# WHAT'S NEW IN ARINC 818 SUPPLEMENT 2

*Paul Grunwald, Great River Technology, Inc., Albuquerque, NM*

*This paper was presented at the Thirty-second Digital Avionics Systems Conference in Syracuse, New York, October 6-10, 2013. Since then, on October 31, 2013, the Executive Committee of the Airlines Electronic Engineering Committee unanimously endorsed the ARINC 818 Supplement 2 draft discussed in this paper. ARINC is expected to publish it as Standard 818-2 in December 2013.*

## Abstract

Avionics Digital Video Bus (ADVB) or officially, ARINC 818 was initially ratified in October of 2006 with great industry support and backing. Since then, ARINC 818 has been used as the video transport protocol for cockpit displays on the Boeing 787, Airbus A350 and A400M, C-130 AMP, and the C-17, F15, F18 upgrade programs, and numerous other commercial and military aircraft. In 2013, the ARINC 818 committee will produce the next version of the specification. This update will add new features and standardize some customer and industry options that have been developed as point designs. Great River Technology is the Industry Editor for the next Supplement; this paper will review the current technical items being added for Supplement 2.

ARINC 818 is a great example of how a well-defined standard, written in a collaborative, industry partnership, can foster interoperability and best practices. Updates to a specification to add new features and capability keep the standards and implementations fresh, insuring that industry needs are being meet. The ARINC 818-2 standardization process brings the participants, thought leaders, and customers all together cooperatively so that the ARINC 818 ecosystem remains healthy and vibrant.

## Introduction

Prior to ARINC 818 there was the FC-AV (Fibre Channel, Audio Video) standard. The official designation of the standard is ANSI INCITS 356-2002. FC-AV uses Layers 0-4 of the Fibre Channel (FC) standards. Like HOTLink®, FC-AV can use copper or fiber for the Physical Layer (FC-0) and also uses 8B/10B encoding as part of the transmission protocol (FC-1). FC-2 defines a container system for the video. The container system describes how the video frame is partitioned in Fibre Channel frames for transmission and is made of a container header and objects. Objects contain ancillary data, audio data, and video data. The container header describes the format of the video and how it is going to be arranged in the following FC frames.

The Fibre Channel management layer (FC-3) is generally not used in FC-AV, but the Mapping Layer (FC-4) is, specifically the Frame Header Control Protocol (FHCP). The frame header is used as a means to communicate information that is needed to reconstruct the video image that is encapsulated in the container. FC-AV is also a bi-directional protocol. For detailed information on FC-AV, please see [http://www.fc-av.info](http://www.fc-av.info) .

In 2005, Airbus and Boeing drove the effort to further capabilities for the new 787 and A400M programs, and a new standardization effort was initiated through the Digital Video Subcommittee of ARINC. The primary driver for the standard was to consolidate many proprietary standards that existed in the avionics supply chain. For example, display manufacturers such as Honeywell, Rockwell Collins, and Thales each had their own protocols for their products. The new standard also incorporated increased bandwidth and features discussed below.

The major aim of the ARINC 818 specification was to provide a robust protocol to handle the high bandwidth of modern avionics video systems and include the precise timings for line synchronous displays. Fibre Channel remains the physical layer for the bus and also offers the advantages of routing and protocol capabilities found in modern networking protocols. FC also is deterministic with low latency. ARINC 818 includes error detection.

### *High Bandwidth*

At the time ARINC 818 was ratified, the fiber channel protocol supported link rates of 1.0625, 2.125, 4.25, and 8.5 Gbps. Since then, link rates of 14.025, and 28.05 Gbps have been released with even higher speeds planned as the market needs it. For example, a display at WQXGA resolution (2560 x 1600 pixels @ 24-bit color) at 30 Hz would need a bandwidth of 3,864 Mbps.

### *Low Latency*

One of the most important features of ARINC 818 is the ability to deliver uncompressed video with very low latency, in many implementations, less than one frame. Low latency is important in real-time cockpit displays and especially in Heads-Up Displays (HUD) where differences in the HUD display images and real-world background can cause vertigo or motion sickness in the pilot.

Latency is generally determined by the implementation. In some cases, the image is streamed through FIFOs and can be almost real-time. Other implementations use two image buffers and display one while the other is filling ("ping pong") giving a latency of a single frame. At 30 Hz, this equals latency of 33 msec, at 60 Hz it is 16 msec, which is low enough for even the most demanding applications [1]. In ARINC 818, there are no limitations on the frame rate and even shorter latencies are possible with high frame rates.

ARINC 818 was originally published in October of 2006 with Supplement 1 released a year later. Since then, the protocol has been used in dozens of programs and ARINC 818 displays are logging hundreds of thousands of flight hours on both military and commercial aircraft.

As these programs have advanced, new requirements and applications for the ARINC 818 protocol have arisen. In the interest of maintaining interoperability in the ARINC 818 community, ARINC Project Initiation/Modification (APIM 13-001) was sent to the Digital Video Working group and the project was approved at the January 2013 meeting in Coral Gables, Florida.

Throughout the spring and summer representatives from Airbus, Boeing, Cotsworks, , Elbit, Thales, Honeywell, DDC, SRB Consulting, Inc, and Great River Technology proposed, discussed, and drafted the items for the Supplement. On August 20-2 in Annapolis, Maryland, a face to face meeting was held and the draft Supplement was completed. It is anticipated that Supplement 2 will be ratified at the 2013 AEEC Mid-Term session in Zagreb, Croatia on October 31st – November 1st.

The following items were incorporated into the Supplement and will be discussed below.

- Faster speeds: Fiber Channel 6x, 12x, 16x, 24x, 32x and others.
- Video compression provisions
- Video encryption provisions
- Video switching guidelines
- Support for Field Sequential Color
- Channel Bonding
- Bi-directional camera interfaces and synchronization
- Data only links
- Support for stereo/3-D displays
- Optical signal performance
- Guidance for Computation of Prior Image CRC

## Speeds

In ARINC 818-1, the following speeds are supported.

**Table 1. ARINC 818-1 Speeds**

| Rate (Gbps) | Note |
|---|---|
| 1.0625 | FC 1x rate |
| 1.5 | |
| 1.62 | |
| 2.125 | FC 2x rate |
| 2.5 | |
| 3.1875 | FC 3x rate |
| 4.25 | FC 4x rate |
| 8.5 | FC 8x rate |

Supplement 2 expanded the list to include the following link rates:

**Table 2. ARINC 818-2 Speeds**

| Bit Rate (Gbps) | Note |
|---|---|
| 1.0625 | FC 1x rate |

| | |
|---|---|
| 1.5 | |
| 1.62 | |
| 2.125 | FC 2x rate |
| 2.5 | |
| 3.1875 | FC 3x rate |
| 4.25 | FC 4x rate |
| 5.0 | |
| 6.375 | FC 6x rate |
| 8.5 | FC 8x rate |
| 12.75 | FC 12x rate |
| 14.025 | FC 16x rate |
| 21.0375 | FC 24x rate |
| 28.05 | FC 32x rate |

The 6x, 12X, and 24X speeds were added to accommodate the use of high speed, bi-directional coax with power as a physical medium. The 5Gbps rate was added to accommodate so implementation specific speeds supported by certain FPGAs.

In addition to the above speeds and Interface Control Document (ICD) can specify other rates for a specific data only return path implementation. For example, a camera might have a low speed control link that does not need even the FC 1x rate.

## Compression and Encryption

The initial ADBV specification was envisioned as carrying only uncompressed video and audio. With today's high resolution sensors and displays, compression is desirable for recording. Also, some data may be sensitive and need to be protected. With these requirements in mind, the specification was amended to allow new object class types to indicate a payload is compressed, encrypted, or both.

As ADVB was originally derived from the Fiber Channel Audio Video Specification, it used the same Object Class types. These class types are specified in the ADVB container header for the Objects 0 -3. These were 50h for ancillary data in object 1, 40h for audio data in Object 1, and 10h for video in objects 2 and 3.

Rather than try and cover every type of compression codec or encryption algorithm the decision was to follow the philosophy of ARINC 818 and let the ICD be controlling document and define the algorithms used for the project. Additional Class types of 51h, 52h, and 53h can now be specified for compressed, encrypted, or both respectively for ancillary data. Likewise, for audio, object types 41h, 42h, and 43h are available. For video, types 11h, 12h, and 13h may be used.

Should an implementation use multiple codecs or algorithms, the Simple Parametric, Digital Video index field is available as a selector. What this means is that like other items in ARINC 818, the specification itself is agnostic and the ICD will specify the implementation details.

## Switching

ARINC 818 was defined as a point-to-point interface to insure 100% quality of service. However since avionics systems often have multiple channels, allowing switching has become important. Again, to insure interoperability, it was important to formalize some of the implementation details and recommendations into the specification. Only a few hard requirements were inserted.

The first requirement is that active switching only occurs between containers. From a practical standpoint, what this means is that if you are transmitting video, the switch would wait until the vertical blanking period to prevent broken video frames. For data and audio, this becomes a little tricky and the container size must be considered or the switching latency may become too large while waiting for the end of a container.

Like the other items discussed, ARINC 818-2 provides guidance on the ICD covering items such as in band or out of band control, multicast, port states, diagnostics, and latency.

## Field Sequential Color

A Video Format Code was added to support field sequential color. The color field-sequential mode will typically send each color component in a separate container. For example, the RGB mode typically would send R, then G, then B and repeat.

Each container would be at 3X the base rate, i.e. 180 Hz for 60 Hz video.

## Channel Bonding

A common method used to overcome link bandwidth limitations has been to use multiple links to transport the video. The video frame is broken up into smaller segments and transmitted on 2 or more links. Using multiple links may be done to reduce the implementation cost, for example, using an FPGA capable of providing 2 links at 3.1875Gbps may be cheaper than 1 at 6.375Gbps.

For example, a WQXGA image with 24-bit color depth at 60 Hz would require bandwidth of 737,280,000 Bps. With Channel Bonding, this image could be split and transmitted on two ARINC 818 4.25 Gbps links.

The method of breaking up the video is implementation specific but is typically left/right halves, or odd/even pixels. Again the ICD is the controlling document and should specify items such as allowable skew and latency between channels.

To be compliant with the specification, each link will transmit a complete ADVB frame with header and ancillary data. To minimize buffer depth, it is recommended that the links be synchronized within 1/5 of the maximum ADVB frame duration.

## Data-only Links

Another provision added to the ARINC 818 spec allows data-only links. Data-only links provide a method for command and control, status, or touch screen coordinates. In this situation, only Object 0 containers are sent. The ADVB container header will communicate the sizes (in bytes) of Object 0 data to the receiver and the receiver will be able to detect that the transfer is data-only in three possible ways:

(1) The Object sizes in the ADVB container header will be set to 0 for Objects 1, 2, and 3.

(2) The row and column values in ancillary data Word 0 will be set to 0.

(3) Object 0 Word 3 (miscellaneous control word) will transmit a Parameter type 1 with bit 8 set.

Data only transfers can be of any size and may be comprised of multiple ADVB frames. The total size (in bytes) will be indicated in the Object 0 size field in the ADVB container header. Any special rules for packetization (e.g., the ADVB frames will be of a fixed size) must be specified in an ICD. Data only ADVB link rates may be of one of the standard link rates described above, or may be at a different rate established by the ICD.

## Bi-directional Camera Interfaces

Practically speaking, a bi-directional camera interface is just a special case of a data only link but it was felt that some guidance for these classes of implementations be incorporated. The video interface from the camera should use one of the standard data rates and the control channel will adhere to the above rules for a data only link. Another potential use of the data only camera control interface is to use the packet for synchronization for multiple cameras as to make operations such as merging and blending easier. In this case, a bit is provided indicating that the container is a sync marker and to synchronize on the Start of Frame Initiate (SOFi) symbol for the video channel. Once again, the project ICD will specify the camera control parameters and video timing tolerances.

## Stereo and Other Displays

It has always been possible to make stereo displays with ARINC 818, but Supplement 2 added some control parameters to give more flexibility to not only do stereo but to also do partial image, tiling, and region-of-interest displays. Examples include vertical banding (Figure 1), horizontal banding (Figure 2), and tiling (Figure 3).

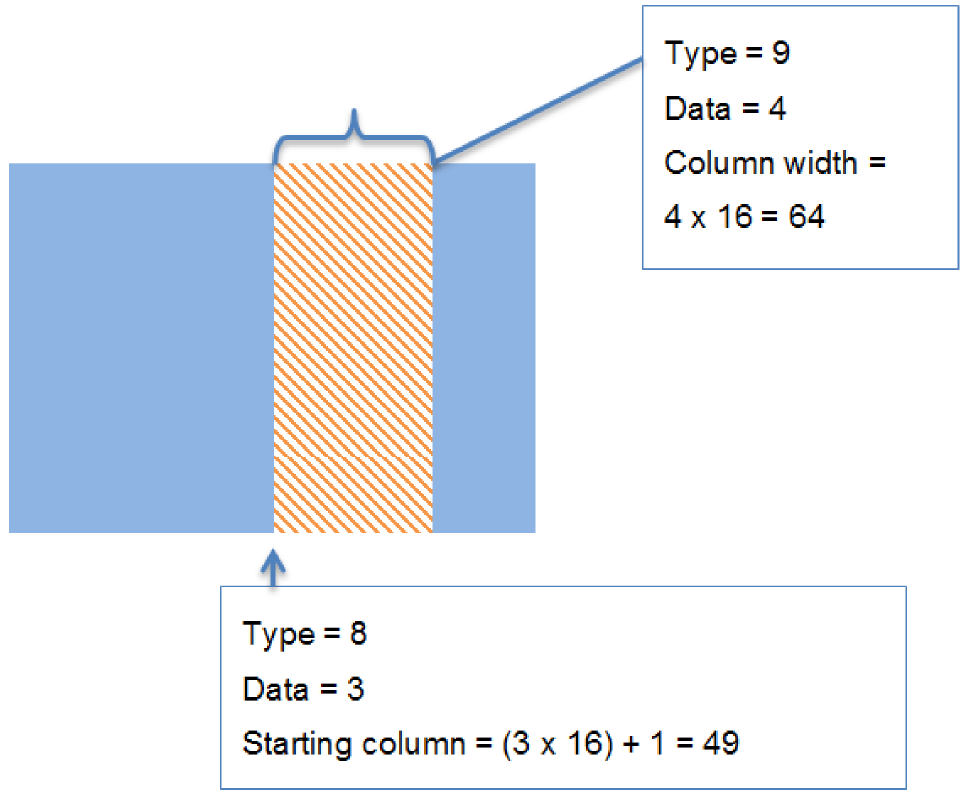


**Figure 1. Transmission of a vertical band using parameters types 8 and 9.**

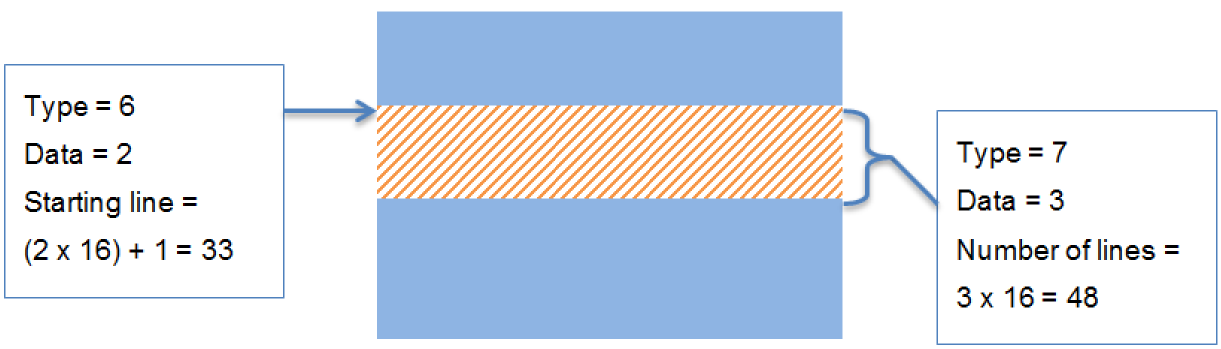


**Figure 2. Transmission of a horizontal band using parameters types 6 and 7.**

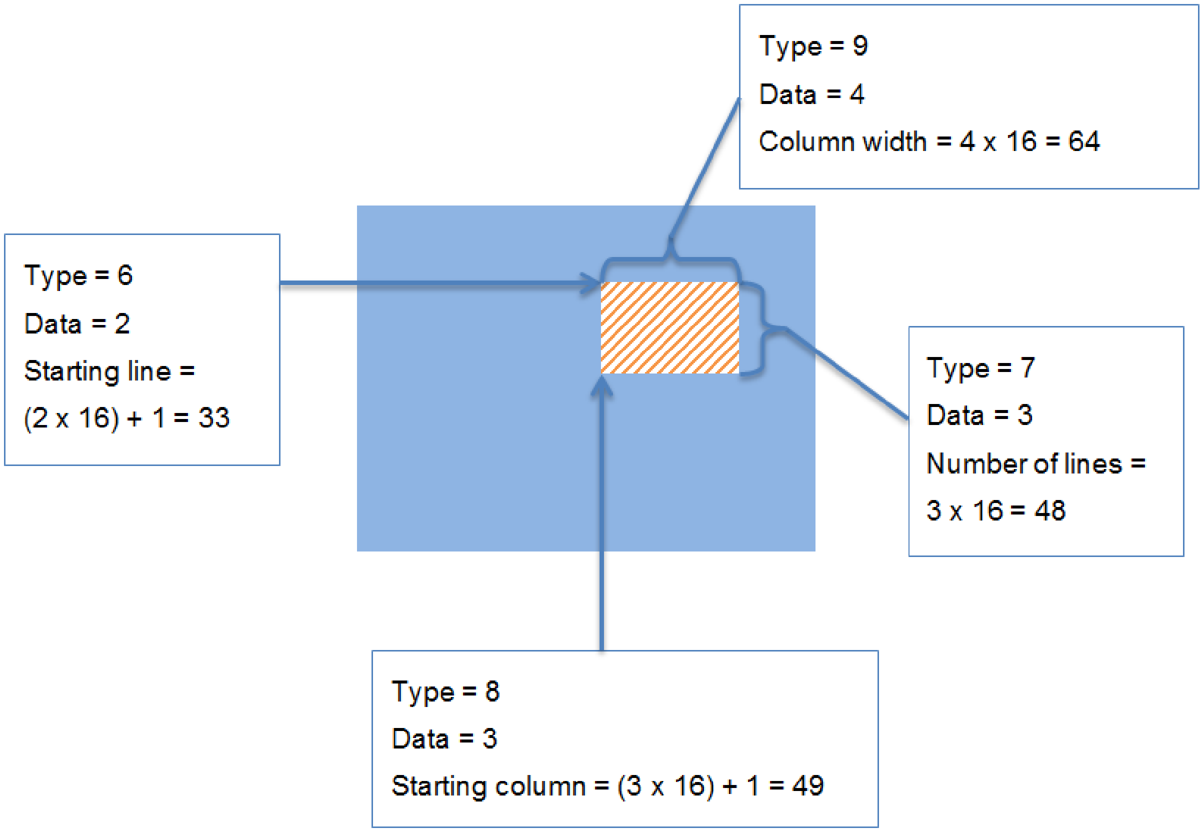


**Figure 3. Transmitting a rectangular tile using parameter types 6, 7, 8, and 9**

With the additional control, it is possible to do horizontal and vertical slices. With a horizontal slice and vertical slice are used together, a region of interest can be defined. Also possible are Left and right channel images, and inset areas. Provisions were also added to insure that the Cyclic Redundancy Check (CRC) is calculated on the desired pixels.

## Optical Performance

The ADVB specification has never directly specified a physical medium; rather it has referenced other specifications such as ARINC 801 (Fiber Optic Connectors) and ARINC 802 (Fiber Optic Cable). To insure interoperability and system performance; an Optical Signal performance section has been added to the ICD. The recommendation is that for transmitters, the ICD contain the following parameters:

- Type of optical fiber in which the signal is injected
    - Multimode or single mode
    - Graded index or step index
    - Core and cladding diameter
- Data rate
- Optical wavelength and maximum spectral width
- Minimum and maximum optical output power
- Peak-to-peak optical modulation amplitude and/or extinction ratio

- Maximum rise and fall times and/or eye diagram

For receivers to following should be added to the ICD:

- Type of optical fiber from which the signal is received
    - Multimode or single mode
    - Graded index or step index
    - Core and cladding diameter
- Data rate
- Optical wavelength and maximum spectral width
- Minimum and maximum received optical power (CW)
- Signal detect assert and de-assert levels

Standard ICD's can now be defined for each link rate.

## CRC Calculation

One of the more difficult implementation issues that arose with ARINC 818-1 was the correct calculation of the prior image CRC. The CRC calculation is complex and easy to make implementation errors. A detailed example has been added showing each step in the Image CRC calculation.

## ARINC 818-2 and Future Systems

The ARINC 818 video interface and protocol standard was developed for high-bandwidth, low-latency, uncompressed digital video transmission. The standard has been advanced by ARINC and the aerospace community to meet the stringent needs of high-performance digital video. Even before its release, the protocol was adopted by major aerospace and military programs, and has become the de facto standard for high-performance military video systems. Already ARINC 818 is being evaluated for application in industry medical and machine vision.

ARINC 818 video systems include infrared and other wavelength sensors, optical cameras, radar, flight recorders, map/chart systems, synthetic vision, image fusion systems, heads-up displays, heads-down multifunction displays, and video concentrators. These video systems are used for taxi and take-off assist, cargo loading, navigation, target tracking, collision avoidance, and other critical functions.

ARINC 818-2 adds features to the specification to accommodate complex, end-to-end video systems, including sensors, processing/ switching and driving displays.

## Conclusion

ARINC 818 continues to be adopted on more and more programs due to its robust error checking, low latency, and high bandwidth for displays, cameras, and sensors. It is being used literally around the world for both civilian and military aircraft new development and upgrade programs. As demonstrated by the active participation in the development of this Supplement to the specification, it ADVB has wide industry support from aircraft manufacturers and suppliers. With the addition of higher speeds, support for compression, and encryption, networking, and sophisticated display schemes, ARINC 818 adoption will continue to grow and expand the mission profiles within and beyond avionics.

## Reference

[1] Randall E. Bailey, J.J. (Trey), Arthur III, Steven P. Williams, and Lynda J. Kramer, “Latency in Visionic Systems: Test Methods and Requirements,” Hampton, VA, NASA Langley Research Center.

*32nd Digital Avionics Systems Conference*
*October 6-10, 2013*