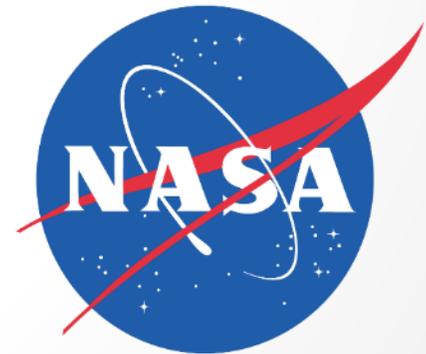


# HRP Commanding Lessons Learned

Commanding to HRF Racks



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# Objective

- For the benefit of the PD community, highlight why we recently reevaluated how we perform technical tasks on console
- Communicate some of our Concept of Operations practices specific to:
  - Commanding
  - Building and analyzing telemetry displays using payload health and status
  - Redundancy and anomaly resolution responses
- Applicable to:
  - PDs who perform commanding to hardware on ISS
  - PDs who make operational decisions based on telemetry displays
  - PDs who have multiple pieces of hardware or hardware with duplicate commands

# Background

- In Increment 43/44, ISSMP was commanding to the HRF Rack on ISS and unknowingly introduced a COL MDM error by sending a command to a non-powered Rack
- The result was that commanding could not be performed until the commanding queue buffer was cleared
- Our root cause analysis found:
  - **The console team was unaware of risk increase associated with sending the wrong command to ISS (PEP software update)**
  - **Communication and anomaly resolution practices relevant to this anomaly were insufficient and resulted in a long recovery time, impacting the POIF Cadre and adding risk to other ISS users**
  - **ISSMP console practices did not mature with the risk/probability of the errors that we could introduce to the ISS**
- As a result, ISSMP revisited what were considered best practices and sought to inject, and in some cases, re-integrate robust mistake-proofing measures<sub>3</sub>

# Anomaly Reaction and Resolution

## Problem #1: Human Error

“It will be impossible to prevent an anomaly like this from occurring again.”

**This realization did not sit well with us and we know the ISS Program and our research colleagues deserved better.**

Because of this, a focus was applied to the **reduction of human-introduced error** and the **communication surrounding anomaly responses**.

Those two focus areas will **reduce the impacts of human error** and **improve the community's ability to recover**.

## Problem #2: Improving Human Factors (Mistake Proofing)

## Problem #3: Anomaly Resolution Response and Communication

# Problem #1 – Human Commanding Error

- Accepted we would not have the resources or the interfaces to fully mitigate the lack of awareness a PD might have to a changing ISS environment
- We chose to accept console errors and mitigate our highest risks via training and console mistake-proofing
- Our evaluated error rate is 0.1 % (~3662 commands over 1 year)
- For this specific error and impact, most PDs would not fall into this category
- The execution environment could change on ISS and you won't know that you have the ability to impact a system larger than your hardware
- This leads to problem 2.
  - If the best way to minimize risk is to mistake-proof our commanding, how can we do this?
  - And how close can we get to “target zero”?

# Problem #2: Improving Human Factors

- 2.1 EPC commanding setup
- 2.2 Command and Data Handling Preparation
- 2.3 Reduce complacency and introduce some formality back into communicating commanding expectations
- 2.4 Other best practices to communicate

# Problem #2.1: EPC Setup

- If a specific command will be used frequently, create a dataset instead of manually editing the user form each time
  - This introduces reliability and mitigates typo errors
- Filter commands in Command Operation that will only be used that day
  - Command Operation refreshes constantly to a default command instead of the queued command the PD is preparing to send
  - This helps the PD make sure the refresh doesn't go unnoticed
- Create displays that are payload/rack specific
  - Do not put commands to multiple racks in a single display
  - HRF had a duplicate payload in both racks so it built a display to handle commanding for both payloads
  - This introduced a chance for human error to inadvertently command to the wrong payload

# Problem #2.1: EPC Setup

- Create a display if a set of commands will be frequently sent in a specific order
  - Create this display to flow in the order the commands will be sent
  - HRF has individual displays to activate the rack in different configurations, not just a generic rack activation display
  - Higher specialization is preferred as this removes command buttons from the display that could be selected by accident
- If off-nominal (infrequent) commands will be used, create a command plan with predefined user form inputs
  - Review command plan with console team during session pre-coordination meeting

**Example in  
backup charts**

# Problem #2.2: C&DH Preparation

- Use naming conventions in PDL that are well defined and easily discernable
  - HRF's Rack 1 and Rack 2 commands were only differentiated by 1 digit
    - “H**1**C42\_TWO\_STAGE\_CMD” vs “H**2**C42\_TWO\_STAGE\_CMD”
  - Make command names that can easily be filtered
- Also allows PRO to monitor commanding through Command Track with better transparency

# Problem #2.3: Reduce Complacency

- Accept that you need to put protections in place to protect you from yourself. Use your PRO/PSE experts to help with this!
- The more common the commanding sessions become, the more your brain goes on autopilot
- Mitigate the normalization of deviance
  - Gradual acceptance of sending the wrong command
  - Our operating environment allowed this as commands are no longer verbalized on the PRO loop as a mechanism for mistake proofing
  - Our internal HRF cadre reset the formality of the interface between our lead and our systems engineer, applied to the communication with the PRO as well

# Problem #2.4: Other Human Factors

- As part of HRF's nominal console session, we bring down log files, create a command delog of all commands sent during the console shift, as well as an activity report with hardware times
- HRF has console checklists that are filled out each session to ensure all information is archived in the proper channels
- Quick access to console documentation detailing previous anomalies + cause + resolution (regardless of if a PAR was generated)

# Problem #3: Anomaly Response

- Console Presence
  - Always alert PRO to off nominal responses immediately (regardless of how benign the issue appears to be)
  - Inclination may be to send for log files or other troubleshooting to better diagnose the issue and come to POIC with a more coherent story, but it's important to verify there is no risk to do so first
  - Always log commands sent (not just what was meant to be sent)
  - Do not assume a systemic issue outside of your payload wasn't caused by you
- Validate human steps prior to assuming broken hardware/software
- Communicate in real-time the expectation for anomaly characterization and recovery
- Start with the small things and work your way to larger systemic issues

# Additional Practices

- Two separate methods for viewing telemetry
  - HRF has a verified redundancy in place should one fail
  - MSIDs into commanding displays
  - Deconstruct the Payload Health & Status (PLHS) into in-house telemetry displays
- Develop and maintain backup crew procedures
  - HRF's crew rack activation/deactivation procedures were out of date in IPV
  - Crew intervention is an easier alternative to the POD with procedures in place
- Hardware used on ISS should be on console
- Simulations are used to reinforce anomaly decision tree

# BACKUP CHARTS

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# Commanding Display

- Screenshot of the Rack Activation display (Thermal)

MOP IN42:Flight Date: 12/4/2014    COL1F4 HRF RACK 1 Thermal Activation    S-BAND AOS F    Ku-BAND AOS

Filename: HRF1\_F4\_FLOW\_CTL\_Procedure\_v1    GMT: 014:19:06:45

(Kg/Hr)	TCS Flow Sensors	Set Counts	Config File Counters			
50.08 N	FS 1 Avionics Leg	0 N	Ancillary Data	2 N	2 N	Payload Telemetry
0.00 N	FS 2 Left Bank	0 N	PHEB LAN Cam	2 N	3 N	Rack Configuration
c	FS 3 Right Bank	0 N	ISS LAN	2 N	4 N	Payload Configuration
c	FS 4 Deployed Payload Leg	127 N	Rack Telemetry	2 N	3 N	Rack Thermal

**WFSV Rack 1 (PCT): 0.86 d**

### 1.305 HRF1 ISPR RACK ACTIVATION

1. Verify Rack Power Switch Position Data (COLOC)    RMS: ON
2. Verify TCS Status (COLOC)
3. Provide Cooling (COLOC) - Verify WFSV = 58% +/- 3%
4. Polling Enablement (PRO) - Auto-enabled on PDU close    POL
5. or 6. PDU Closure (Main or Aux) (ESA) - Verify PDU Amperage, confirm Bootloader startup
  - PDU Main (AMP): 0.000 d    OFF d    Bootloader Display    BL Command Window: 0 N
  - PDU Aux (AMP): 0.000 d    OFF d
7. Caution and Warning Activation (COLOC)    DISABLED d
  - CIFA/Mixing Fan (VDC): 0.00 d - Verify CIFA (Mixing Fan) Voltage > -2.5V (less negative) (COLOC)
  - SD Obscuration (PCT): 53.4188 d < 25%    SD Scatter (PCTO3/M): 0.3301 d < 1%    SD Scatter Graph
8. TCS verification (COLOC) - HRF Requires 27-33 kg/hr through SSV (HRFSYS)
  - If needed: adjust to meet HRF Requirements (COLOC)

Confirm Thermal Case - Rack Configuration  
Begin HRF Commanding    RIC Commands Received: 15 N

SET -> PC to EMU	UPLINK PC to EMU	Verify PC to EMU    ACT
Verify Laptop as Rack File Retrieval Drive after HRLC boot		
WOL PC1	WOL PC3	UPLINK    SUP04 I01 (AMP): 0.000 d    SUP04 Current Graph
Config Files	Checkpts	UPLINK CONFIG FILES    Verify Config File counters increment (HRFSYS)
SET -> OPERATE	UPLINK RACK MODE	Mode: 3 N    Verify Rack Mode = "2" (HRFSYS)
Enable PC1 Comm	UPLINK	PC1: 24971 N    Confirm heartbeats incrementing
Enable PC3 Comm		PC3: 10672 N

**Configure Rack Thermal Cooling**

Open HRF1 Thermal Graph

Configure SSV to desired flowcase    Verify SSV @ desired flowcase (HRFSYS)  
Configure PLD8/PLD7 to desired flowcase    Verify PLD Valves @ desired flowcase (HRFSYS)

*Wait at least 5 min and watch trend on flow graph before requesting more flow.*

**Coordinated Activation Complete. Continue with HRF activation**

Messages  
2016 014:19:05:12 Connection to IMS complete

# Commanding Display

- USND2 display
- Separate display for USND2 on Rack 2

S-BAND AOS F Ku-BAND AOS

MOP IN42:Flight **ULTRASOUND 2: COL1F4 HRF RACK 1** S-BAND AOS F Ku-BAND AOS F  
Date: 12/4/2014 Filename: HRF1\_F4\_USND2 GMT: 014:19:11:38

1.1 Complete Coordinated ESA/PRO/HRF activation procedure  
[Open Coordinated Activation Procedure](#)

1.2 Configure rack for ULTRASOUND support  
[Enable USND2](#) [uplink](#) Ch 29 O/P State: 0 N 1 = Power enabled  
[Route USND Video](#) [uplink](#) ISS Video Source Location: 0 N

1.3 Notify OPS Lead and PRO that HRF1 is activated and in a good configuration for scan

1.4 Open USND2 Current Draw Graph [Open USND2 Graph](#) [Open SUP Current Graph](#)

1.5 Establish connection with USND2 and verify data exists on USB  
[TS: CMD](#) [uplink](#) [TS: CMD](#) [uplink](#) [Y:\ \(USB\)](#) [uplink](#)  
[LA: Explorer X:](#) [uplink](#) [LA: Explorer Y:](#) [uplink](#) [Init Downlink](#) [uplink](#)

1.6 Copy data from USND2 USB to HRF PC1  
[TS: CPALL](#) [uplink](#)  
[LA: CPALL](#) [uplink](#) Discuss appropriate copy time with USND 2 HSE (at least 10 min)

1.7 Verify all data copied to HRF PC1, Clean USND2 USB drive, and Verify clean  
[D:USND2](#) [uplink](#) [TS: CLEAN](#) [uplink](#) [Y:\ \(USB\)](#) [uplink](#)  
[Init Downlink](#) [uplink](#) [LA: CLEAN](#) [uplink](#) [Init Downlink](#) [uplink](#)

1.8 Add USND2 files to downlink  
[Add USND Data](#) [uplink](#) 0 N Confirm # of Enabled Files

1.8.1 Confirm Number of Enabled Files  
Confirm TSC ground systems are prepared for downlink and initiate downlink  
[Init PC1 Downlink](#) [uplink](#) 0 N Confirm # of Enabled Files = 0 after downlink

1.9 If performing data downlink, open data downlink display  
[Data Downlink](#)

1.10 Complete Coordinated ESA/PRO/HRF deactivation procedure  
[Open Coordinated Deactivation Procedure](#)

**Ultrasound 2: Rack 1 Complete**

USER Enabled CONNECTION

## Messages

**i** 2016 014:19:11:17 Connection to IMS complete

# Commanding Error - How did it happen?

- Changes to PEP software allowed what was once a benign human-introduced error to become something more serious
- PD community was notified of the release of the software update, but not all of the implications were understood
- Commands that are sent are put into a queue to be executed
- Before the software change, each remote terminal (so each HRF Rack) had a unique queue
- After the software upgrade, all payloads on the same PL MDM bus had the same queue
- The command to the unpowered rack clogged up the queue for all other payloads on the PL Bus (including other PLs in Col module)
- Our specific command error in this case only applies to command data sets that have the same commands for two different pieces of hardware

# HRF Perspective

- The HRF Racks (HRF1 and HRF2) are modified Express Racks...
- We can send upwards of 100 commands in a single console shift depending on the session
  - Increments 39-42 (1year) HRF sent 3662 commands and 4 commands were sent to an unpowered rack
  - 0.1 % error rate
- Average # of commands that we send for a
  - Rack Activation,
  - Downlink,
  - Rack Deactivation

# Mistake Proofing

- Lean Six Sigma overview of the techniques we applied
- Applicable waste – Human Error:
  - Unintentional mistakes or errors relating to fatigue or distraction
  - Misapprehension or making conclusions even if the information is not complete
  - Classification or seeing the circumstances incorrectly
  - Deficient in set of standards
- Guidelines for correcting process:
  - If it is unfeasible for the mistake to happen, think of means to discover the mistake and reduce its consequences.