IEEE P802.1DP | SAE AS6675 TSN Profile for Aerospace

Overview

Abdul Jabbar
GE Research

Objective

- ***High-level overview of TSN Aerospace profile***
- ***Introduction for new participants***
- ***Key aspects of the profile***
- ***Standardization process/timeline***

Motivation for Aerospace Profile

<u>Use Case Perspective</u>

- Static engineered networks
- Relatively small topologies
- Fully centralized configuration
- Specific requirements due to safety applications – high integrity, high availability, and fault tolerance
- Unique environment
- Long lifecycle (20yrs min, 50yrs expected)

<u>Aerospace Industry Perspective</u>

- Significant commonality across use cases
- Common TSN solution that meets aerospace network requirements
- Interoperability across devices and vendors
- Industry acceptance and certifiability as a common standard
- Increased vendor base
- Lower “lifecycle” effort

<u>Well defined</u> TSN profile provides an efficient solution for all aerospace use cases

“Goal is to have a highly prescriptive profile tailored for aerospace industry”

Profile Development

Joint Project

IEEE 802.1 TG
TSN Experts

SAE AS-1A
Aerospace Experts

+ Any interested person regardless of affiliation

Dual Logo Standard:

IEEE 802.DP / SAE AS6675

TSN Profile for Aerospace

Development

Project
Approval
Dec 2020

Project
Expiration
Dec 2026

Virtual Meetings

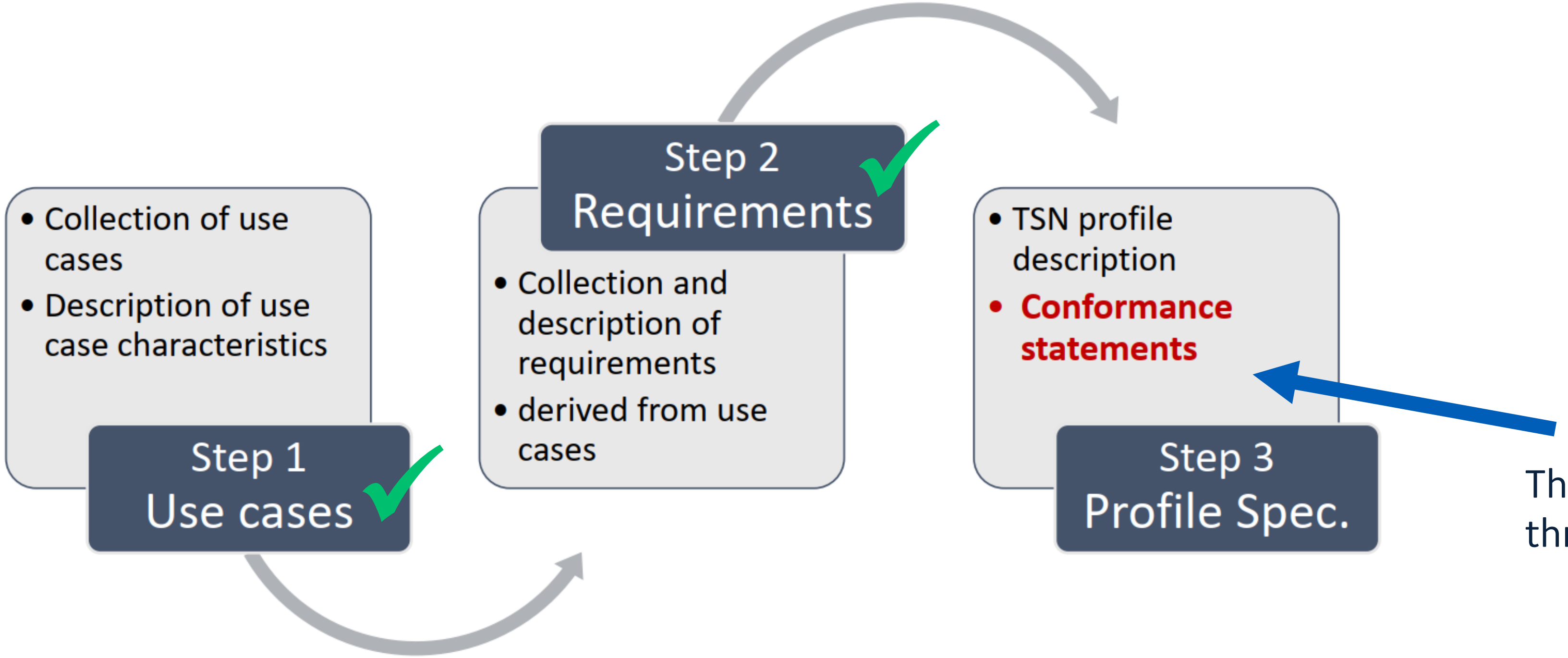
Weekly: Wednesdays
10:00 AM to 12:00 PM ET

Face-to-Face Meetings

3 IEEE Interim Sessions
3 IEEE Plenary Sessions
2 SAE AS-1 Meeting

Participation open to all without barriers
https://1.ieee802.org/tsn/802-1dp/

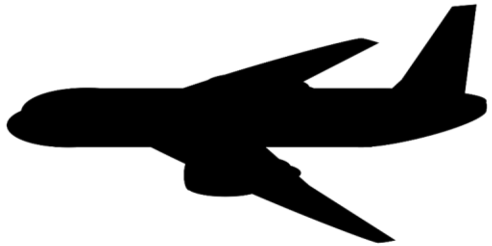
TSN Aerospace Profile Development



The Group is at step 3: working through TSN features for the profile

Reference: IEEE 802.1 TSN Profiles, Janos Farkas
https://www.ieee802.org/1/files/public/docs2021/dp-farkas-TSN-profiles-0221-v01.pdf

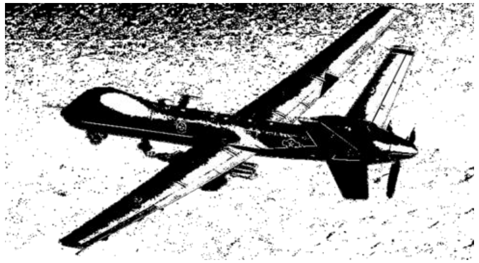
Use Cases Documented



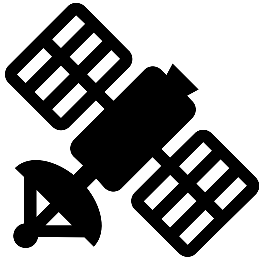
Commercial/Civil Aircraft
- Aircraft Control Domain Network (ACD)
  small and large passenger aircraft
- Cabin Network (ACD, AISD, PIESD)
  large passenger aircraft

Fixed Wing Military Aircraft
- Mission Network (small, combat, large)
- Flight Network (VMS)
- Fiber Channel over TSN (convergence)

Rotary Wing Military Aircraft
- Mission Network
- Flight Network



Unmanned Military Aircraft Network



Satellite
- Platform Network
- Payload Network

12 detailed use cases contributed by OEMs and tier1/2/3 suppliers documenting both network and traffic characteristics

Reference: AEROSPACE TSN USE CASES, TRAFFIC TYPES, AND REQUIRMENTS, SAE AS1-A2 committee
https://www.ieee802.org/1/files/public/docs2021/dp-Jabbar-et-al-Aerospace-Use-Cases-0321-v06.pdf

Use Case Summary - Topologies

Table 6-2—Summary of Aerospace Use Cases

Characteristic	Current Use		Known/ Desired Future Use	Use case driving the most restrictive bound
	Lower Bound	Upper Bound		
Number of Nodes	5	100	500	Large Passenger Aircraft (ACD)
Physical Topology	Bus (command/response protocol), Point-to-point/ multipoint, Ring (daisy chained), switched star or combination		Hybrid - Ring and Star	N/A
Number of Switch Hops	0	5	15-30	Large Passenger Aircraft (PIESD)
Max Number of Streams per Switch	50	2000	4096	Large Passenger Aircraft (ACD)
Network Redundancy	Two independent networks (A,B). End systems are dual homed to redundant LANs (ARINC664 part 7); Fault-tolerant Ring; None on point-to-point links. Subsystem or full system level redundancy (dual, triple, or quad)		same as current use cases	All fault-tolerant use cases
Redundancy Mode	Bus Failover (Hot Standby), Frame Failover (Hot Active); Hot Active with voting		same as current use	DAL* A/B systems
Data Rates	10 Kbps	1 Gbps	100 Gbps	MIL-STD-1553 and Satellites on the low bound. Military MS on the high end.
Media type	Copper: 1394,1553, RS-485/422, ARINC 429/629, Ethernet. Multimode Fiber: Fibre Channel, 100BASE-SX and 1000BASE-SX		Optical fiber for higher data rates	All aircraft

Use cases inform the profile choices, but do not, in any way, limit the use for any aerospace application

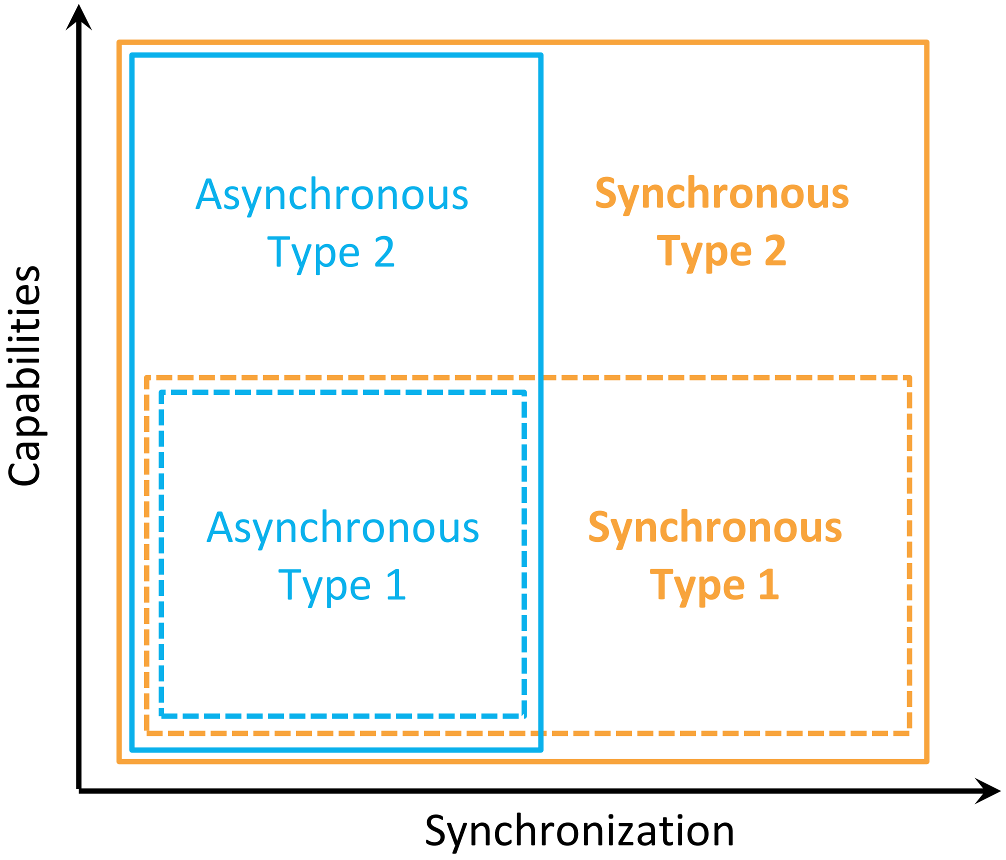
Use Case Summary – Traffic Types

Table 6-4—Summary of Aerospace Traffic Types

Traffic Characteristic	Current Use (range)		Known/ Desired Future Use Bound	Use Case Driving the Most Restrictive (right) Bound
	Left Bound (loosest)	Right Bound (tightest)		
Synchronism	Asynchronous	Synchronous	no change	Ultra-low latency and/or jitter (right bound)
Application synchronized to network?	No	Yes	no change	Ultra-low latency and/or jitter
Periodicity or Cycle Time	Aperiodic	<1 ms	100 µs	Flight critical controls, sensors, and weapon systems
Latency Mode Guarantee Value	100 ms	1 ms	100 µs	high criticality asynchronous events
Tolerance to interference (delay variation/ jitter)	up to latency limit	< 1 µs	no change	fly-by-wire, synchronous sensors
Tolerance to Loss*	3 consecutive frames	zero	no change	Parametric data (left bound), Flight control or weapon release (right bound)
Payload size	8 bytes	2112 bytes	no change	Sensor data (left bound) Fibre Channel over TSN (right bound)
Data Criticality	no safety effect	DAL A	no change	Safety critical and flight control

Use cases inform the profile choices, but do not, in any way, limit the use for any aerospace application

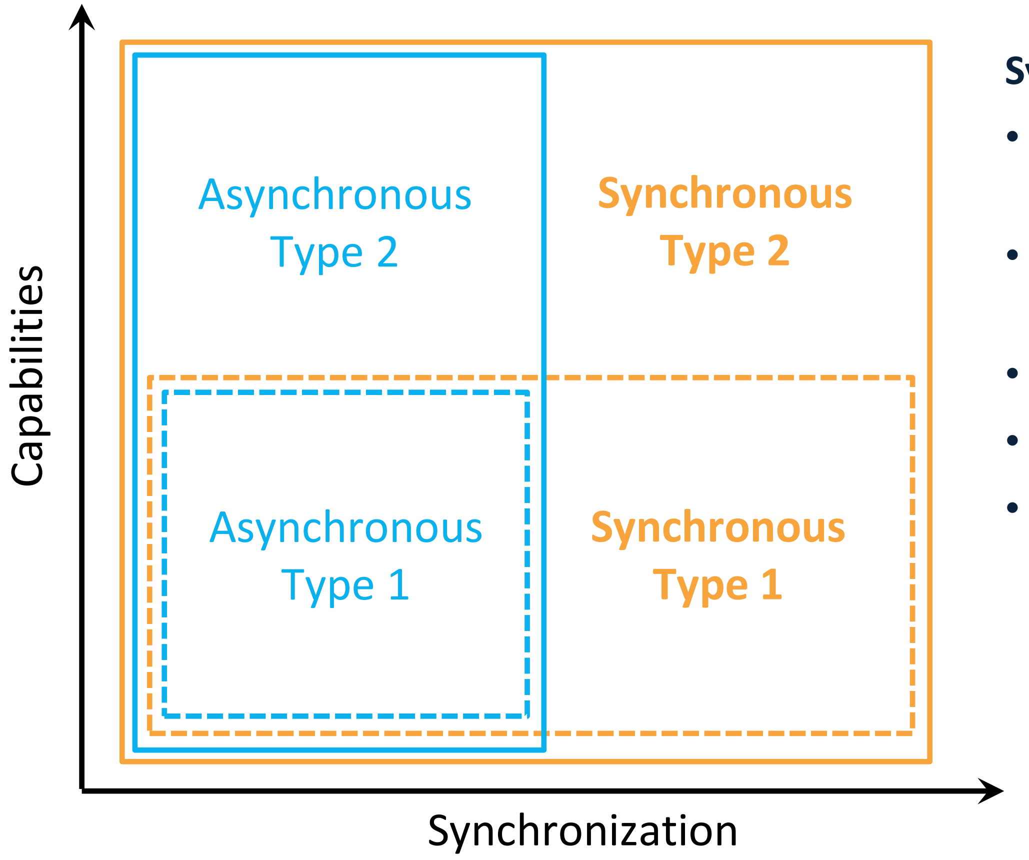
Conformant Profiles for End Stations and Bridges



Conformant Profiles for End Stations and Bridges

Asynchronous Profiles

- Asynchronous with slower cycle times (> 50 msec)
- Sensitive to latency but not delay variation (jitter)
- Single criticality traffic on a controlled network
- Simple network redundancy
- Common clock/time not required



Synchronous Profiles

- Synchronous with cycle times in the order of 1 msec
- Sensitive to latency and delay variation (jitter)
- Convergence of mixed critical traffic
- Flexible redundancy
- Platform wide clock time distribution

Required Functions for Aerospace Networks
Status

Functions	Profile Specification	Relevant Standards
Time Synchronization	Generalized precision time protocol* Fault tolerance with time integrity*	802.1AS-2020 P802.1ASed
Traffic Shaping	Credit based shaper Time aware Shaper*	802.1Q-2020, 8.6.8 Previously 802.1Qav and 802.Qbv
Redundancy	Frame replication and elimination	802.1CB-2017
Stream Isolation	Stream identification Per-Stream filtering and policing	802.1Q-2020, 8.8.5 Previously 802.1Qci
Configuration	Fully centralized with YANG modeled config data	802.1Q-2020, 46 802.1Qcw, 802.1CBcv
Active Topology Control	Per-stream static forwarding	802.1Q-2020
Management and Monitoring	Required error, fault, and performance metrics	802.1Q-2020

Ongoing work

** Only applicable to Synchronous profile*

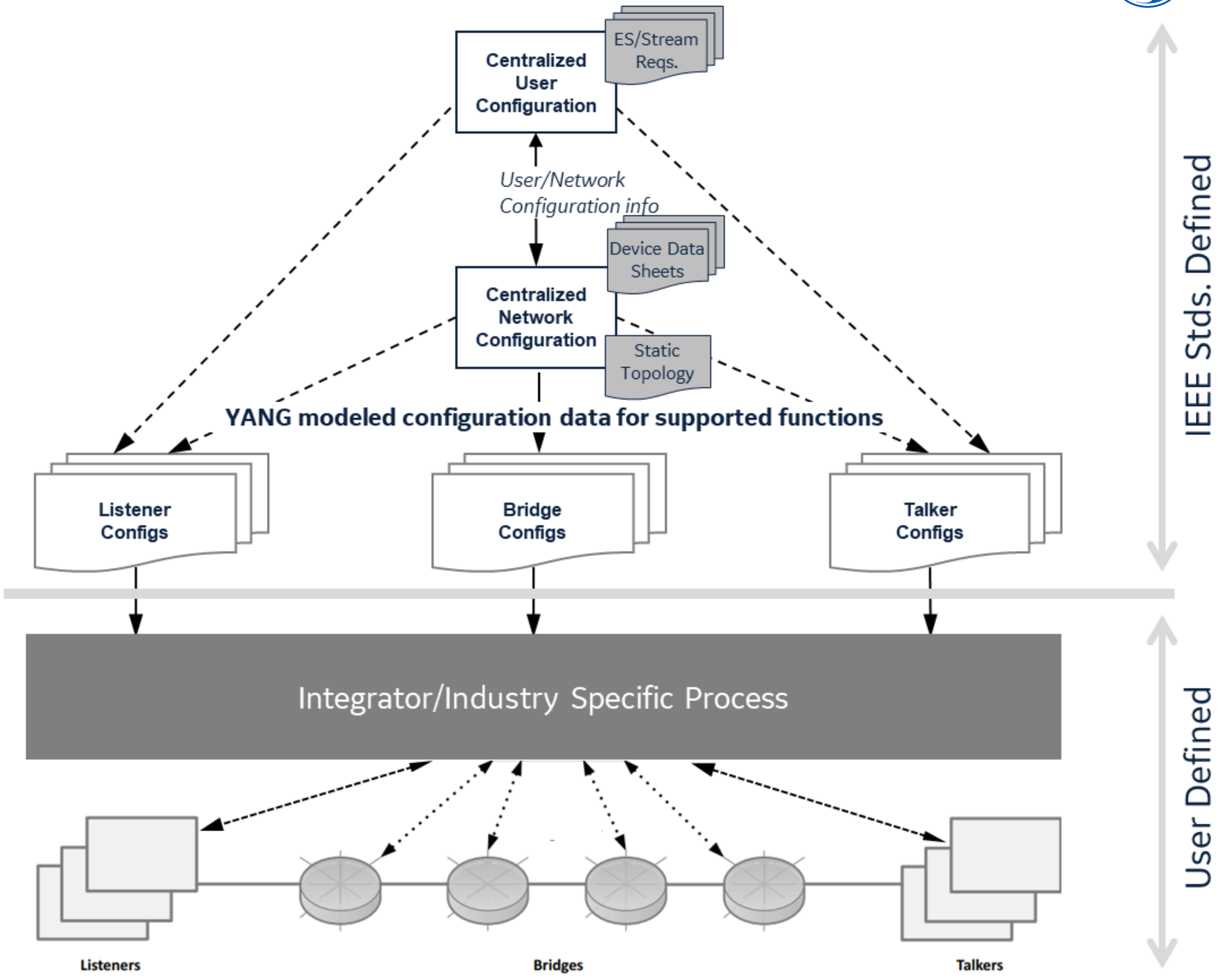
Standardization Timeline

	2021	2022	2023		2024		2025 (estimated*)	
IEEE P802.1DP/ SAE AS6675	Use Cases and Requirements	Committee Development Draft 1.0	Balloting: IEEE TG SAE Sub-Comm	Update Draft Draft 2.0	Balloting: IEEE WG SAE Committee	Update Draft Draft 3.0	Balloting: IEEE SA SAE Counsel	IEEE/SAE Board Approvals Publishing
IEEE 802.1ASed (Time Integrity)		Initial Development	TG Ballot (as part of DP)	Split from DP	New project – Ased Draft 1.0	IEEE TG Ballots Update draft Draft 2.0	WG Ballots Draft 3.0 SA Ballots	Board Approval Publishing

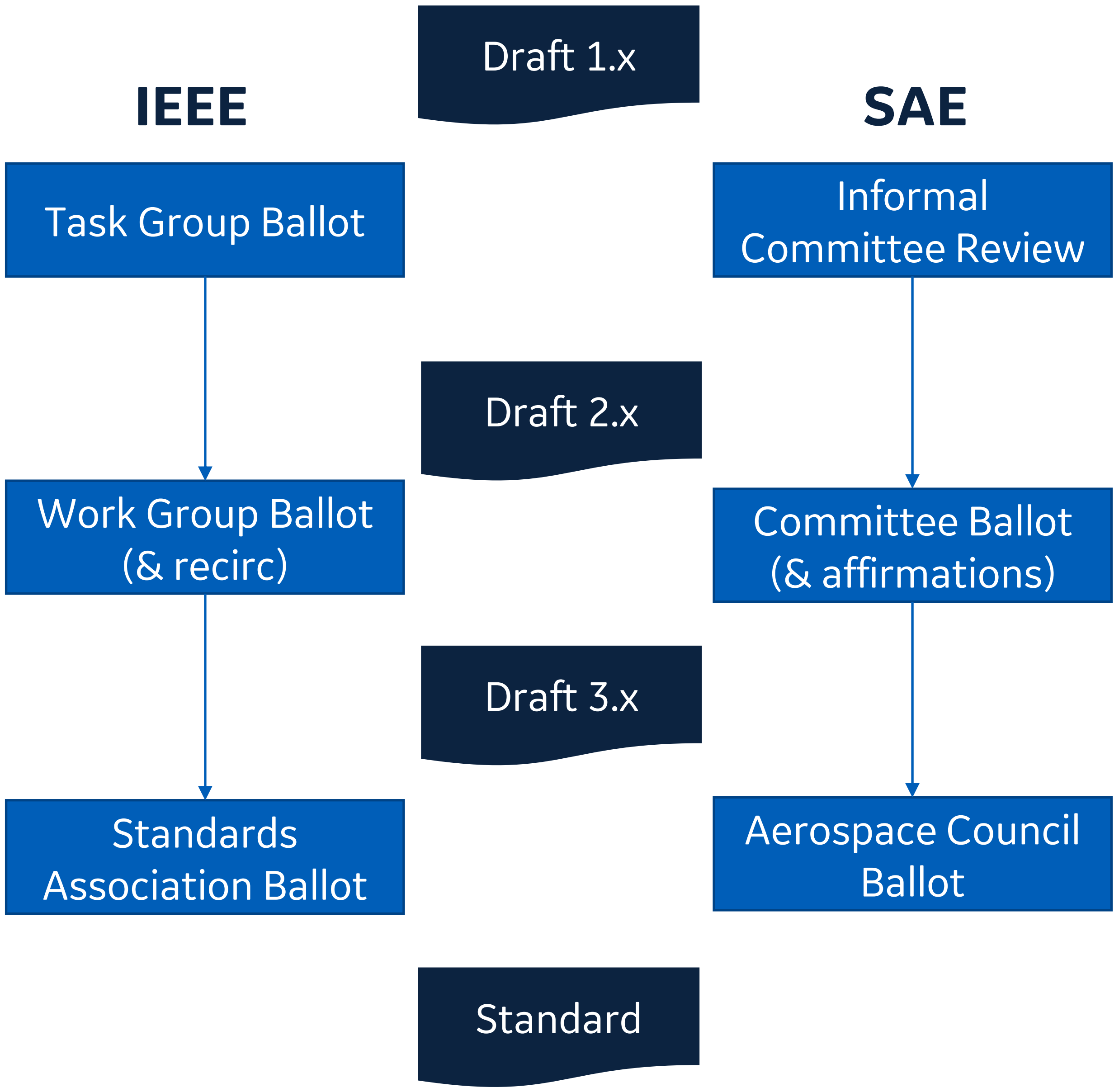
** Future timeline is subject to standardization process*

Configuration Model

- Fully centralized configuration model
- Engineered network with static topology
- No direct comms between ES/Bridges and CUC/CNC
- Design/Engineering tool generates all input to CUC/CNC
- File based configuration for all end stations and bridges
- Integration and configuration across multiple TSN device vendors for an aerospace vehicle to be driven by YANG modeled configuration data.
- DP drives the interoperability



Simplified coordination of SAE and IEEE balloting process



We are here

Motion to go to SA ballot Nov 10th , Draft 3.0

Based on IEEE/SAE joint development guide

Miscellaneous Remarks

- Attention is being paid to the safety critical nature of aerospace and regulatory certification needs
- Scope, direction, and approach are well aligned with the aerospace industry
- Strong participation from all stakeholders
- Dual logo standard with an open development standard enables wide acceptance