IEEE SA STANDARDS ASSOCIATION

Advancing Space, Aviation, and Autonomous Flight

From drones and aircraft to satellites, deep-space missions, space nuclear systems, and next-generation data centers, IEEE standards can help technologies connect, communicate, interoperate, operate securely, and remain resilient.

Space Cybersecurity Starts Before Launch

Security has to be designed into the components and systems a mission depends on. Ground systems, communications links, space vehicles, software, hardware, and integration layers all contribute to the mission. Each one can also introduce vulnerabilities or affect the mission's ability to keep operating when something goes wrong.

THE TECH

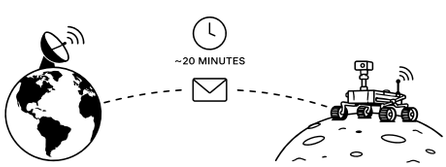
- Space vehicles
- Ground systems
- Communication links
- Mission software
- Integration layers
- Cybersecurity systems

WHAT HAS TO STAY PROTECTED

- Commands
- Mission data
- Spacecraft operations
- Ground infrastructure
- Communications
- System integrity

Image generated by AI

FUN FACT

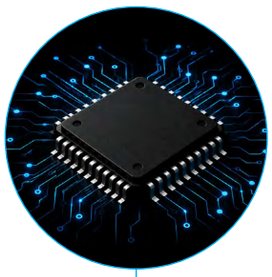


Up to ~20 Minutes One Way
At its greatest distances, a message between Earth and Mars can take roughly 20 minutes to arrive. Deep-space missions can't depend on immediate help from Earth when something goes wrong.

IEEE P3349™ addresses cybersecurity across five connected parts of the space system.

USER — SPACE — LINK — GROUND — INTEGRATION

The IEEE Connection



IEEE 3536™-2026
A component-level technical design process for developing cybersecure space systems.

IEEE P3349™
Cybersecurity controls spanning users, ground systems, space vehicles, link segments, and integration layers.

The Link Between Earth and Orbit

Antennas, networks, communications systems, and cybersecurity keep information moving. Satellites depend on communications throughout their missions. Command links send instructions from Earth. Telemetry reports the spacecraft's status. Mission data travels back to ground systems for processing and use.

Image generated by AI

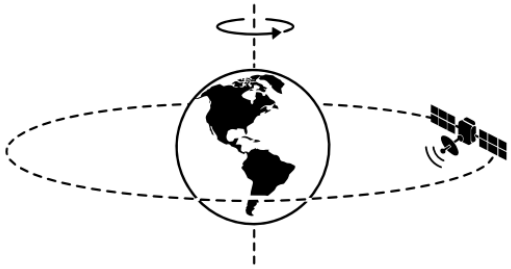
THE TECH

- Satellites
- Ground stations
- Antennas
- Wireless communications
- Data networks
- Tracking systems

WHAT MOVES

- Commands
- Telemetry
- Mission data
- Tracking information
- Status information
- Science data

35,786 km Above Earth
A satellite in geostationary orbit circles Earth at the same rate Earth rotates, allowing it to remain over roughly the same point on the planet. NASA's Tracking and Data Relay Satellites operate at this altitude.



FUN FACT

The IEEE Connection

IEEE 145™-2025
Standard definitions for antennas and antenna systems.

IEEE 149™-2021
Recommended practices for measuring antenna transmitting and receiving properties.

IEEE 211™-2018
Standard terminology for radio-wave propagation across telecommunications, remote sensing, and space-related propagation environments.

IEEE 802™-2024
The overarching architecture for the IEEE 802 family of networking standards used across connected communications systems.

IEEE P3349™
Space-system cybersecurity controls that specifically include the communications link segment, along with the ground system, space vehicle, and integration layer.

IEEE 3536™-2026
A cybersecurity design process for the components that make up secure space systems.

Fast Isn't Enough. Timing Matters.

Mission-critical aircraft networks need data to arrive predictably as well as quickly. Modern aircraft contain networks of flight-control systems, sensors, actuators, processors, displays, and other electronics. Many of those systems have to exchange information under strict timing and reliability requirements.

- Onboard Ethernet
- Time-Sensitive Networking
- Sensors
- Actuators
- Controllers
- Processors
- Displays
- Data concentrators

WHAT THE NETWORK HAS TO DELIVER

- Predictable timing
- Low latency
- High reliability
- Synchronization
- High bandwidth
- Interoperability

FUN FACT

Ethernet Is More Than 50 Years Old
Ethernet was invented in 1973 and adopted as an IEEE standard in 1983. Today, the same technology family is being adapted for time- and mission-critical aerospace networks.

The IEEE Connection

IEEE/SAE 802.1DP™-2025
Time-Sensitive Networking profiles for deterministic aerospace onboard Ethernet communications.

IEEE 802.1™ TSN
Extends Ethernet for applications where time synchronization, reliability, and predictable performance matter.

IEEE 802.11™
Onboard wireless access points (WAPs) connect devices to a local server hosting the airline portal, flight maps, and stored media.

Autonomous Flight Needs Common Ground

Standards help different Unmanned Aerial Vehicle (UAV) components and technologies work together. Unmanned aircraft systems can support everything from mapping and infrastructure inspection to emergency response and remote sensing. Their usefulness depends on much more than the aircraft itself. Payloads, sensors, mechanical and electrical interfaces, communications, data handling, and environmental durability all have to work together.

THE TECH

- Cameras
- LiDAR
- Sensors
- Payload systems
- Cellular communications
- Flight-control systems

WHAT DRONES CAN DO

- Map terrain
- Inspect infrastructure
- Collect remote-sensing data
- Support emergency response
- Monitor traffic
- Operate beyond direct visual range

Image generated by AI

424,000+ Nonrecreational Drones

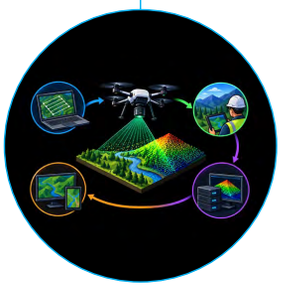
The FAA counted roughly 424,000 active nonrecreational small Unmanned Aircraft Systems in the United States at the end of 2025. Its 2026 base forecast puts the fleet above 457,000.

FUN FACT

The IEEE Connection

IEEE 1937.1™-2020
Common mechanical, electrical, and data-interface requirements for drone payloads.

IEEE 1937.6™-2026
A framework for UAV LiDAR remote-sensing operations and data handling.

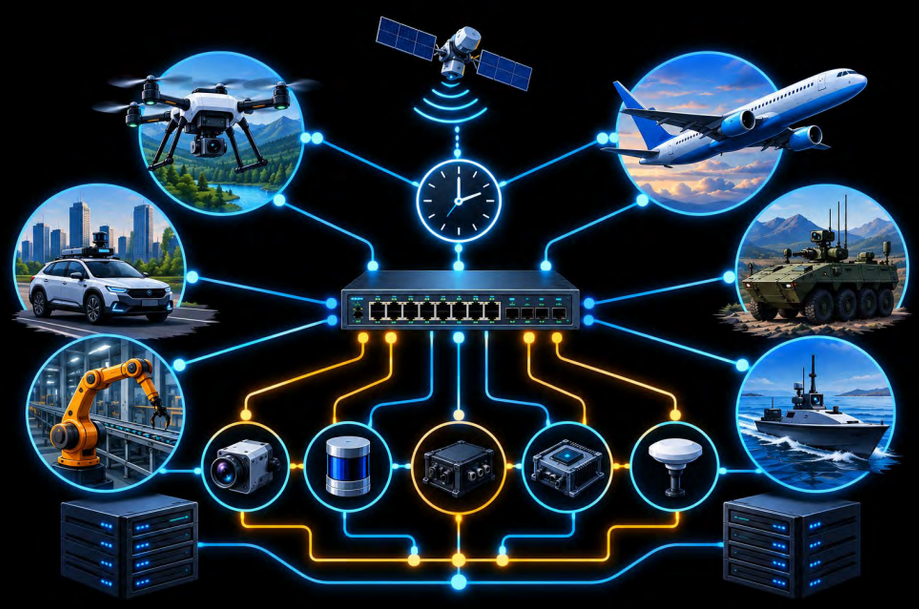


IEEE 1937.8™-2024
Communications interfaces for cellular-connected UAVs.

IEEE 802.11™
Some drones use wireless local area networks (WLAN) to communicate with each other when operating in a swarm, as well as to users.

The Network Behind Autonomous Operations

Autonomy depends on data moving predictably among sensors, controllers, and processors. Time-Sensitive Networking (TSN) extends Ethernet into applications where time synchronization matters. Instead of simply moving data as quickly as possible, deterministic networks are designed so critical information arrives when the system expects it.



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THE TECH

- Ethernet
- Time-Sensitive Networking
- Sensors
- Controllers
- Processors
- Network switches
- Time synchronization systems

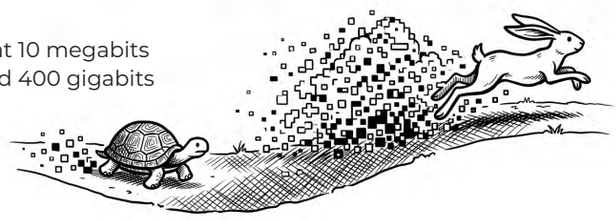
WHAT TSN ADDS

- Deterministic delivery
- Low latency
- Traffic prioritization
- Synchronization
- Reliability
- Interoperability

FUN FACT

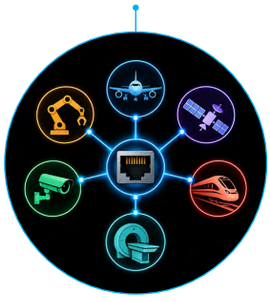
10 Mb/s → 400 Gb/s

The original IEEE Ethernet standard operated at 10 megabits per second. IEEE 802.3™ standards later reached 400 gigabits per second—a 40,000-fold increase.



The IEEE Connection

IEEE 802.1™ TIME-SENSITIVE NETWORKING
Ethernet-based technologies for applications with demanding time synchronization and reliability needs.



IEEE/SAE 802.1DP™-2025
An aerospace-specific TSN profile for onboard Ethernet communications.

IEEE 802.3™-2022
Wireless networking standards that help move data between connected systems

IEEE 1588™-2019
Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

IEEE 802.1AS™-2025
Time synchronization for Time-Sensitive Applications over networks

One Earth. Many Ways to Measure It.

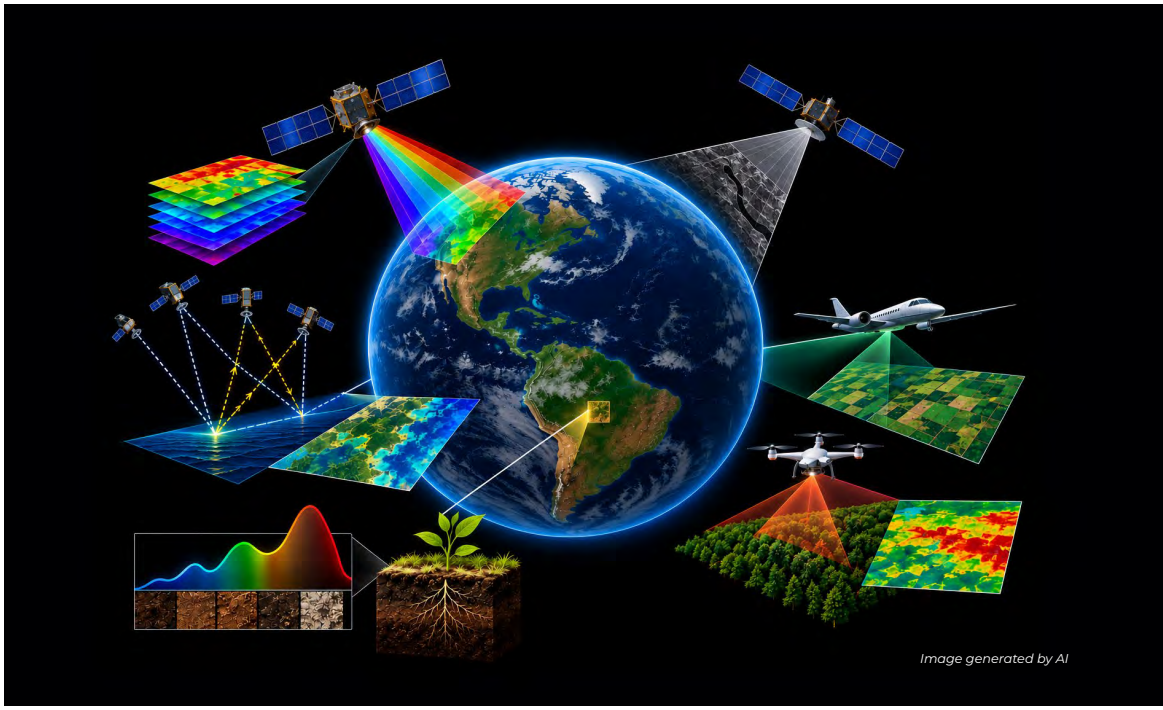
Light, radar, reflected navigation signals, and spectral measurements reveal different information about our planet. Satellites, aircraft, and UAVs can all serve as remote-sensing platforms. Hyperspectral imagers measure light across many narrow wavelength bands. Synthetic aperture radar uses radio waves. Global Navigation Satellite System (GNSS) reflectometry analyzes navigation signals after they bounce off Earth's surface. Soil spectroscopy links spectral measurements to physical properties on the ground.

THE TECH

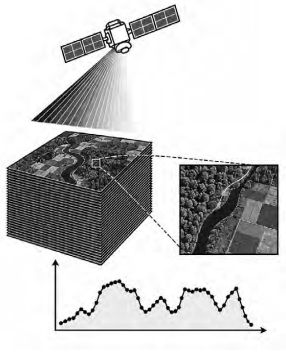
- Hyperspectral imaging
- Synthetic aperture radar
- GNSS reflectometry
- Soil spectroscopy
- Remote-sensing satellites
- UAV and aircraft sensors

WHAT GETS MEASURED

- Spectral signatures
- Radar returns
- Reflected GNSS signals
- Surface characteristics
- Soil properties
- Environmental change



Hyperspectral Sensors Capture Fine Detail
A typical multispectral image may use only 3–10 wavelength bands. Hyperspectral sensors can divide the spectrum into hundreds or even thousands of much narrower bands.



FUN FACT

The IEEE Connection

IEEE 4001™-2025
Performance characteristics and image metadata for hyperspectral imaging devices.

IEEE P4002™
A developing standard for synthetic aperture radar metadata content.

Image generated by AI

IEEE 4003™-2021
Data and metadata content for spaceborne GNSS reflectometry.

IEEE P4005™
A developing protocol for soil spectroscopy measurements.

IEEE P4006™
A developing method for assessing radio-frequency interference affecting space-based remote sensing.

Where? Which Way? What Time?

Positioning, navigation, and timing (PNT) answer three questions critical systems constantly need answered. Aircraft, autonomous systems, communications networks, power systems, financial networks, and spacecraft can all depend on accurate information about location and time.

THE TECH

- GNSS satellites
- Atomic clocks
- PNT receivers
- Antennas
- Time synchronization systems
- Resilience algorithms

WHAT PNT PROVIDES

- Position
- Navigation
- Time Synchronization
- Velocity
- Orbit and vehicle tracking

Image generated by AI

FUN FACT

30 Nanoseconds
GPS can transfer time relative to UTC with an accuracy of 30 nanoseconds or better (30 billionths of a second) 95% of the time, under specified operating conditions.

The IEEE Connection

IEEE P1952™
Technical requirements for resilient Positioning, Navigation and Timing user equipment.

Building a Resilience-Ready Space Workforce

IEEE SA is helping professionals apply mission-focused cybersecurity and resilience engineering in practice. Standards and technical requirements only matter if people know how to apply them. The **IEEE Space Systems Resilience Engineering Program** addresses the practical work of connecting cybersecurity, resilience, and systems engineering to mission needs.

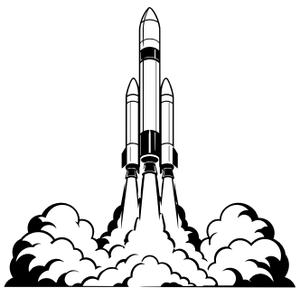
Image generated by AI

THE TECH

- Cybersecurity engineering
- Threat analysis
- Mission assurance
- Systems engineering
- Protection requirements
- Resilience assessment

WHAT PARTICIPANTS LEARN TO DO

- Identify mission threats
- Evaluate exposure
- Connect risks to mission needs
- Develop protection requirements
- Trace requirements to mission objectives
- Apply the IEEE 3536 process



FUN FACT

~100 Professionals. 10 Founding Organizations.
IEEE SA's pilot cohort brings together roughly 100 participants from 10 founding organizations to help develop and test the Space Systems Resilience Engineering credential.

The IEEE Connection

IEEE SPACE SYSTEMS RESILIENCE ENGINEERING PROGRAM

IEEE SA work focused on applying cybersecurity and resilience engineering to the needs of space systems and missions.

IEEE SPACE SYSTEMS RESILIENCE ENGINEERING PILOT COHORT

A training and certification initiative that teaches professionals to apply mission-focused resilience engineering in practice.

IEEE 3536™-2026

Defines a component-level technical design process for developing cybersecure space systems.

Across the Aerospace Ecosystem

Different aerospace systems face different technical challenges. Across Earth, atmosphere, orbit, and beyond, standards help provide the common approaches that allow increasingly complex technologies to work together.

IEEE