# Preliminary Flight Results of the

## Microelectronics and Photonics Test Bed

## NASA DR1773 Fiber Optic Data Bus Experiment

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### Security Classification: Unclassified

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Abstract

NASA Goddard Space Flight Center's (GSFC) Dual Rate 1773 (DR1773) Experiment on the

Microelectronic and Photonic Test Bed (MPTB) has provided valuable information on the performance of

the AS1773 fiber optic data bus in the space radiation environment. Correlation of preliminary experiment

data to ground based radiation test results show the AS1773 bus is employable in future spacecraft

applications requiring radiation tolerant communication links.

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## Summary

### Introduction

Over the past decade, NASA GSFC has been at the forefront of fiber optic data bus utilization for spacecraft applications. Aerospace Standard (AS) 1773 is an emerging fiber optic data bus technology that NASA is considering for use on several future missions. The purpose of the DR1773 experiment on MPTB was to collect radiation effects data on the AS1773 bus in a harsh radiation environment and to demonstrate proof-of-concept for future NASA missions. This implementation of the DR1773 bus is intended to be suitable for NASA missions requiring a radiation hard command and telemetry communication link up to 20Mbps.

### AS1773 Description

The AS1773 bus standard was created by the Society of Automotive Engineers (SAE) Avionics Systems Division (ASD) [1]. AS1773 is derived from the MIL-STD-1773 fiber optic data bus, which operates at a single data rate of 1Mbps. Because of the success of the Small Explorer Data System (SEDS) 1773 fiber optic data bus [2-6], the next generation AS1773 fiber optic data bus capable of higher bandwidth was developed for spaceflight applications. MIL-STD-1773 is essentially the fiber optic version of the all-

electrical MIL-STD-1553 bus, utilizing the same communication protocol but differing in the physical

transmission medium. AS1773 maintained the 1773 and 1553 logical protocol heritage, but added greater

bandwidth capability by introducing the 20Mbps operation in addition to the 1Mbps 1773 standard. Figure

one shows the AS1773 A bus in its full capacity 32x32 configuration. AS1773 is a star coupled dual

redundant bus, therefore utilizing two 32x32 buses in its full implementation. A single host terminal will

connect to both buses via an AS1773 protocol chip, thereby providing complete cross strapping of all the

subsystems on the spacecraft. A host may configure its protocol chip to operate in either 1Mbps or 20Mbps

mode, however all nodes must operate at the same rate. The host may also configure the protocol chip to

operate as a remote terminal (RT) slave device or a bus controller (BC) master device. Messages can be

sent from RT to RT, BC to RT or RT to BC, with all message transfers controlled by the BC. The AS1773

bus shown in figure one in its 32x32 star-coupled configuration can support up to 32 inputs and 32 outputs.

In this configuration one BC and up to 31 RTs can be implemented on the spacecraft.
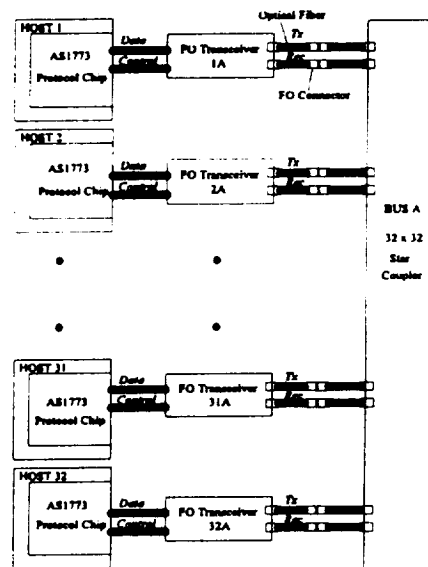


Note: AS1773 is a dual redundant bus. Bus B is not shown in this diagram.

Figure One

## DR1773 Experiment Design

The goal of the DR1773 experiment design was to simulate an AS1773 spacecraft bus [7]. Figure two

shows a block diagram of the DR1773 experiment design layout. The experiment consists of three

sections; the optical section, device under test (DUT) section, and the experiment control section. The

experiment control section is located inside an A1280 Actel FPGA. This FPGA controls the experiment

operation and houses the command and telemetry interface to the MPTB motherboard. The optical section

consists of the 100/140um optical fibers, 8x8 fiber optic star coupler and fiber optic terminations. The DUT section consists of two Boeing 1300nm AS1773 transceivers. The experiment begins with a mode command from the MPTB host processor. Once this command is received, the control section will generate a Manchester encoded 32-bit pseudo-random message. The control section will then select a DUT transmitter and receiver and send the message out over the bus. The control section then reads the message back for comparison. If the return message is different from the generated message then an error counter is incremented. This process is continued until another mode command is sent, or the experiment is turned off. For each message sent over the fiber optic link, a total word counter is incremented. Bit error rate information is then derived from the values of the total word counter and the error counter corresponding to the operation mode.

Experiment Results

As discussed previously, there are two modes of operation for the DR1773 experiment. Mode one operation has counted a total of five errors in the Boeing transceiver one to Boeing transceiver two communication link after approximately seven months of continuous operation. Preliminary analysis show that mode one data corresponds highly to expected experiment results based on pre-flight analysis and ground radiation test results from proton testing at the University of California at Davis Crocker Nuclear Lab [8]. These results will be discussed herein. Mode two results however, do not correlate well with mode one data or expected results. A higher than expected BER on mode two suggests an anomaly on the Boeing transceiver two to Boeing transceiver one data link. Analysis of preliminary data suggests two possible causes; an optical link margin problem caused by fiber optic connector misalignment, optical fiber degradation, or transmitter launch power degradation, or total dose degradation of the circuit control FPGA running at maximum speed without derating. These possible mode two anomalies will be examined in greater detail, as more data becomes available.
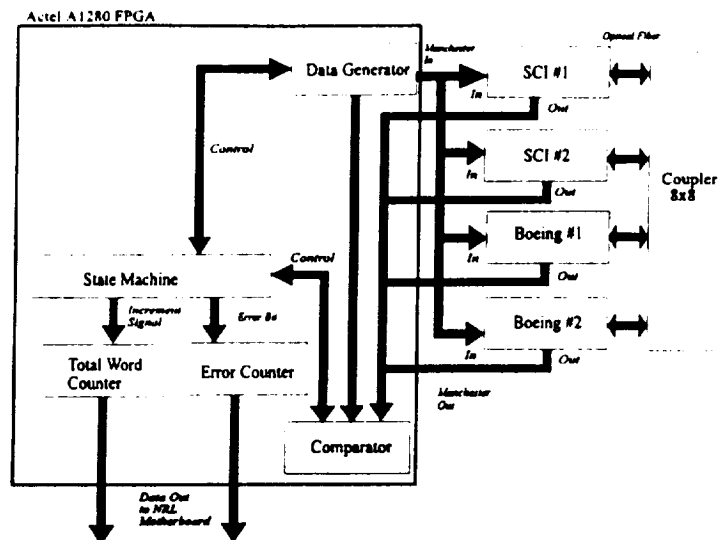
Figure Two

## Conclusion

The MPTB DR1773 experiment is providing valuable data on the emerging technology AS1773 fiber optic data bus. This experiment has provided an opportunity to validate AS1773 ground radiation test and on orbit prediction models. Preliminary mode one data suggests that Boeing DR1773 transceivers meet the radiation specification for most NASA spaceflight missions.

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