# FIBEROPTIC TRANSMISSION SYSTEM FOR IMPROVING RAMP TM RECEPTION

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## ABSTRACT

The requirement for improved ramp telemetry data and video coverage has prompted the Telemetry Branch at the Naval Air Warfare Center Aircraft Division (NAWCAD) to install an L and S-Band Fiberoptic Transmission System linking multiple hangar locations to the Telemetry Data Center. This system uses Commercial-off-the-Shelf (COTS) equipment and is capable of transmitting analog telemetry data and video from multiple sites to one location for processing and display. The system at NAWCAD has been in use since 1996 and is continually growing to accommodate additional requirements.

## KEY WORDS

Fiberoptic Transmission System, L and S-Band Telemetry Transmission, Telemetry on Fiber

## INTRODUCTION

Reception of aircraft and missile telemetry data is a very commonplace event for the Telemetry Data Center (TDC) at NAWCAD. However, telemetry data quality has encountered problems in the ramp areas around the hangars when the aircraft are doing static testing or taxiing to/from the runway areas. A multipath condition occurs due to the reflection of the telemetry signal off buildings, airplanes and other obstacles located nearby the test aircraft on the apron of the hangar. Multipath is the result of destructive interference between the direct ray and one or more reflected or refracted rays of the telemetry signal. This interference is particularly apparent when the tracking antenna is located a distance away from the telemetry source and is pointing toward a hangar or an area with a lot of ground clutter, which is often the case.

One solution for reducing the multipath problem is to position a small directional receiving antenna close to the telemetry source, with attention paid to minimizing the elevation pointing angle. This will reduce interference from reflected/refracted rays received. However, using a remote receiving antenna complicates the matter of transporting the received telemetry signal from the antenna to the receivers in the ground station. A reliable solution for this is a fiberoptic transmission system with sufficient bandwidth to pass L and S-Band telemetry signals from the receiving antenna to the ground station.

## HISTORY

The first application of telemetry on fiber used by the Telemetry Data Center was an RF link from an antenna atop a microwave tower approximately 1000 feet away from the ground station. This system was installed in November 1995 and then used for a period of two years in support of the F-18 E/F program. The main purpose of the system was to provide telemetry data and video from aircraft doing testing and flight pre-checks on the apron of the hangar and entering and exiting the runway areas. Trees and man-made structures blocking the line-of-sight to the test aircraft on the hangar apron obstructed the tracking antennae normally used during flight operations. This system had an L-Band and an S-Band antenna mounted on a pan-and-tilt unit and included a video camera bore-sighted with the antennae. The RF and video signals were transported to the TDC on fiber and the pan-and-tilt unit control was accomplished with copper wire. The system performed adequately but a multipath problem still existed due to buildings, aircraft maintenance equipment and other ground clutter surrounding the aircraft.

In December 1997 the relay system on the microwave tower was removed and installed two miles away at a more desirable location closer to the aircraft under test. The system was installed on the roof of Hangar 115 and pointed to the area on the apron where the aircraft performed most of the pre-flight checks. This change of location substantially reduced the multipath interference problem; however, it created the need to move the received telemetry signal to the receivers in the TDC 2.25 miles away. Since the singlemode fiberoptic transmitter is capable of driving the signal approximately eleven miles, the system performed very well with no degradation resulting from the separation of the telemetry source and the receivers. In fact, this system is still being used today.

At approximately the same time, a requirement arose to transport telemetry data and video from the NAWCAD Force Warfare Hangar, building 306, to the Telemetry Data Center in support of P-3 aircraft tests. Telemetry coverage of both P-3 flight lines was inadequate due to building obstruction and masking, which created severe "drop-outs" (losses of signal lock) and impaired data reception in those areas of the hangar apron. A very similar system to the one installed on Hangar 115 was proposed, and in December of 1998, another addition to the analog fiberoptic link was installed. The same model of analog fiberoptic transmitter was used, but the video fiber transmitter was upgraded to one which also handled point to point audio communications. This simplified checkout and testing of the system prior to aircraft testing. This system was mounted on a building adjacent to the Force Warfare Hangar and commanded a clear view of the apron and front flight line. It has performed well and is currently being used for E-2C and P-3C flight line checks.

Yet another expansion to the system is currently in progress to add support for the Joint Strike Fighter program. An antenna system with a video and analog telemetry data transmitter is being added to a third hangar, Hangar 201, at NAWCAD to support pre-flight tests and static testing on the apron. The system is installed on a pan-and-tilt pedestal with tracking control residing in a telemetry trailer located within the hangar. The data and video signals are being supplied to both the trailer in the hangar and the Telemetry Data Center 2.5 miles away.

With the completion of a buried fiberoptic backbone structure at NAWCAD, the addition of more remote antennae to the Telemetry Data Center's fiberoptic relay system has become greatly simplified. The only requirement needed to add an additional link to the system is the hardware at both ends and a point-to-point fiber connection provided by the base fiberoptic backbone. The analog fiber receiver for a telemetry data link is easily accommodated by the addition of another module to a nineteen-inch rack mount chassis. Transmitting analog telemetry data over fiber has become commonplace to the Telemetry Data Center at NAWCAD.

## SYSTEM ARCHITECTURE

The basic fiberoptic transmission system consists of three main subsystems: the antenna subsystem, the fiberoptic components, and the receiving system hardware. Figure 1, the System Block Diagram, illustrates the basic architecture of the fiberoptic transmission system configured from commercially available hardware.

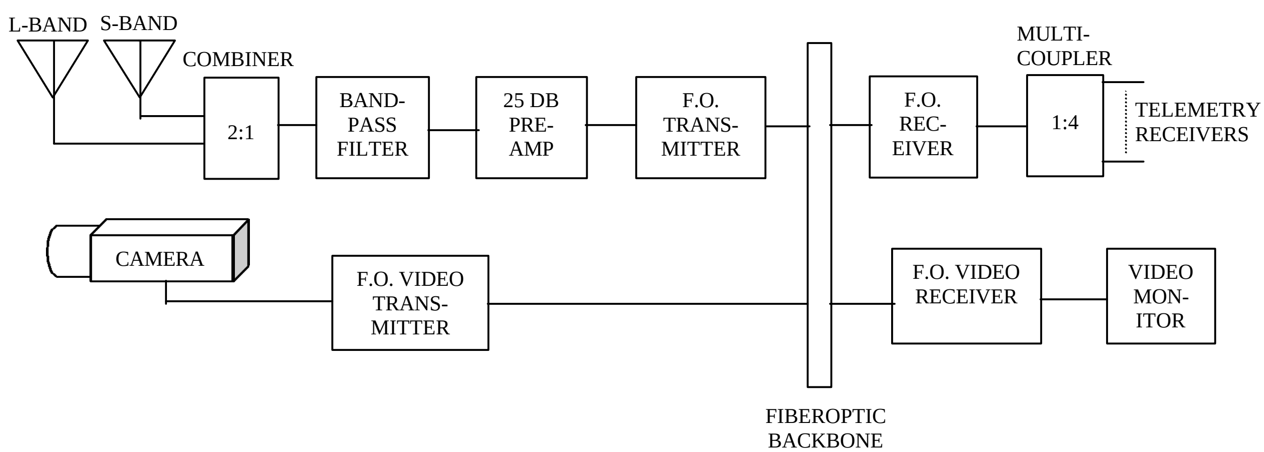


Figure 1. System Block Diagram

ANTENNA SUBSYSTEM

The antenna system consists of both L-Band and S-Band directional helical antennae. Both are manufactured by Tecom Industries (Models 401020 and 401022 respectively) and are approximately a foot long and very lightweight. These antennae are circularly polarized and have a 35 degree beamwidth and a gain of 12 dB. The outputs of both antennae are then connected to a 2:1 combiner. The combined signal is then fed into a bandpass filter, which provides protection for the pre-amp that follows. The bandpass filter is a Reactel Inc. Model 12C11-1917.5-1000S11, which limits reception to the 1435 to 2400 MHz band. The pre-amp is relatively low noise and is made by JCA Technology. This unit provides 25 dB gain with a 1.3 dB noise figure across both L and S Bands. The final component is a Panasonic Model WV-CP410 color video camera which is bore-sighted to the antennae for viewing the aircraft under test. If a pointing system is needed, the antenna subsystem can be mounted on a pan-and-tilt pedestal assembly with remote control via fiber or copper cable.

## FIBEROPTIC COMPONENTS

The fiberoptic components consist of both the transmitter and receiver for the RF data and the transmitter and receiver for the video signal. The fiberoptic RF data transmitter is an Ortel Corporation Model 3540A. This unit is in a flange-mount package and is capable of passing frequencies from 0.01 to 5 GHz. Module and rack mount configurations are also available with frequencies ranging up to 18 GHz depending on the model used. The 3540A drives singlemode 1310 nm fiber and is capable of long distance transmission due to its high dynamic range. This allows for the fiberoptic receiver to be miles away with no degradation of the signal. The counterpart to the 3540A is the Ortel Corporation Model 10450A fiberoptic receiver. This unit is a plug-in module, which inserts into a 19-inch rack-mount chassis. The 10450A features wideband analog signal reception (0.1 to 3 GHz) with a high optical return loss (>45dB) which enables high quality noise performance for more sensitive optical links. Other models are available in flange, module and rack-mount units with frequency ranges up to 20 GHz.

The fiberoptic video transmitter is a Math Associates Model FX-1500A-7 analog transmitter. The corresponding video receiver is a Math Associates Model FR-1500A-7 analog receiver. The FX-1500A-7/FR-1500A-7 has a system bandwidth of 15 MHz and an optical loss budget of 10 dB over singlemode fiber. Both units are available in stand-alone and rack-mountable versions and accept/output 1.0 Volt peak-to-peak analog video signals. The FR-1500A-7 has an output level adjustment to compensate for varying optical fiber cable attenuation. Other video transmitter/receiver models are available which also allow the addition of two-way audio communications. This feature aids the users at either end to test/checkout the video and data system prior to operational requirements.

## RECEIVING SYSTEM HARDWARE

The output of the fiberoptic data receiver is connected to a Satellink, Inc. Model SMC1424-00NA1 Telemetry RF Multicoupler. This unit receives a single input signal and supplies four separate outputs to the telemetry receivers. The SMC1424-00NA1 covers a frequency range from 1435 to 2400 MHz. The last component in the system is the telemetry receivers. The telemetry front end uses a combination of two types of receivers, Scientific Atlanta Model 930B and Microdyne Model 700-MR. Both of these telemetry receivers perform adequately with the system and either model is used depending on project data bandwidth requirements.

The output of the video fiber optic receiver is connected to a video switching matrix to be routed to the appropriate location within the Telemetry Data Center. The video signal is then displayed on a standard video monitor.

## CURRENT CONFIGURATION

The current fiberoptics transmission system configuration at the NAWCAD consists of two systems providing data and video coverage from Hangar 115 and Hangar 306 back to the Telemetry Data Center for processing and display. Hangar 115 is approximately 2.25 miles from the Telemetry Data Center line-of-sight using more than 3 miles of fiberoptic cable. Hangar 306 is approximately 3.64 miles from the Telemetry Data Center line-of-sight with the fiberoptic cable length being over 6 miles in length. Figure 2, the Analog Telemetry Fiberoptic Transmission System Map, shows the relative positions of both Hangar 115 and Hangar 306 to the Telemetry Data Center.

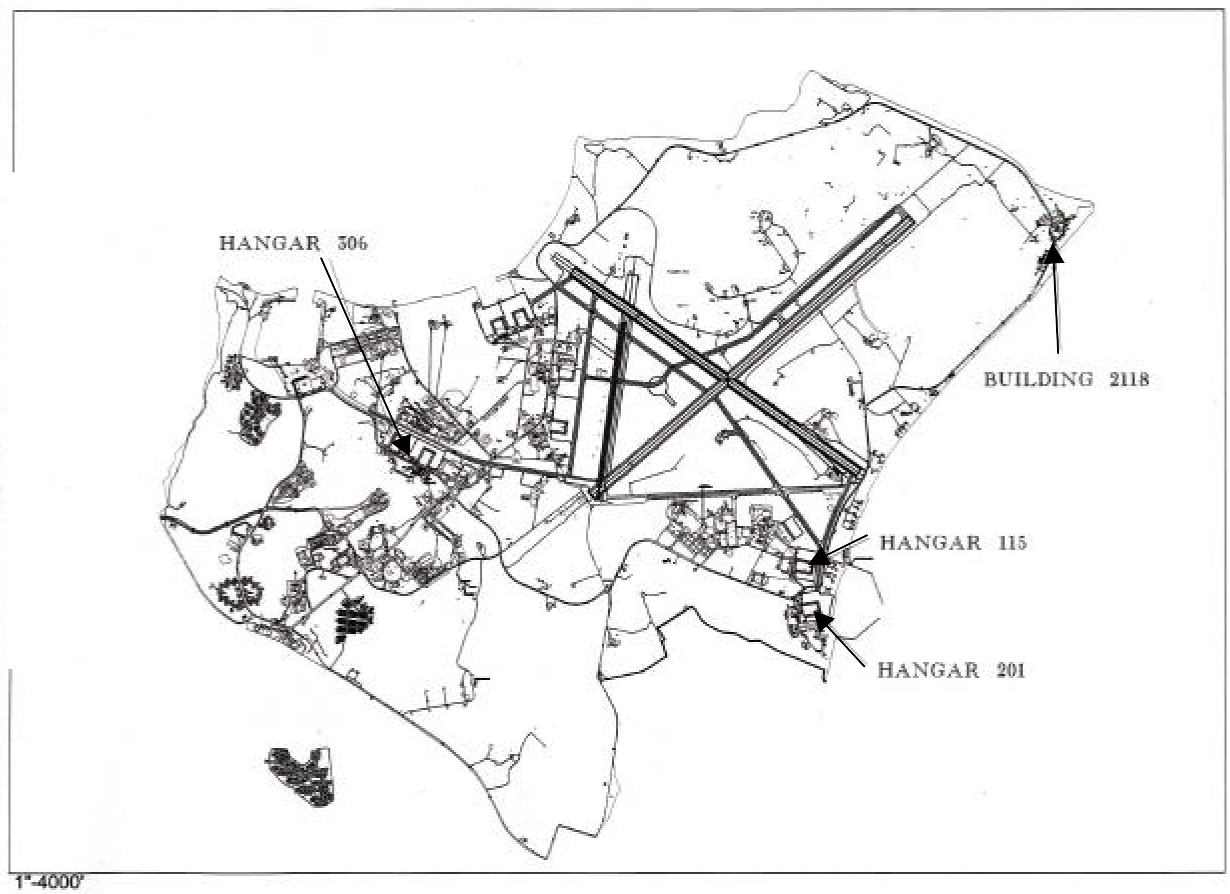


Figure 2. Analog Telemetry Fiberoptic Transmission System Map

The system installed at Hangar 115 is as described in the System Architecture section above. The Hangar 306 system is similar with the exception of a few minor differences in the components. However, both systems use the Ortel Corporation transmitters and receivers. The Hangar 306 video link is the major difference between the two systems. It uses a video one-way fiberoptic link that also contains two-way audio communications over a single fiber. The hardware used are Model 2044B/SB transceivers made by Fiber Options Inc. Optical multiplexing is used to provide two-way transmission over a single fiber. This system allows for audio communications between both ends of the fiber link and facilitates ease of maintenance/repair of system components.

A third system is being added to the current configuration. This system is being installed on Hangar 201 with its relative location to the Telemetry Data Center shown in figure 2. A TSM Model HS110PE pan-and-tilt pedestal assembly, with control routed to a telemetry trailer located within Hangar 201 enables elevation and azimuth adjustments of the entire antenna mount and provides zoom control of the camera lens. The pan/tilt is controlled via RS-422 protocol, which allows operation over a fiberoptic link to a distance of many miles. In this application, 20 gauge copper wire was used allowing control up to 5 miles away. The analog telemetry data and video signals are being sent via fiberoptic cables both to the trailer located within Hangar 201 and also to the Telemetry Data Center for processing and display. The entire system configuration is shown in figure 3, Total System Configuration, with the new system indicated by dashed lines.

## OTHER APPLICATIONS

Another application arose for the system installed on Hangar 115 in February of 1999. A requirement was established to acquire telemetry data from a remote location on NAWCAD and transport it to the Telemetry Data Center miles away. Because of the nature of the tests being performed, drop-outs of the telemetry signal could not be tolerated. The remote location where the aircraft was doing testing could not be accessed by existing telemetry tracking antennae. The analog fiberoptic system on Hangar 115 had a partial line-of-sight to the testing area but ground clutter and buildings obscured the area enough to cause data reception problems. The solution was to install a flexible fiberoptic telemetry connection to the aircraft, which allowed dynamic repositioning of the aircraft while its engines were turning, and "re-rad" (re-radiation of a received telemetry signal to a local fixed antenna) the signal to the Telemetry Data Center. A temporary telemetry trailer was parked within 300 feet of the aircraft and a fiber optic transmitter was installed on the aircraft. A multimode fiberoptic cable was run from the aircraft to the trailer and into a fiberoptic receiver. The output of this receiver was then connected to a telemetry transmitter attached to a small antenna similar to the one used by the Hangar 115 system. This antenna was mounted on an elevated pole on top of the trailer and pointed in the direction of the system on Hangar 115. The system on Hangar 115 was then used to re-rad the telemetry data from the aircraft to the Telemetry Data Center for processing. This implementation supported day and night testing of the aircraft over a seven-week period, providing the high quality telemetry required by the project. The whole link worked remarkably well and the re-rad portion was completed within a matter of 2 to 3 days using existing assets.

## CONCLUSION

The use of fiberoptic components to improve the transmission of analog telemetry data is a very practical and viable solution to multipath interference and line-of-sight problems encountered on the ramps around aircraft hangars. The technology used is very mature, and has become a routine method of relaying telemetry data from otherwise inaccessible locations to the TDC. Fiberoptic devices available easily allow for the addition of a video camera to the antenna platform to provide video coverage of the aircraft under test. A remotely controlled pan-and-tilt pedestal can be added to provide pointing capability to the antenna platform to compensate for aircraft movement around the hangar ramps. Furthermore, with the advancements of technology in the field of fiberoptics, transmitting analog telemetry data and video over fiber should be considered as an invaluable tool in aircraft flight testing for many years to come.

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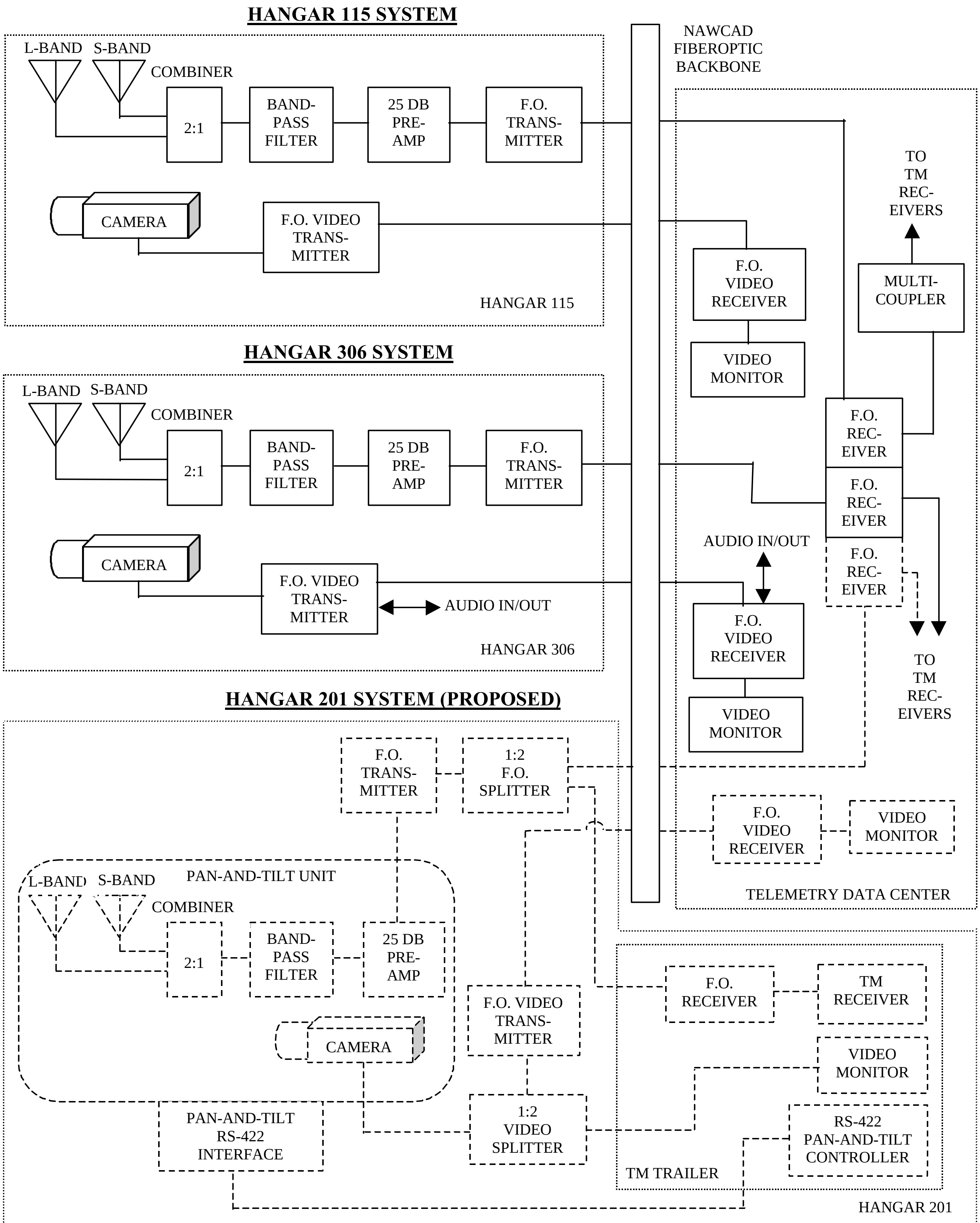


Figure 3. Total System Configuration