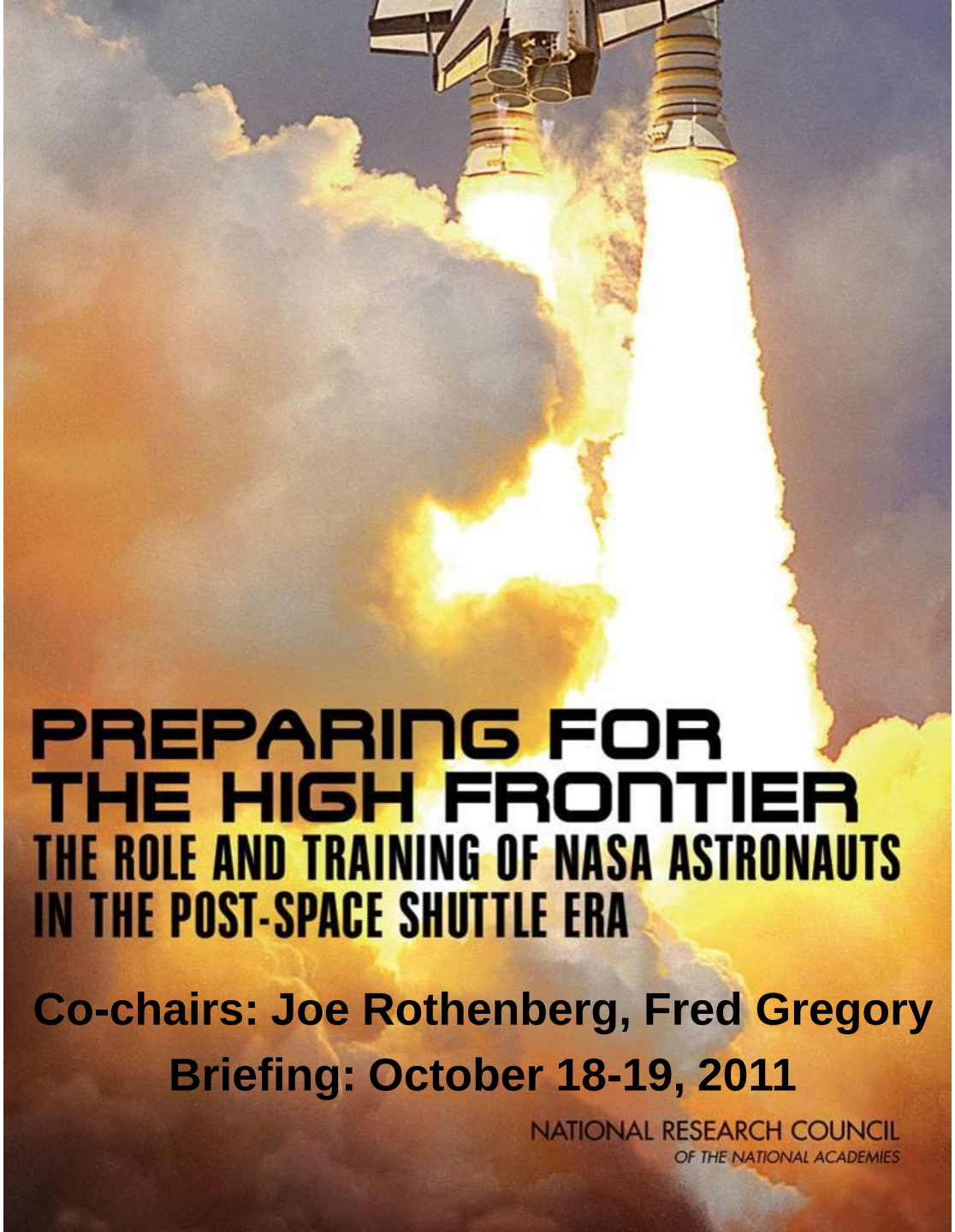

PREPARING FOR
THE HIGH FRONTIER
THE ROLE AND TRAINING OF NASA ASTRONAUTS
IN THE POST-SPACE SHUTTLE ERA
Co-chairs: Joe Rothenberg, Fred Gregory
Briefing: October 18-19, 2011
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

# Statement of Task

An ad hoc committee will conduct a study and prepare a report on the activities of NASA's human spaceflight crew office. In writing its report the committee will address the following questions:

- **How should the role and size of the activities managed by the Johnson Space Center Flight Crew Operations Directorate change after space shuttle retirement and completion of the assembly of the International Space Station (ISS)?**
- **What are the requirements of crew-related ground-based facilities after the space shuttle program ends?**
- **Is the fleet of aircraft used for the training the Astronaut Corps a cost-effective means of preparing astronauts to meet the requirements of NASA's human spaceflight program? Are there more cost-effective means of meeting these training requirements?**

The NRC was not asked to consider whether or not the United States should continue human spaceflight, or whether there were better alternatives to achieving the nation's goals without launching humans into space. Rather, the NRC's charge was to assume that U.S. human spaceflight would continue.

# Committee on Human Spaceflight Crew Operations

- FREDERICK GREGORY, Lohfeld Consulting Group, Inc., *Co-Chair*
- JOSEPH H. ROTHENBERG, Swedish Space Corporation, *Co-Chair*
- MICHAEL J. CASSUTT, University of Southern California
- RICHARD O. COVEY, United Space Alliance, LLC (retired)
- DUANE DEAL, Stinger Ghaffarian Technologies, Inc.
- BONNIE J. DUNBAR, President and CEO, Dunbar International, LLC
- WILLIAM W. HOOVER, Independent Consultant
- THOMAS D. JONES, Florida Institute of Human and Machine Cognition
- FRANKLIN D. MARTIN, Martin Consulting, Inc.
- HENRY McDONALD, University of Tennessee at Chattanooga
- AMY R. PRITCHETT, Georgia Institute of Technology
- JAMES D. VON SUSKIL, NRG, Texas
- RICHARD N. RICHARDS, Boeing Corporation (retired)

DWAYNE A. DAY, Study Director

# Findings and Recommendations

# Role and Size of the Flight Crew Operations Activities

**Finding** - NASA's current Astronaut Office's role is to support six tasks (in priority order):

1. Provide well-trained spaceflight operators to support the NASA flight manifest.
2. Provide ground support personnel for tasks required specifically to support the NASA flight manifest.
3. Provide support for new program development, ranging from development of relatively small payloads and equipment to development of whole new spaceflight designs.
4. Provide operational knowledge and corporate memory of human spaceflight.
5. Provide for collaboration with other governmental and private organizations as needed and directed by NASA.
6. Provide support for public and educational outreach to society.

The first task is the one used in FCOD's model that drives the size of the Astronaut Corps -- the number of astronauts qualified to fly in space. But the demands of tasks 2 through 6 add to the workload. The committee supports these roles as a proper use of an important core capability both now and into the future.

Management (inactive) astronauts serving in civil service positions in the Astronaut Office provide supplemental support for tasks 2 through 6. They do not use training assets except as instructors, evaluators, mentors, or providers of expertise; are ineligible for flight; and do not provide a reserve capacity for flight assignments.

# Role and Size of the Flight Crew Operations Activities (cont.)

**Finding** - Although NASA's human spaceflight program and its post-shuttle crew requirements have not been well defined beyond operation of ISS, the sizing of the Astronaut Corps to meet ISS crew requirements has been well modeled by using ISS crew selection, training and flight recovery times, and a plan for post-Shuttle force reduction.

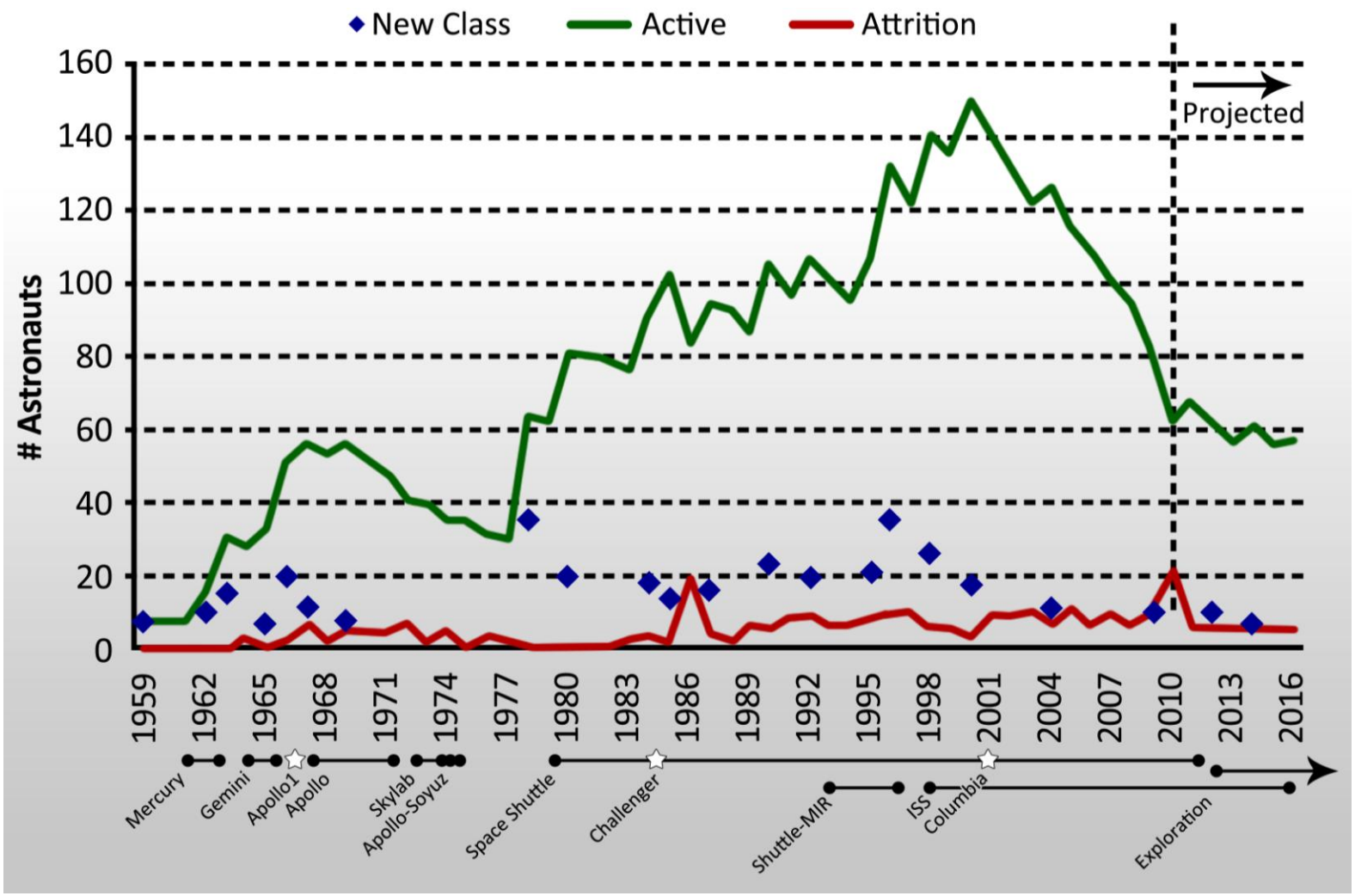
**Finding** - Astronaut anthropometric (physical size) limitations for flying in the Soyuz limit flexibility in crew assignments in response to contingencies.

The Soyuz TMA-12 prepares to dock at the International Space Station on April 10, 2008. SOURCE: Courtesy of NASA.

# Role and Size of the Flight Crew Operations Activities (cont.)

**Conclusion** – On the basis of its assessment of known and potential needs, the committee concludes that the currently projected minimum staffing target size for the active Astronaut Corps poses a risk to the U.S. investment in human space flight capabilities. The committee concludes that given the array of potential crew assignment constraints and uncertainty in future requirements, the Astronaut Corps appears to be sized below the minimum required. The committee notes that the current plan for the size of the Astronaut Corps does not have the flexibility to accommodate commercial, exploration, and new mission development tasks, or unexpected increases in attrition.

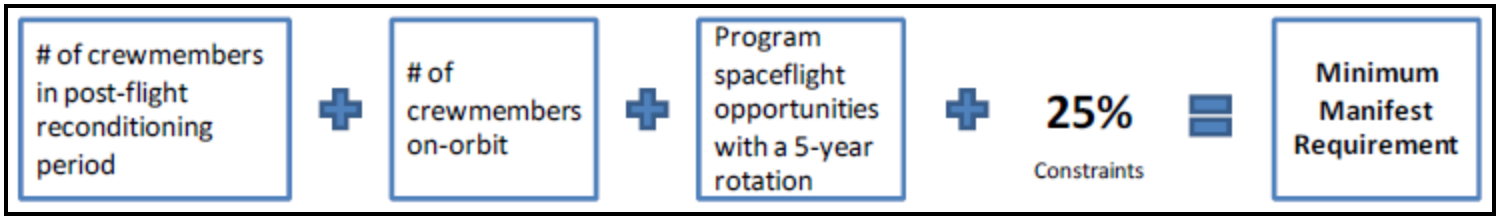
# Astronaut Corps Population as of December 15, 2010



# Role and Size of the Flight Crew Operations Activities (cont.)

**Recommendation**

- The committee recommends that the factor for uncertainty used by the Astronaut Office in its model to determine its minimum staffing requirements for the Astronaut Corps be increased above the current 25 percent, which is inadequate to provide sufficient flexibility to meet the current flight manifest requirements reliably.




(Current Model)

- In addition to task 1, the Astronaut Office should maintain the staff required to accomplish tasks 2 through 6.

# Role and Size of the Flight Crew Operations Activities (cont.)

**Finding** - In addition to the need to meet NASA requirements, there is an expectation on the part of commercial crew providers and the Federal Aviation Administration that FCOD expertise and capabilities will be available in the future.

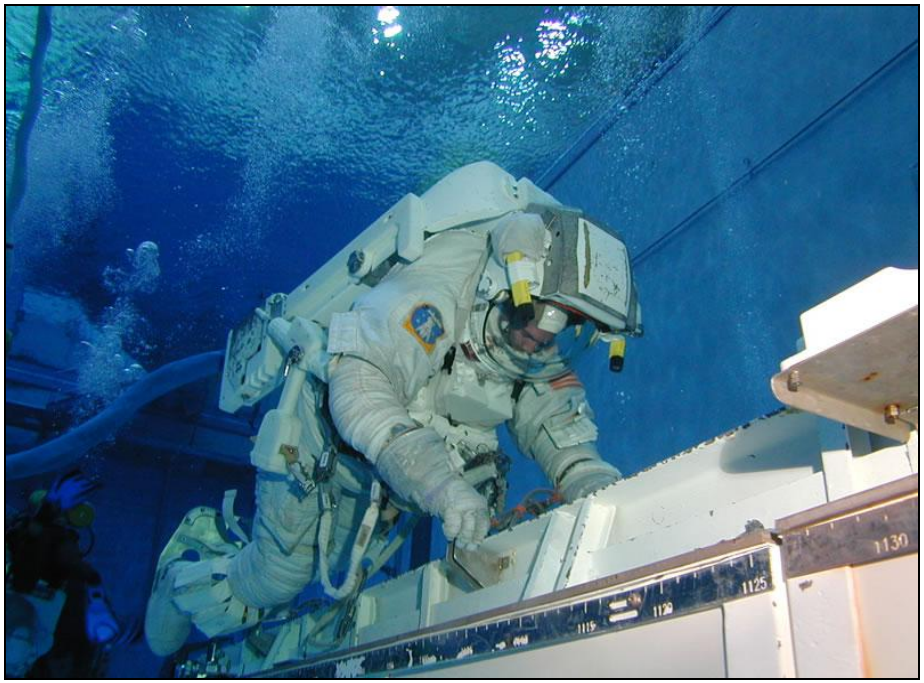
**Recommendation** - NASA Flight Crew Operations Directorate should continue to serve as a national resource for U.S. human spaceflight experience and knowledge. This resource should be:

- Maintained to ensure appropriate staffing and training of the Astronaut Corps in support of the ISS manifest;
- Applied to the future development of NASA human spaceflight and exploration activities;
- Available to the emerging commercial industry and the FAA; and
- Applied to support authorized agreements with international partners.

# Ground Training Facilities

**Finding** - The NASA plan for post-Shuttle retirement of Shuttle-specific training facilities is generally appropriate. However, the Shuttle Engineering Simulator Dome may be useful in training for future activities, such as rendezvous and docking operations during commercial transportation of ISS crew.

**Recommendation** - NASA should evaluate potential future requirements for the Shuttle Engineering Simulator Dome and, if it will be needed, preserve this facility.




Astronaut training in the Neutral Buoyancy Laboratory.
SOURCE: Courtesy of NASA.

# Ground Training Facilities (cont.)

**Finding** – Now that the shuttle is retired, the specific spaceflight crew operations shift from Shuttle operations and ISS assembly to Soyuz and ISS nominal and emergency operations, ISS payload operations, and ISS maintenance. The requirements for training of flight crews for those ISS operations include emergency response training, extravehicular activity operations, and the full suite of nominal operations for U.S. and international partner ISS elements, including Soyuz. Thus, the ISS ground-based training facilities are required for the support of crew training for future operations and maintenance of the ISS.

**Finding -** The requirements for U.S. astronaut training include international partner ISS element operations at international partner facilities and Soyuz operations in Russia. The U.S. international partner agreements also require that the United States provide for enhancing skill proficiency and training for the international partner astronauts.

**Recommendation** - NASA should retain the capability and training facilities to conduct ISS mission-specific training after retirement of the space shuttle to ensure the continued safety and mission success of ISS operations.

# Aircraft Training

**Finding** - The space flight readiness training (SFRT) requirement is derived from safety and mission success requirements, not tied to the specific mission. Although the requirement is not expressly documented at the NASA Headquarters program level, it was developed by the Flight Crew Operations Directorate in response to the NASA Headquarters-controlled safety and mission success requirements and embedded at the NASA JSC Certificate of Flight Readiness for safe operations of flight, which is then provided to NASA Headquarters. Any changes in spaceflight readiness training need to be made with great care because changes can result in increased risk to safety and mission success.

**Finding** - Spaceflight readiness training using high-performance aircraft has been demonstrated and documented to prepare crews for successful and safe spaceflight, dating back 50 years, from the inception of the Mercury program through to the current International Space Station program. SFRT is more than just flying—the full spectrum of the experiences gained is not restricted to the operation of the high-performance aircraft but extrapolates to crew resource management and performance under stress. SFRT is used effectively internationally to produce qualified members of the Astronaut Corps who are independent of crew position or vehicle design.

**Recommendation** - To ensure continued safety and mission success, NASA should maintain a spaceflight readiness training program that includes high-performance aircraft.

# Aircraft Training (cont.)

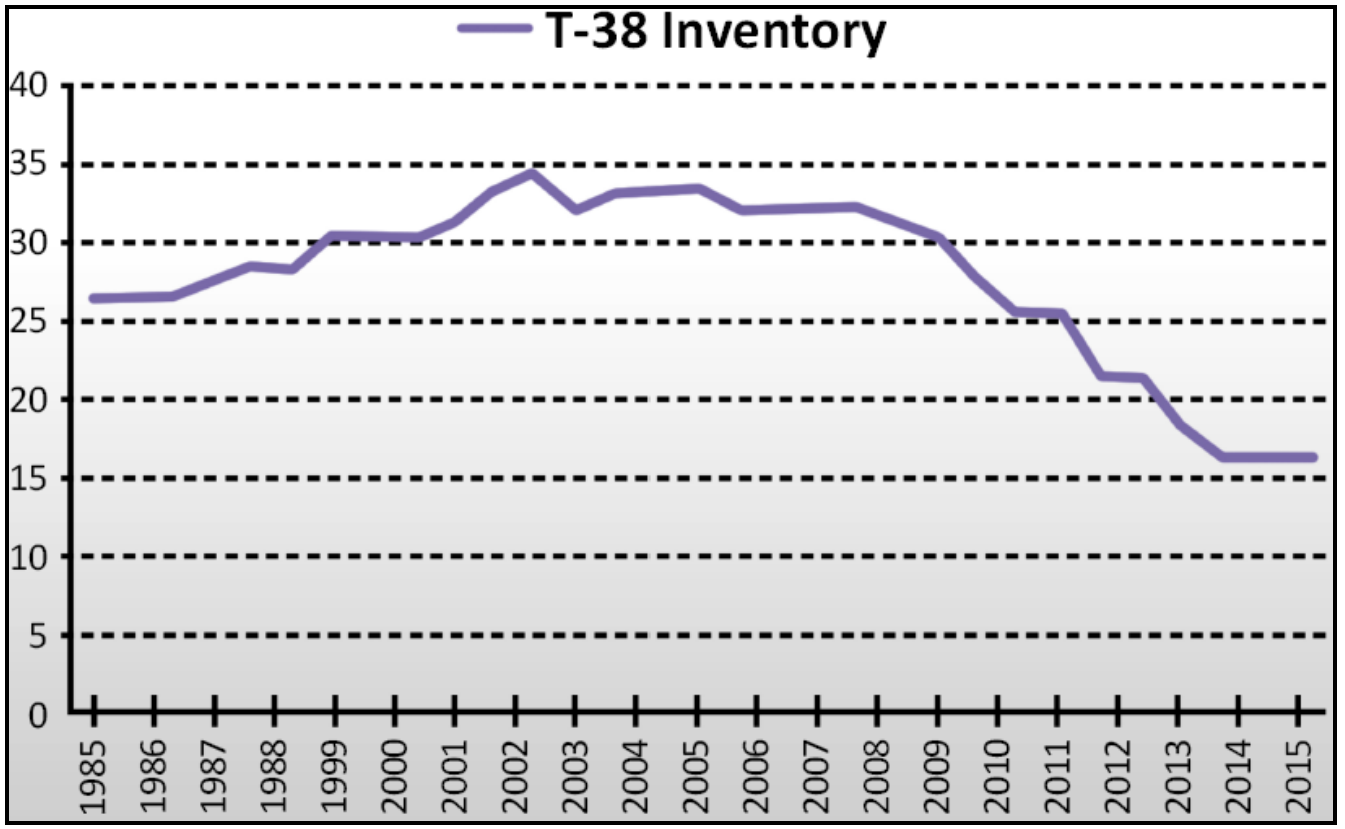
**Finding** - FCOD maintains the Astronaut Corps and provides the capability to conduct SFRT.

**Finding** - High-performance aircraft present conditions, including crew disorientation and rapid fluctuation in G-forces, under which the flight crew must carry out complex tasks in a stressful and potentially life-threatening environment. This combination of unique environments, demand for rapid, critical decision making, and historical evidence convinced the committee that SFRT provides experienced-based training that cannot be duplicated by current, or to the best of the committee's knowledge, projected alternative techniques or technologies.

**Finding** - Given the current investment in the existing T-38N fleet, this fleet is the most cost-effective means for providing SFRT in the near term. In the long-term, new technology that may be a more cost-effective means for providing SFRT might be demonstrated and proved.

# Aircraft Training (cont.)

**Finding -** The size of the T-38N SFRT fleet is projected to fall to 16 aircraft in 2013 .



# Aircraft Training (cont.)

**Recommendation** - NASA should retain the T-38N fleet for spaceflight readiness training and should fund the fleet at a level commensurate with projected required size of the post-Shuttle Astronaut Corps.


T-38N jets in flight over NASA's Dryden Flight Research Center in California.
SOURCE: NASA Dryden Research Center. NASA/Jim Ross.

# Learning from Other Occupations

**Finding** – Substantial research is being undertaken on selection and training of personnel in related high-stress occupations. Some of that work is leading to continually improving methods and technologies for training for team and individual performance in stressful high-risk situations.

**Recommendation -** NASA should continue to monitor training methods and technologies in related fields for possible ways to enhance the astronaut selection and training process.

# Backup Slides

# Committee Meeting Dates

- 1st Meeting 5-7 January 2011
  - Received briefings from JSC, ISS, FCOD, Astronaut Office, AOD
- 2nd Meeting 1-3 March 2011
  - Received briefings from JSC, Naval Reactors Program, Sierra Nevada Corps, NASA HQ, SpaceX
- 3rd Meeting 18-20 May 2011

## 7.9 MS ANNUAL QUALIFICATION CHECK

### 7.9.1 OBJECTIVE

The purpose of the MS annual qualification check is to ensure that the MS is proficient in assisting the pilot in normal and emergency situations. Crew coordination, checklist procedures, instrument procedures, and systems knowledge should be emphasized.

### 7.9.2 Expected Standards of Proficiency for Mission Specialist Crew Duty Day Extenders

**NOTE**

*For details on expected aircrew proficiency e standards, see AOD 33869, T-38 Aircrew Proficiency Standards.*

- Be able to quote or write all boldface items from memory
- Have the following ops limits memorized: EGT flight limits, nozzle limits, minimum fuel, oil pressure limits, hydraulic pressure limits
- Calculate TOLD from the checklist
- Check weather, NOTAMs, and servicing availability if going cross-country.
- File a flight plan, copy clearances, get ATIS, and program flight plan in FMS
- Perform all preflight inspections including aircraft walk-around, parachute and ejection seat preflight
- Communicate with ATC (ideal), or understand radio transmissions(minimum)
- Navigate: select EHSI/EADI screens as requested by pilot or for the situation; have required navigation aids, displays, altitudes, headings, MDA's, and courses set in order to accomplish the SID/STAR/ en route navigation/approach
- Direct an inflight divert
- Verify correct aircraft configuration
- Compute final approach airspeeds
- Ensure completion of checklists (specifically, "Before takeoff", through "after landing")
- Have a basic knowledge of systems and emergencies
- Be able to locate emergency procedures in the PCL during flight, and execute them
- Have a thorough understanding of ejection system, lap belt, parachute, and oxygen system
- RECOGNIZE ANY UNSAFE SITUATION/CONDITION!!!!

### 7.9.3 PREFLIGHT BRIEFING

a. Complete Boldface and Ops Limits Test
b. Grade and review written exams
c. Brief FOD prevention
d. Brief Cabin Pressure Loss
e. Brief a procedure selected from the following list:
   - anti-ice
   - weather radar
   - approach categories
   - cold weather procedures
- weather minimums



f. Brief an Emergency Procedure (EP) selected from the following list:
   - generator failure
   - Nav System failure
   - radio out
   - Hydraulic systems
   - Engine systems
   - landing gear systems
g. Standard Briefing from In Flight Guide
h. Ejection Seat Briefing (before or after the flight)

### 7.9.4 Prior to flight MS will:

- Check PIF
- Check Weather
- Check Notams
- File Flight Plan
- Calculate Take off and Landing Data

### 7.9.5 MANEUVER PROFILE - REQUIRED ITEMS

a. Manage comm and nav on instrument approaches.
   1. Precision
   2. Non-precision.

b Perform area maneuvers (if weather permits - optional)
   1. Engine shutdown and relight
   2. Stalls
   3. Aerobatics (optional).

c. Simulated Emergency Procedures
   1. Aircraft emergency
   2. Divert

d. Perform visual patterns. (IP demonstration - optional)
   1. Heavyweight single-engine
   2. Single-engine touch-and-go and go-around (climb to 2,000 feet AGL).
   3. No flap
   4. Minimum run.

**DEBRIEF:**

### 7.9.7 EJECTION SEAT BRIEFING

**a.** Ejection envelope (0 feet, 50 knots)

**b.** Pre-ejection

1. Oxygen
2. Parachute straps
3. Other items.

**c.** Ejection

1. Body position (head, elbows in, feet)
2. Trigger guard (trigger guard, leg guard movement).

**d.** Post-ejection

1. Beat the system
2. Oxygen
3. Check parachute canopy
4. Four line cut
5. Survival kit deployment
6. Landing, body position, parachute release.

**e.** Emergency ground egress

**f.** Parachute accessories

1. Survival kit (in parachute)
2. Beeper, radio
3. Strobe light.

**g.** Survival kit contents