Information from SAE AS-1 to IEEE 802.1

Establishing a joint group between SAE AS-1A2 and IEEE 802.1 TSN TG to develop TSN profile for aerospace

SAE AS-1A2 Committee

Presented by Abdul Jabbar, GE Research

SAE Aerospace Council Organization Chart

sae.org/standards

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Aerospace Council

Avionics Systems

Avionics Networks

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INTEGRATED VEHICLE HEALTH MANAGEMENT (IVHM) STEERING GROUP
n: +1.724.272.0495

AEROSPACE GENERAL PROJECTS SYSTEMS GROUP COMMITTEES
Chair: TBD

- G-10 Aerospace Behavioral Engineering Technology(ABET) Steering Group
  - G-10A Aeronautical Information System
  - G-10D Color Display
  - G-10E Enhanced Vision/ Synthetic Vision Systems
  - G-10EAB Executive Advisory Group
  - G-10G Realistic Training
  - G-10HWD Head Worn Display
  - G-10J Charting
  - G-10OL Operational Lasers
  - G-10P Perspective Flight Guidance
  - G-10T Laser Safety Hazards
  - G-10TDS Touch Interactive Display Systems
  - G-10U Unmanned Aerospace Systems
  - G-10V Vertical Flight
  - G-10W Weather Information Systems
- G-18 Radio Frequency Identification (RFID) Aerospace Applications
- G-20 Airport Lighting
- G-25 Avionics/Electronics Corrosion
- CS Commercial Space
- G-26 Helicopter Hoists
- G-27 Lithium Battery Packaging Performance
- G-28 Simulants for Impact and Ingestion Testing
- G-30 Unmanned Aircraft Systems Operator Qualifications
- G-31 Electronic Transactions for Aerospace
- G-32 Cyber Physical Systems Security
- G-34 Artificial Intelligence in Aviation

AIRCRAFT SYSTEMS GROUP COMMITTEES
Chair: Robert Garner

- A-4 Aircraft Instruments
  - A-4 ADWG Air Data Working Group
  - A-4 ED Electronic Display
  - A-4 EFIS, Electronic Flight Instrument System Display
  - A-4 FLW Fuel Flowmeters
  - A-4 HUD Head Up Displays
  - A-4 ULD Underwater Locator Devices
- A-5 Aerospace Landing Gear Systems
  - A-5A Wheels, Brakes & Skid Controls
  - A-5B Gears, Struts & Couplings
  - A-5C Aircraft Tires
- A-10 Aircraft Oxygen Equipment
- A-20 Aircraft Lighting Steering Group
  - A-20A Crew Station Lighting
  - A-20B Exterior Lighting
  - A-20C Interior Lighting
- A-21 Aircraft Noise Measure and Noise Aviation Emission Modeling
- A-22 Fire Protection & Flammability Testing Committee
- AC-9 Aircraft Environmental Systems
- AC-9C Aircraft Icing Technology
- AC-9M Cabin Air Measurement
- S-7 Flight Deck & Handling Qualities Strds for Transport Aircraft
- S-9 Cabin Safety Provisions
  - S-9A Safety Equipment & Survival Systems
  - S-9B Cabin Interiors & Furnishings
  - S-9C Operational & Human Factors Issues
- Aircraft SEAT
- ACBG Airframe Control Bearings Steering Group
  - ACBGPB Plain Bearing
  - ACBGREB Rolling Element

AEROSPACE ELECTRONICS & ELECTRICAL SYSTEMS GROUP COMMITTEES
Chair: Jim Ide

- AE-2 Lightning
- AE-4 Electromagnetic Environmental Effects (E3)
  - AE-4EMC Civil Aircraft EMC Working Group
- AE-7 Aerospace Electrical Power & Equipment
  - AE-7A Generators/Controls/ Magnetic Devices
  - AE-7B Power Management, Distribution & Storage
  - AE-7C Systems
  - AE-7D Energy Storage and Charging
  - AE-7EU Europe
  - AE-7M Aerospace Model Based Engineering
  - AE-7P Protective and Control Devices
- AE-8 Aerospace Electrical/Electronic Distribution Systems Steering Group
  - AE-8A Electrical Wiring & Fiber Optic Interconnect Systems Installation
  - AE-8C1 Connectors
  - AE-8C2 Terminating Devices & Tooling
  - AE-8D Wire & Cable
- AE-9 Electrical Materials

AEROSPACE MECHANICAL & FLUID SYSTEMS GROUP COMMITTEES
Chair: Sanford Fleishman

- A-6 Aerospace Actuation, Control and Fluid Power Systems
  - A-6A Systems/Sub-system Integration TG
  - A-6A1 Commercial Aircraft
  - A-6A2 Military Aircraft
  - A-6A3 Flight Control Systems
  - A-6B Actuation and Control TG
  - A-6B1 Hydraulic Servo Actuation
  - A-6B2 Electrohydrostatic Actuation
  - A-6B3 Electro-Mechanical Actuation
  - A-6C Power Generation & Distribution TG
  - A-6C1 Contamination & Filtration
  - A-6C2 Seals
  - A-6C3 Fluids
  - A-6C4 Power Sources
  - A-6C5 Components
- AE-5 Aerospace Fuel, Inerting & Lubrication Systems Steering Group
  - AE-5A Aerospace Fuel, Inerting & Lubrication Systems
  - AE-5B Aircraft and Engine Fuel and Lubricant Systems Components
  - AE-5C Aviation Ground Fueling Systems
  - AE-5D Fuel Tank Flammability Reduction Systems
- G-3 Aerospace Couplings, Fittings, Hose and Tubing Assemblies
  - ISO/TC20/SC10 U.S. SCAG
  - PRI-QPL/QML Panel
  - G-3A Aerospace Couplings TG
  - G-3B Aerospace Fittings TG
  - G-3C AS-EN Harmonization
  - G-3D Aerospace Hose TG
  - G-3E Aerospace Tubing Installation TG

AEROSPACE AVIONIC SYSTEMS GROUP COMMITTEES
Chair: Bill Woodward

- AS-1 Aircraft Systems & Systems Integration
  - AS-1A Avionics Networks
  - AS-1B Aircraft-Store Integration
  - AS-1C Avionic Subsystems
- AS-2 Embedded Computing Systems
  - AS-2C Architecture Analysis & Design Language TG
  - AS-2D Time Triggered Systems & Architecture TG
  - AS-2D1 Time-Triggered Fieldbus
  - AS-2D2 Deterministic Ethernet & Unified Networking
- AS-3 Fiber Optics and Applied Photonics
- AS-4 Unmanned Systems
  - AS-4JAUS Joint Architecture for Unmanned Systems
  - AS-4UCS Unmanned Aircraft System Control Segment

AEROSPAC… SYSTEMS GR… Chair:

- AE-1 Engine Accessory Installations
- AE-6 Starting Systems & Auxiliary Power
- E-25 General Stds for Aerospace and Propulsion S…
- E-30 Propulsion …
- E-31 Aircraft Eng… Emissions M… E-31B Bleed… E-31G Gase… E-31P Particulate Matter
- E-33 In-Flight Propulsion Measurement
- E-34 Propulsion Lubricants
- E-36 Electronic Engine Controls
- E-38 Aviation Piston Engine Fuels and Lubricants
- E-39 Unmanned Aircraft Propulsion
- E-40 Electrified Propulsion
- EG-1 Aerospace Propulsion Sys Support Equip
  - EG-1A Balancing
  - EG-1B Hand Tools
  - EG-1B1 Power Tools - Productivity, Ergonomics and Safety
  - EG-1E Gas Turbine Engine Test Facilities and Equipment
- S-12 Powered Lift Propulsion
- S-15 Gas Turbine Performance Simulation Nomenclature and Interfaces
- S-16 Turbine Engine Inlet Flow Distortion

E MATERIALS UP COMMITTEES …an Fletcher

SYSTEMS GROUP COORDINATING COMMITTEE

- … Materials Advisory

…TURING

- …Manufacturing
- Additive Manufacturing Metals
- Additive Manufacturing Non-Metallic
- AMS AM-R Additive Manufacturing Repair

METALS & RELATED PROCESSES

- AMS B Finishes, Processes & Fluids
- AMS D Nonferrous Alloys
- AMS E Carbon & Low Alloy Steels & Specialty Steels & Alloys
- AMS F Corrosion & Heat Resistant Alloys
- AMS G Titanium, Beryllium & Refractory Materials
- AMEC Aerospace Metals Engineering
- ASEC Aerospace Surface Enhancement

NON-METALS & RELATED PROCESSES

- AMS CE Elastomers
- AMS P Polymeric Materials
- AMS P-17 Polymer Matrix Composites
- AMS CACRC ATA/IATA/SAE Commercial Aircraft Composite Repair
- AMS G-8 Organic Coatings
- AMS G-9 Aerospace Sealing
- AMS J Aircraft Maint Chemicals & Materials
- AMS M Aerospace Greases

NON-DESTRUCTIVE EVALUATION

- AMS K Non-destructive Methods & Processes Magnetic Particle & Penetrant Methods TF

SYSTEMS DEVELOPMENT & SAFETY, COMPONENT PROCESS AND MANAGEMENT SYSTEMS GROUP

QUALITY, RISK AND SAFETY SYSTEMS | Chair: Buddy Cressionnie

- S-18 Aircraft & Systems Development and Safety Assessment
- G-14 Americas Aerospace Quality Standards
- G-19 Counterfeit Electronic Parts
  - G-19A Test Laboratory Standards Development
  - G-19AD Authorized Distributor
  - G-19C Standard Compliance Verification
  - G-19CI Continuous Improvement
  - G-19D Distributor
  - G-19DR Distributor Risk Characterization
  - G-19T Terms and Definitions
- G-21 Counterfeit Materiel
  - G-21B Counterfeit and Substandard Battery Risk Mitigation
  - G-21R Counterfeit Refrigerants
- G-22 Aerospace Engine Supplier Quality (AESQ)
- G-23 Manufacturing Management

COMPONENT MANAGEMENT | Chair: Anduin Touw

- APMC Avionics Process Management
- CE-11 Component Parts
- CE-12 Solid State Devices
- G-24 Pb-free Risk Management Committee for ADHP

RELIABILITY, MAINTAINABILITY, AND HEALTH MANAGEMENT SYSTEMS GROUP COMMITTEES
Chair: Pete Carini

- G-11M Maintainability Supportability & Logistics
- G-11PM Probabilistic Methods Technology
- AISCSHM Aerospace Industry Steering Committee on Structural Health Monitoring
- E-32 Aerospace Propulsion Systems Health Management
- HM-1 Integrated Vehicle Health Management (IVHM)

AIRPORT/GROUND OPERATIONS AND EQUIPMENT SYSTEMS GROUP COMMITTEES
Chair: Jeffery Walsh

- AGE-2 Air Cargo
- AGE-3 Aircraft Ground Support Equipment
- AGE-4 Packaging, Handling and Transportability
- G-12 Aircraft Ground Deicing Steering Group
  - G-12ADF Aircraft Deicing Fluids
  - G-12DF Deicing Facilities
  - G-12HOT Holdover Time
  - G-12M Methods
  - G-12E Equipment
  - G-12ID Ice Detection
  - G-12RDP Runway Deicing Product
  - G-12T Training & Quality Program
  - G-12FG Future Deicing
- G-15 Airport Snow & Ice Control Equipment

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Aerospace Standards by the Numbers

535+ new documents started in 2019

Average 900 standards published (new, revised) per year

125 Meetings worldwide

7,600+ SAE Aerospace Standards in marketplace

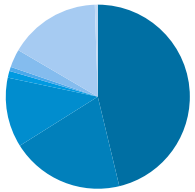
8,300+ individuals on committees

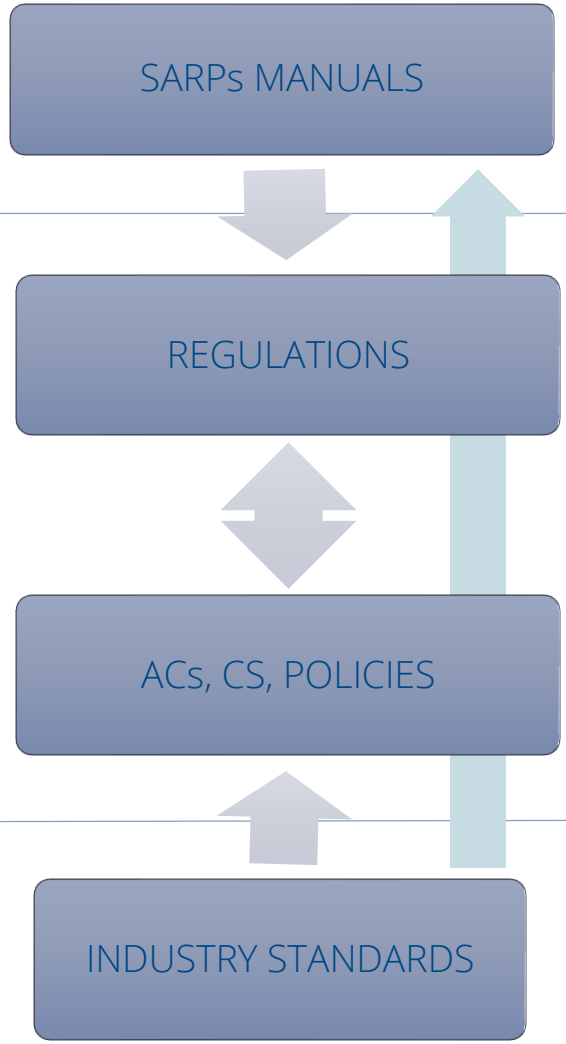
180+ technical committees

The Public-Private Partnership: Civil Aviation

Transport Canada

Transports Canada





Tasking Request
List of Intl. Orgs

150 SAE standards in EASA Material

400+ SAE standards on FAA material

17 Tasking Requests

Regional Office Support: DC, Europe, China

SAE Aerospace Council, Global Custodians: Oversight and Governance

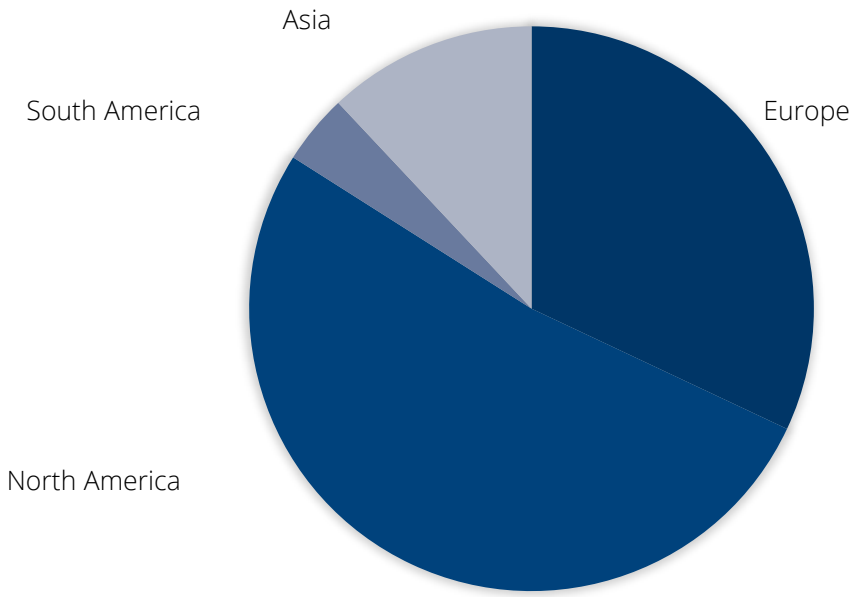
- Airbus
- A4A
- American Airlines
- AVIC
- BAE Systems
- Boeing
- Bell
- CAPE
- CIRA
- COMAC
- EASA
- Embraer
- FAA
- Leonardo
- GE Aviation
- Gulfstream Aerospace
- Honeywell Aerospace
- Lockheed Martin
- Lufthansa Technik
- Meggitt
- Northrop Grumman
- Pratt & Whitney / UTC
- Rolls-Royce
- Safran
- Sikorsky
- Textron Aviation
- U.S. Department of Defense
- UPS
- Wichita State University

2019 Meetings at COMAC, Shanghai and SAE AeroTech, Bordeaux

Stakeholders:
Industry, Operators, Government, Research

ICAO Observer Role

Global Stakeholders: Matching the Industry



Industry Managed Process and Stakeholders

Standards Need

Technical Development

Committee: Expertise

Governance

Council: Oversight

Publication

Marketplace

AS-1A Avionic Networks Committee

Chair: Stefano (Sam) Lassini

Document List		Display: All Documents	
Document	Title	Date	Status
AIR1207	A Primer of Aircraft Multiplexing	Jan 01, 1972	Canceled
AIR1189A	Airborne Internal Interface Standards for Moderate Bit Rate Digital Time Division-Multiplex Systems	May 22, 2006	Canceled
AIR4272A	Power Controllers: Signal Interface Applications and Considerations	May 22, 2006	Canceled
ARP4258A	Application of Low Speed Avionic System Discrete Signal Interfaces	May 22, 2006	Canceled
AS5706	Test Plan/Procedure for AS5643/1 S400 Copper Media Interface Characteristics Over Extended Distances	May 01, 2007	Issued
AIR4288A	Linear Token Passing Multiplex Data Bus User's Handbook	May 03, 2012	Stabilized
AIR4289A	Handbook for the SAE AS4075 High Speed Ring Bus Standard	May 03, 2012	Stabilized
AIR4903A	Pi-Bus Handbook	May 03, 2012	Stabilized
AIR4980A	Modular Avionics Backplane Functional Requirements and Consensus Items (MABFRACI)	May 03, 2012	Stabilized
AS4075/1A	Optical Implementation Relating to the High Speed Ring Bus (HSRB) Standard	May 03, 2012	Stabilized
AS4075A	High Speed Ring Bus (HSRB) Standard	May 03, 2012	Stabilized
AS4290A	Validation Test Plan for AS4074 Linear Token Passing Multiplex Data Bus	May 03, 2012	Stabilized
AS4710A	Pi-Bus	May 03, 2012	Stabilized
AS5657	Test Plan/Procedure for AS5643 IEEE-1394b Interface Requirements for Military and Aerospace Vehicle Applications	Apr 29, 2013	Reaffirmed
AS5653B	High Speed Network for MIL-STD-1760	Jan 03, 2014	Revised
AS1393	Serial Hi-Rel Ring Network for Aerospace Applications (RingNet)	Oct 08, 2014	Reaffirmed
AS5643B	IEEE-1394b Interface Requirements for Military and Aerospace Vehicle Applications	Apr 04, 2016	Revised
AIR4271A	Handbook of System Data Communications	Oct 21, 2016	Stabilized
AIR4295A	Handbook for the Digital Time Division Command/Response Multiplex Data Bus Test Plans	Oct 21, 2016	Stabilized
AIR4886A	Statement on Requirements for Real-Time Communication Protocols (RTCP)	Oct 21, 2016	Stabilized
AIR5683A	High Performance 1553 Research and Development	Oct 21, 2016	Stabilized
AS15532A	Data Word and Message Formats	Oct 21, 2016	Stabilized
AS4074/1B	Type F-1 Fiber Optic Media Interface Characteristics	Oct 21, 2016	Stabilized
AS4074/2B	Type F-2 Fiber Optic Media Interface Characteristics	Oct 21, 2016	Stabilized
AS4074/3B	Type E-1 Electrical Media Interface Characteristics	Oct 21, 2016	Stabilized
AS4074B	Linear Token Passing Multiplex Data Bus	Feb 21, 2017	Stabilized
AS15531A	Digital Time Division Command/Response Multiplex Data Bus	Mar 21, 2017	Stabilized
AS4111A	Validation Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Remote Terminals	Aug 10, 2017	Stabilized
AS4112A	Production Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Remote Terminals	Aug 10, 2017	Stabilized
AS4117A	Test Plan for The Digital Time Division Command/Response Multiplex Data Bus Couplers, Terminators, and Data Bus Cables	Aug 10, 2017	Stabilized
AS4114A	Production Test Plan for the Time Division Command/Response Multiplex Data Bus Bus Controllers	Aug 14, 2017	Stabilized
AS4116A	Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Bus Monitors	Aug 14, 2017	Stabilized
AS4115A	Test Plan for the Digital Time Division Command/Response Multiplex Data Bus System	Aug 15, 2017	Stabilized
AS4113A	Validation Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Controllers	Aug 18, 2017	Stabilized
AS6089	Verification Methods for AS5653 Network Controller	Oct 11, 2017	Issued
AS5652A	10 Megabit/sec Network Configuration Digital Time Division Command/Response Multiplex Data Bus	Jan 18, 2018	Revised
AS6260	Verification Methods for AS5653 Network Controller, Network Terminal, and Switch Physical Layer	Aug 13, 2018	Issued
AS6088	Verification Methods for AS5653 Network Terminal	Apr 24, 2019	Issued
AS5643/1A	S400 Copper Media Interface Characteristics Over Extended Distances	Jul 09, 2019	Revised
AIR5654A	IEEE-1394b for Military and Aerospace Vehicles - Applications Handbook	Aug 12, 2019	Revised

Aerospace Communications

1. Vehicle/Flight Systems [Safety Critical]
    a. Inner loop controls (flight controls, fly by wire, engine controls, autopilot, autonomy-related-functions)
    b. Displays (artificial horizon, primary flight display, engine status)
    c. Situational awareness communications (cockpit audio, flight control communication, radios)
    d. Flight management systems (navigation, flight planning)

2. Mission Systems [Mission Critical]
    a. Mission controls, sensor systems, video/displays, radar, data storage
    b. Passenger hosted systems, maintenance
    c. Flight health management
    d. Situational awareness communications

3. Weapons Systems [Mission and Safety critical]

4. Expanded Use Cases
    a. Vehicle to ground (in air or on ground)
    b. Vehicle to vehicle communications

Aerospace Communications

Safety Critical	Mission Critical
Strict Latency Bounds (sub milliseconds)	Moderate Latency bounds (hundreds of milliseconds)
Moderate Bandwidth (up to 100Mbps)	Very High Bandwidth (up to 100 Gbps)
High Availability	High Availability
High Integrity (low prob. of undetected erroneous data)	Medium Integrity
DO-178C/DO-254 Certification at DAL A-B Failure impact on safety, operation, or crew workload: **catastrophic** or **hazardous**	DO-178C/DO-254 Certification at DAL C-E Failure impact on safety, operation, or crew workload: **major, minor,** or **none**
Very infrequent updates to design, HW, SW	Periodic updates to design, HW, SW

Current (Aircraft) Networks

Current Military Aircraft Networks		
Standard	Std. Evolution	Max Data Rate
MIL-STD-1553 (Serial)	1973 – 1978	1 Mbps
IEEE 1394 (Firewire)	1994 – 2008	3.145 Gbps
MIL-STD-1760 (Fibre Channel)	1993 – Present	1.0625 Gbps
IEEE 802.3 Std Ethernet	1980 – Present	10 – 400 Gbps

Current Civil Aircraft Networks		
Standard	Std. Evolution	Max Data Rate
ARINC 429 (serial)	1977	100 Kbps
ARINC 629 (serial)	1995	2 Mbps
ARINC 825 (CAN)	2007	4 Mbps
ARINC 664 (AFDX)	2005 – 2009	100 Mbps

Motivation for Next Gen Networks:

Higher Bandwidth and Convergence/Interoperability (weight)

Motivation for Next Gen Networks:

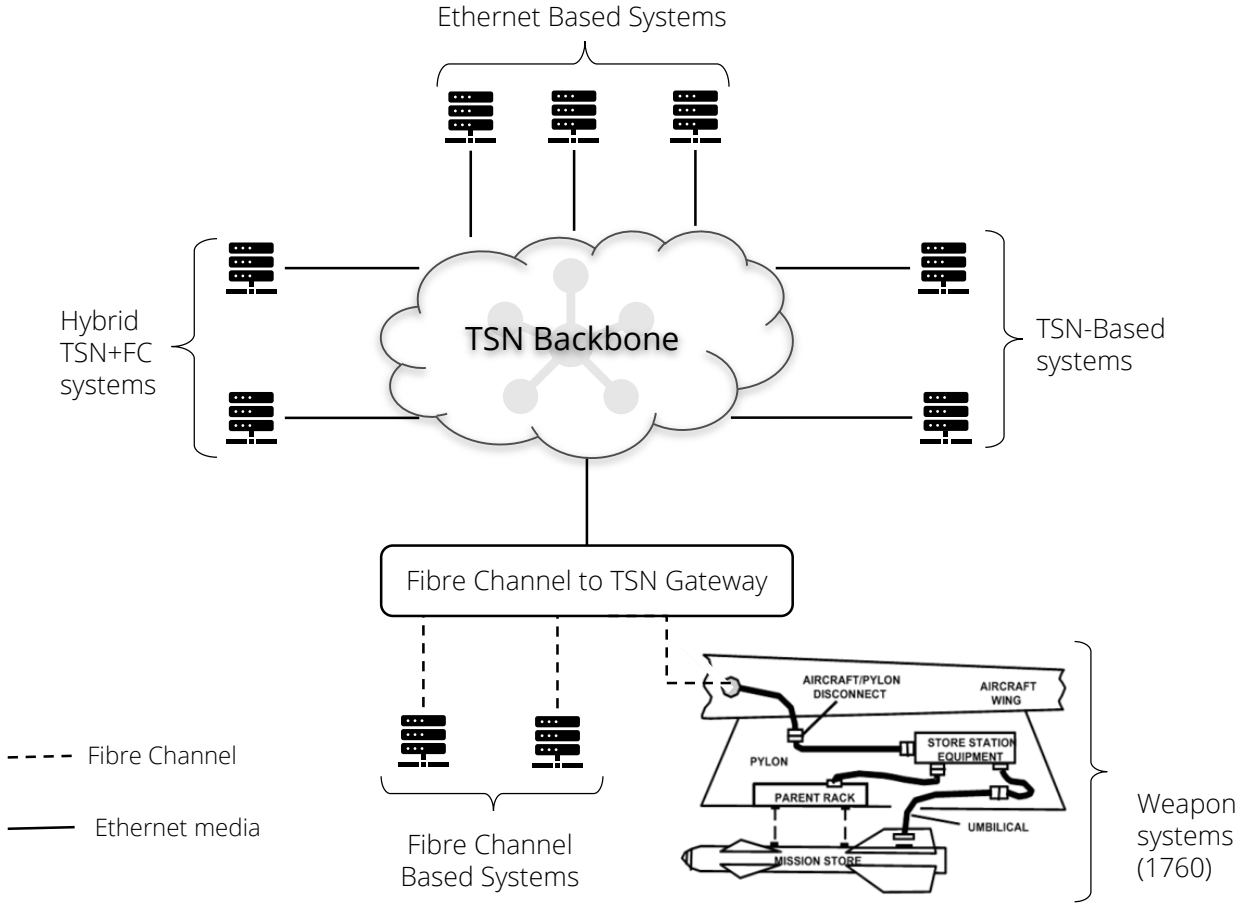
Lower "lifecycle" cost and Broad industry support/suppliers

Common **Open systems** requirement: **Standards Based**, **License Free**, and **Evolvable**

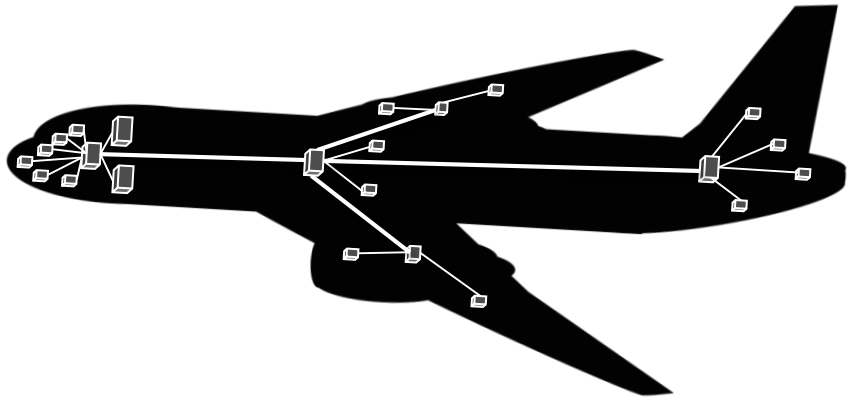
TSN seems to be a good fit

TSN Objectives in Aerospace Networks

Convergence of legacy buses on a deterministic, high performance backbone



Certifiable, standards-based (license free) deterministic, high bandwidth network



Potential: Future aerospace networks primarily based on TSN

Current SAE AS-1A2 Standards Activity

Convergence of legacy buses on a deterministic, high performance backbone

Certifiable, standards-based (license free) deterministic, high bandwidth network

	AS6509 - CAIN	**AS6675 – ATP**
Title	Converged Aerospace Integrated Network	Aerospace TSN Profile
Objective	Converge Fiber Channel & COTS Ethernet into single network domain for military applications	Interoperable TSN networks suitable for aerospace applications
Approach	Map FC and Ethernet on to TSN backbone	Profile TSN for aerospace applications
Status	In Progress; AS-1A2 Committee	In progress; AS-1A2 Committee

TSN Profile for Aerospace

Objectives

- Meet aerospace network requirements (traffic characterization in progress)
- Certifiability (reduced complexity and code)
- Interoperability
- Increased vendor base
- Lower “lifecycle” cost
- Security: neutral or positive impact
- Timely completion (AS6509 dependency, active programs and acquisitions)

Uniqueness

- Smaller number of use cases
- Smaller user community
- Smaller topologies
- Consensus driven by Integrators and certification
- Unique environment
- Long lifecycle (20yrs min, 50yrs expected)

Goal: Well defined TSN profile for aerospace – leading to cost effective certifiable solution for both civil and military use cases

TSN Profile for Aerospace – Initial Thoughts

Synchronous Profile

- Time Synchronization (AS-Rev)
- Traffic Shaping (Qbv)
- Redundancy (CB)
- Ingress Policing (Qci)
- Configuration Models (Qcw, CBcv)

Asynchronous Profile

- Traffic Shaping (Qav/Qcr?)
- Redundancy (CB)
- Ingress Policing (Qci)
- Configuration Models (Qcw, CBcv)

Conclusion

- TSN is a good fit for next generation aerospace networks
- There is a need for TSN profile for aerospace
- SAE AS-1 group has domain expertise in avionics systems
- SAE AS-1A group has expertise in avionics networks
- IEEE 802.1 TSN TG has expertise in TSN and TSN profiles
- **Proposal: A collaboration between SAE and IEEE groups to jointly develop and publish a "TSN Profile for Aerospace"**
- Organizational agreements in progress…
- SAE AS-1A2 committee would like to better understand IEEE 802.1 TSN TG process

Thank You