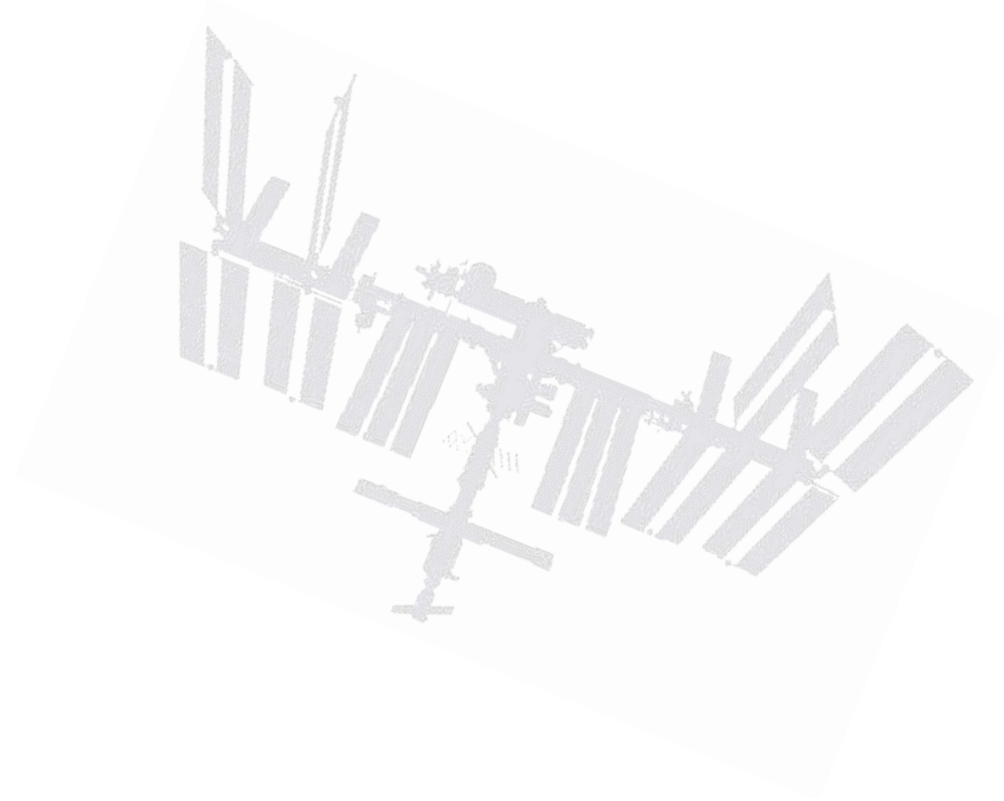




Flight Operations

Zero Knowledge to Mission Complete



Greg Forest

- **Certified SPARTAN Flight Controller and Instructor**
- **Started at Johnson Space Center in SPARTAN in June, 2008**
 - Attained Operator Certification in October, 2010
 - Attained Instructor Certification in August, 2012
 - Attained Specialist Certification in October, 2016
- **Graduated from Louisiana State University, 2008**
 - Bachelor of Science in Electrical Engineering
- **SPARTAN assignments**
 - Expedition 44 Lead SPARTAN Instructor (December 2012 to May 2016)
 - Trained the One Year ISS crew
 - ATV 5, OA6, and OA5 Lead SPARTAN Instructor
 - Russian Electrical Power System Systems Matter Expert
 - ISS US Segment Reconfiguration SPARTAN Lead
 - Training Class 13 Mentor



Alex Apyan

- **Certified SPARTAN Flight Controller**
- **Started at Johnson Space Center in SPARTAN in January, 2013**
 - Attained Operator Certification in July, 2014
 - Attained Specialist Certification in August, 2015
- **Graduated from The University of Cincinnati June, 2012**
 - Bachelor of Science in Aerospace Engineering
- **SPARTAN Assignments**
 - External Thermal Control System Systems Matter Expert
 - Formal Eval Administrator
 - Certified to teach ETCS Operator Classes
 - Operations POC for ETCS related matters.
 - Spartan Planning Assistance Team Lead
 - TTCR EVA Lead (Completed September, 2016)
 - Training Class 13 Mentor
 - Increment 47 Spartan Lead (March 2016 – June 2016)



Objective

- Outline the process that takes new hires with zero knowledge all the way to the point of completing missions in Flight Operations. Audience members should be able to outline the attributes of a flight controller and instructor, outline the training flow for flight controllers and instructors, and identify how the flight controller and instructor attributes are necessary to ensure operational excellence in mission prep and execution.
- Identify how the simulation environment is used to develop crisis management, communication, teamwork, and leadership skills for SGT employees beyond what can be provided by classroom training.



Outline

- **Flight Operations**
- **Identifying a future Flight Controller and Instructor**
- **Flight Controller Training**
 - Boot Camp
 - Technical Knowledge Capture
 - Sim Flow
- **Instructor Training**
- **Mission Prep**
- **Mission Execution**



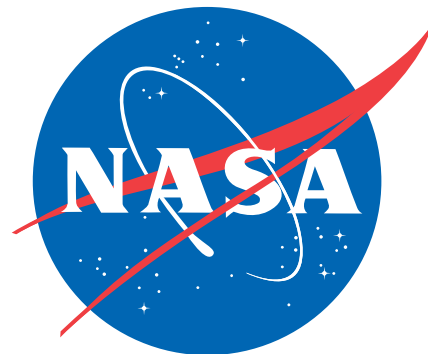
ISS Operations are based in Houston, Texas

Our facilities are located at the NASA Johnson Space Center in Houston.

There we are within the Flight Operations Directorate (FOD).



Mission Control Center (MCC)



We Plan, Train and Fly Human Space Flight Missions

FOD - A Proud History of Space Flight Excellence

■ Our Vision:

- The Flight Operations Directorate is the premier Flight Operations Team on and off the planet.

■ Our Mission:

- To select and protect our astronauts and to plan, train and fly human space flight and aviation missions.

■ From Our Foundations:

- To instill within ourselves these qualities essential to professional excellence: *Discipline, Competence, Confidence, Responsibility, Toughness, Teamwork, and Vigilance.*



Mercury-Gemini
1961-1966



Apollo-Skylab-ASTP
1967-1975



Space Shuttle
1981-2011



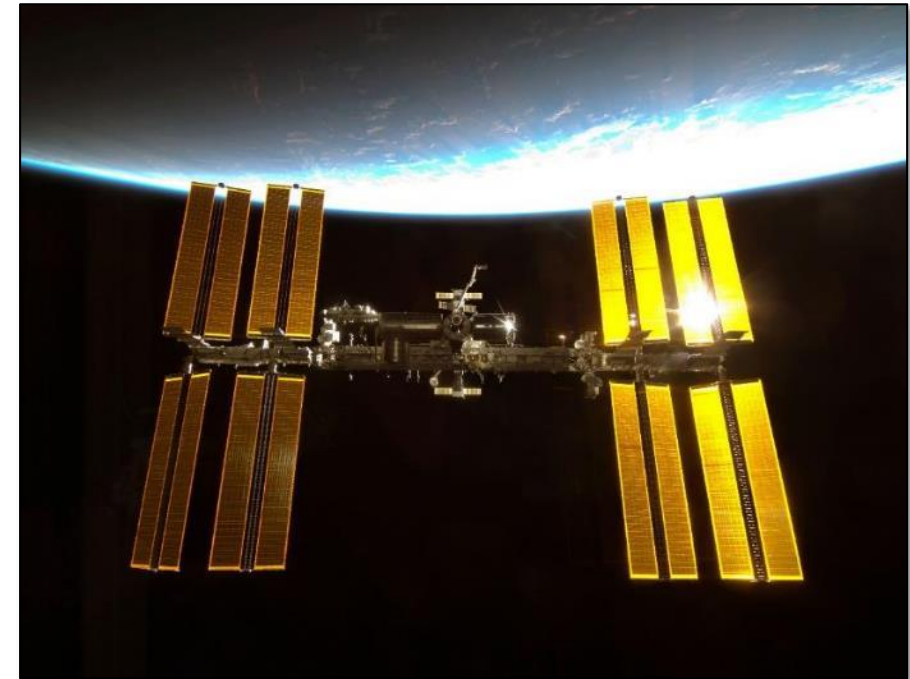
International Space Station
1998-Present



NASA Programs Supported by IMOC

International Space Station (ISS)

- First Element Launch (Zarya) in November 1998
- Continuous human presence since November 2000
- Over 192 space walks to date in support of assembly and maintenance
- Typical altitude is 225 miles
- Orbital speed = 17,500 mph (1 orbit every 90 minutes)
- Internal pressurized volume of 32k cubic feet, equal to a Boeing 747
- Truss and solar arrays measures the length of a football field
- Solar array area = 1 acre, power generation = 75-90 kilowatts
- 52 onboard computers control the ISS



IMOC employees are entrusted by NASA to fly safe and successful Human Space Flight missions

NASA Programs Supported by IMOC

Exploration initiatives and new Space Flight programs

- Orion Program
- Space Launch System Program
- Commercial Crew/Cargo Programs

IMOC employees provide expertise in the development and testing of systems for future operations



We Plan, Train and Fly Human Space Flight Missions

IMOC Employees are responsible for

- **Planning:**
 - Encompasses all mission preparation activities required for safe and successful mission operations - understanding strategic objectives, integrating requirements among domestic and international partners, developing operating procedures and mission plans.



We Plan, Train and Fly Human Space Flight Missions

IMOC Employees are responsible for

- **Training:**
 - Prepare astronauts and flight controllers to achieve mission objectives safely and effectively. This includes curriculum design, training product development and training execution through various media including high fidelity simulations.



We Plan, Train and Fly Human Space Flight Missions

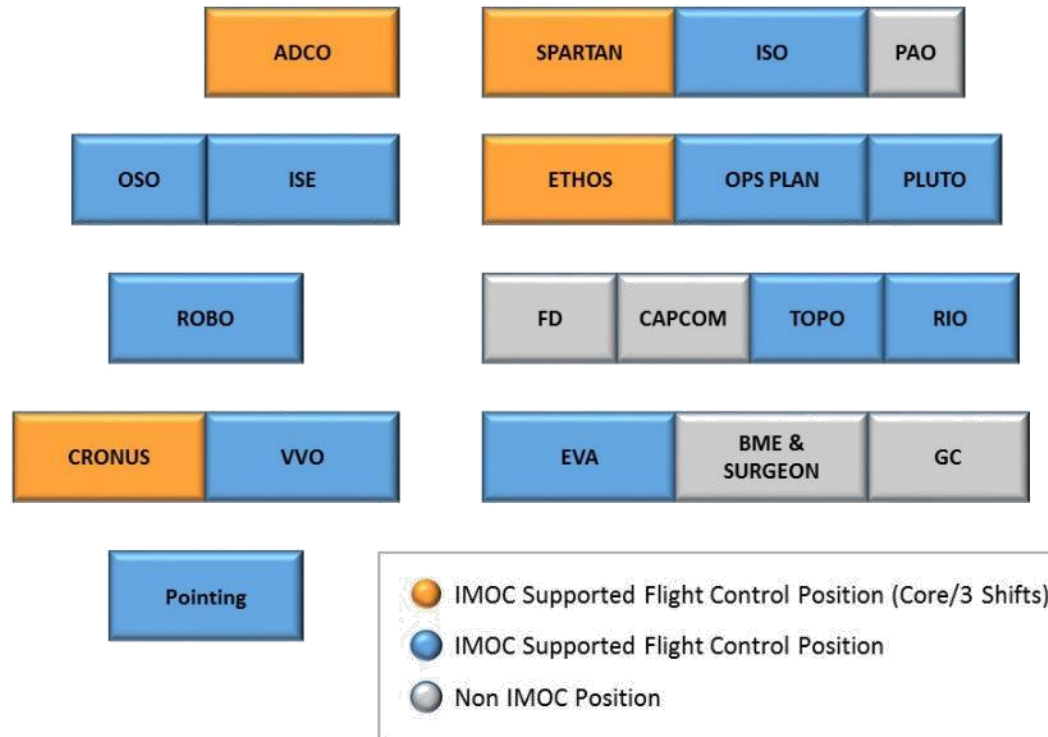
IMOC Employees are responsible for

- **Flying:**
 - Mission execution is the culmination of all integrated support functions - flight planning and design, analysis and procedure development, and crew and flight controller training. The crew and the flight control team work in tandem to safely and successfully execute all mission objectives.



Flight Operations/IMOC Positions in the ISS Mission Control Center (MCC)

MISSION CONTROL FRONT SCREEN DISPLAYS



Flight Operations/IMOC Positions – Core Systems

- Attitude Determination and Control Officer (ADCO)
- Communication Radio Frequency Onboard Network Utilization Specialist (CRONUS)
- Environmental and Thermal Operating Systems (ETHOS)
- Station Power, Articulation and Thermal Control (SPARTAN)
- Extra-Vehicular Activity (EVA) Officer
- Robotics Officer (ROBO)
- Operations Support Officer (OSO)
- Trajectory Operations Officer (TOPO)
- Visiting Vehicle Officer (VVO)
- Pointing
- Operations Planner (Ops Plan)
- Vehicle Integration and Daily Operations Positions:
 - Plug-in Plan Logistics and Utilization Officer (PLUTO)
 - Inventory Stowage Officer (ISO)
 - Integration and Systems Engineer (ISE)
 - Daily Operations and Crew Support (DOCS)*



* Support is provided off console





Finding and Creating Flight Controllers and Instructors

Attributes of a prospective Flight Controller/Instructor

- Intellectual Capacity
- Multi-tasking ability
- Self Sufficiency
- Confidence
- Self-Awareness
- Pro-activeness
- Social Aptitude
 - Communication skills
 - Team Focus
 - Situational Awareness
 - Leadership

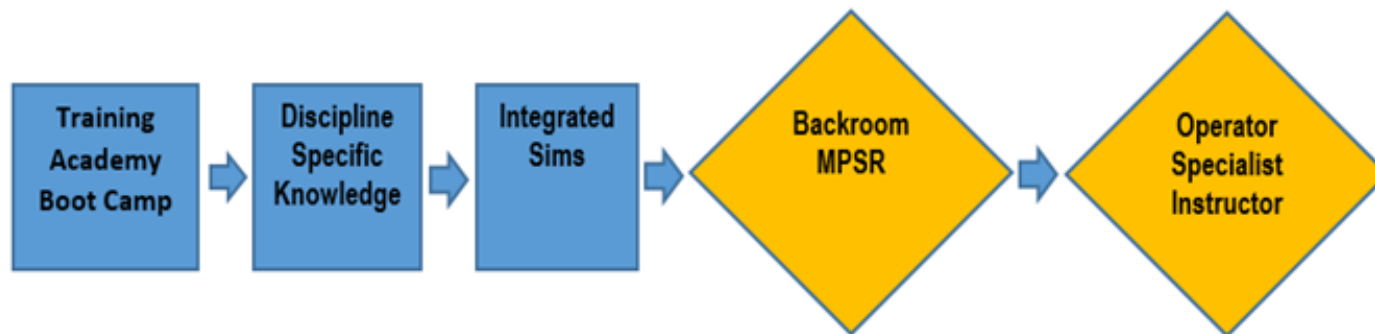
Foundations of FOD

- *Competence*
- *Confidence*
- *Discipline*
- *Responsibility*
- *Toughness*
- *Teamwork*
- *Vigilance*

IMOC Flight Controller, Instructor, and Analyst Training

IMOC employees go through an extensive training and certification program ensuring they have both a complete understanding of the material and the ability to apply it prior to their first position assignment.

Each Flight Operations division has their own specific certification flows and progression through positions of increasing responsibility. Below is an example of the certification flow options for core ISS positions. It typically takes 18 months to achieve the first (MPSR or Operator) certification in this example.



Instructor Flight Controller (IFC) model in which employees progress through multiple possible certification paths, with each position requiring increasing technical knowledge and experience and bestowing increased opportunities and responsibility.

IMOC employees have long term career opportunities through the progression of certifications and through supporting multiple programs including ISS, Commercial Crew/Cargo, and Exploration

Boot Camp

- First step in the training of new Flight Controllers and Instructions.
- New hires are introduced to the Flight Operations Directorate (FOD) culture and gain a basic understanding of ISS Operations.
 - Overview of all ISS systems
 - Familiarization with the work environment including the Mission Control Center (MCC) and Space Station Training Facility (SSTF)
 - First certification is obtained: ISS Command Certification
- Following completion of boot camp, you are now an FOD STEM Cell, ready to be plugged into place. Congratulations!



Technical Knowledge Capture

- **Flight controllers and instructors receive technical training in their system prior to applying this knowledge in an integrated environment.**
- **Multiple methods of delivering technical knowledge**
 - Segmented learning
 - A detailed understanding of a subsystem is gained prior to learning about another subsystem.
 - For example, an ETHOS learns all about the Waste Processing Assembly (WPA) prior to learning about the Oxygen Generation Assembly (OGA)
 - Spiral learning
 - A high level understanding of every subsystem is gained prior to gained a detailed understanding of all subsystems.
 - For example, a SPARTAN gains a fundamental understanding of hardware function in the Electrical Power System (EPS) and External Thermal Control System (ETCS) prior to gaining a more detailed understanding of the software and fault response.

Simulations

▪ Mini Sims

- First opportunity for Flight Controller in training to work in a team environment
- Includes the four core systems controller positions: ADCO, CRONUS, ETHOS, SPARTAN
- Focus in this training environment is on practicing the soft skills.
 - Communication, teamwork, situational awareness.
- Expectation that students have completed most of the technical training prior to beginning Mini Sims.

▪ Integrated Sims

- Training in a full flight control team environment.
- Simulated cases include complex operations
 - Extra Vehicular Activity (EVA)
 - Visiting Vehicle rendezvous and capture
 - ISS Reboost/Debris Avoidance Maneuver
- Trainees will obtain a certification in a backroom (MPSR) flight control position prior to becoming a front room (FCR) flight controller or instructor.



Instructor Training

- New instructors begin with a technical knowledge base gained through their initial training flow.
- Simulator operations are trained. Knowledge is gained on multiple simulation facilities (SSTF, FCPTT, PTT).
- Instructors certify to teach to multiple audiences (Flight Controllers, Astronauts) in multiple settings.

Flight Controller, Crew and Mission Support Personnel Training

Trainers are certified and training products are validated to ensure each member of the team is adequately prepared to provide safe and successful mission performance.

- The Space Station Training Facility (SSTF) is used to train and certify flight controllers and instructors utilizing high-fidelity ISS simulations.
- The Dynamic Skills Trainer (DST) is used to train and certify astronauts, flight controllers, and instructors in skills required to safely and efficiently operate the Station Robotic arm.



Flight Controller, Crew and Mission Support Personnel Training

IMOC personnel utilize various facilities and media, including high-fidelity simulations, to train flight controllers, astronauts, flight directors and other mission support personnel.

- The Space Vehicle Mockup Facility (SVMF) is used to provide hands-on training for crew, flight controllers and instructors on space vehicle operations.
- The Neutral Buoyancy Laboratory (NBL) is used to prepare for missions involving spacewalks (EVAs).





Mission Prep and Execution



Mission Prep and Execution

- **Preparation**

- Nominal, Contingency, Emergency Ops Planning.

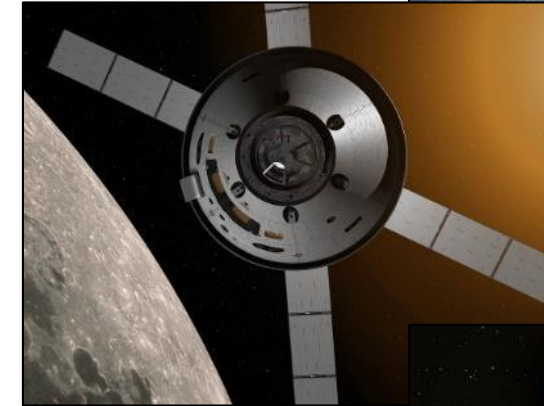
- **Execution**

- Nominal, Contingency, Emergency Ops Execution.



Our Future is Bright!

IMOC will continue to support the ISS through at least 2024 and possibly longer. We are also currently working on future Exploration programs which will take us beyond low Earth orbit and eventually to Mars!



Questions?



**STINGER
GHAFFARIAN
TECHNOLOGIES**



Backup Slides



Flight Operations/IMOC Positions – Core Systems

Attitude Determination and Control Officer (ADCO)

- Works together with Russian flight control counterparts to calculate and manage the attitude (or orientation) of the ISS. ADCO also plans upcoming orientations and attitude maneuvers, and visiting vehicle dockings to the ISS. This person monitors the ISS position, velocity (speed and direction) and attitude to make sure that they do not change unless commanded to do so by the computers aboard the ISS.

Communication Radio Frequency Onboard Network Utilization Specialist (CRONUS)

- Manages the transfer of data between communication satellites which orbit the Earth, the ISS, and the Mission Control Center (MCC). CRONUS also provides support by administering computer software updates to the ISS and ensuring the ISS computer network systems and crew laptops are functioning properly. Finally, CRONUS is responsible for running and maintaining the Caution and Warning system on the ISS.



Flight Operations/IMOC Positions – Core Systems

Environmental and Thermal Operating Systems (ETHOS)

- Manages the systems which help provide a clean, safe and comfortable living area for the crew, including the monitoring of air and water onboard the ISS. Every day, ETHOS makes sure that the life support systems are working properly. This person also helps plan activities for the crew when working with environmental and thermal systems, and keeps track of the oxygen, nitrogen, and water resources that are depleted.

Station Power, Articulation and Thermal Control (SPARTAN)

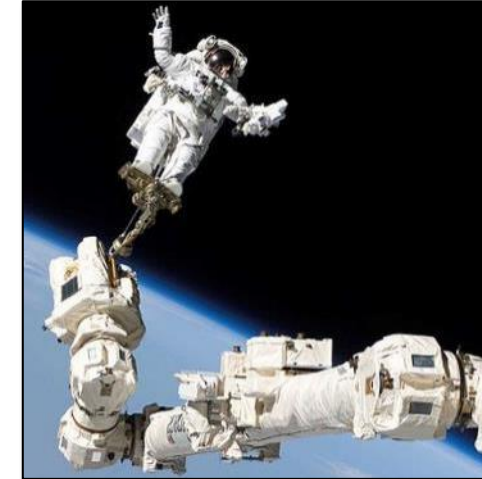
- Manages U.S. segment electrical power and thermal control systems hardware and software on the ISS. This flight controller oversees these main functions: conversion of solar energy to electrical power; control, storage, and distribution of electrical energy throughout the ISS; and management of all external thermal control systems which radiate waste heat generated by ISS systems to space.



Flight Operations/IMOC Positions

Extra-Vehicular Activity (EVA) Officer

- Provides the lead role in real-time operational support for all U.S. spacewalks (EVAs) associated with the ISS and future programs. Serves as the technical authority for new and experienced astronauts learning to operate space suits. Generates procedures for repairs and reconfigurations on the exterior of the ISS.



Robotics Officer (ROBO)

- Responsible for the ISS Robotic Arm flight control and analysis. Develops procedures to complete robotic operations and builds computer simulations to design procedures. Supports real time on board training and operations for the ISS astronauts and performs many of the operations via ground commanding from the MCC.



Operations Support Officer (OSO)

- Provides real-time support and procedures development in the areas of external mechanisms operations, internal vehicle assembly and modifications, core systems maintenance, crew systems operations (habitation, sleeping quarters, food prep), and photography and video operations.



Flight Operations/IMOC Positions

Trajectory Operations Officer (TOPO)

- Plans ISS trajectory and coordinate with ISS partners as needed. Assesses accuracy of ISS state vector (onboard and ground) and updates as required. Maintains ISS onboard tracking and data relay satellite state vectors. Evaluates trajectory of ISS and associated visiting vehicles for conjunctions and potential debris avoidance maneuvers.



Visiting Vehicle Officer (VVO)

- Provides rendezvous expertise and integration with MCC Houston to assure safe operations as vehicles are approaching or departing from the ISS. Visiting vehicles include SpaceX, Orbital, Japanese HTV, and Russian Soyuz and Progress, as well as the future Boeing CST-100 and other new commercial crew vehicles. Interfaces extensively with the control centers of visiting vehicles.



Pointing

- Performs line-of-sight analysis used in determining science viewing opportunities and communications coverage for the ISS and visiting vehicles. Ensures effective communications coverage as well as other functions dependent on vehicle, antenna, or sensor pointing.

Flight Operations/IMOC Positions

Operations Planner (Ops Plan)

- Integrates and manages onboard activities. Activity windows range from long term planning (months) to the timeline for an individual crew member's day. Works closely with the flight director, flight control team, and crew to properly sequence activities and objectives.

Vehicle Integration and Daily Operations Positions:

- Plug-in Plan Logistics and Utilization Officer (PLUTO) - Manages the ISS Operations LAN components: Station Support Computer (SSC) clients, printers, and file servers. Coordinates portable equipment power utilization.
- Inventory Stowage Officer (ISO) - Manages stowage of equipment and cargo. Critical for visiting vehicle operations.
- Integration and Systems Engineer (ISE) - Responsible for monitoring key systems and operations of the visiting vehicles approaching and mating to US Segment of the ISS.
- Daily Operations and Crew Support (DOCS)* - Provides support to crew members through the development of training materials and personal support software/media. Trains astronauts on usage of daily systems.

* Support is provided off console



What are we selling?

- **Technology allows us to grow team, leadership, and communication skills via simulation training.**
 - FCPTT, Gen Sims, Paper Sims.

