Radio Frequency Identification (RFID) in Space

RFID Reader and Tags for ISS Inventory Management

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Agenda

- Introduction to Space
- RFID Project Status
- RFID Advantages in the ISS Program
- Some Special Issues
- Future Space RFID

Special Thanks:

- Tim Brown, Patrick Fink, Bill Hartwell, Phong Ngo, and Robert Stonestreet are the technical leads of the RFID effort for the International Space Station program, and have created much of the content of this presentation.

The ISS is Huge

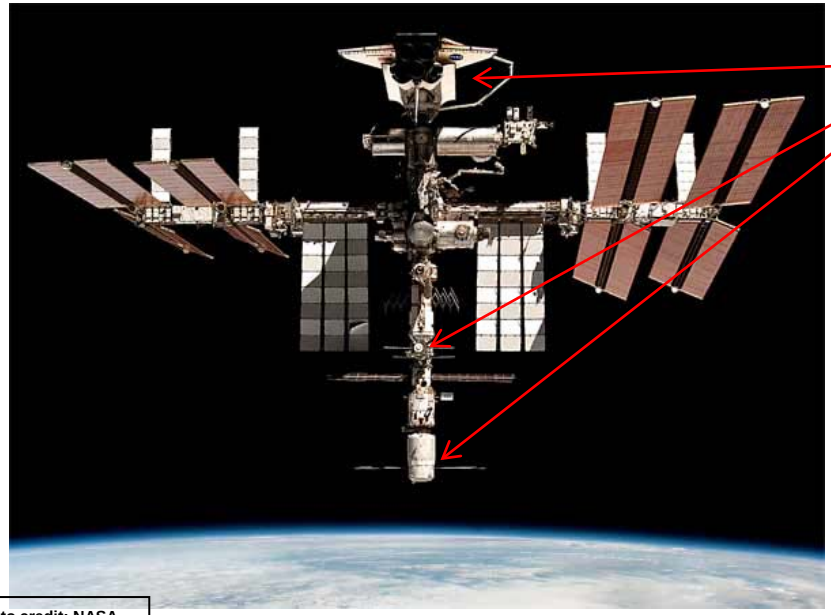
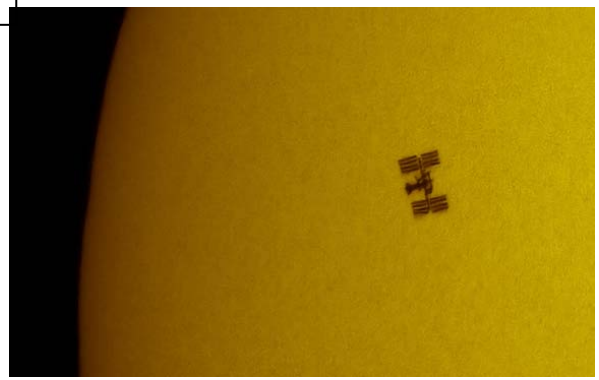


Photo credit: NASA



The ISS 400 km in space is resolvable to the human eye (seen here silhouetted against the sun (Photo credit: Thierry Legault)

- (Cargo ships the size of freight cars)
- 440,000 kg core station
  - 100m x70 m
  - 4-m diameter tubular living areas
- Six “permanent” crew
  - in 6-month overlapped shifts
- 6 partner agencies
- 30-year station life possible

The work we do there is important, expensive, and difficult

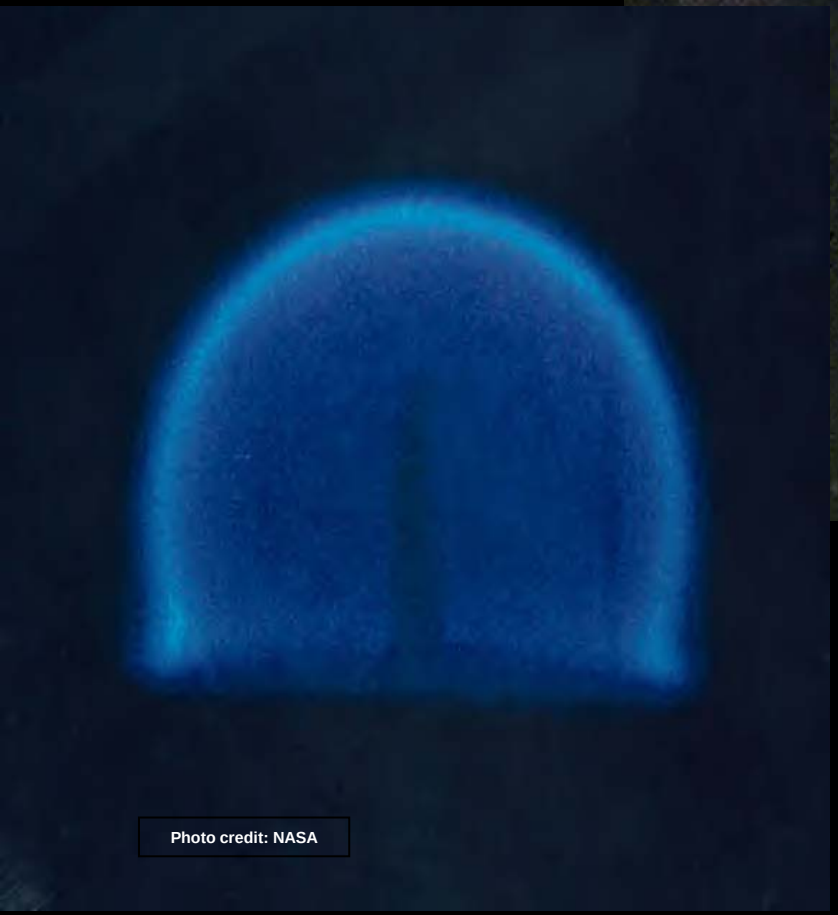
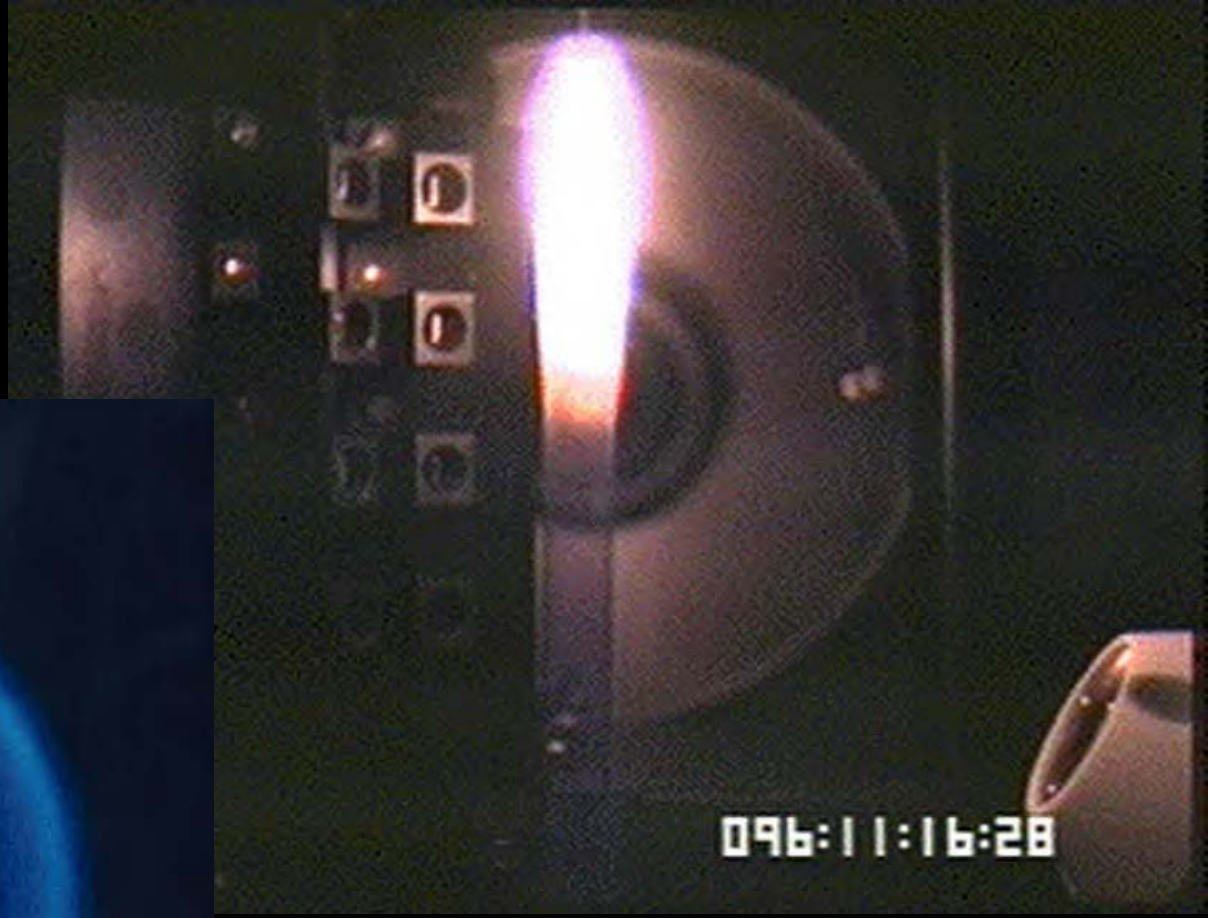


Photo credit: NASA



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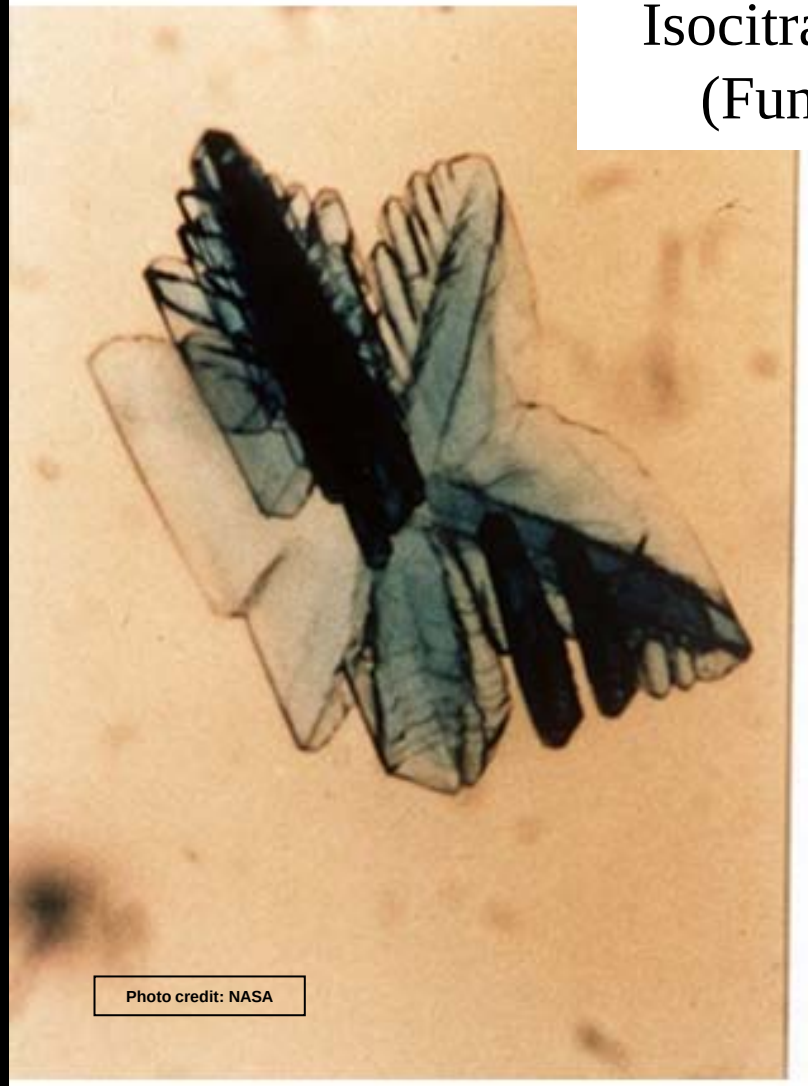
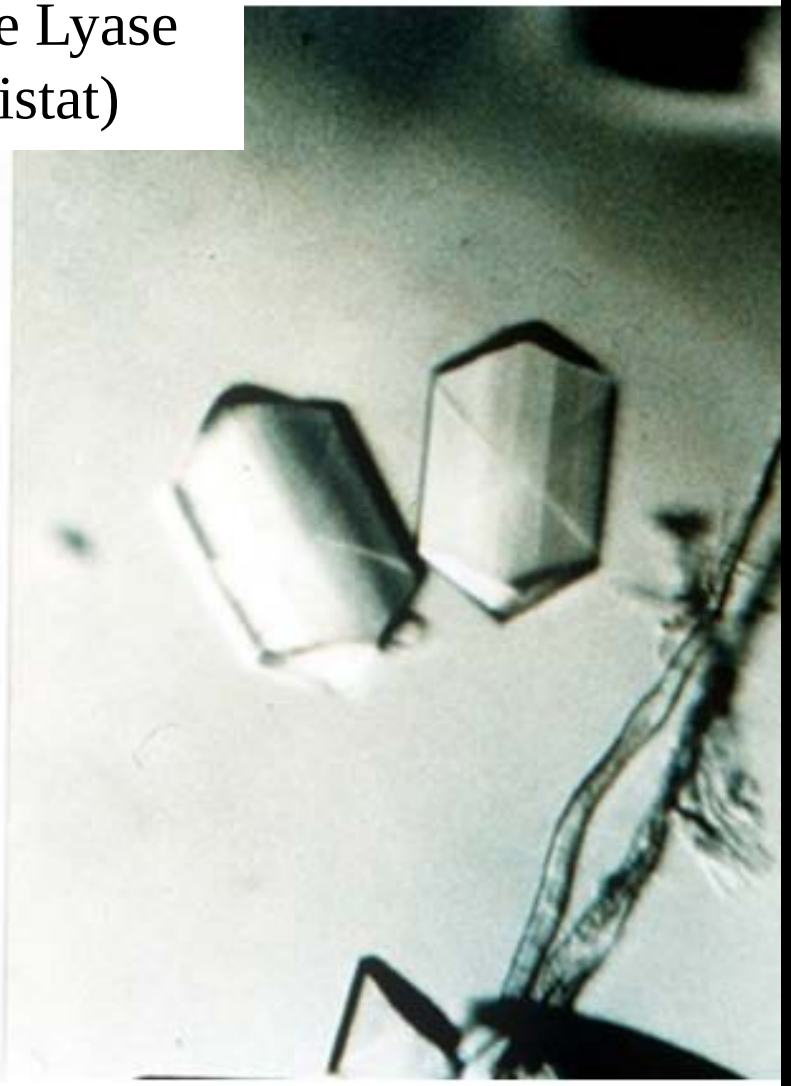
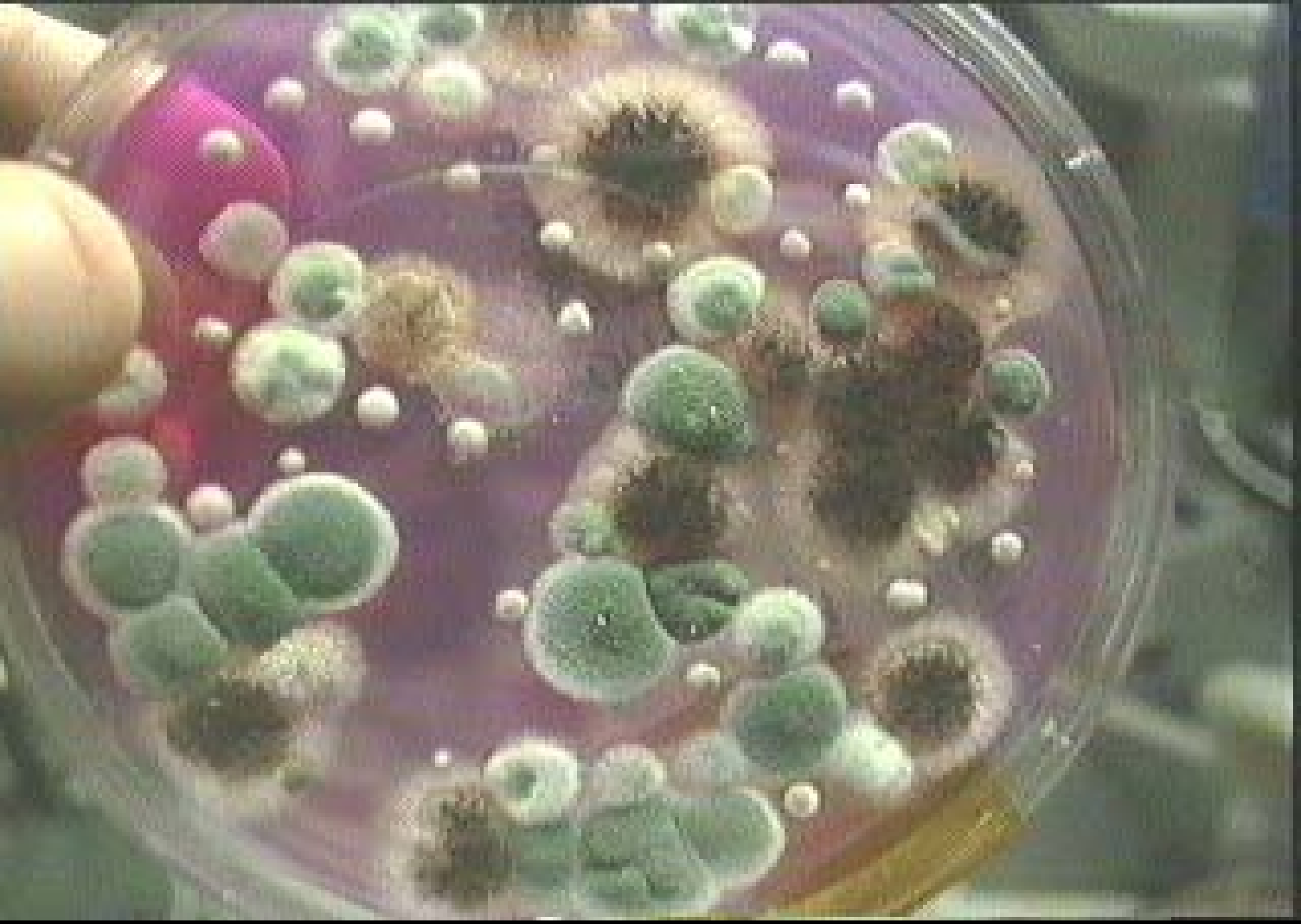


Photo credit: NASA

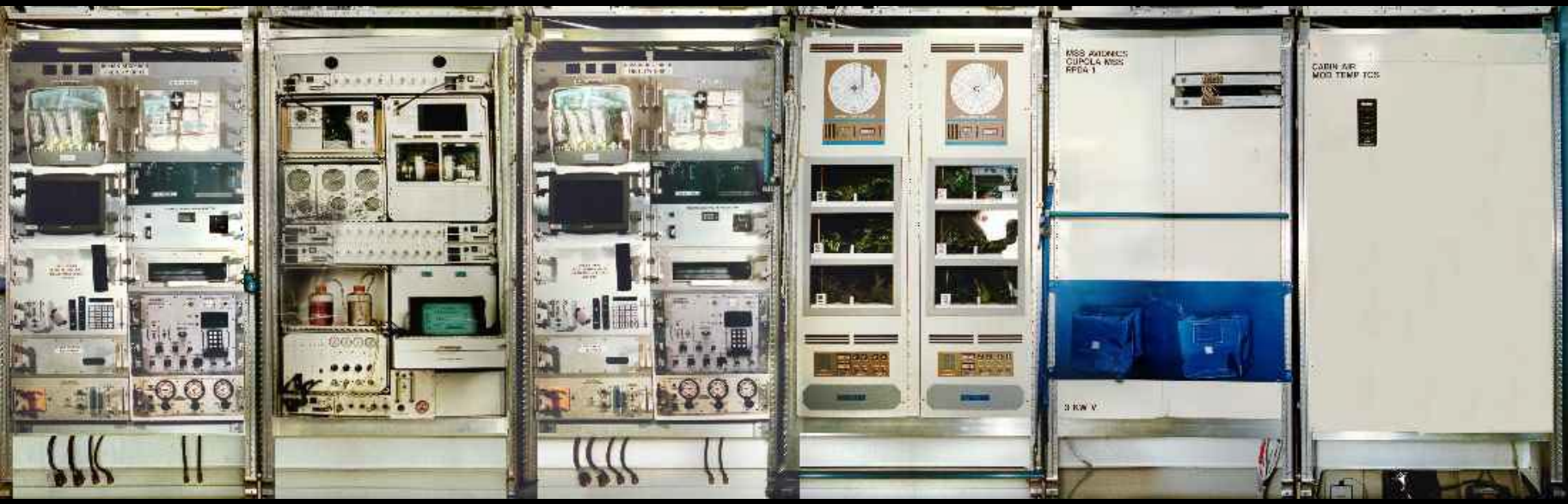


ZnCdHg



- The inventory onboard is:
  - vast
  - densely-packed
  - packed by other people
  - often behind metal
  - mobile
  - diverse
  - and often small, unique, and irreplaceable

…and it costs ~$30 USD per gram to launch


MSS AVIONICS
CUPOLA MSS
RPDA 1
CABIN AIR
MOD TEMP TCS
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JUICE
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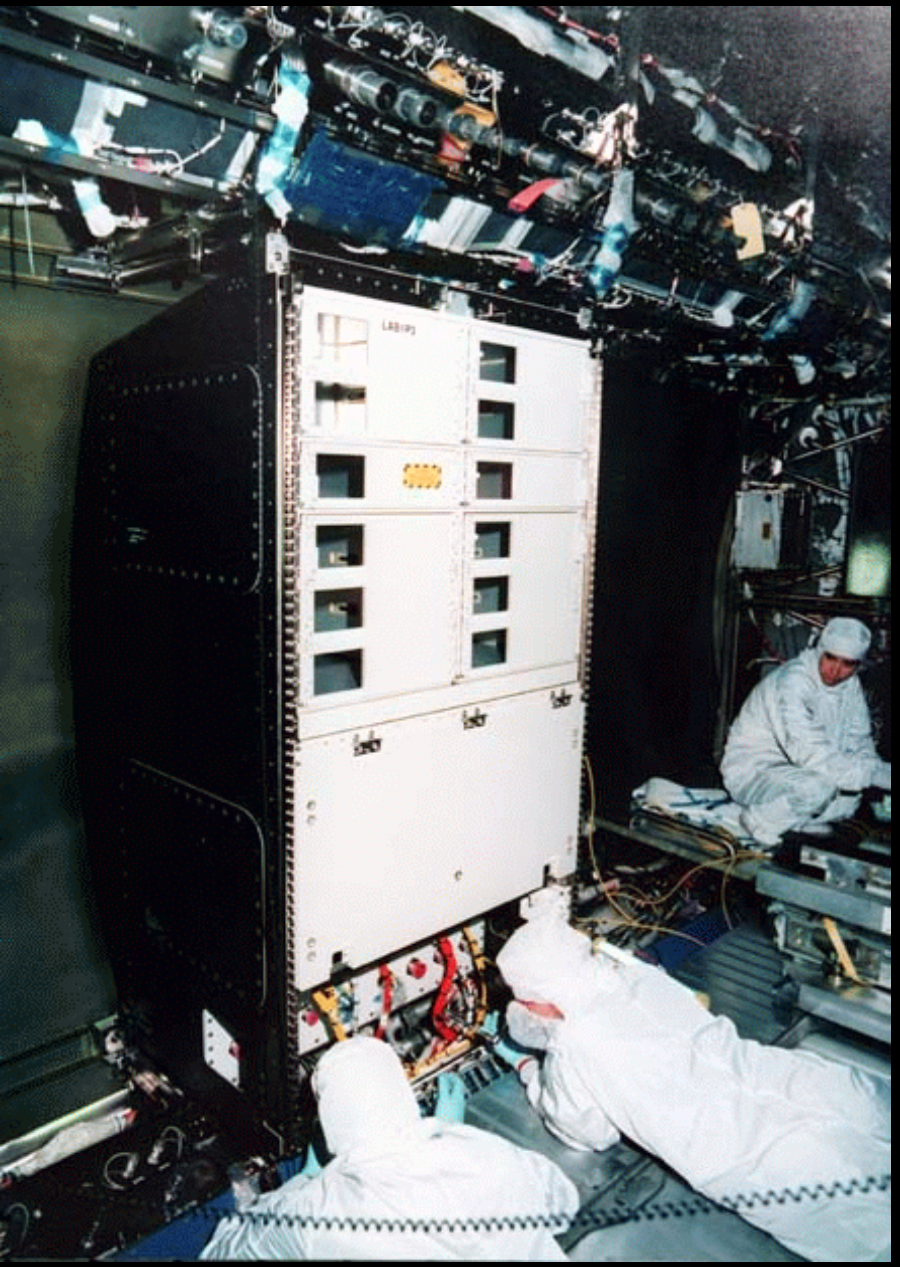
COFFEE
FRESH FOOD
SNACKS
BEVERAGES
Tropicana
PEPSI
Coca-Cola
Market Central



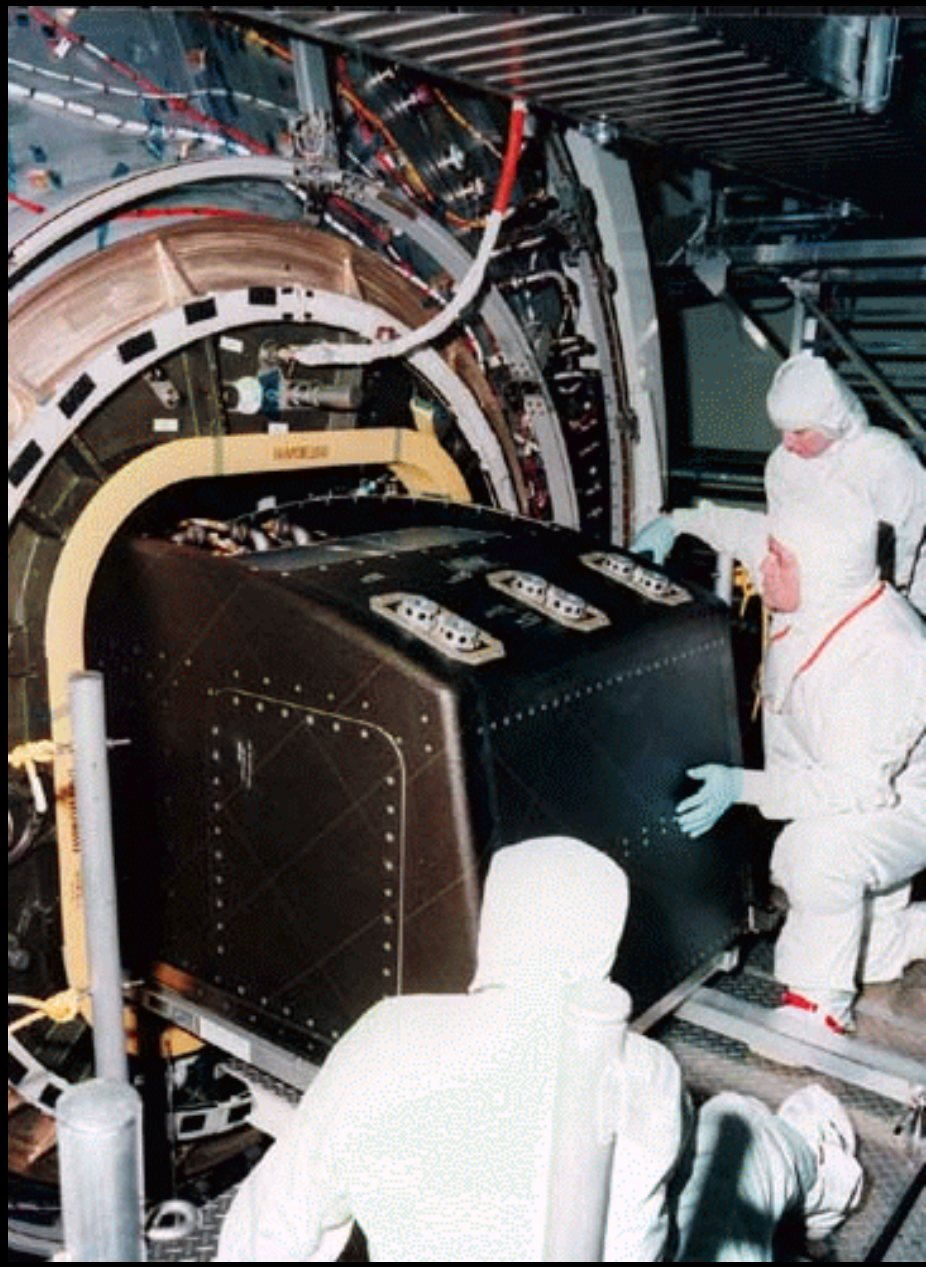



Photo credit: NASA

Photo credit: NASA


17500


SPEED
LIMIT
17500
28000
km/h
FGB

System Overview

Hardware

Main Features Of The Next Generation Reader (NGR):

- Has both barcode and RFID capabilities
- Download via Wi-Fi (batch mode capability as backup)
- User interface software designed in-house based upon requirements coordinated with Crew, Electronics Engineers, and Mission operations.
- Battery powered

Specs for the ACC 570u:

- 900 MHz, EPC Global Class 1 Gen 2
- OS: Microsoft Windows CE 5.0
- CPU: Intel Bulverde PXA 270, 520MHz
- Display: 3.5 inch, QVGA
- Weight: 528g
- I/O: Wi-Fi, USB, SD Slot
- Memory: 128Mb ROM
- Batteries: Main & Secondary (in the handle)

ISS RFID
Project Status

Project RFID includes the Next Generation Barcode / RFID Reader (NGR)

- Deployed and operational August 2011
- Replaces existing (very old) Dolphin barcode reader
- Has both barcode and RFID capabilities
- RFID technology supplements barcode system (does not replace)
- Interfaces with the existing Inventory Management System (IMS)

Next Generation Reader (NGR)

Status of Reader:

- Four units for US segment launched by Russia in April 2011
- Deployed for regular use August 2011
- Certification for use on US side is complete: Russian side pending
- Russian Segment certification awaiting Electromagnetic Interference (EMI) testing against all existing onboard equipment.
  - Testing scheduled to be complete October 2011
- Russia plans to launch two flight units on Progress after Russian certification is complete

Status of RFID tags

- After last shuttle flight, there were over 2500 RFID tags onboard ISS on Crew Provisions and Food
- This count will grow with every new flight

RFID Tags
First Tags Certified for ISS

ISS Program has certified the following passive (unpowered) RFID tags as our <u>first</u> tags used on ISS:

Tag Type	Inlay Used	Manuf.	Best Use	Read Range
4" x 1" Tag	ALN-9640 Higgs-3 "Squiggle"	Alien Technologies	General Use: zip-locks, consumables, etc.	Up to 10 ft.
4" x 6" Tag	ALN-9640 Higgs-3 "Squiggle"	Alien Technologies	General Use: zip-locks, consumables, etc.	Up to 10 ft.
OMNI-ID Tag	On Demand, 2-part, Tags	OMNI-ID	Metal objects & fluid filled objects	0.5 to 2 ft.

- All of these tags were selected because they allow high volume production, which is good for tagging consumables, and easy integration with legacy IMS barcode system.
- The “Squiggle” tags have been certified and approved for use on items which already require flammability control using stowage, such as on zip-lock bags stowed in cloth crew transfer bags (CTBs).
- The OMNI-ID On Demand 2-part tags are for metal items or fluid-filled items. They are more durable than the “Squiggle” tags (cannot easily bend), but are not ruggedized (not impact resistant).

Certified RFID Tags
Flat Labels by Alien Technologies

4” x 1” RFID label (P/N:SDG32111604)
CMC Decal Lab prints barcode on outside and encodes RFID chip with same barcode number.

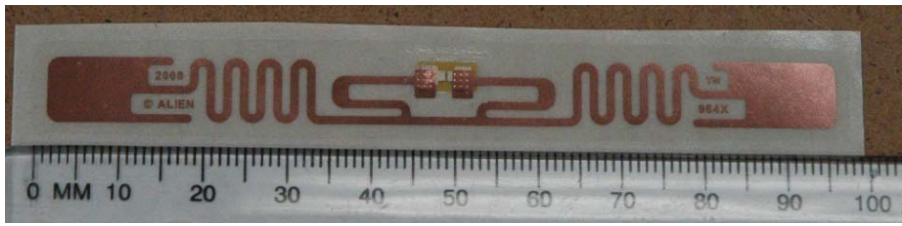
RFID Label Drawing Numbers:
- **4”x1” RFID label: SDG32111604**
- **4”x6” RFID label: SDG32111605**

Inside label

Pros:
- **Can be produced using RFID printer**
  - **Easy to print IMS barcode on top**
  - **Allows high volume production**
- **Read range is very good (high performance)**
  - **Makes it easier to locate a lost item**

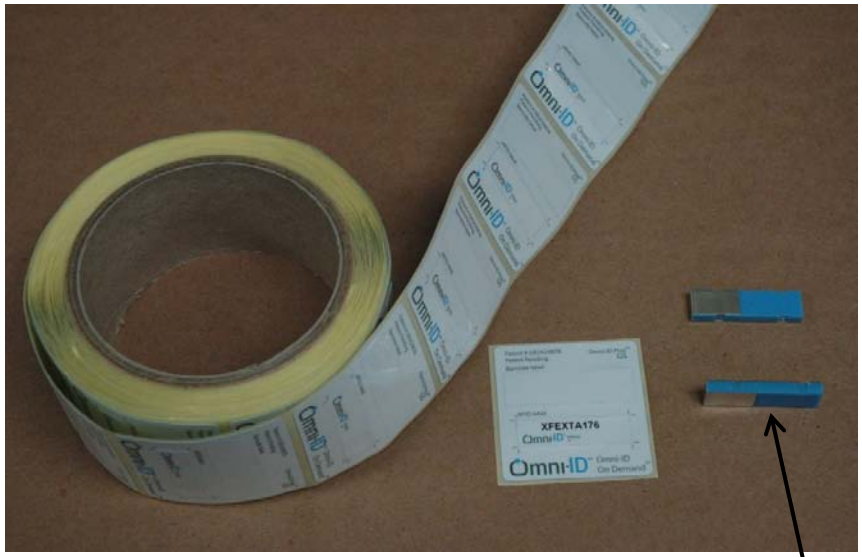
Cons:
- **Not very durable**
- **Cannot be used on metal or on containers with liquid**
- **Flammable (must be stowed in non-flammable bags)**

ALN-9640 “Squiggle” antenna and microchip used in the 4”x1” and 4”x6” labels. This part is called the RFID “inlay”



Certified RFID Tags

Omni-ID Tags for Metal / Liquid-Filled Items



RFID Label Drawing Numbers:

- **OMNI-ID RFID label:** SEG32111601
  SEG32111601-301,-302, -303

OMNI-ID 2-part RFID Labels

Assembled Product

Thick structure which improves antenna's performance

Pros:

- Can be produced using RFID printer
  - Easy to print IMS barcode on top
  - Easy to encode RFID label
  - Allows high volume production
- Can be used on metal and fluid-filled items

Cons:

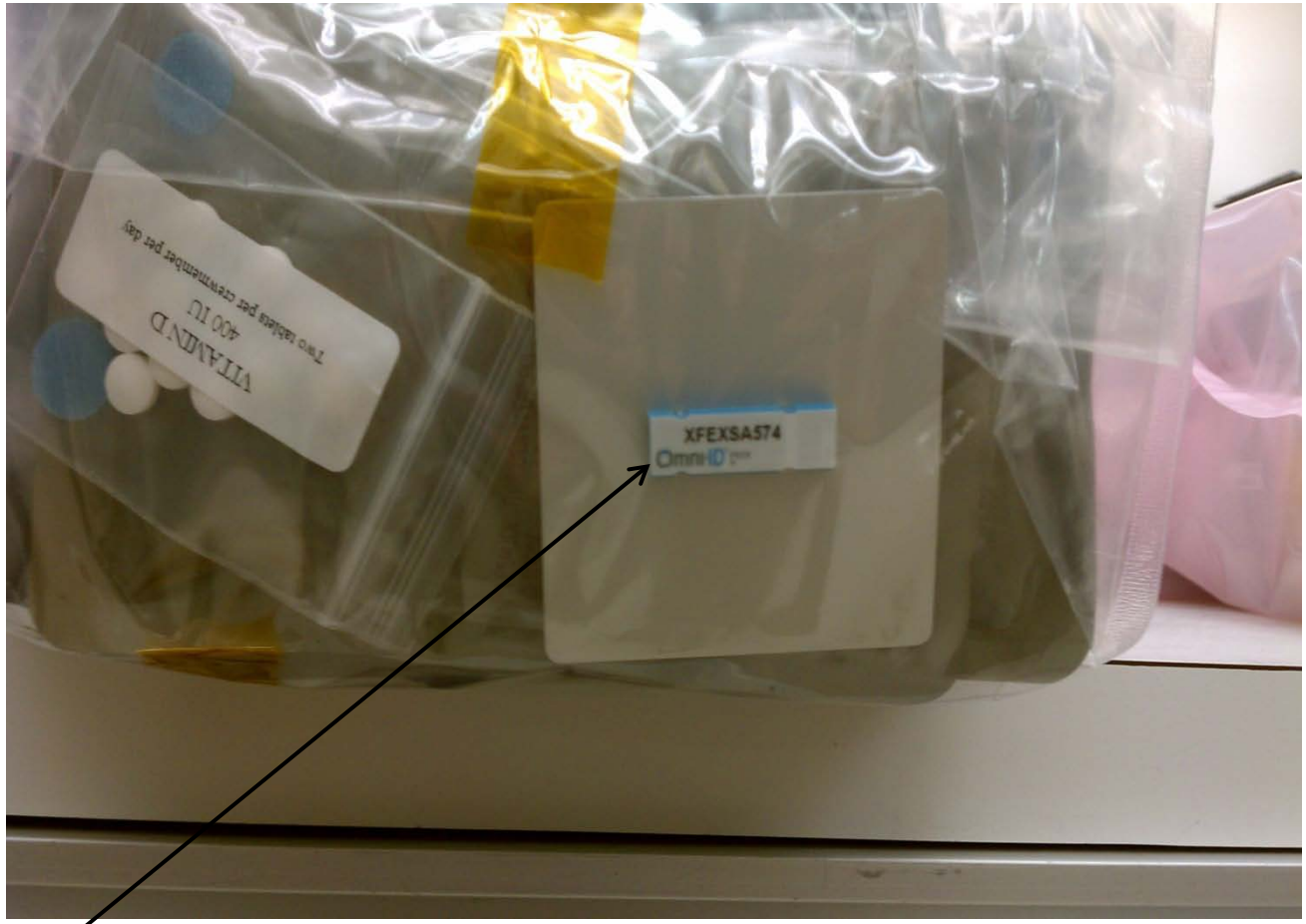
- Barcode label is a separate sticker from RFID label
- Not very durable
- Short read range. Not good for locating lost items
- Tag is thick

RFID Tags

Current Tagging Techniques

Challenge:
Applying RFID labels to Food BOBs (Bulk Overwrap Bag) that are full of metal foil pouches and liquid filled items.

Solution:
An OMNI-ID tag is adhered to a 3.5” x 3.5”, thin metal plate (OMNI’s work better on metal). Each of these tags are placed at each end of BOB. They are placed on the inside of bag to reduce opportunities for FOD.
Note: A separate barcode label is also adhered to the outside of bag.



SEG32111601-301
(OMNI-ID w/ Metal Photo plate)

Class I Food BOB for ULF7

RFID Tags

Current Tagging Techniques

Challenge:
Applying RFID labels to individual X-static shirts and pairs of socks, which contain metal (silver) fibers.

Solution:
An OMNI-ID tag is adhered to a bendable sheet of Lexan (OMNI-ID tag adheres well to Lexan). Each tag w/ Lexan is placed at end of each rolled-up shirt or pair of socks. Several shirts or socks are placed in a zip-lock bag. When these are packed into CTB's, the ends w/ tags are faced to outside of CTB to allow more reliable scanning.

Class III X-static Socks with flight-like tags
X-Static Clothing has metal (silver) fibers

SEG32111601-303
(OMNI-ID w/ Lexan)

RFID Tags

Current Tagging Techniques

Challenge:

Applying RFID labels to packages of batteries (metal items)

Solution:

4” x 1” “Squiggle” tag is placed on the outside of the zip-lock bag. The tag is placed on the “locking” edge of the zip-lock so that the tag does not rest on top of metal batteries.

4”x1” Squiggle tag
SDG32111604

Class I Crew Provisions at 42P packing

RFID Tags

Current Tagging Techniques

Challenge:
Applying RFID labels to individual packages of Huggies wipes (some fluid)

Solution:
Testing showed that there is not enough fluid in Huggies packages to warrant an OMNI-ID tag or special placement of tag. So, a 4”x1” “Squiggle” tag is placed on the outside of each package. However, since there is some fluid, the read range of the Squiggle is shorter (but still better than the OMNI-ID tag.

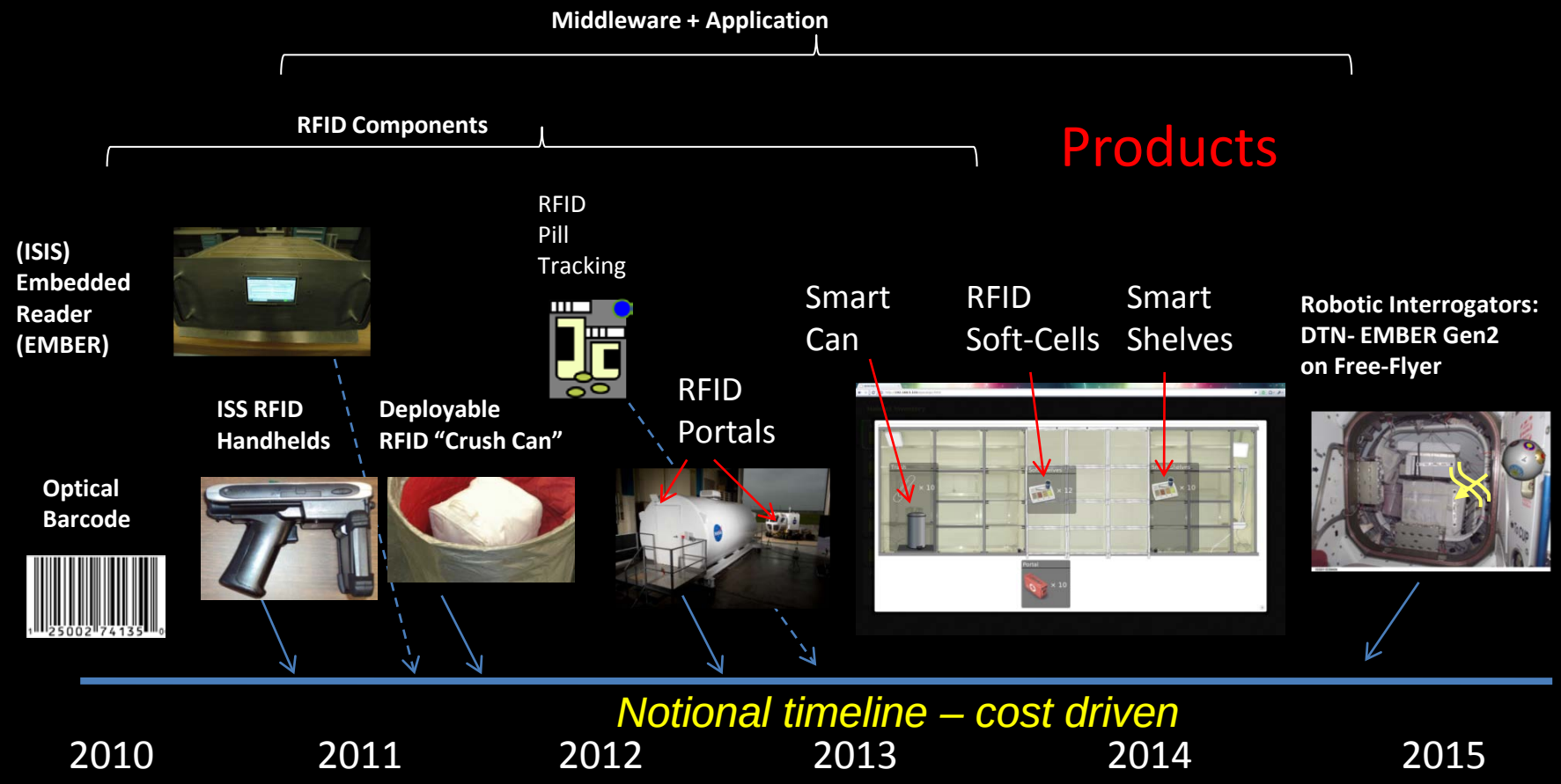
4”x1” Squiggle tag
SDG32111604

Class I Crew Provisions at 42P packing

The Future:

- ISA-100 Multi-hop wireless network
  - Ideal for noisy space operations
- Ubiquitous, cooperating readers
  - Inside metal boxes
  - On wrists
  - On free-flyers
- Embedded Reader (EMBR) in metal containers reports sub-contents
- Self-illuminating inventory that responds to query

Integrated RFID Environment



Conclusion

The ISS has some significant inventory management challenges

RFID solves many of these, and was deployed 8/2011

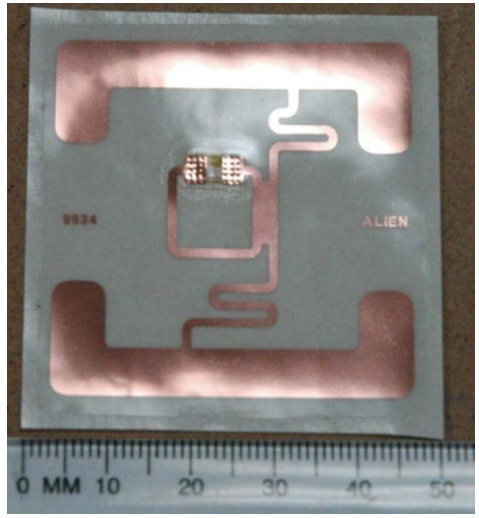
Significant issues (some unique to spacecraft) remain

NASA is interested and investing in technologies that will help to overcome the remaining issues.

BACKUP

Additional Tags

- **Examples of some additional types of RFID tags which will be needed:**
  - **Non-flammable versions of the flat tags**
  - **Flag labels to be used on cables and hoses (non-flammable)**
  - **Durable tags for long life onboard ISS for use on ORUs, tools, etc.**



2x2” inlay is one candidate for creating a high-performance (long read range) non-flammable flag label.

Hardware Candidates For Tagging

- **Examples of hardware being evaluated for tagging:**
  - **Critical / Safety hardware: Station program management, safety, and vehicle designers have expressed a concern for quickly finding particular critical and safety related hardware**
  - **Cables and Hoses: Based on crew comments regarding trouble locating particular cables/hoses (requires a non-flammable tag)**
  - **Cargo Transfer Bags (CTB)**
  - **Experiment Food: Crew says they can lose a lot of time looking for specific bags of experiment food**
  - **Water Kits: Program could benefit from improved inventory auditing of water sample kits on ISS**

RFID Uses:

Current Planned Uses of RFID on ISS:

- Inventory Audits: RFID capability eliminates line-of-sight requirement. Therefore, it can significantly reduce crew time for auditing consumable items

- Physical Search for lost items
  - Ground tests of the latest Next Generation Reader (NGR) software and latest ops concepts have shown good potential for the NGR to help locate lost items on ISS
  - Concepts need to be proven onboard

RFID Technology
Limitations of RFID

Most limitations have to do with RFID tags not receiving a strong enough signal from the RFID reader:

Direction / Angle of RFID Signal With Respect to Tag:

- If radio frequency signal from reader hits the RFID tag edge-on, tag may not receive enough power to stimulate the chip (orientation of tag matters)

Tag Compression:

- If two RFID tags are compressed together, the tags are not likely to be detected by the reader

Metal and Many Fluids Impede RFID Signals:

- Bags full of metallic items can be difficult to read (e.g. metal foil packages with body wash, drink pouches, etc.)
- Tags behind metal panels can be difficult to read
- Items filled with fluid can be difficult to read

RFID Tags
General RFID Tag Characteristics

- **NASA is using RFID EPCglobal UHF Class1 Generation 2 standard on ISS:**
- **"Class 1 Gen 2" RFID Tags come in a vast array of shapes and sizes. Tags are designed with specific requirements in mind. Some examples include:**
  - Designed for metal or fluid-filled items
  - Ruggedized for impact or extreme temperature tolerances
  - Hang off of an item
  - Stitched onto an item (clothing)
- **In most cases: smaller tag = smaller antenna = shorter read range**
  - Read range: maximum distance reader can be from tag and still read the tag
  - Longer read range helps with finding lost items
- **RFID tags can be active or passive**
  - Passive: without battery (most common type used in industry, due to low cost and simplicity)
  - Active: contains a battery (much greater read range than passive tag)

RFID Printer/Encoder

- Printer encodes the RFID chip and prints the barcode on top of the label
- RFID printers are located in the Decal Lab (DDPF) Facility where all flight RFID labels for ISS are produced
- Only some types of RFID tags can be run through the printer, including
  - Flat labels by Alien Technologies
- Some types of RFID tags need to be encoded using what is called a stationary RFID reader