RFID-Enabled Autonomous Logistics Management (REALM)

REALM-3: “Smart Enclosures”

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Overview

- Brief review of “smart enclosure” technology prototypes
- Considerations for “smart enclosures”
- NASA is currently flying two “smart drawers” on ISS
- This presentation addresses prototype “Smart-ZSR”, “Smart Trash Can”, and “Smart-CTB”, only

“SMART ZERO-GRAVITY STOWAGE RACK (ZSR)"

Zero-g Stowage Rack (ZSR)

- **Objective**
  - Assess performance of integrated RFID system ("smart ZSR")
- **Operational Goals**
  - Minimal changes to current textile structure
  - Interchangeable inserts
- **Design Process: Full scale 1-g mockup**
  - Conductive fabric enclosure
  - Sample ISS inventory items
  - Computational analysis
  - Testing

Zero-g Stowage Rack (ZSR)

ZSR Soft Stowage Shelving

Full Scale 1-g Mockup

Operational ZSR Mock-up in B9 Training Facility

Full-scale Mock-up in B14 with RFID Capabilities

- Dense Zone RFID enclosure
  - First concept: D-insert (1/2 rack)
    - Largest volume
      - → Potential for increased number of tags, hardware, & item locations
- Manufacture
  - Conductive fabric enclosure attached to all faces of enclosure

ZSR Inventory

- 18 Zero-g Stowage Racks on-board ISS
- **Use Case:**
  - Cargo Transfer Bags (CTBs) bungeed/Velcroed in ZSR
- **Inventory from ZSR NOD1O4**
  - March 2012
  - Maximum number of items: 687 per full rack

  D-insert (1/2 rack)≈ 300 items
  - Sample items borrowed & purchased
  - RFID tagged & packed



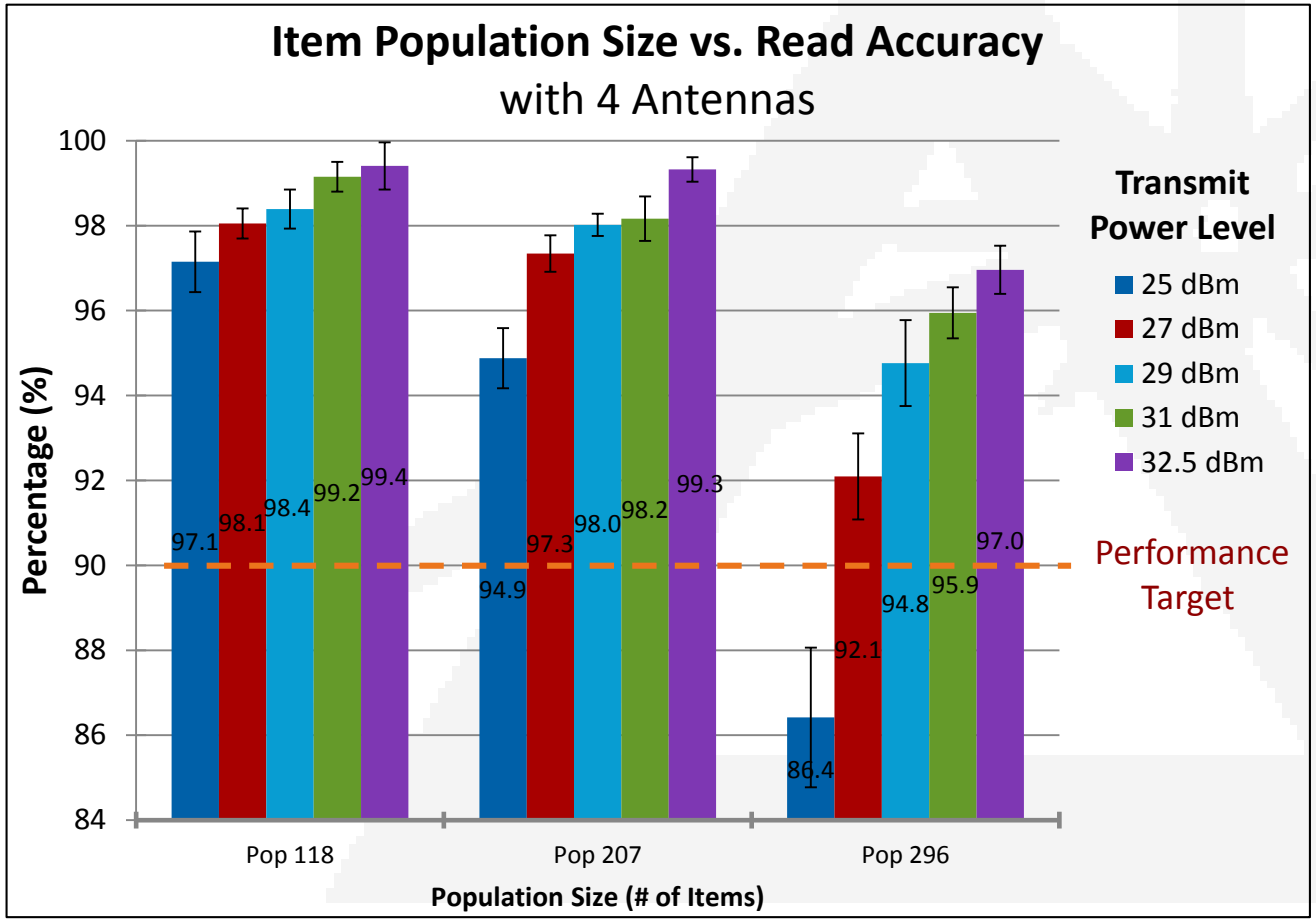


Sample RFID-Tagged Inventory: Huggies, Tape, Gloves, Laptops & Clothing

ZSR Testing Populations: D-Insert

ZSR Testing Results

Read accuracy as a function of transmit power for three population sizes (118, 207, 296 items)



More transmit power required for an increase in population size

→System performs at an acceptable level with 296 item inventory except at lowest power setting

“SMART TRASH RECEPTACLE”

“Smart Trash Can”

- NASA 2012 “smart trash receptacle” prototype
- Lined with conductive fabric
- RFID reader in side pocket
- Reads tags on consumed items (trash)
- Trigger options:
  - Upon closure (event-driven)
  - Crew manual (backup, only)
  - Scheduled
  - Commanded from ground
- Note: compacting trash can damage RFID tags

“SMART CARGO TRANSFER BAG (CTB)”

“SMART CTB”

- CTB is lined with conductive fabric for shielding
- RFID reader resides in pocket with RF cable interface to interior antennas (1-2)
- Reader has WiFi radio that interfaces to an e-textile antenna for external data transfer
- Possible concepts of operation include inventory for frequently used CTBs or crew workbag for collection of experiment supplies and tools

NASA AES/Logistics Reduction RFID-enabled CTB

“Smart Enclosure Considerations”

- Applies to all “smart enclosures”: ZSR, Cargo Transfer Bags, Trash Cans
- Conductive material is desired around all sides of the enclosure (container); that is, good shielding
  - Gaps reduce read accuracy and can introduce unintended reads from tagged items external to the container
  - Must consider whether to send up conductive inserts or new racks that have conductive boundaries (walls)
- Read accuracy is affected by an abundance of items with metal or liquid, but performance > 90% accuracy can still be expected with proper design
- Availability of power
  - If powered by a battery, it is probably necessary to limit the rate at which the enclosure is read in order extend the life
- Data transfer – telemetry and commands
- Triggering mechanisms
  - Upon closure (event-driven)
  - Crew manual (backup, only)
  - Scheduled
  - Commanded from ground