Leadership in a High Performing, High Reliability Organization

Insights from NASA's International Space Station Mission Control

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Mission Control Center – Houston
FCR-1, est. 1965

Inside Mission Control

- Each console manages one subsystem
- Flight Controllers
  - Specialize in operations
  - Complete a documented training and evaluation plan for MCC ops
  - Divide time between office (plan, train) and console (fly)

NASA/ISS Program Oversight

Mission Management

Increment Lead Flight Director

Real Time
Decision Making
Risk Management

Flight Director

Nominal and Off-Nominal System management

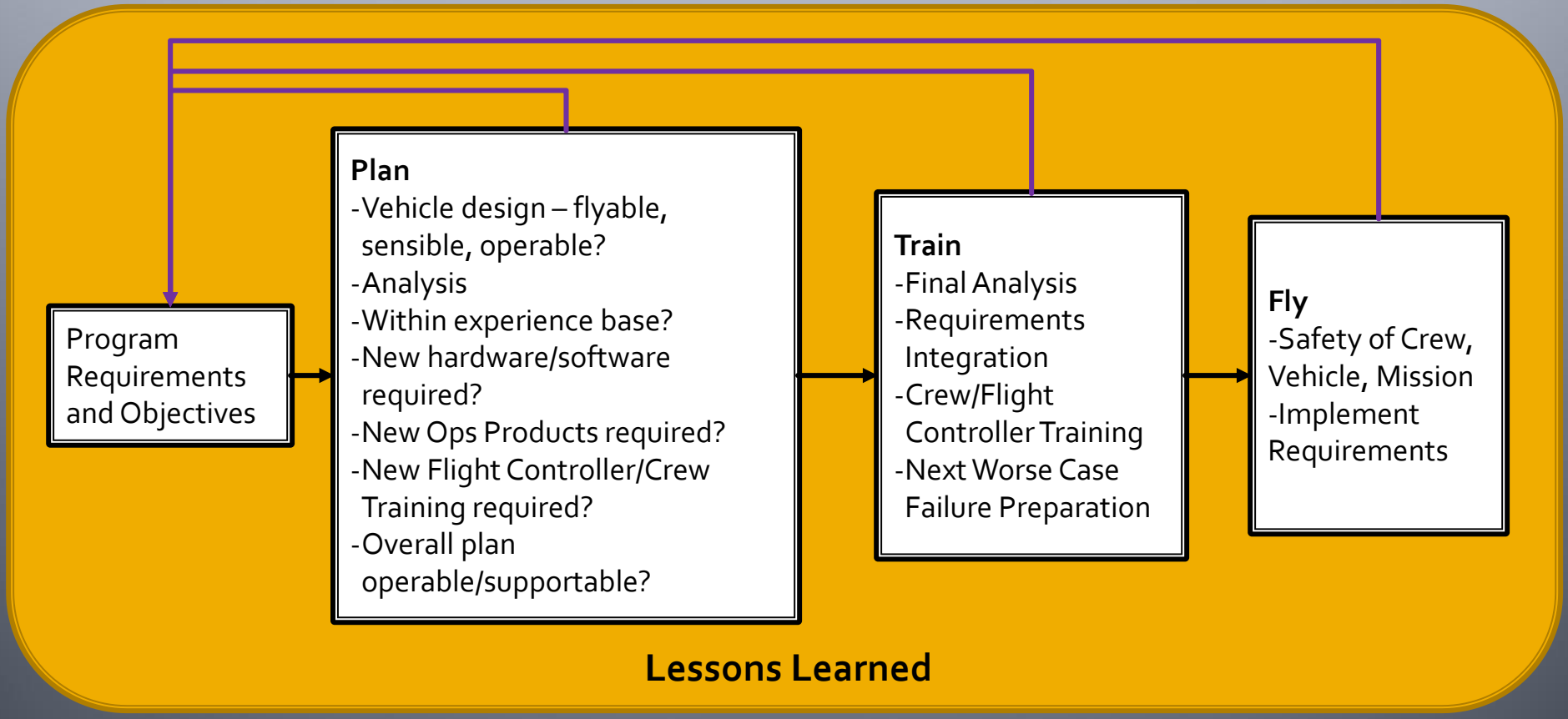
Flight Controllers

Crew

- *Office Support*
- *Offline Analysis*
- *Engineering Support*
- *Development*

Offline/Non Real Time Support

Flight Operations - Plan/Train/Fly



- All aspects of P/T/F embedded in Lessons Learned culture
  - Encode, Duplicate successes
  - Learn from, Avoid mistakes
- All aspects of P/T/F provide feedback to the Program on the risks/concerns/recommendations of Program Requirements and Objectives

High Performing Organizations

- **Leadership** – *Leadership is aligned and effective deep within the organization*
- **Leadership in Mission Control**
  - Unambiguous chain of command within MCC-H and between Control Centers
  - Leadership within a discipline is expected on and off console; "Lead Your Leader" reflects our goal for leadership development at all levels

- **Design** – *The structure is lean and reflects the organization's strategic focus*
- **Design in Mission Control**
  - Documented processes, training flows, and certification guides establish both the ends and the means; regularly reviewed to ensure the methods align with changing strategic goals

- **People** – *The organization effectively translates business strategy into a powerful people strategy, attracting and retaining the most capable individuals*
- **People in Mission Control**
  - Selective recruiting, Flight Controller Boot Camp, progressively complex training and simulations, regular skills assessments and pass/fail evaluations with documented pass/fail criterion

Source: Bhalla, Vikram; Caye, Jean-Michel; Dyer, Andrew; Dymond, Lisa; Morieux, Yves; Orlander, Paul (2011). "High-Performance Organizations, The Secrets of Their Success," Used with permission

High Performing Organizations

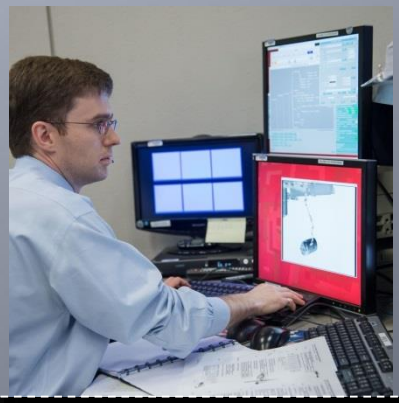
- **Change Management** – *The organization can drive and sustain large-scale change and anticipate and adapt*
- **Change Management in Mission Control**
  - Mission Control is a balance between being nimble enough to adapt to unexpected change yet knowledgeable enough to ascertain whether the change is within accepted limits; Next Worse Failure planning

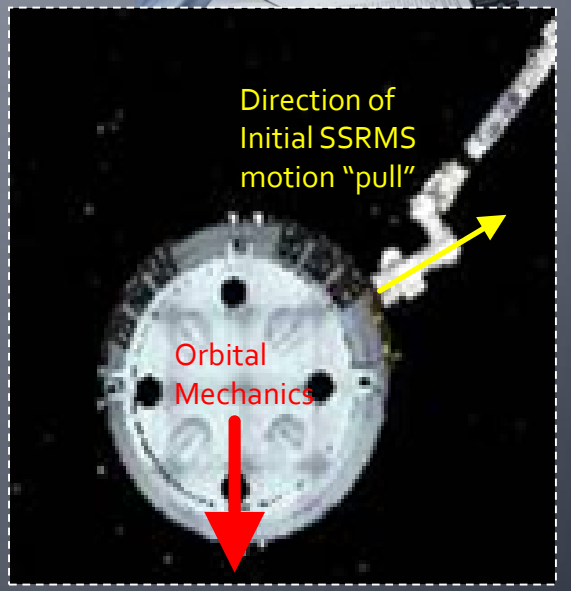
- **Culture and Engagement** – *The culture is shaped to achieve strategic goals. Employees pursue corporate objectives.*
- **Culture and Engagement in Mission Control**
  - Flight Controller Manifesto, Stone Tablets of Flight Control, Foundations of Flight Operations, Plan/Train/Fly, Next Worse Failure, Lessons Learned JOPs

Source: Bhalla, Vikram; Caye, Jean-Michel; Dyer, Andrew; Dymond, Lisa; Morieux, Yves; Orlander, Paul (2011). "High-Performance Organizations, The Secrets of Their Success," Used with permission

Example: HTV-3's Abort

- August 2012: HTV grapple fixture stuck on the ISS robot arm as the arm backed away
  - Caused HTV to drift towards ISS, resulting in an unexpected automated abort
- HTV-4 scheduled for August 2013, 9 months later:
  - Don't let HTV-3 happen again!
  - What happened, why, how do we prevent it?
  - Cannot change HTV vehicle design
- ISS Program, Engineering, Flight Operations, Canada, Japan needed to fully engage
  - Key to on-time success – operating as a High Performing Org
  - Assemble to agree on direction/priorities, release teams to do work, reassemble to assess/integrate results and agree on next step(s)





High Reliability Organizations

- Mission Control is a "High Reliability Organization"
- Characteristics of successful organizations in high-risk industries
  - **Preoccupation with Failure**
  - **Reluctance to Simplify Interpretations**
  - **Sensitivity to Operations**
  - **Commitment to Resilience**
  - **Deference to Expertise**

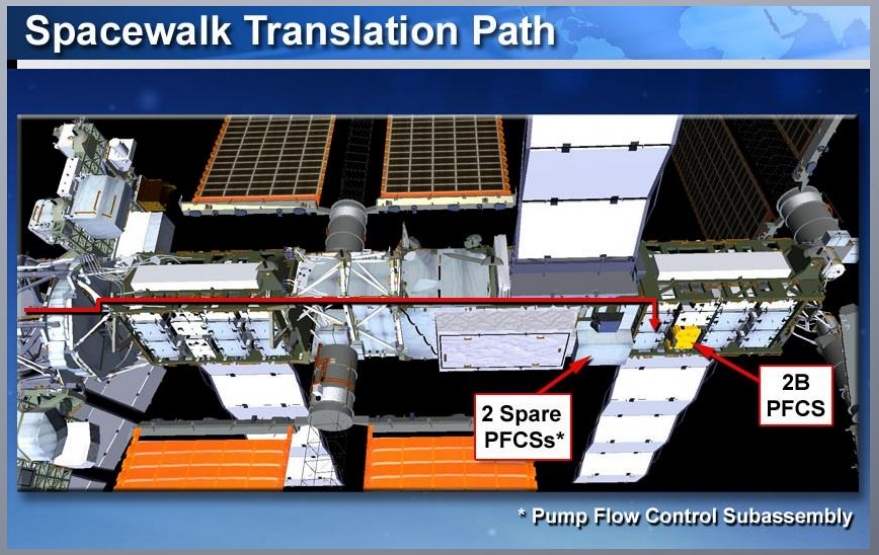
Anticipation (Prevention)

Containment (Reacting)

Source: Weick, Karl E.; Kathleen M. Sutcliffe (2001). Managing the Unexpected - Assuring High Performance in an Age of Complexity. San Francisco, CA, USA: Jossey-Bass. pp. 10–17. ISBN 0-7879-5627-9

Example – US EVA 21, May 2013

- Crew reported 'snow flakes' outside
- MCC-H saw a large increase in a previously slow NH_3 leak
- Program decided to execute a contingency spacewalk (EVA) in 2 days to replace a pump
- We had never done an EVA in so short a time!
  - EVAs typically take 12+ months to plan and train
  - "Critical Contingency EVAs" need at least 9 days
- Decision to do it so quickly based on
  - Catch the leak while it was still leaking
  - Before a crewmember returned to Earth in a Soyuz in 5 days



Should we have had an accident?

EVA is the most dangerous activity in human spaceflight outside of launch, entry, and landing

Two separate schools of safety said we were asking for an accident:

1. Hollnagel's Efficiency-Thoroughness Trade-Off (ETTO)
   - Never have enough time/ resources, so people must trade between efficiency and thoroughness
     - Not doing the documented process -> variation -> error
     - *We certainly were rushed*
2. Dekker's Drift into Failure
   - With very complex systems teams stove-pipe expertise/ processes and then hand-off products
     - Teams make locally rational decisions that don't make sense in the global context
     - *We certainly had a lot of teams over several shifts making locally rational decisions*

So why didn't we have an accident?

Because we were **mindful** that we had the right …

- Circumstances
  - Sensitivity to Operations
- Processes
  - Reluctance to Simplify Interpretations
- Culture
  - Preoccupation with Failure
  - Commitment to Resilience
  - Deference to Expertise

Circumstances

- EVAs 18, 19 and 20 set us up
  - Fall 2012; one was contingency
- Many controllers had worked together
- Several had experience in contingency planning
- Astronauts were very experienced at this worksite
- Only leak location we could repair was the pump
- FOD, Engineering, ISS Program were already familiar with the technical details

Processes
Matrix mgmt is bad, except when it's good

- ETTO says you need diversity of mental models
- Drift into Failure says someone needs "The Big Picture" and to integrate across 'silos'
- 'Matrix mgmt' is how we institutionalized these
- Teams had to work
  - Across disciplines (EVA, SPARTAN, Engineering, etc)
    - Different mental models : "that is not what we need"
  - Within disciplines
    - Same mental models : "that is not what I thought"
  - **Leadership** (HPO trait) at all levels enables Flight Directors and Program Managers to remain at the 'Big Picture' level to ask "Have you considered …"

Culture

- You are allowed to be wrong
  - Experts can make mistakes, co-ops can make big saves
- It is a team event
  - "All in" event (engagement) – even if one person's role was simply making sure there were ample snacks to help reduce stress
  - Leaders had to delegate tasks and trust the answers that came back
- Okay and expected to have someone look over your shoulder (design)
- It is okay to be the 'squeaky wheel'
  - Even if you know that it might mean causing a team to have to start over or perform major rework
- EVA is one of the most dangerous things we do
  - Solving/Fixing the problem is not nearly as important as the Priority 1 task – getting the crew back inside alive

If we need to do a 2-day EVA in the future

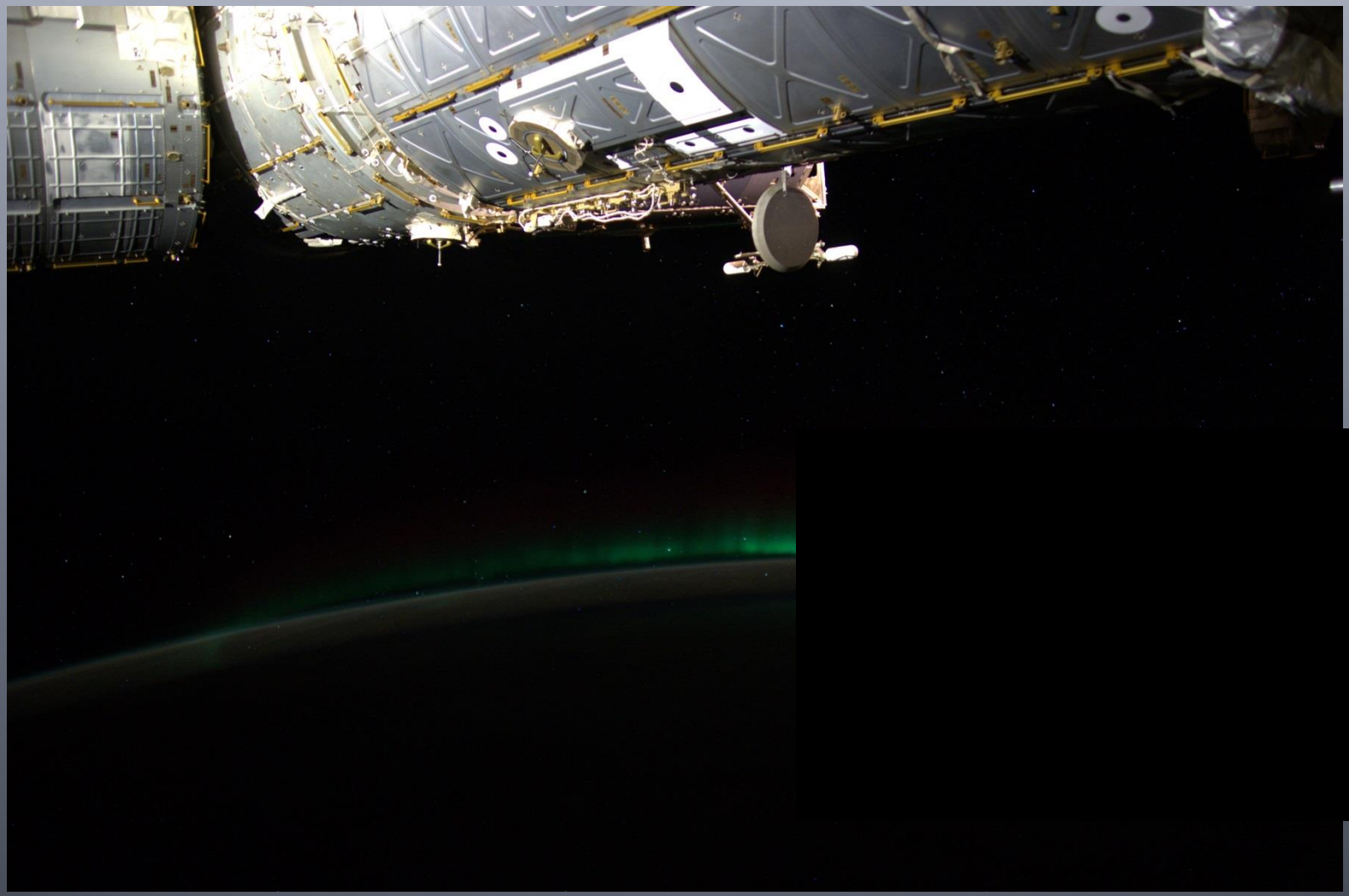
- Because we did it once does not mean we can do it again
  - How are these **circumstances** different than what we had in EVA 21?
  - Do we still have the same **processes**?
  - Is our **culture** different?
- How can we decide if we would (would not) be as safe as we were for EVA 21?
  - Start from the beginning of the process and do not rely on "it worked before"

High Performing AND High Reliability Organizations

- HROs and HPOs can exist independently
- When an organization implements both, results can be considerably compounded

- Leadership in High Reliability and High Performing Organizations often means
  - Stepping back and letting others lead while at the same time retaining overall leadership and integration authority
  - Never relying solely on "what worked before" to get you through a situation
  - Ensuring both the failures and the successes of today enable the team to do it even better next time by performing "after action" reviews with defined actions for improvement
  - Continuous Improvement is a way of life

Questions?



Backup Material

Foundations of Flight Operations

1. **To instill within ourselves these qualities essential to professional excellence**
   - ***Discipline***…Being able to follow as well as to lead, knowing that we must master ourselves before we can master our task.
   - ***Competence***…There being no substitute for total preparation and complete dedication, for flight will not tolerate the careless or indifferent.
   - ***Confidence***…Believing in ourselves as well as others, knowing that we must master fear and hesitation before we can succeed.
   - ***Responsibility***…Realizing that it cannot be shifted to others, for it belongs to each of us; we must answer for what we do or fail to do.
   - ***Toughness***…Taking a stand when we must; and to try again and again, even if it means following a more difficult path.
   - ***Teamwork***…Respecting and using the abilities of others, realizing that we work toward a common goal, for success depends upon the efforts of all.
   - ***Vigilance***...Being always attentive to the dangers of flight; never accepting success as a substitute for rigor in everything we do.

2. **To always be aware that, suddenly and unexpectedly, we may find ourselves in a role where our performance has ultimate consequences.**

3. **To recognize that the greatest error is not to have tried and failed, but that, in the trying, we do not give it our best effort.**

Stone Tablets of Flight Control

I. Come prepared for your shift. Understand how your discipline fits into the day's activities. Be familiar with unique Flight Data File for the activities.

II. Listen closely when the crew talks. If you determine that the information doesn't affect your discipline then you may resume your discussions, unless they were on the flight loop.

III. Condition yourself to react to A/G discussions without having to be prompted by the Flight Director.

IV. When the crew's comments affect your discipline immediately follow their call with a tailored acknowledgment on the flight loop. For example:

"WE COPY FLIGHT, STANDBY WHILE WE LOOK AT IT."
"COPY FLIGHT, IT'S A TRANSDUCER FAILURE, NO ACTION."
"WE COPY AND CONCUR FLIGHT."
"COPY FLIGHT, HAVE THEN WORK MAL...."

I. Listen closely to your instructions that get read to the crew. If it has been a while since you made the request for the uplink, report on the flight loop that you copied the uplink. This lets the flight director know the instructions were read as you intended and you are ready to observe the result. When the crew repeats uplinked instructions, particularly those with more than a couple of steps, acknowledges on the flight loop with "GOOD READ BACK FLIGHT".

II. Minimize you discussions on the flight loop when the crew is talking. Criticality of your need will dictate this. A good rule of thumb would be to wait so CAPCOM can listen, if waiting is possible.

III. An ideal exchange between the crew and the MCC is one in which the Flight Director talks the least. In this case the Flight Director can use quick vocal approvals on the flight loop to enhance the efficiency of the communication.

IV. Minimize discussion over the airways. Use loops unless impractical to do so.

V. Be ahead of the crew in finding changes to procedures based on flight plan changes or previous failures. Look ahead.

VI. Switch/circuit breaker actions should be called out with panel, row, and device nomenclature.

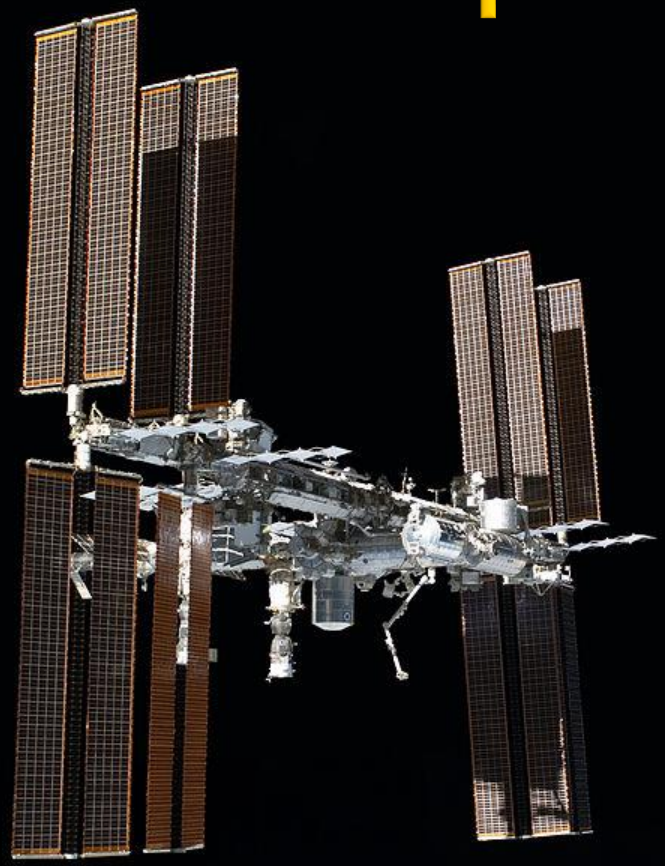
VII. If you have time to write a flight note, write a flight note.

VIII. Flight note and/or vocal actions should include what you want done, by when, and why. When vocalizing this the preferred order is to report what has happened followed by the action required within some time frame. For example:

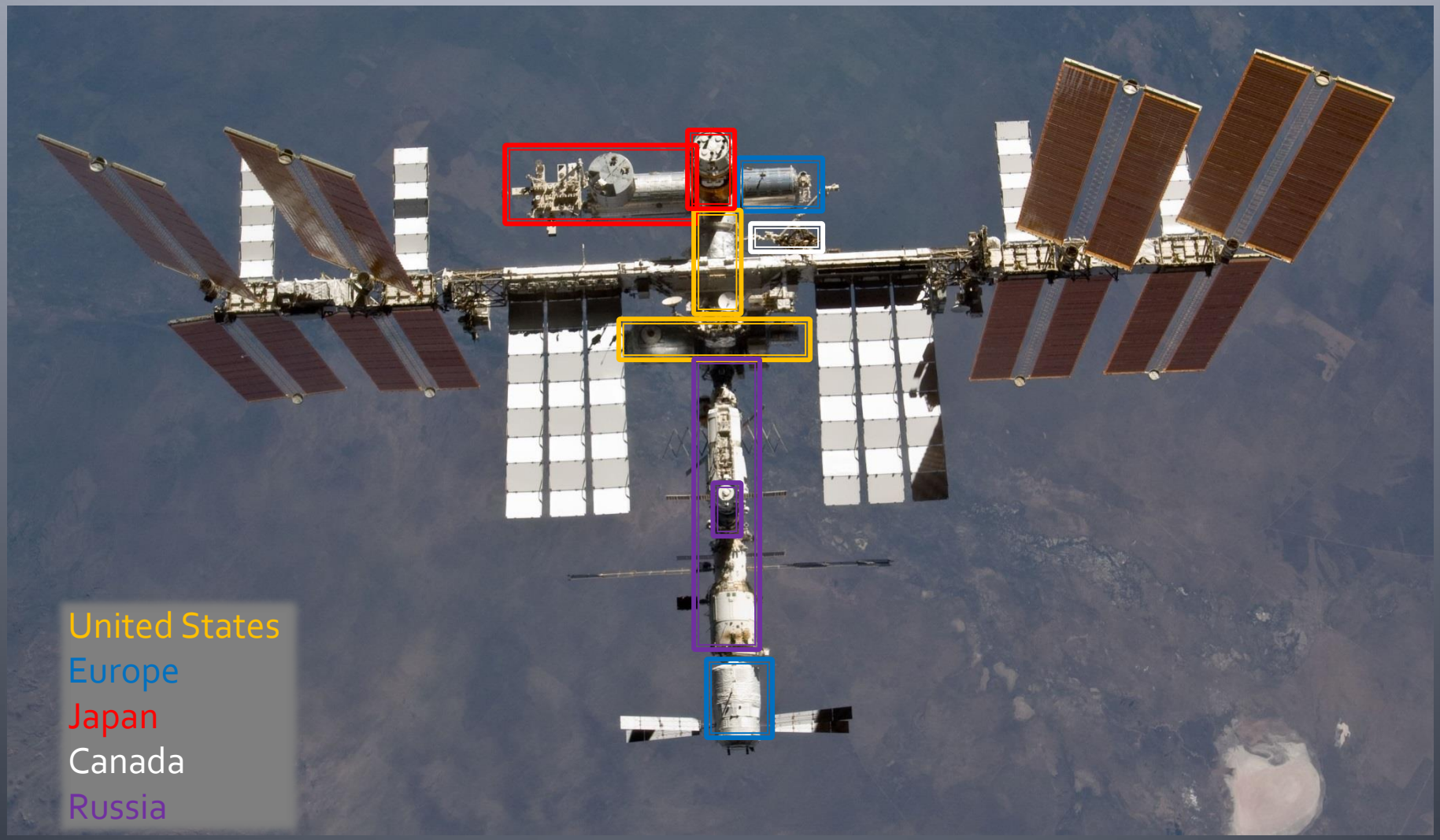
"FLIGHT, THE "A" HEATER ON XYZ JUST FAILED SO I WOULD LIKE THE CREW TO SWITCH TO THE "B" SIDE WITHIN 10 MINUTES. THE SWITCH IS ON PANEL....."

Last Updated: 7/4/96

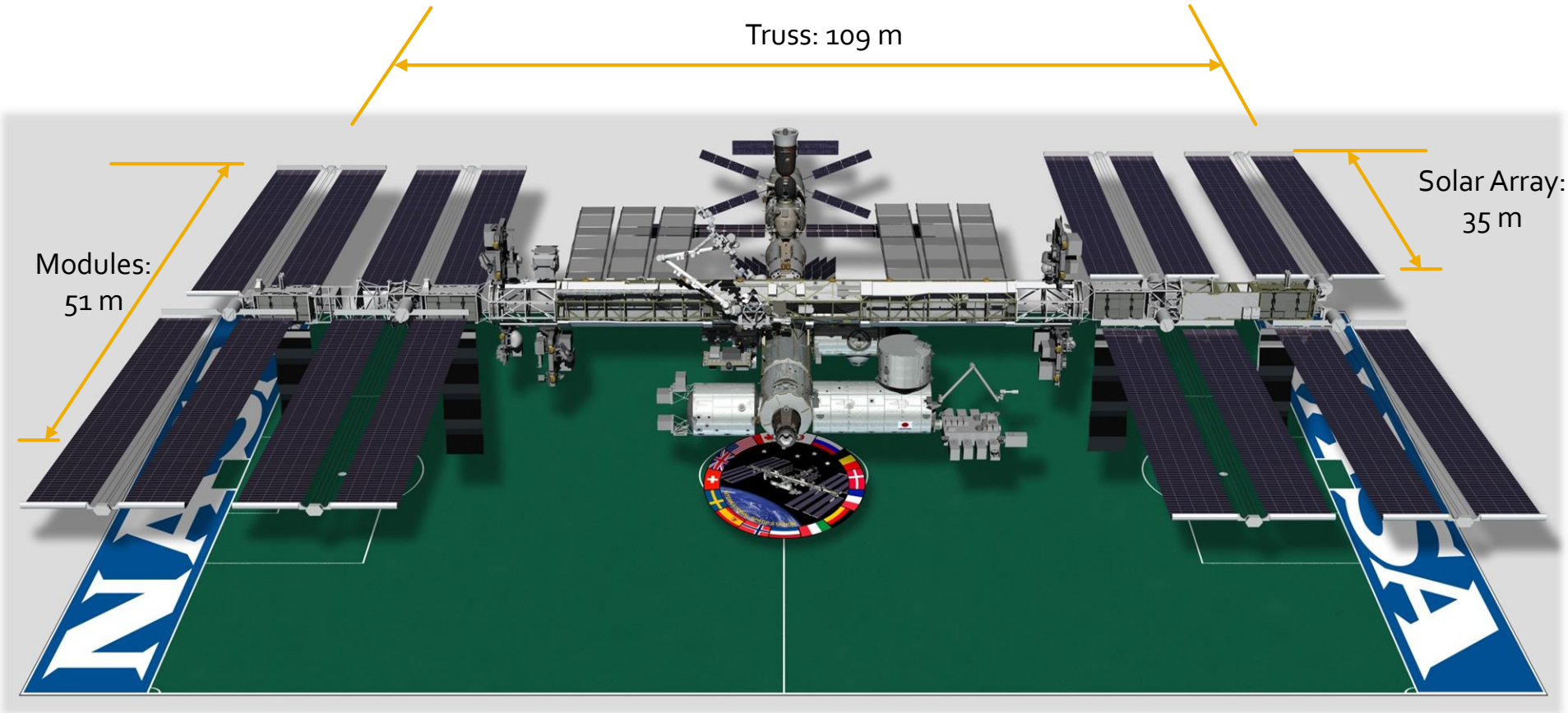
International Space Station



- Microgravity research laboratory assembled in orbit between 1998-2011, manned continuously since Nov 2000
  - 15+ Years!
- Components built by hundreds of companies across 16 nations. 100+ launches from Florida, Virginia, Russia, Japan, and French Guiana
- Research crew of 6 astronauts and cosmonauts serve 6 month stays, rotating 3 at a time from Earth by a Russian Soyuz spacecraft

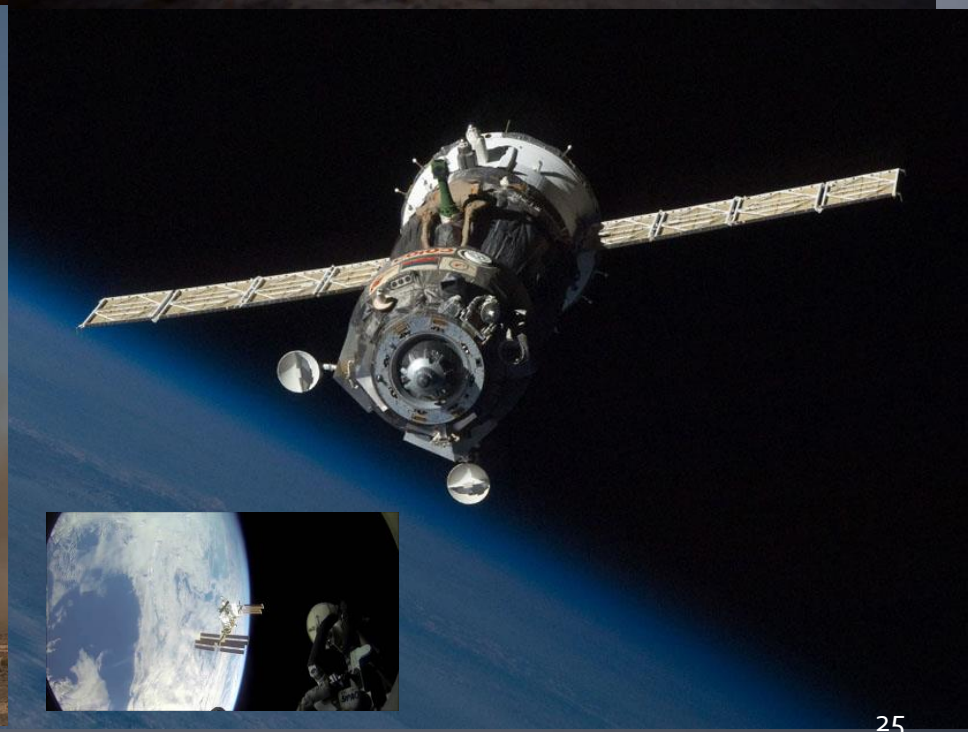

United States
Europe
Japan
Canada
Russia

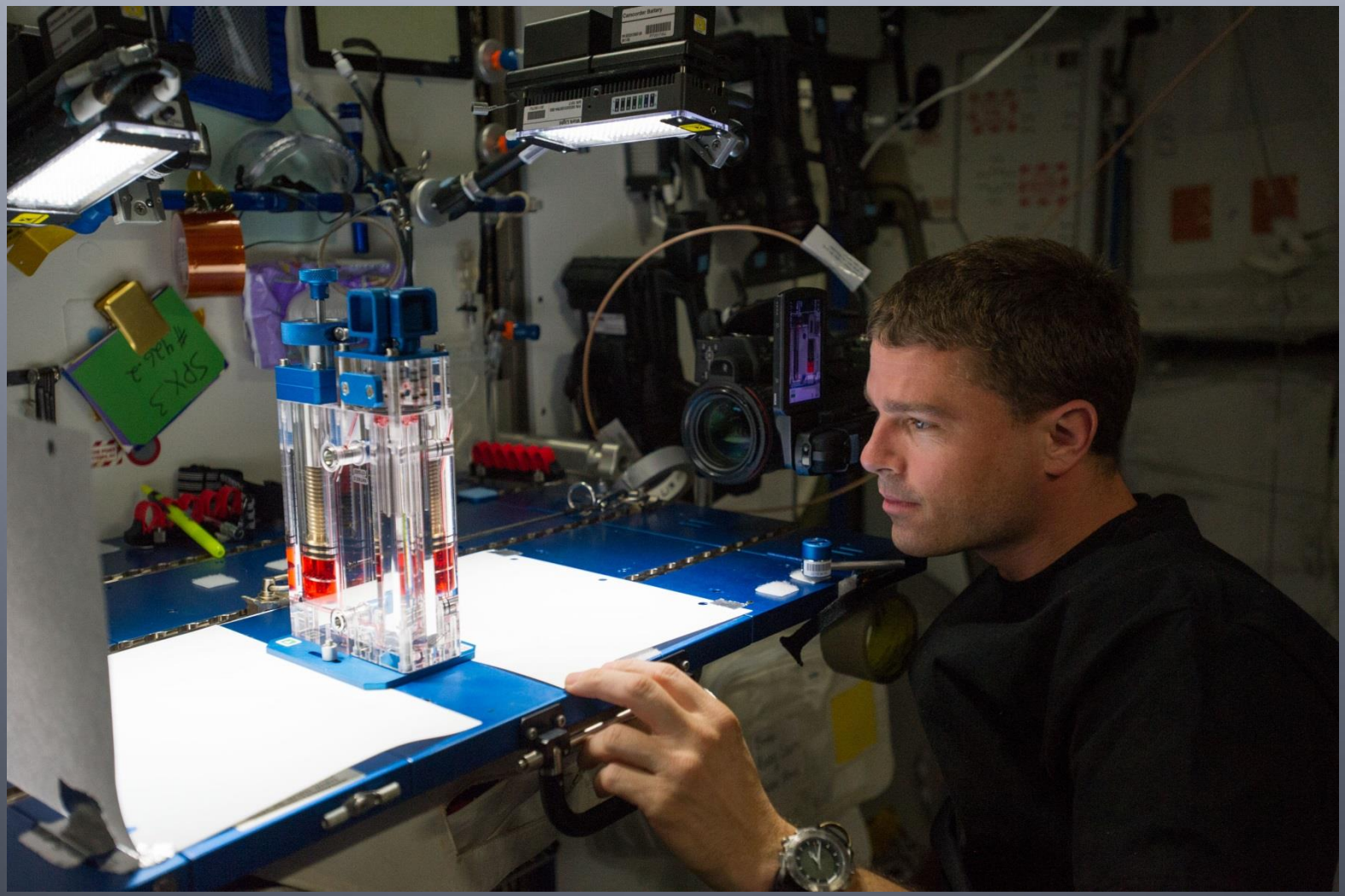
Earth's Only Microgravity Research Laboratory

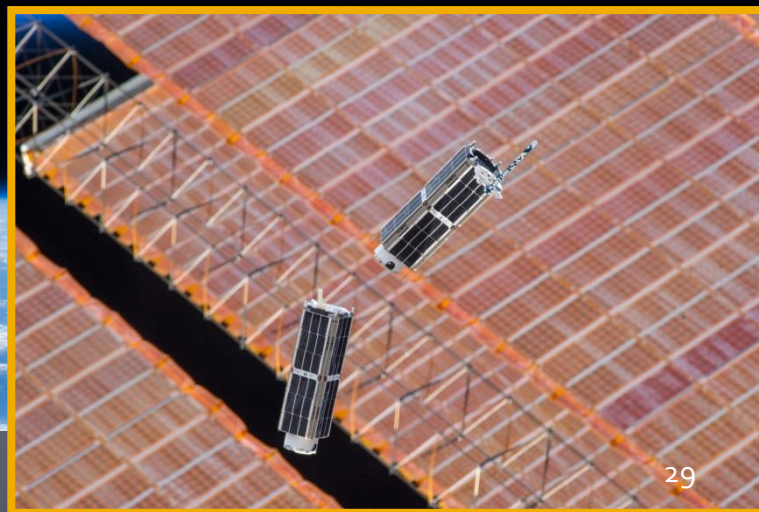


Mass: 420,000 kg
Habitable Volume: 388 m^3
Solar Power Generation Capability: 84 kW

Altitude: 415 km
Orbital Speed: 28,000 kph (7.8 km/sec)
Orbital Period: 90 minutes (16 sunrises/sunsets per day)





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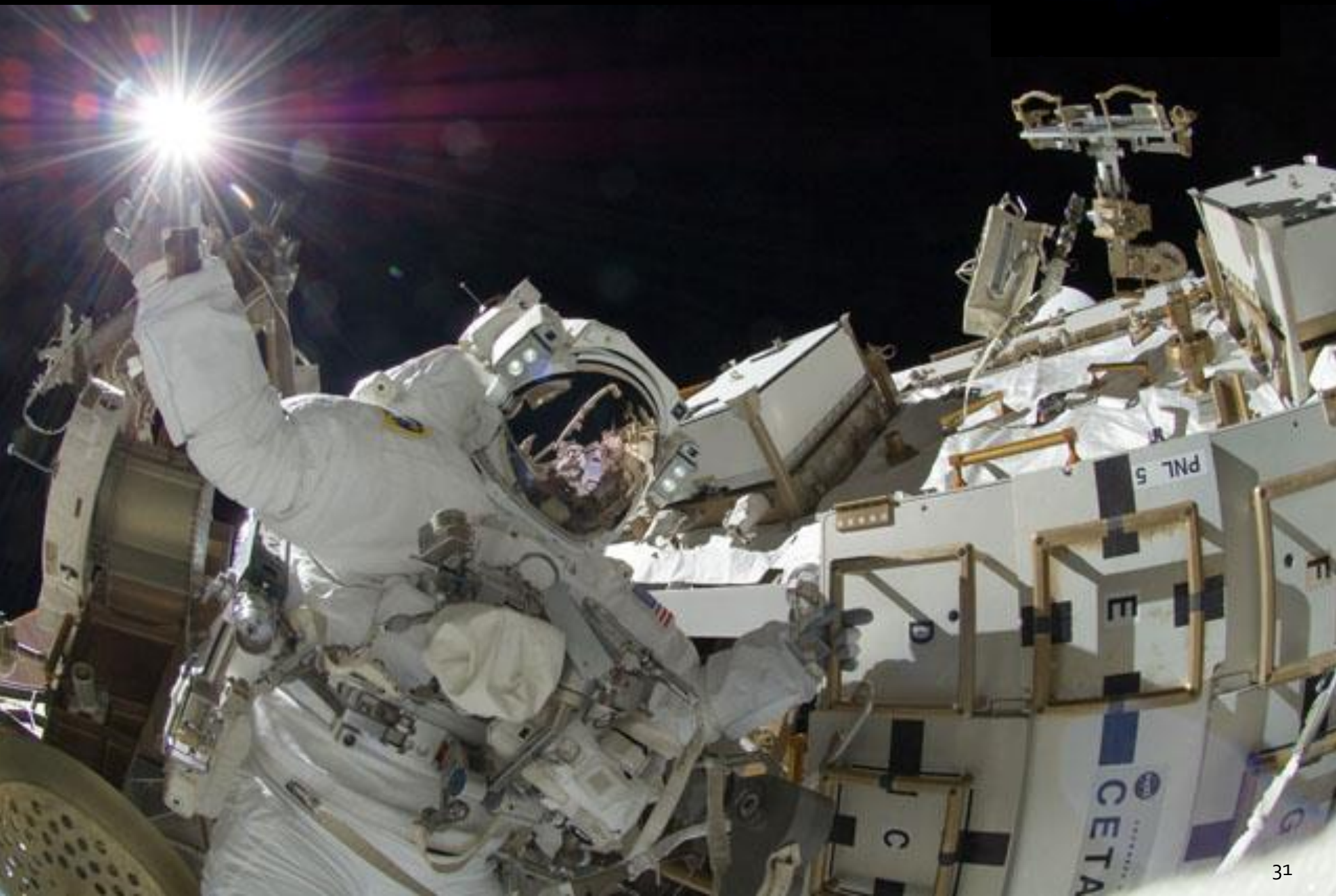
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E
CETA


To LAB


S. KELLY
С. КЕЛЛИ