cannon

The Connected Flight: On-Board Ethernet Networks for Commercial Aircraft

ITT

ENGINEERED FOR LIFE

ABSTRACT

Modern commercial airliners are technology rich environments, packed with avionics, sensors, communications and entertainment systems, all of which rely on on-board networks to make safe, comfortable and connected travel possible for millions. Ethernet has, for some time, been the network infrastructure protocol of choice for commercial aircraft, thanks to its high performance, reliability and universally accepted open standards.

More recently, bandwidth requirements, particularly on large passenger aircraft, have increased substantially. The advent of on-board Wi-Fi, In-flight Entertainment & Connectivity (IFEC) systems delivering High-Definition (HD) video, Global Position System (GPS) data, and satellite content streamed directly to passengers' seats, as well as new avionics systems in the cockpit, have put a strain on existing aircraft networks.

This trend has forced aircraft operators to make trade-offs around the technologies they choose to equip in their cabins. As passengers increasingly see these bandwidth-intensive amenities as differentiators in the highly competitive airline market, operators and integrators need to find ways to boost on-board network performance effectively and affordably.

The starting point is to understand that these networks can be used in conjunction with copper cable or optical fiber. Each has its own benefits and drawbacks, and a solution should be selected based on a number of considerations:

- What are the network/performance requirements based on your required equipment?
- What kind of data are you channeling?
- How many nodes are on the network?
- What degree of packet loss are you willing to incur?
- What is the level of expertise of installation and maintenance personnel in working with fiber vs. copper?

This technical review paper is intended as a guide to help aircraft manufacturers, integrators and operators think about how best to implement high-bandwidth Ethernet networks on commercial platforms given their desired applications, requirements and constraints.

INTRODUCTION

Wireless Internet is currently one of the primary applications driving the need for high-speed Ethernet networks in aircraft cabins. The introduction of 802.11 and 802.11ac wireless access specifications, along with existing passenger data and content delivery systems are pushing aircraft network performance requirements higher.

To ensure that aircraft networks meet growing demands in the near and long term, planners and integrators must first answer important questions on expected network performance, size, data types and acceptable levels of packet loss.

The answers to these questions will help define the network's equipment requirements, including the appropriate power supply, network adapters, cabling, switches and access points. Connectors play a crucial role in the performance and fidelity of an Ethernet network, and are essential to enabling network performance and ensuring compatibility with different cabling mediums, including copper and optical fiber.

In addition to wired networks, aircraft often provide wireless access points to passengers, also channeled by either high-speed copper or optical glass fiber. The wireless standards typically used in this environment are 802.11 and 802.11ac.

ETHERNET NETWORK ADVANTAGES:

- Data transfer speed of one gigabit per second (Gbps) or greater
- Unlimited network length
- Robustness and reliability through use of established hardware components (switches, adaptors, RJ-45 connectors)
- Increased system performance enabled network-wide by high-bandwidth connectors and contact systems including Quadrax, OctoGig™ and ARINC 801-Compatible Fiber Optics

In addition to wired networks, aircraft often provide wireless access points to passengers, also channeled by either high-speed copper or optical glass fiber. The wireless standards typically used in this environment are 802.11 and 802.11ac.

ETHERNET NETWORK CHALLENGES:

- Applying Ethernet-based technology in the on-board environment presents some technical challenges, both in terms of network configuration and component performance.
- The main challenges with respect to aircraft cabin network requirements are related to fault tolerance (i.e. a network resilient to the failure of one or more of its components), topology due to cabin design, and response time or network latency–the amount of time it takes for a packet to travel along a network path from sender to receiver.
- The data cabling and connectors deployed in the network must satisfy very strict aviation fire and smoke standards and meet rigorous mechanical and environmental requirements, primarily to do with vibration, sealing and temperature.

IMPLEMENTING ETHERNET:
Defining Requirements

The first step an aircraft manufacturer or airline must take is to define the performance requirements for their Ethernet network – in terms of megabits or gigabits per second – a specification that will depend upon the bandwidth requirements of desired on-board systems.

These requirements are driven largely by the kinds of data the aircraft operator wishes to channel over the network, the size and complexity of the network, and the degree of data loss that the operator is willing to incur.

Data and Network Characteristics

Many airlines provide seatback IFEC consoles capable of delivering locally hosted video, audio and interactive content. Some on-board networks also provide content to passengers streamed via satellite link to seatback IFEC or, as is becoming increasingly popular, to personal electronic devices such as computers, smartphones and tablets.

The kinds of data and content a network delivers to passengers and the configuration of the IFEC system (number of seats, different layouts for different classes, in-flight wireless networks, etc.) are the key factors that will influence both network performance requirements, as well as the number of nodes and network complexity.

Once these factors are considered and performance expectations determined, the next step is to define a corresponding Ethernet application, to establish the right network transmission hardware and protocol. The appropriate Ethernet class for the application will be based on the network performance requirements, as well as key variables like cabin topology (the length of aircraft and the number of seats, for example) which have a bearing on the required channel length(s) for the network.

Cabling: Copper or Fiber

The next major consideration is cabling. The two main standards in use today include twisted pair copper cabling and optical glass fiber, each of which offer unique characteristics suited to different applications. The Ethernet and Cabling Standards section on pages 7-8 explains the relationship between Ethernet class, application, data rate, the number of pairs/fibers needed, maximum bandwidth, cable construction and channel length requirements.

While fiber optic cable is much lighter than copper cabling, and therefore helps contribute to important weight reduction initiatives on modern airliners, it does present serviceability challenges, requiring specialized skills from installation and maintenance teams. Consequently, fiber is typically favored for long cable runs due to weight savings, but copper is preferable for short runs to help make maintenance easier and more cost-effective.
Fiber also offers near perfect losslessness in data transmission, which is desirable for certain types of data (such as sensor information delivered to avionics computing systems) but less important in other cases, like video, for which the loss budget may be higher.

Connector Considerations

A high-performance, fault tolerant Ethernet network is an aircraft-specific infrastructure, able to transfer not only typical dedicated flight data (such as that for command, control and maintenance), but also passenger multimedia services, Internet connectivity and IP telephony. More recently, the trend toward wireless systems connected directly to passengers' personal devices reduces the number of network nodes required, as well as the overall complexity the of the Ethernet network.

Transmission across the network is typically achieved with twisted pair copper cable or optical glass fiber. While there is no formal standard for interconnect within most modern aircraft control systems, ARINC 600 and 38999-Style Series III Connectors are among the most commonly used in commercial aircraft applications. Several examples of contact systems compatible with these standards, along with their features, include the following:

High-Frequency, High-Bandwidth Coax Connectors

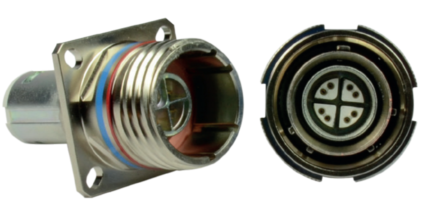
Aircraft 802.11 wireless networks typically broadcast in the 2.5 – 5 GHz range. But network control systems typically require surplus RF bandwidth in the 2.8 – 6.2 GHz range to support overhead requirements in addition to passenger use. ITT Cannon has a complete selection of high-bandwidth Coax/RF Connector Solutions that are fully compatible with these cabin wireless access point (CWAP) performance requirements.

OctoGig™ 10 Gigabit Ethernet (10 GbE) Solution

- ITT Cannon's OctoGig™ is an eight-contact, high-bandwidth copper solution designed for space and weight savings. OctoGig™ can be integrated into a variety of connector bodies, including ARINC 600 Rack & Panel and 38999-Style Series III with standard size 22 contacts, making it easier to install and maintain than competing solutions.

- OctoGig™ enables data transfer rates up to 10 Gigabits per second (Gbps), supporting mission-critical functionality such as providing pilots with enhanced visibility in extreme weather conditions and bringing passengers an array of high-definition programming.

- This ultra-high speed, 10 GbE connector offers significant increases in data transfer rates compared to existing solutions in the commercial aviation market.



ITT Cannon KJB 38999-Style
Series III OctoGig™

ITT Cannon BKA
ARINC 600 OctoGig™

Quadrax Multi-Signal Contact Systems

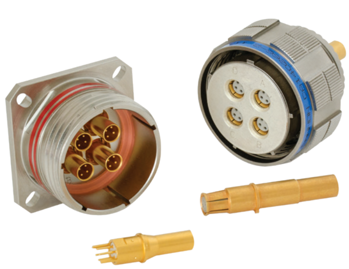
- Quadrax Multi-Signal Contact Systems deliver reliable high-speed data transfer rates up to 2.5 Gbps and are available in a wide range of commercial aerospace connectors including ARINC 600 Rack & Panel and 38999-Style Series III Circular.
- Designed as a Size 8 contact assembly installed in a clocked Size 8 contact cavity insert, Quadrax Multi-Signal Contact Systems contain four matched impedance signal contacts within a shielded Size 8 body. High-speed data is transmitted through the signal contacts, which are terminated to signal wires within a shielded Quadrax cable. The outer shield of the cable is terminated to the contact outer body to assure the signal contacts are shielded from outside noise.
- ITT Cannon's Quadrax-based connector systems have a significant flight history, with more than 20 years of proven reliability in high-speed data applications. They can be found in a number of commercial aerospace applications including In-Flight Entertainment, Wireless Connectivity and Connected Cabin Systems.

ARINC 801 Fiber Optic Solutions

- ITT Cannon's ARINC 801-Compatible Fiber Optic Series offers an end-to-end solution featuring Connectors, Termini and Cable Harnesses. Designed for high bandwidth applications that require quick and accurate data transfer, these fast, lightweight and highly reliable interconnects operate at transmission speeds of 10 Gbps or higher and are ideally suited for IFEC, Avionics and Navigation.
- ITT Cannon offers complete fiber optic manufacturing services including testing, inspection and polishing (Flat, APC, PC), as well as complex assembly of a variety of cable constructions. All capabilities are performed by highly skilled technicians and team members trained in the manufacturing and assembly of fiber optic interconnects.

PHD Fiber Optic Connectors & Termini (Size 16 & 22)

- ITT Cannon's PHD Fiber Optic Termini for multi-channel interconnects are designed to deliver reduced insertion loss, less channel-to-channel variance, and easy integration into High Density Interconnect connectors.
- PHD Fiber Optic Termini are compatible with a wide range of interconnects including PHD Panel Mount, D-Subminiature, ARINC 600 Rack & Panel, PHD Backplane and 38999-Style Series III Circular.



ITT Cannon KJA Series III Circular with Quadrax Contact System

ITT Cannon ARINC 801-Compatible Fiber Optic Solutions

ITT Cannon PHD Fiber Optic Termini in Circular Connector

Additional Information on Ethernet & Cabling Standards

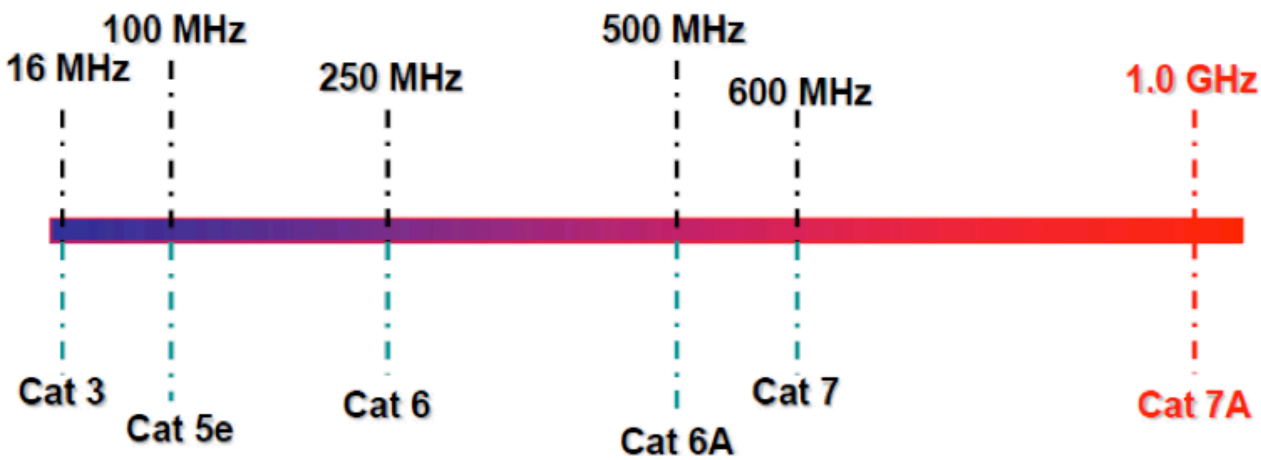
Ethernet based technologies are defined by IEEE 802.1 and 802.3 standard families. In particular, the IEEE 802.3 group specifies the performance and versions for wired networks. There are no specific cabling standards for railcars, so industry players mainly refer to ISO/IEC11801 – information technology – generic cabling for customer premises specifications for transmission.

ISO/IEC 11801 specifies general-purpose telecommunication cabling systems (structured cabling) that are suitable for a wide range of applications, such as analog and ISDN telephony, various data communication standards, control systems, factory automation, etc. The standard covers both balanced copper cabling and optical fiber cabling.

This standard specifies generic installation and design topologies that are characterized by a "category" or "class" of transmission performance. It defines several link/channel classes and cabling categories of twisted-pair copper interconnects, which differ in the maximum frequency for which a certain channel performance is required:

- Class A: link/channel up to 100 kHz using Category 1 cable/connectors
- Class B: link/channel up to 1 MHz using Category 2 cable/connectors
- Class C: link/channel up to 16 MHz using Category 3 cable/connectors
- Class D: link/channel up to 100 MHz using Category 5e cable/connectors
- Class E: link/channel up to 250 MHz using Category 6 cable/connectors
- Class EA: link/channel up to 500 MHz using Category 6A cable/connectors
- Class F: link/channel up to 600 MHz using Category 7 cable/connectors
- Class FA: link/channel up to 1000 MHz using Category 7A cable/connectors

Common cable types include U/UTP (unshielded cable); U/FTP (individual pair shielding without the overall screen); F/UTP, S/UTP or SF/UTP (overall screen without individual shielding); and F/FTP, S/FTP or SF/FTP (overall screen with individual foil shielding).



ETHERNET STRUCTURED CABLING STANDARDS AND CORRESPONDING FREQUENCY RANGES

ISO/IEC 11801 also defines several classes of optical fiber interconnect that support 10 Gigabit Ethernet, at a minimum:

- OM1: Multimode fiber type 62.5 µm core; minimum modal bandwidth of 200 MHz•km at 850 nm; supports 10GbE at lengths up to 33 meters
- OM2: Multimode fiber type 50 µm core; minimum modal bandwidth of 500 MHz•km at 850 nm; supports 10GbE at lengths up to 82 meters
- OM3: Multimode fiber type 50 µm core; minimum modal bandwidth of 2000 MHz•km at 850 nm; supports 40GbE and 100GbE at lengths up to 100 meters
- OM4: Multimode fiber type 50 µm core; minimum modal bandwidth of 4700 MHz•km at 850 nm; supports 40GbE and 100GbE at lengths up to 150 meters
- OS1: Single-mode fiber type 1 dB/km attenuation
- OS2: Single-mode fiber type 0.4 dB/km attenuation

The cabling standards are subsequently referenced in applications standards, such as IEEE for Ethernet, as a minimum level of performance necessary to ensure application operation.

Connect with your ITT Cannon representative today
or visit us at ittcannon.com

Connect with the experts

ITT Cannon is a world leader in the design and manufacturing of highly engineered interconnect solutions for the commercial aerospace market.

ITT

ENGINEERED FOR LIFE

CHINA—Shenzhen City
+86.755.2726.7888

FRANCE
+33.1.60.04.93.93

GERMANY—Weinstadt
+49.7151.699.0

HONG KONG
+852.2732.2720

INDIA—Bangalore
+91 22 67843000

ITALY—Lainate
+39.02938721

JAPAN—Kanagawa
+81.462.57.2010

MEXICO—Nogales
+52.631.311005

SINGAPORE
+65 66974205

UK—Basingstoke
+44.1256.347400

USA—Irvine, CA
+1.800.854.3028