Wireless Technologies In Support of ISS Experimentation and Operations

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Outline

• Wireless Communications
  – Internal
  – External

• RFID (Radio Frequency Identification)
  – Existing and R&D

• Wireless Sensor Networks
  – Existing and R&D

• Ultra-Wide Band (UWB)
  – R&D
WIRELESS COMMUNICATIONS
Internal Wireless LAN

• Wireless access points provide 802.11g services on the Joint Station LAN (JSL) in support of Operations, but not Payloads

• Extensions to 802.11n are in work
  – In addition for use in Operations, this upgrade will provide network access for Payloads in the EXPRESS (Expedite the PRocessing of Experiments to the Space Station) racks
  – EXPRESS rack is a standardized payload rack system that transports, stores, and supports experiments aboard ISS
External Wireless Communications

- Provision of external wireless communications has been initiated.
- Initial objective is to provide 802.11n services to payloads on the Express Logistics Carriers (ELC).
- Expected operational date: X WAP expected delivery: 12/2012.
- Expected data rates: 6-35 Mbps.
- It is possible that sufficient experimenter demand for extended coverage could result in addition of 802.11n bridges.
TCP Data Rate for ELC Payload Sites
Myers Antenna

ELC 1
- Inboard Aft: 10 - 24 Mbps
- Outboard Forward: 6 - 20 Mbps

ELC 2
- Outboard/Inboard Forward: 10 - 20 Mbps

ELC 3
- Outboard Aft: 16 - 35 Mbps
- Inboard Forward: 16 - 35 Mbps

ELC 4
- Inboard Aft: 14 - 29 Mbps
- Inboard Forward: 14 - 33 Mbps

P3 Truss ELCs

EV6/ESCG

S3 Truss ELCs

03/31/2011
ISS 17A Configuration: ELCs and Node 3 not shown
RADIO FREQUENCY IDENTIFICATIONS (RFID)
Components of an RFID System

- Basic RFID system (IC-based):
  - An **interrogator** (reader) with antenna
  - A **transponder** (RF tag) containing an antenna and IC

- Consultative Committee for Space Data Standards recommended practice for RFID for Inventory Management: EPC Class 1, Generation 2  
  RFID Standard: UHF 860 – 960 MHz
  - Passive tag, interrogator-talks-first
RFID Technology Infusion Into ISS

• **Background**
  – RFID-enabled inventory processes can reduce crew time for audits thus increasing time for science

  – RFID handheld readers and tags are currently on orbit to supplement the optical barcode function and facilitate searches for missing items

  – Currently, about 3,000 items on ISS are RFID-tagged
Current RFID Infrastructure

- Handheld RFID/barcode reader is current basis for on-board RFID technology
  - Two primary RFID functions:
    - Crew-assisted Cargo Transfer Bag (CTB) audits
      - 20 seconds compared to 2 minutes per CTB audit
      - Translation of CTB to tag-free area for scan increases cost to several minutes per CTB
    - Search for missing items – audible rate increases with proximity
Notional RFID Roadmap: Integrated RFID Environment

- **Middleware + Application**
  - 2012
  - 2014

- **Embedded RFID: ZSR / CHeCS / ISIS**
- **MODULAR RFID READER (EMBER)**
- **Optical Barcode**
- **ISS RFID Handhelds**
- **Deployable RFID "Crush Can"**
- **RFID Soft-Cells**
- **RFID Zone/Portal Readers**
- **Robotic Interrogators: SPHERES**

Notional timeline – cost driven

- 2010
- 2011
- 2012
- 2013
- 2014
- 2015

20 min/CTB  2 min/CTB  10 sec/CTB  0 : no crew involvement in inventory management
RFID Technologies for IM Automation

Embedded RFID Reader (EMBER)

EMBER on ISIS Drawer

Zero-g Stowage Rack (ZSR)

CEM Model for RFID Enclosure

RFID Enabled Waste Receptacle
WIRELESS SENSOR NETWORKS
Current Wireless Sensor Networks

(Addressed in another talk):
- Internal Wireless Instrumentation System (IWIS)
- External Wireless Instrumentation System (EWIS)
- For structural health monitoring
- Covered in separate presentation
Proposed Wireless Sensor Networks

• Architecture emphasizing **infrastructure** over **application**
  – multiple applications join single, standards-based network
  – applications cooperate rather than compete

• Follows CCSDS Wireless Working Group (WWG) recommended practices (low-datarate)
  – IEEE 802.15.4 for contention-free access
  – ISA100.11a for contention-based access

• CCSDS WWG recommendations for high-datarate in works
  – modular hardware for rapid prototyping
  – Smart Sensor Inter-Agency Reference Testbench (SSIART) proposed for evaluation environment

photo by Mary Lynne Barends, NASA-JSC
Proposed Ultra-Wide Band R&D

• **Key Features**
  – Immunity to interference from narrow band RF systems due to ultra-wide bandwidth
  – Low impact on other RF systems due to extremely low power spectral densities
  – Capable of precise tracking due to fine time resolution (picoseconds)

• 3-D localization of EVA/IVA assets to aid in telerobotic operations i.e. SPHERES, R-2
Conclusions

- Wireless communications systems are either new or are in the process of being upgraded
  - External wireless communications (new)
  - Internal wireless communications for Payloads (new)
  - Internal wireless communications for Operations (upgrade)

- New RFID capability might be useful to Experimenters in two areas
  - Inventory tracking for equipment, samples, consumables, etc.
  - Localization, robotic object recognition

- Proposed wireless sensor network capabilities might provide infrastructure for highly reliable data transport in challenging environment and high precision localization of assets or robots