WEB — A WIRELESS EXPERIMENT BOX FOR THE DEXTRE POINTING PACKAGE ELC PAYLOAD

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The Wireless Experiment Box (WEB) was proposed to work with the International Space Station (ISS) External Wireless Communication (EWC) system to support high-definition video from the Dextre Pointing Package (DPP). DPP/WEB was a NASA GSFC proposed ExPRESS Logistics Carrier (ELC) payload designed to flight test an integrated suite of Autonomous Rendezvous and Docking (AR&D) technologies to enable a wide spectrum of future missions across NASA and other US Government agencies. The ISS EWC uses COTS Wireless Access Points (WAPs) to provide high-rate bi-directional communications to ISS. In this paper, we discuss WEB's packaging, operation, antenna development, and performance testing.

EXTENDED ABSTRACT

The ability of space assets to rendezvous and dock is a cross-cutting capability enabling a wide spectrum of future missions across NASA's mission directorates and other US Government agencies. The Dextre Pointing Package (DPP) AR&D testbed was purposed as an International Space Station (ISS) ExPRESS Logistics Carrier (ELC) payload to flight test an integrated suite of AR&D technologies applicable across the Agency's future missions.

The DPP AR&D testbed consists of a complement of active and passive sensors, sensor processing, relative navigation algorithms, and control algorithms whose purpose is to maneuver a space vehicle in position and orientation to successfully achieve final docking or capture of a target spacecraft. The ISS provides a unique environment to test non-cooperative AR&D capabilities with the various visiting vehicles that frequently dock with the orbiting outpost.

The DPP AR&D testbed is unique relative to other ISS external payloads in that it was designed to attach to an end effector of Dextre, also known as the Special Purpose Dexterous Manipulator (SPDM), and operate while Dextre is attached either to the Space Station Remote Manipulator System (SSRMS) or to targeted Power Data Grapple Fixtures (PDGFs), see Figures 1 and 2. In order to support high data-rate communication to and from ISS at these locations, a Wireless Experiment Box (WEB) bus component is included in the DPP package.

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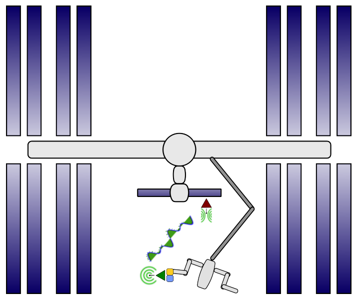

Figure 1: Cartoon visualization of DPP placement on Dextre.

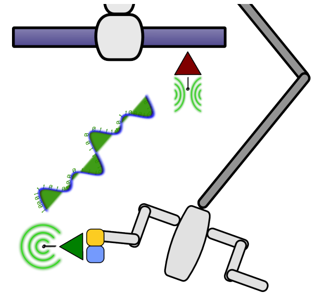

Figure 2: Cartoon visualization showing DPP placed on Dextre and communicating with WEB via EWC to ISS.

The WEB provides a wireless 802.11 radio and antenna system that could be used with ISS external payloads to communicate with the new External Wireless Communication (EWC) system currently being developed and deployed on the ISS. The WEB enables high-rate video transmissions from the end effector, real-time video for AR&D, and high-rate data transfer to and from the ISS. The WEB currently includes development of a custom, novel, all-metal patch antenna; testing and network performance assessment of a ruggedized Commercial Off The Shelf (COTS) Wireless Access Point (WAP) card; and fabrication of a custom Engineering Test Unit (ETU) flight enclosure and Power Control Unit (PCU).

The initial development of the WEB was sponsored by the NASA Goddard Space Flight Center (GSFC) Space Servicing Capabilities Office in support of the DPP payload. Unfortunately, the DPP payload is not presently manifested for a payload slot on the ISS; however the WEB system was developed to the point of a flight-like ETU and could be utilized by a variety of future ISS payloads.

To support the wide motion envelope of DPP, a novel, all-metal patch antenna was developed to operate in the Unlicensed National Information Infrastructure (U-NII) radio band in the radio frequency spectrum used by IEEE-802.11a devices. Up to four (4) antennæ are used in the flight configuration to ensure sufficient link margin regardless of the orientation of DPP with respect to the ISS EWC receive antennæ. While the patch antenna is targeted specifically to support the low-U-NII band, its design enables it to maintain much of the desired gain at the expense of increased directionality should the operational frequency move to the higher U-NII bands.

The performance of the COTS WAPs were evaluated using freely available, open source network testing tools, embedded within a custom automated system. The test system was used to assess the Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) performance of the WAPs, including bandwidth, delay jitter, and in the case of UDP, datagram loss. In particular, bandwidth for both TCP and UDP was evaluated, over hard-line connections, for a range of Received Signal Strength Indicator (RSSI). In addition, network performance was tested over-the-air, using the all-metal patch antenna and a simulated ISS EWC antenna, in the anechoic chamber at the GSFC.

Space survivability on ISS required that the COTS WAP undergo a total repackaging design effort. The enhanced package includes: custom chassis with space grade interface connectors on the front panel, a custom power supply card designed and built with space qualified parts, a thermal frame designed to fit over the original COTS WAP circuit card and draw heat away from the card, and thermal filler placed under the COTS WAP card, again serving to improve heat transfer from card to chassis, see Figure 3. Thermal and

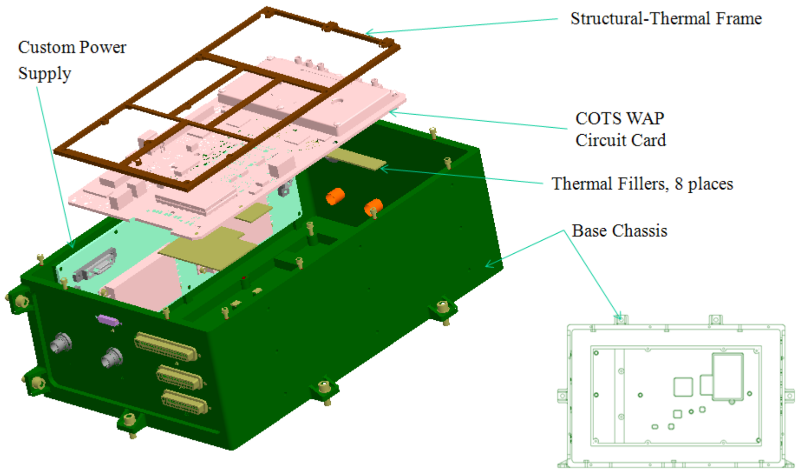

Figure 3: Exploded view of the WEB flight enclosure.

structural analysis performed on the design showed there was positive margin versus the DPP specific launch and operating conditions.

In this paper, we discuss the antenna development and placement considerations; the COTS WAP configuration, operation, performance and telemetry requirements; the design and manufacture of the system enclosure and PCU; and considerations for repackaging the WAP card in the WEB enclosure.