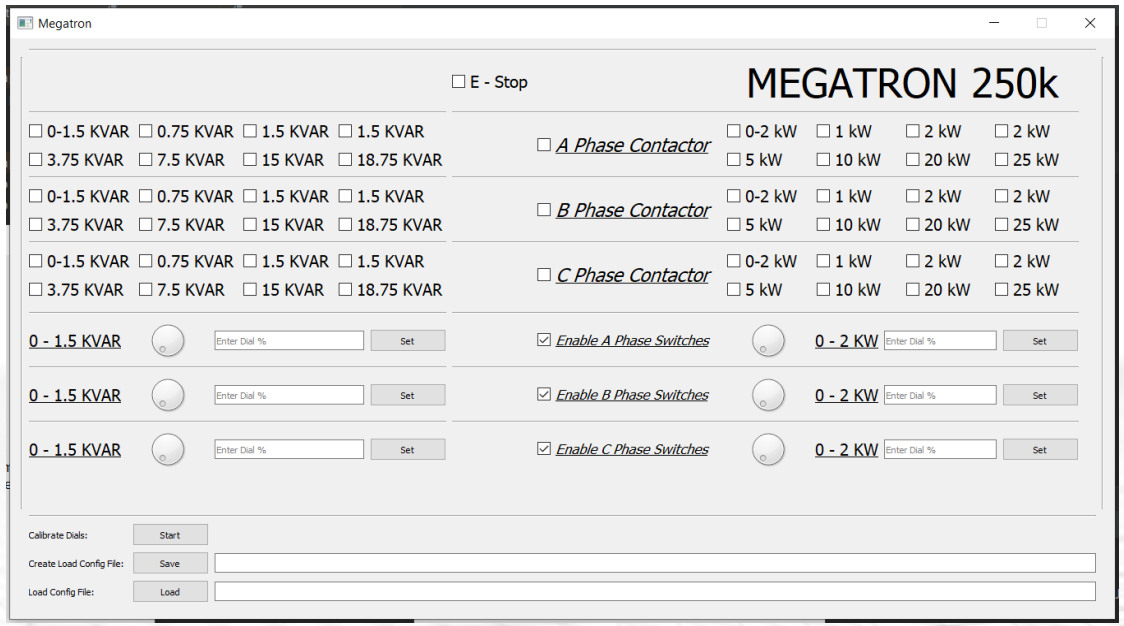
TMS COMPLIANCE TESTS

- Test Stand automates most TMS compliance checks.
- Some TMS testing requires manual intervention or human-in-the-loop.
- ATC can:
  - Compare TMS reported values against calibrated sensors
  - Ensure signage for power is accurate
  - Verify grid operations
  - Check for safety and human engineering requirements



TMS INTEGRATION WITH TEST INFRASTRUCTURE

- Facilitates automation of TMS Compliance Tests
- Executes load changes based on time or trigger events
- Consistent, repeatable, tracible



TACTICAL MICROGRID STANDARD

Question and Answer Panel

TMS

TACTICAL MICROGRID STANDARD

Concluding Remarks

TMS INDUSTRY DAY POST-EVENT SURVEY

- Please provide feedback through survey below.
- Link will also be sent to all attendees after the event

https://forms.osi.apps.mil/r/P0LEfFBAnL

TMS APAN Community

MIL-STD 3071 Document

https://go.mil/tms