



# Launch Fast Learn Fast

Lessons Learned from the R5-S2 and R5-S4 Missions

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# Purpose



**R5 developed 2 propulsive 6U spacecraft  
from CDR to delivery in 6 months  
with a total parts cost of < \$80k**

**These spacecraft successfully operated for their entire  
10-month missions**

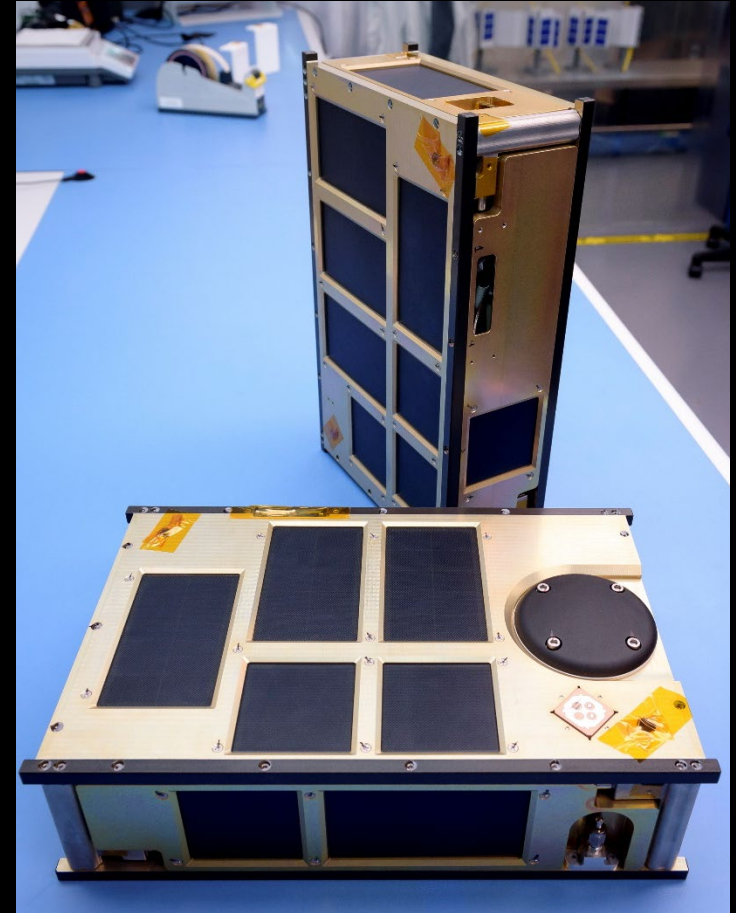
**We'd like to share how we did this so you can reduce your  
space mission cost and schedule**



# R5 Objectives



- Accelerate low-cost (<100k), risk-tolerant systems capable of hosting low TRL payloads
- Develop enabling technologies
- Advance tech for in-space inspection



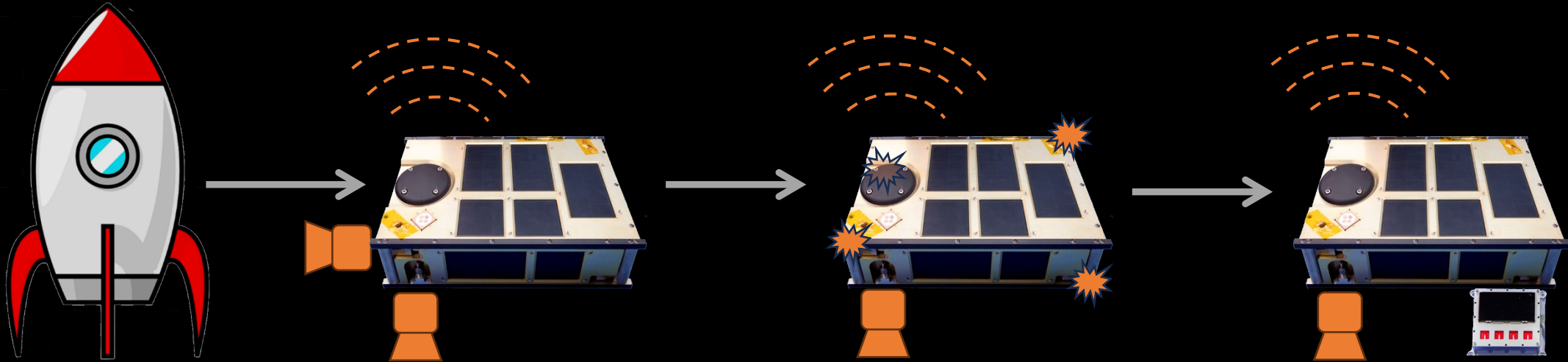


# Background: R5-S2 and R5-S4



R5 Spacecraft 2 (R5-S2) and R5 Spacecraft 4 (R5-S4)

- Mission: demonstrate core bus, cold gas propulsion, and ELROI

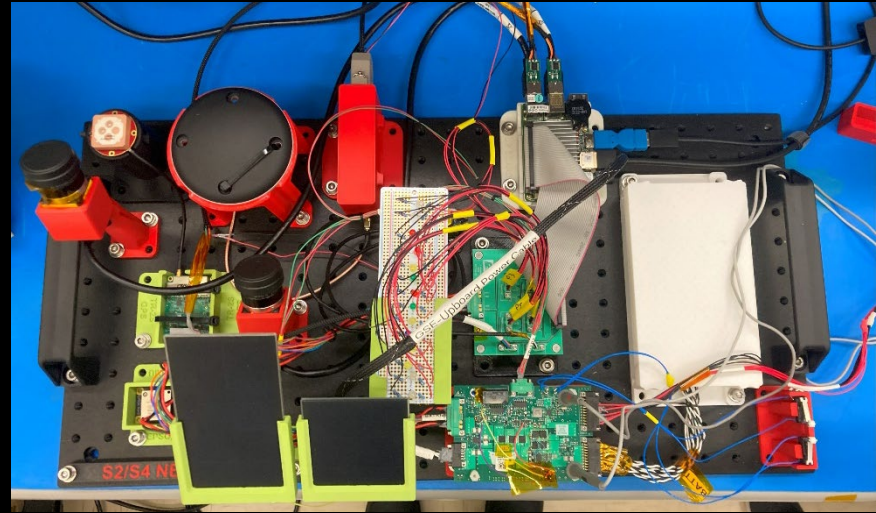


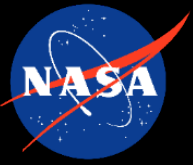


# The R5-S2 and R5-S4 Process

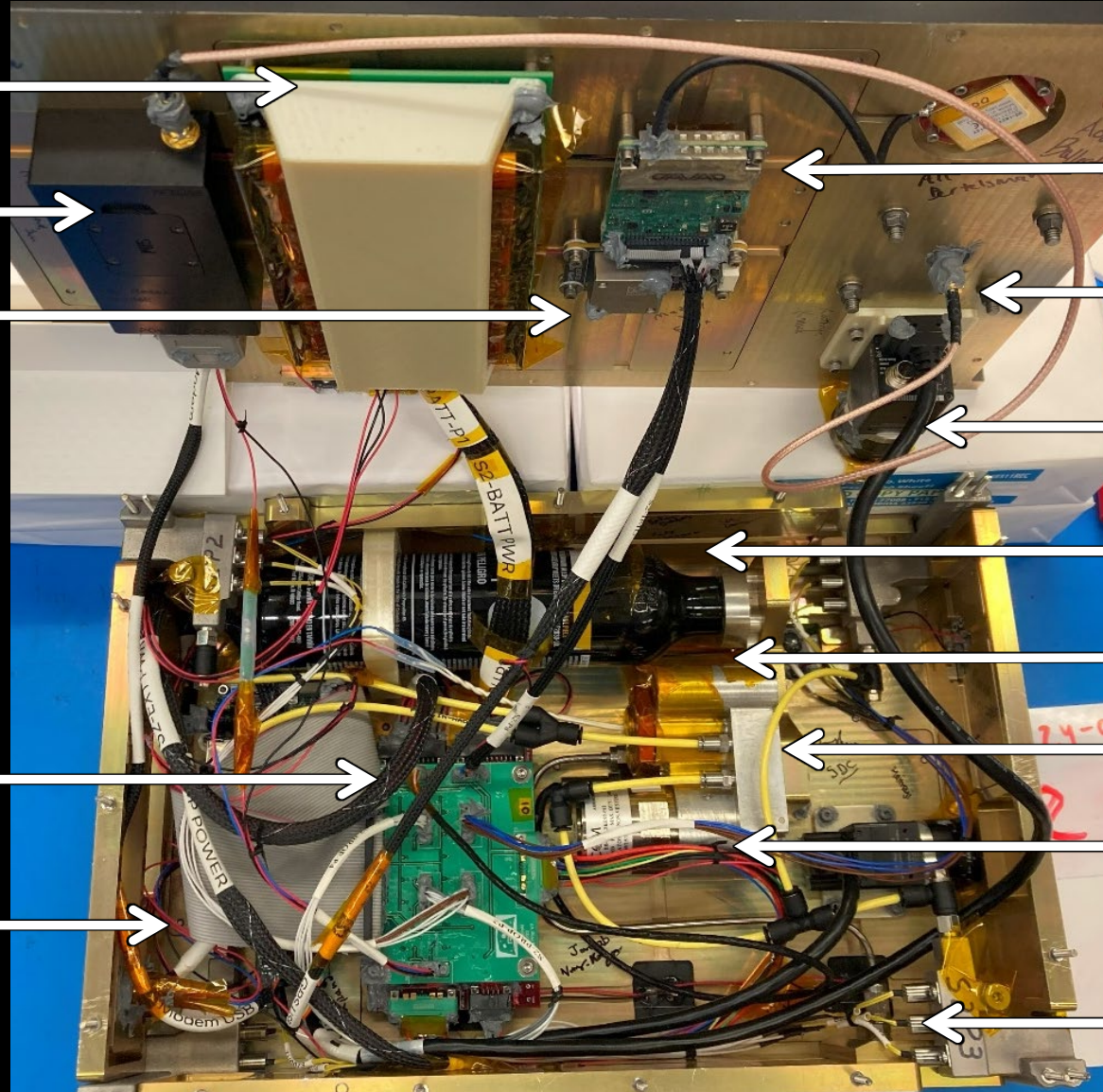


- Emphasis on personnel safety
- Trust the data, not the dogma
- Test like you fly as soon as possible
- Quickly recover from hardware failure
  - Design for human error and handling
  - Enable hardware rich environment
  - Create an open reporting culture





# What's inside the box?



Battery Pack  
(custom, KULR-welded)

Iridium Modem  
(NAL A3LA-RS)

IMU  
(Epson G370)

Power and Data Distribution  
(Custom)

Flight Computer  
(UP CHT01)

GPS  
(JAVAD TR-2S)

Iridium Antenna  
(NAL SAF 2040B)

Star Tracker  
(Ximea MC023+Fujinon HF35 lens)

Propulsion Tank  
(Tippmann 13ci)

Isolation Valve  
(Lee Co)

Pressure Manifold  
(Custom)

Regulator  
(Tescom)

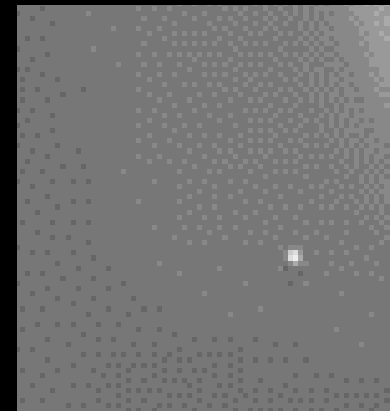
Thruster Valves  
(Parker C7)



# R5-S2 and R5-S4 Flight Results



- Radios operated with minimal modifications for space
- Demonstrated propulsion system (valves, pressure, leak rate)
- Enabled LANL ELROI payload observations
- Validated environment assumptions, hardware robustness, and minimal environment test plan
- Imaged a resident space object





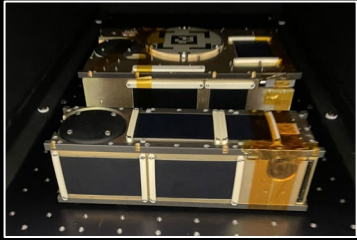
# Top 3 Lessons Learned



- Increase inter-subsystem communication
- Work towards system traceability and control
- Verify all relevant component specifications



# R5 missions launched by next SmallSat



*Spacecraft 3 and 5 (1-2 month AIT)  
Payload Demonstrations*



*Spacecraft 7 (6 day AIT)  
Proximity Operations*



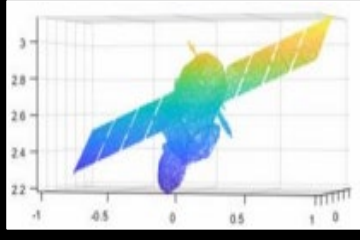
*Spacecraft 9  
Payload Demonstrations*



*Spacecraft 10  
Proximity Operations*



*Astroscale Docking Plate*



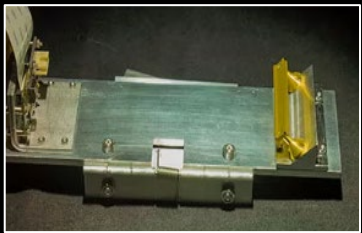
*Martian Sky 3D Reconstruction*



*SNL Payloads*



*IDS Event Camera*



*UC Davis Prototype RCW and Image  
Processing*



*Movia LiDAR*



*Aerospace Optical Comm  
Transmitter*



*(Finalizing agreement to release  
client name)*

**And more!**



# Conclusion



- R5 flew 2 \$40k propulsive spacecraft with 0 space grade parts
  - Suggests cost and schedule can be significantly reduced
- Check out our paper for details on the process and subsystems
- If you want to fly things cheaper and faster or have a payload you want to fly come say hi!
  - Email: [james.w.berck@nasa.gov](mailto:james.w.berck@nasa.gov)