AN AUTOMATED MEDICAL INVENTORY SYSTEM (AMIS) TO ENABLE EARTH INDEPENDENT MEDICAL OPERATIONS

Courtney Schkurko[1]

Moriah Thompson[2], Rahul Suresh[2], Kimesha Calaway[3], Justin Yang[4]

[1]NASA Glenn Research Center, Cleveland, OH
[2]NASA Johnson Space Center, Houston, TX
[3]ZIN Technologies, Inc, Cleveland, OH
[4]Aegis Aerospace, Houston, TX

Aerospace Medical Association
94th Annual Scientific Meeting, Chicago, IL
May 8, 2024

Disclosure Information

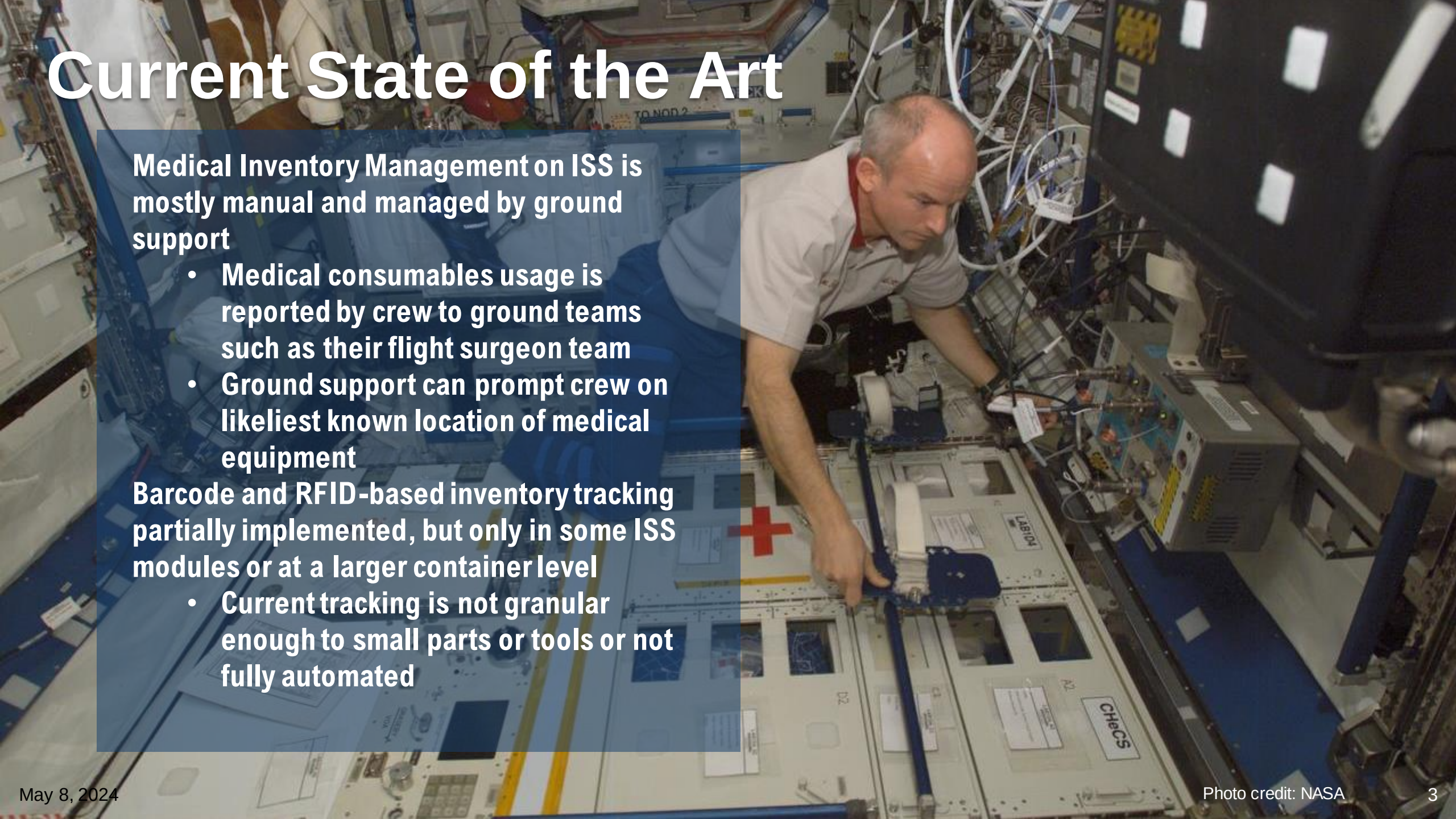
94th Annual Scientific Meeting

Courtney Schkurko

I have no financial relationships to disclose.

I will not discuss off-label use and/or investigational use in my presentation

Current State of the Art



Medical Inventory Management on ISS is mostly manual and managed by ground support

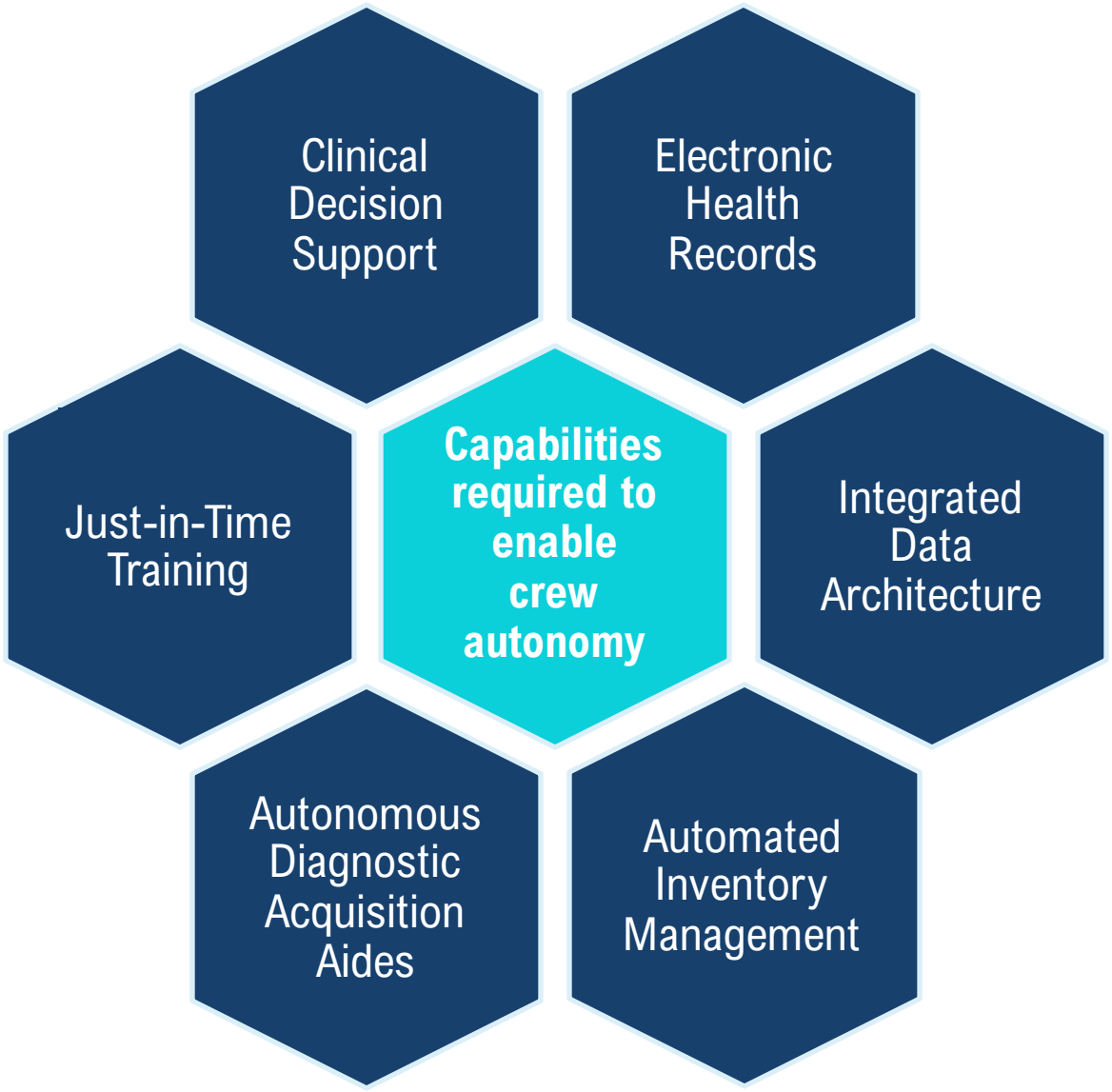
- Medical consumables usage is reported by crew to ground teams such as their flight surgeon team
- Ground support can prompt crew on likeliest known location of medical equipment

Barcode and RFID-based inventory tracking partially implemented, but only in some ISS modules or at a larger container level

- Current tracking is not granular enough to small parts or tools or not fully automated

Photo credit: NASA

THE NEED: Medical Inventory Management



For long duration missions, an integrated & comprehensive inventory management system must be developed to support more Earth-independent crew operations

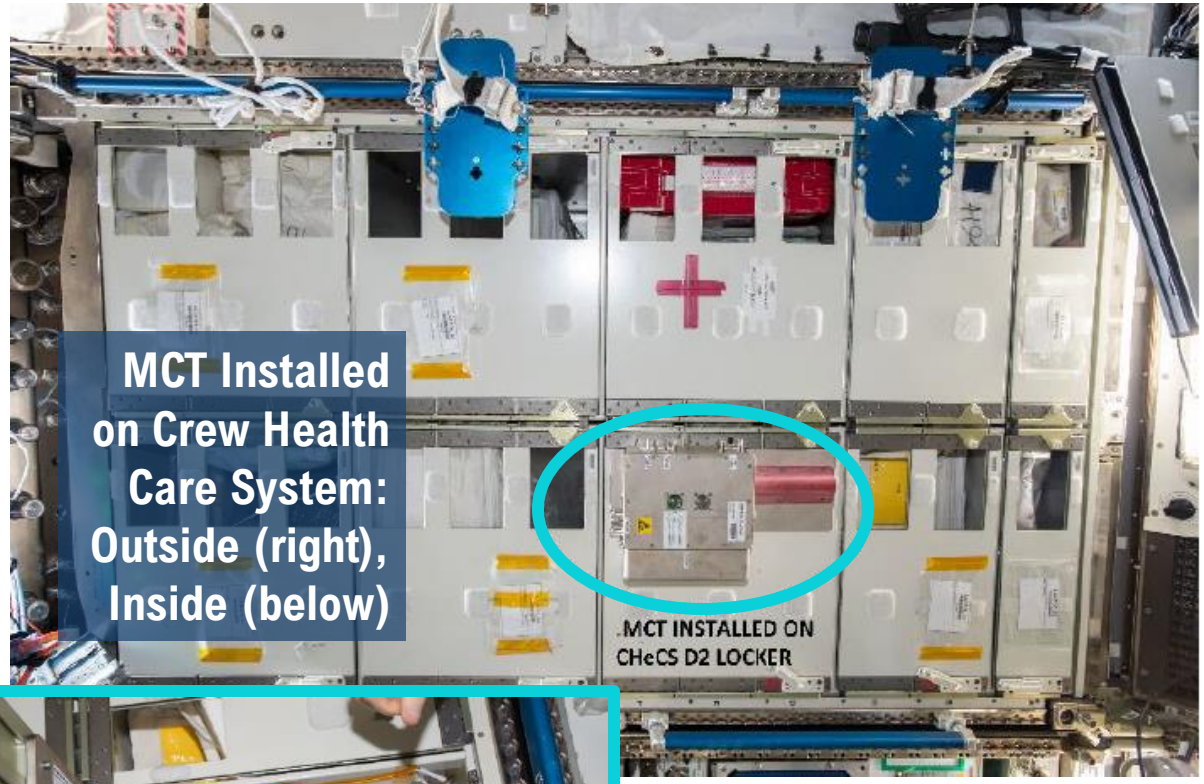
An Automated Medical Inventory System (AMIS) would perform the inventory management of medications, medical consumables, and medical devices.

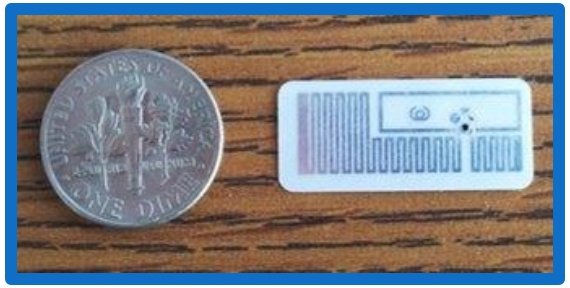
- **Reduce the manual effort** associated with ground and in-flight medical inventory
- **Increase accuracy** of inventory reporting
- Help ensure users can **locate items efficiently** for quick use, especially in emergency situations
- **Enable crew medical autonomy** as exploration progresses beyond low-Earth orbit with limited/no resupply or evacuation capabilities.

Previous NASA Efforts: MCT Project

The Medical Consumables Tracking (MCT) project was demonstrated on ISS in 2016 & 2017

- Developed under NASA's Human Research Program Exploration Medical Capability.
- **Radio frequency identification (RFID) based, battery-powered, system** that performed an automated scan of the Medication Convenience Pack, 1 of 8 medical kits, within the Crew Health Care System on ISS every 720 hrs. or upon manual initiation.
- RFID Tags were attached via labels to packaged medications.
- An inventory scan of approximately 300 items completed in **under 3 minutes.**
- **80-92% tag read accuracy** depending on density & orientation of supplies.





RFID Tag Size Comparison

Market Survey & Trade Study

- **Completed a market survey in 2022 to evaluate commercial solutions for automated inventory management.**
- **AMIS Project kicked off after market survey with a goal to accomplish a technology down-select.**
  - No single COTS solution meets the functional requirements of a medical inventory management system.
  - System Requirements Review completed in early 2024 to baseline requirements.

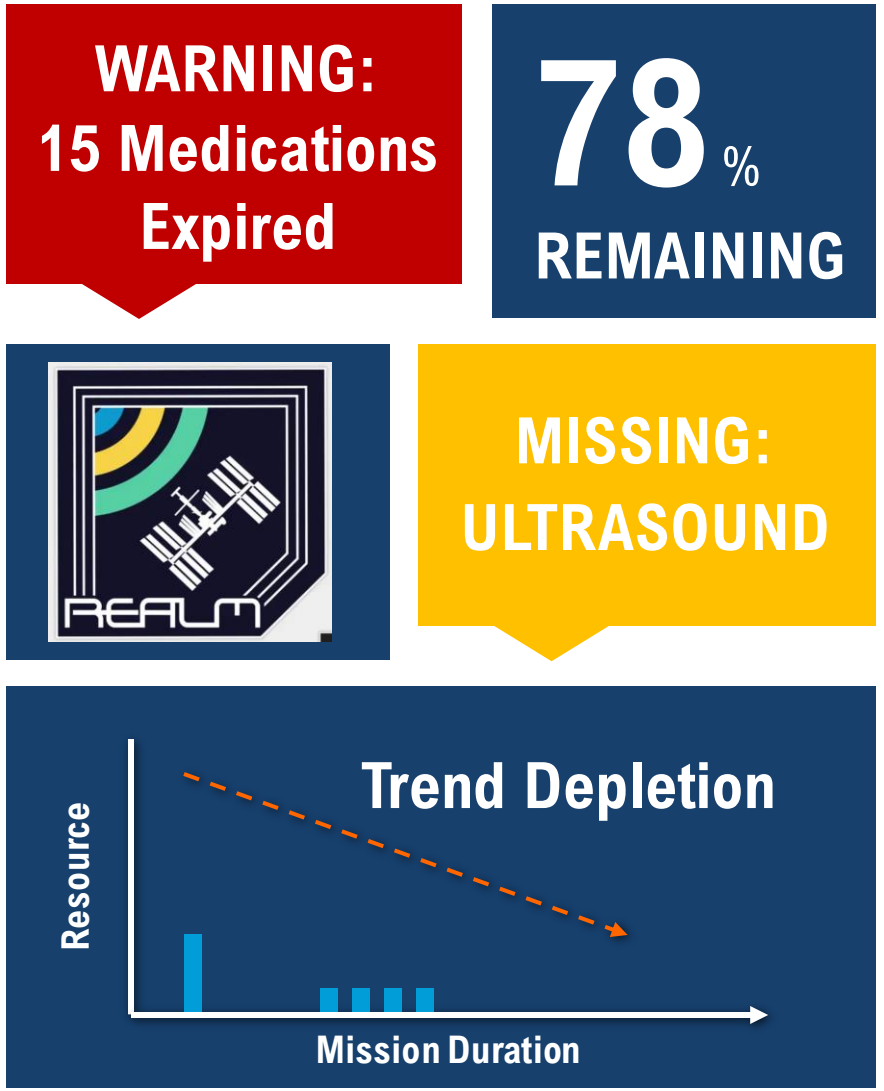
Tech	RFID	Barcode / QR	BLE	Vision Systems	Dispensers
Pros	Low power consumption	Easy to use	Excels at location tracking; Fast	Emerging tech with potential for high accuracy	Technologies like Smart blister packs show promise for individual pill tracking
Cons	Challenging to track liquids or smaller consumables	Requires line of sight for location; can suffer physical damages	Typically more expensive than RFID	Power & data heavy; Affected by altered gravity environments	Displace volume that could be used for treatment items

REALM, RFID Enabled Autonomous Logistics Management, is a NASA project currently addressing logistics management challenges using RFID-based solutions to minimize reliance on ground support and increase autonomous localization, transfer, and status tracking of resources.

- REALM technologies could provide some of the capabilities of an AMIS and more work is needed to understand what gap exists and what a future development path looks like

Functional Capabilities

- **AMIS should track location and quantity, but does not need to track individual usage.**
  - Equipment, pharmaceuticals, medical tools, etc.
- **AMIS should integrate with other vehicle capabilities like CHP-IDA, REALM, or clinical decision support tools.**
  - Tracking movement of critical medical supplies between vehicles is also desired (e.g. lander to rover).
- **AMIS should not restrict access to medical items or hinder crew from providing care in the event of a medical emergency.**
- **AMIS should provide status notifications and could support advanced analytics.**
  - Status: Out of stock, expiration, item condition, etc.
  - Analytic: Pharmaceutical burn rate for long mission
- **AMIS does not need to operate continuously but should allow for periodic scans as well as manual initiation.**

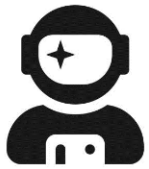


**List is representative & not comprehensive*

Why is this problem so hard?

- **Location tracking:**
  - Being able to track the location of a singular critical medical device (e.g. ultrasound) as it moves throughout the vehicle or between vehicles is desired, but tracking the location of a single bandage is excessive.

- **Quantity tracking:**
  - For ISS, pharmaceuticals or medical consumables are removed from manufacturer packages and repackaged in plastic baggies; medications must still be labeled with critical drug information or have substance controls
  - Packages can contain various quantities of pills and not all medications are critical to track at the pill level.
    - Example: 699 of 700 Tylenol remaining vs. 1 of 2 remaining epinephrine pens



- **Operational dynamics:**
  - The crew member removing a medical item might not be the person consuming it.
  - Creating restrictions for how or where crew take medications is not desirable and reduces medical privacy.

- **Vehicle medical kit vs. personal crew medical kits:**
  - For current ISS operations, crew are allocated personal medical kits. If a crew member has a headache on ISS, he or she may take a package of 10 ibuprofen from the main medical supplies and any remaining pills from the pack of 10 may be stored in their personal medical kit.
  - For Mars missions, research is still ongoing to understand how pharmaceutical packaging may need to change to meet mission demands and how operational norms may need to be modified.

AMIS - Example Use Case

IV Fluid is about to expire half-way through a Mars Mission

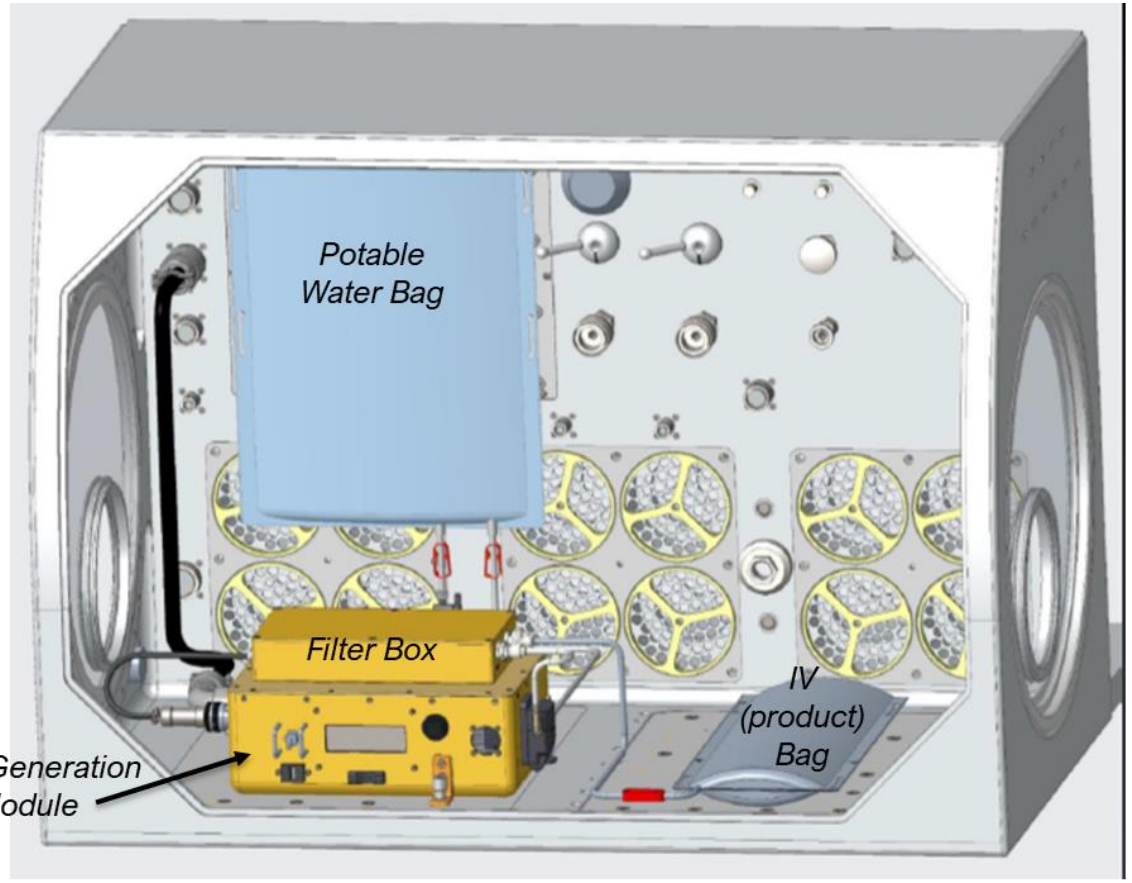
AMIS alerts crew of upcoming fluid expiration

Crew initiates fluid generation process to replenish stock

Old IV Fluid is purged and reclaimed by the life support system

Newly generated IV Fluid is inventoried & stowed in the medical locker

AMIS inventory information is updated



NASA IVGen Mini Flight Hardware System Concept for ISS Technology Demonstration

THANK YOU

Courtney Schkurko
courtney.m.Schkurko@nasa.gov

Image Source: NASA