2

Who should fly?

'ASTRONAUT':
A person who is trained
to travel in a spacecraft
The Concise Oxford Dictionary,
1991 edition.

When NASA announced the call for a new group of astronauts in July 1976, it was made clear right from the start that the agency was seeking up to 20 (later reduced to 15) pilots to train to fly the Space Shuttle Orbiter, and an equal number of Mission Specialists (MS) to meet the objective of developing new working practices in orbit rather than simply training pilots to fulfill those roles.

Unlike the two earlier Scientist-Astronaut selections in 1965 and 1967, intended to provide scientific crewmembers for future (and mostly cancelled) Apollo and Apollo Applications objectives, these new MS were not required to 'fly' the Orbiter and therefore would not have to undergo a rigorous military jet pilot course, as the majority of the Scientist-Astronauts had endured before progressing in their astronaut careers[1]. In another change, the new astronauts would not immediately be called 'astronauts'. Previously, all members of the earlier selections had taken that title on day one at NASA, without having to do any training or receive an assignment. However, starting with the Class of 1978, all future selections, both pilots and MS, would be known as 'candidates' until they passed a new two-year Astronaut Candidate (or 'Ascan') basic training program. They would then take up more technical assignments and, hopefully, progress to advanced training prior to be being considered for selection to a flight crew. In addition to the

[1] Some of the Class of 1978 had gained civilian pilot licenses earlier in their careers

D. J. Shayler, C. Burgess, *NASA's First Space Shuttle Astronaut Selection*,
Springer Praxis Books, https://doi.org/10.1007/978-3-030-45742-6_2

significant changes in selection criteria, it was clear that the path from candidate to orbit was also not going to be easy, straightforward, or indeed guaranteed to culminate in a flight into space.

Despite the difficulties, this system, pioneered by the 35 members of Group 8, proved very effective for NASA. Between 1978 and 2004, a total of 246 candidates (89 pilots and 156 MS) were chosen in seven groups to train specifically as crewmembers on the Space Shuttle. From those groups, crewmembers for 129 Shuttle missions were chosen between STS-7 in 1983 and the retirement of the Shuttle fleet with STS-135 in 2011.

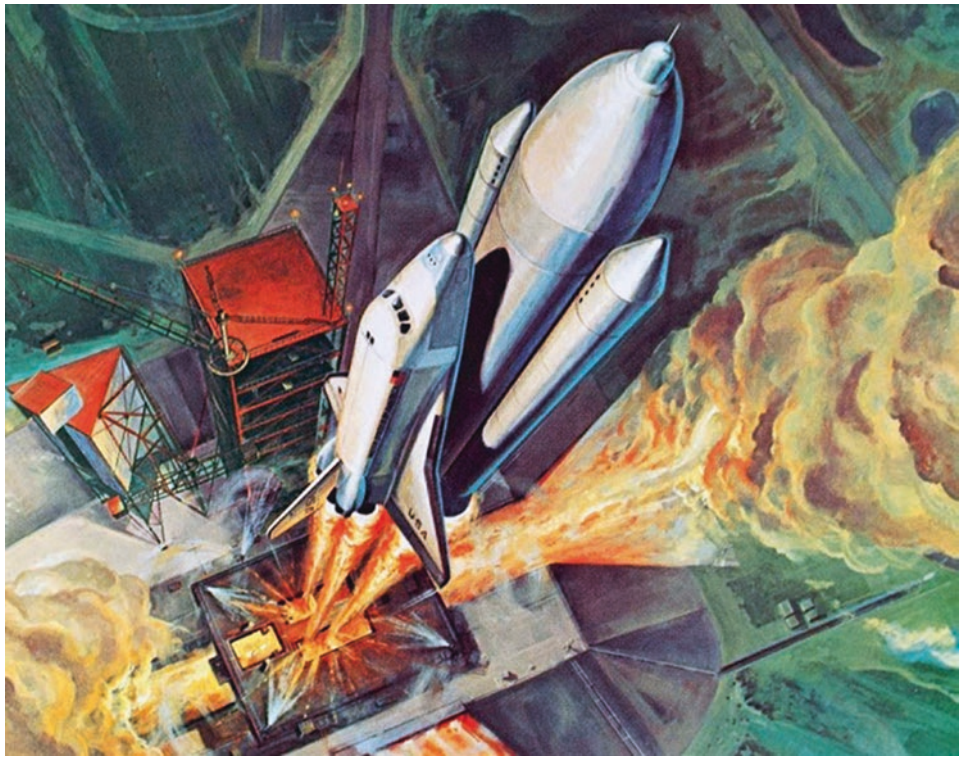

Fig. 2.1: 1970s artist's impression of a Shuttle launch

THE EVOLUTION OF A SHUTTLE CREW

Across the 30-year program, the designations of Shuttle *Pilot* or *Mission Specialist* became familiar to those who followed the program. But how did those roles evolve from the era of the Apollo Command or Lunar Module Pilots? We need

only to go back to the late 1970s, when that first Shuttle Ascan group was announced to the world. Just a few years earlier, NASA was emerging from the Apollo era and commencing detailed preparations for flying the Shuttle Orbiter in a series of test flights. Delays in preparing the major components of the new Space Transportation System for flight meant that it would be over five years after their selection before the first four members of the 1978 group (one pilot; three MS) would fly, on the seventh flight of the Shuttle program. So how did the positions, designations and roles of a Shuttle crew evolve in the decade prior to that first selection in 1978?

NASA's Astronauts of the First Generation

In the 1960s, the primary role of the crew of America's first generation, single-mission-designed orbital spacecraft, was to have astronauts with superior piloting skills 'fly' or 'control' the vehicle. It was only in the latter stages of the Apollo era that skills other than flying were considered for the crewing process.

Mercury: For the one-man Mercury series, flown by astronauts with background in testing military aircraft, the designation was simple: 'Pilot'[2].

Gemini: The introduction of a two-man crew required a lead astronaut – hence the designations of Command Pilot and Pilot, with the Command Pilot responsible for rendezvous and docking with an unmanned target, among other things, and the Pilot for assisting him and performing any Extra-Vehicular Activity (EVA, or spacewalking) objectives.

Apollo: Originally, the designations in 1966 for the Command and Service Module (CSM)-only Apollo Block I Earth orbital missions were Command Pilot, Senior Pilot (ideally previously flown) and Pilot (normally a rookie). Then, in a memo from Deke Slayton dated November 29, 1966, the designations for the more advanced Block II (lunar) missions were amended to Commander (CDR), Command Module Pilot (CMP) and Lunar Module Pilot (LMP) respectively, reflecting the more specialist requirements for the increased challenge of the lunar missions ahead. Though capable of flying the Lunar Module, the LMP was more of a systems operator, officially leaving the control and handling of the ungainly vehicle to the CDR.

[2] The Mercury astronauts argued strongly against calling their space vehicles "capsules," insisting on using the word "spacecraft" over one they equated to something associated with medication.

Skylab: Under the Apollo Applications Program (AAP), the Commander (CDR) and CSM Pilot (CMP) designations were retained. For the third, scientific member of the crew, the designation was initially to be known as the Mission Module Pilot (MMP), but by the time AAP became Skylab this had changed. When the crews were announced in January 1972, the third member was identified as the Science Pilot (ScPLT).

Apollo-Soyuz: The final Apollo flight in 1975 still featured a Commander and CMP, but instead of flying a Lunar Module there was a smaller Docking Module unit that allowed the CSM to link up with, and the crew transfer to, the Soviet Soyuz. Without the LM there was no need for the LM Pilot designation, so the third position for this final flight of Apollo was changed to the not-very-original Docking Module Pilot (DMP), even though there was actually nothing to 'pilot' in the DM.

These designations worked fine for Mercury, Gemini and Apollo, crewed by a small number of pilots and pilot-trained scientists in the Astronaut Office, but for Space Shuttle, new criteria needed to be devised for its multiple crewmembers.

Early developments

This summary of the evolution of the Shuttle 'crew' takes up the story from early 1968, a decade before the first of those chosen to fulfill the majority of the flight crew roles were named.

On February 29, 1968, NASA Administrator James E. Webb appointed the Director of Langley Research Center, Dr. Floyd L. Thompson, as his Special Assistant and head of the NASA Interim Working Group based at NASA Headquarters in Washington D.C. Thompson was given the remit to examine future manned space programs beyond Apollo, including studies looking at the development of a Space Shuttle and, by default, its crew. **[1]**

On August 10 of that year, Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight, speaking at the British Interplanetary Society in London on the occasion of his award of Honorary Fellowship of the Society, told the audience that he believed the future expansion of space exploration was severely limited by the cost of placing an object in orbit and the inaccessibility of payloads once they have been launched. Mueller forecast "that the next major thrust in space will be the development of an economical launch vehicle for shuttling between Earth and the installations such as orbiting space stations which will be operating in space." **[2]**

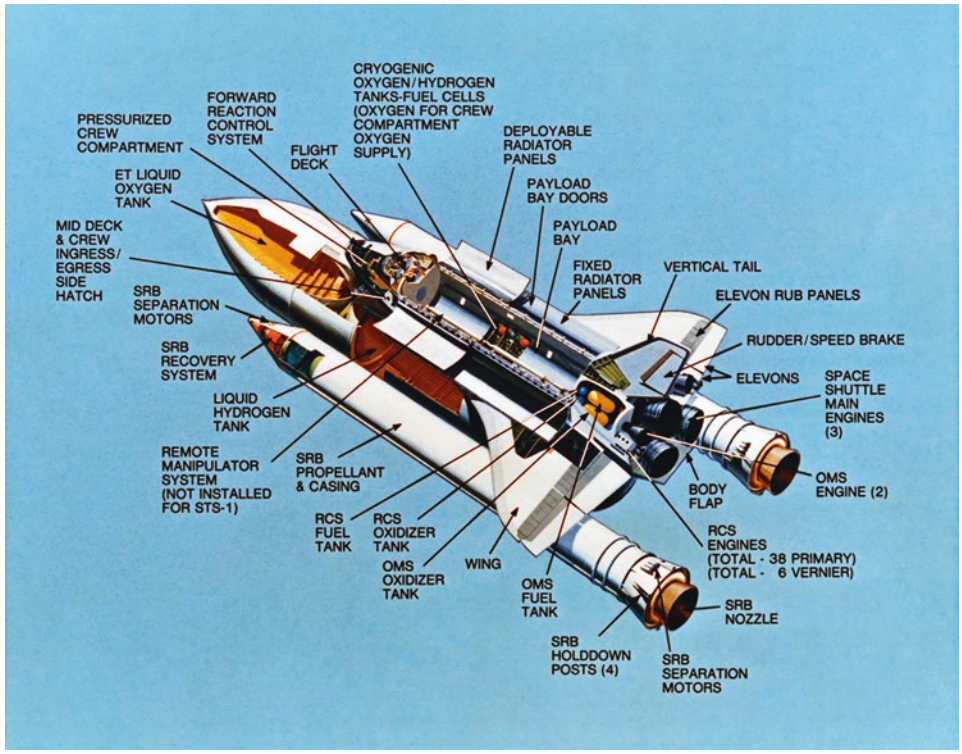

Fig. 2.2: The components of the Shuttle 'stack', consisting of an Orbiter (OV) with its three Main Engines (SSME), the External Tank (ET) and twin Solid Rocket Boosters (SRB).

In his speech, held at a special meeting of the members of the BIS at Imperial College, Dr. Mueller outlined the concept of a reusable shuttle vehicle designed to perform a range of missions in Earth orbit. These projected 'missions' included recycling; repair; inspection and transport; supporting the creation of larger space stations beyond those planned for Apollo Applications (which were to utilize the third stage of the Saturn V as an orbital workshop); and rotating station crews. Mueller explained that the aim of the shuttle vehicle was to reduce the cost of deploying a payload in orbit significantly, by using reusable hardware and therefore lowering the launch costs. At this point there were no details of crewing, but hints that the system would operate "in a mode similar to that of large commercial air transports," capable of operating in all weathers, and that the cockpit "would be similar to that of large intercontinental jet aircraft." An accompanying illustration shown during the presentation suggested that NASA was thinking of a

two-man crew to fly the vehicle, with up to seven 'passengers' enclosed in a payload module behind the crew station. This was described as a *pressurized crew compartment*, with an attached *mission payload compartment* that could be adopted to ferry passengers or cargo with "comfort comparable to large transport aircraft." Pilots would obviously be required to fly the vehicle, though Mueller indicated that "the landing would be completely automatic, with prime dependence upon the spacecraft's guidance system but with ground control back-up." Though the nomenclature of the crewmembers were not revealed, the definitive 'mission' module would clearly require specialists trained to handle the cargo, a possible genesis for what became known as the 'Mission Specialists.'

Eight months later, on April 24, 1969, during the first meeting of the Space Shuttle Task Group held at NASA HQ in Washington D.C., the discussions led to the identification of a number of future directions, requirements and discussion topics on "a nominal 12-person capability for crew and passengers." **[3]**

By May 30, just six days after Apollo 10 had returned from the Moon, George Mueller was back at the BIS in London to accept, on behalf of NASA, the BIS Silver Trophy for the achievement of the first manned flight into lunar orbit with Apollo 8. This time, he explained NASA's desire to extend the Apollo lunar program beyond the envisaged ten lunar landings and the creation of a lunar base. This was followed by a discussion about the potential of space stations, and then on the development of the Space Shuttle and how studies had progressed in the nine months since his last presentation. At this time, he explained, there were more than ten different designs proposed for the shuttle system, but despite this Mueller estimated that the rapid development on the program to date indicated that "the Space Shuttle can be operational in seven years," i.e., by 1976. **[4]**

On July 28, 1969, four days after the return of the Apollo 11 astronauts, a preliminary statement of work was circulated in advance of the Phase B Space Transportation System (STS) contracts, which noted that the ultimate goal of STS was to "introduce a new, more mature and routine mode of space transportation than past programs. Men [*authors' note*: no mention of females or minorities was made at this stage] will travel into space and return in a shirtsleeve environment similar to the present-day commercial aircraft." In the accompanying design reference mission, a crew of two astronauts would fly the 'shuttle', together with a crew of up to *ten* to occupy the envisaged 12-man space station. **[5]**

In September that year, the Space Task Group issued its *Post-Apollo Space Program: Directions for the Future* report to President Richard M. Nixon. This blueprint for the next decade or so highlighted the need to develop a new space transportation system, with emphasis upon vital factors of *commonality, reusability, and economy.* In relation to the Shuttle, this meant incorporating fewer major systems across a wide variety of missions (commonality); the repeated use of the same systems over many missions (reusability) and a reduction in 'throwaway'

elements (economy). This, the report suggested, would improve the overall cost and operational capability, and encourage the ability to *carry passengers* and items of hardware to and from orbit in airline-like routine operations.

As the design of the vehicle was being debated, the media at the time picked up on the variety of missions to be flown, the reusability aspect and the projected reduction in launch-to-orbit costs. Largely overlooked in all this was the crew configuration, which was not surprising as the actual decision on crewing was still some way off. This omission did not stop the media putting forward suggestions that access to space would soon be opened up for all. One typical contemporary account, published in 1970 and aimed at teenage readers (who may have dreamed of flying on the Shuttle themselves one day), suggested the Shuttle would "open the way for ordinary men and women to go into space." However, the idea of scores of commercial passengers being ferried to and from huge space stations, or even hotels in orbit, in the near future remained more in the minds of those involved with reporting on the Shuttle, rather than those who were actually developing it.

Fig. 2.3: 1973 artistic impressions of a 'typical' Shuttle mission profile.

The 'big sell' to politicians, the press (and through them to the public) and potential customers, was in the projected ability to fly a mission after a turn-around of just two weeks, thus reducing the launch costs, and by operating a fleet of between four and six shuttles which would complete up to 60 missions a year "between 1977 and 1990." It was reported that the older Orbiters would be replaced by new vehicles every five or six years. This suggested an Orbiter production line of 18 to 24 vehicles, which clearly was not accurate. In these accounts, each Orbiter would feature a large, 60ft by 15ft (18.28 by 4.57 meters) cargo bay that could not only be adopted to carry satellites or packed with freight ferried to a space station, but also transport up to 50 passengers in a pressurized compartment. For a younger generation enthused by the success of Apollo this looked like a bright future, but unfortunately, as the decade progressed, the realities of trying to develop and deliver on those broad claims became apparent within in the program. **[6]**

Schedule Analytics Chart circa early 1970s

To demonstrate a more accurate, but still ambitious, mode of planning being developed for Shuttle crewing, even in the early 1970s, an analytics chart (undated and shown in Figure 2.4) included these assumptions:

- There would be FIVE operational Orbiters, with the first flight under the orbital test program completed during 1978–1980 (by OV-102). OV-101 would then join the fleet, followed by OV-103, OV-104 and finally OV-105.
- The payload program was to be operational by October 1, 1979
- Each Orbiter would fly on five-month cycles
- There would be one flight each month from KSC.

This planning forecast would also see a Pilot and Co-Pilot for each of the Orbiters (five pairs), with a 'mission team' of 2–4 (only men were included in this projection) made up of either cargo handlers, Flight Engineers, Payload or Mission Specialists, Principle Investigators or passengers.

In this plan, the Orbiter 1 Pilot/Co-Pilot pairing, for example, would fly with mission Team A (and Payloads 1, then 16, then 31 etc.); Team B (payloads 6, 21, 36); and Team C (Payloads 11, 26, 41) etc. The pairings for the other four operational Orbiters would follow a similar profile. Under this plan, therefore, 15 teams of astronauts would be required (three teams for each of the five Orbiters), each dedicated to a specific payload (presumably with a built-in attrition rate within the team) and with projections of 45 payload missions between the Fourth Quarter of 1979 and the Second Quarter of 1983.

As analytically useful as this may have appeared on paper, it was not long before such paper studies were amended, scrapped or revised, and then changed again many times before any astronaut's name appeared on a manifest.

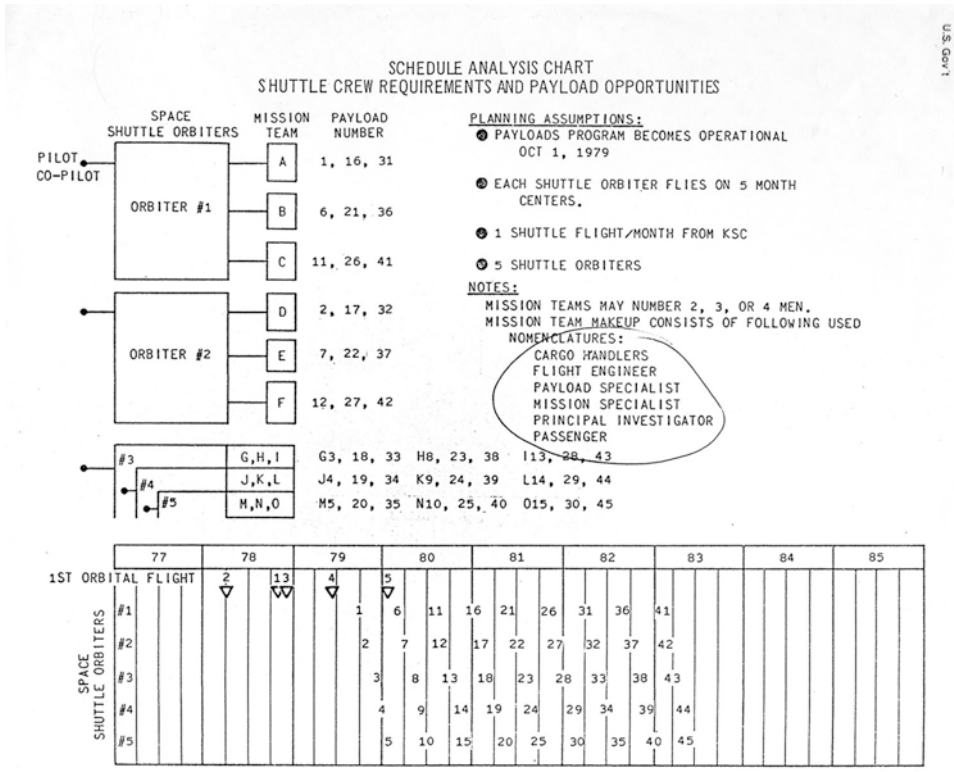

Fig. 2.4: Schedule Analysis Chart for Shuttle Crew Requirements and Payload Opportunities circa early 1970s. Note the early mention of Cargo Handlers, Mission and Payload Specialists, Principle Investigators and Passengers.

An early status report

On January 5, 1972, the year of the final Apollo missions to the Moon, President Richard M. Nixon announced the nation's decision to develop the Space Shuttle. That same month, the U.S. House of Representatives Committee on Science and Astronautics published a timely 1,000-page status report entitled *Space Shuttle–Skylab, Manned Space Flight in the 1970s*, compiled using information attained from NASA field centers, key industrial contractors and from briefing transcripts, describing the current status of both the Skylab Orbital Workshop and the Space Shuttle programs (then undergoing Phase B preliminary design studies). As the letter of submittal by Thomas N. Downing, Chairman of the Sub-Committee on NASA Oversight, stated in the report, the hope was "that this status report will contribute to those decisions necessary to determine our nation's role and participation in our future space-related activities." Of note was a report on the

development of Shuttle payloads by Mr. William T. Carey of Marshall Space Flight Center (MSFC), Huntsville, Alabama, dated October 26, 1971, which focused upon the analysis of the first ten Shuttle missions.

One of these featured missions was the Large (later Hubble) Space Telescope, for which Carey suggested that it would be more cost effective to modify the telescope on orbit than to return, refurbish and then re-launch it, adding "you can also put up an astronomer once in a while with the Shuttle." He also suggested, rather strangely, that perhaps even a *graduate student could be flown* [author italics] as part of the crew on their educational career path towards becoming a professional astronomer! Carey added that one or two MS "would be ideal" on many of these first flights. **[7]**

Fig. 2.5: 1970s cutaway image of the Orbiter crew compartment showing the upper flight deck and lower middeck living area.

A second presentation, this time by North American Rockwell Corporation Space Division at Downey, California, dated November 19, 1971, focused on the status of the program at Space Division and gave an early indication of some of

the various designations being assigned to the crew. In this presentation, the basic Shuttle crew configuration was given as a two-man flight crew, supported by one or two astronauts trained in a particular mission and identified as "Mission Specialists (MS)," or by one MS and one crewmember who would have an in-depth knowledge of a particular payload, identified here as a "Payload Specialist (PS)." As Mr. Franklin stated in the presentation: "In the early days of the Shuttle …we would like to look at what is the most logical way to introduce man into the pertinent operations of the Shuttle and to make that investment in such a way that it leads us in that direction." Part of that work was being conducted at Langley Research Center, Hampton, Virginia, where the types of payload that should be included on the Shuttle were being evaluated in a program called the Shuttle Orbital Applications and Requirements (SOAR). The SOAR program looked at various payloads which involved the crew in their operation, or those which did not require manned intervention. A second, parallel program to define potential research on the Shuttle was being conducted at MSFC. Called the Research Application Module (RAM), this was a pressurized module located in the Shuttle payload bay (which would eventually evolve into the European-built Sortie Module that became Spacelab), within which an "experiment management crew" would work to conduct a fairly wide variety of missions in what was described as "an inexpensive way." **[8]**

Fig. 2.6: The four-seat flight deck showing the pilots and Mission Specialists in their launch and (as shown here) entry positions. In this 1970s image, a multi-racial crew is evident, as is the lack of pressure suits.

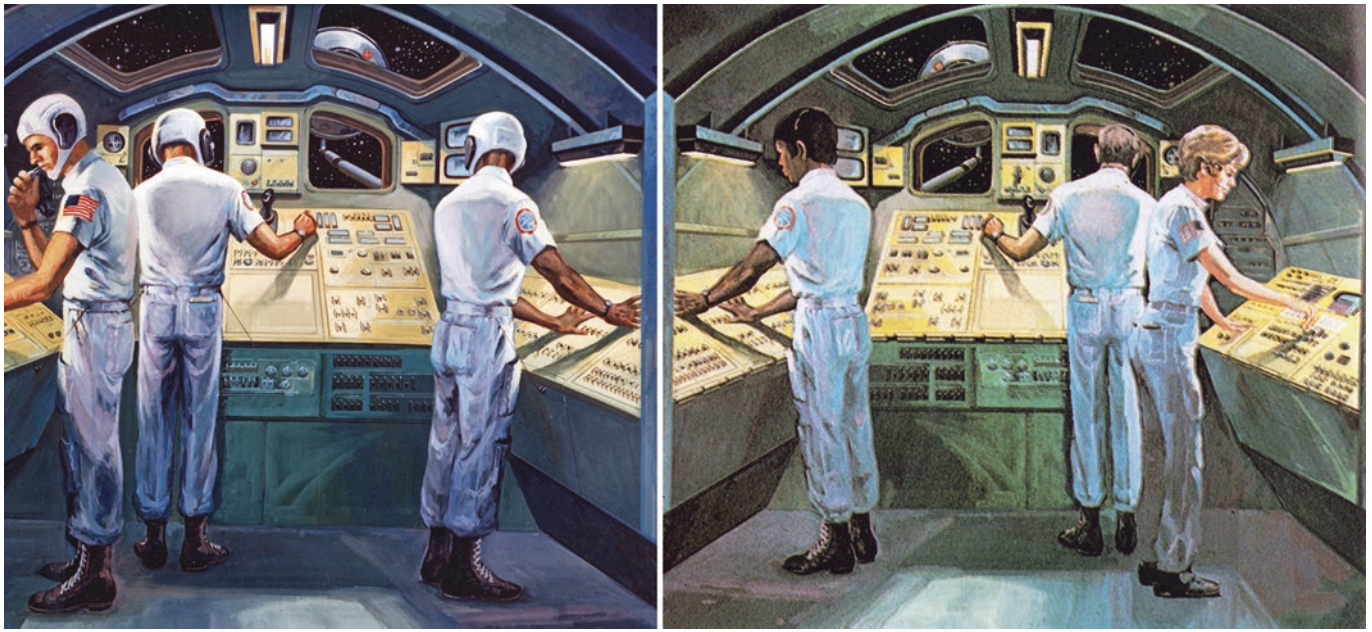

Fig. 2.7: These two interesting, almost mirror images (note the RMS and payload positions out of the windows) show on-orbit activities at the aft flight deck. Compare these 1970s artistic impressions of what Shuttle activities were expected to look like to actual views inside the Orbiter on real missions.

Getting rid of irrelevant pilot training?

On March 2, 1972, NASA Administrator James C. Fletcher was at the Kennedy Space Center (KSC, Florida), addressing an audience of 200 at the Equal Employment Opportunities Conference. He stated: "We are working on plans to get members of minority groups into space. The Space Shuttle, which is the keystone in all our future space programs, will be an important factor in accomplishing this goal." **[9]** This was all well and good, but for some time any appearance or speech given by an astronaut had prompted questions about when NASA would send female or black astronauts into space. With the authorization of the Shuttle in April 1972, concerns were being raised over this same question, especially following recent 1972 amendments to the 1964 Civil Rights Act, which subjected the U.S. Government (including NASA as a government agency) to equal opportunity legislation. In his response to reporter questions at the KSC event, Fletcher commented that where Equal Employment Opportunities were concerned, he was attempting to cut out all the red tape and remove the symbolic blocks that had hindered progress in this area. Later, in the *New York Times* dated March 28, 1972, University of Michigan astronomer James A. Louden wrote that one of the Shuttle's most important aspects was its ability to carry passengers: "For the first time, scientists will be able to perform experiments in space without spending years in irrelevant pilot training first." With the authorization of the Shuttle program and the reduced launch and landing loads that its design projected, the case for recruiting non-piloting astronauts in the space program – including females and minorities – gathered pace.

Early ideas for crewing

For several years, the Crew Training and Simulation Division (Code CE) at MSC/JSC conducted numerous reviews into exactly what the crew duties would be on a 'typical' Shuttle mission[3] and who would be responsible for what. Just *one* example of this early planning can be found in a March 1972 memo, in which the established four-person crew baseline was adopted and was intended to be "quite general so as to accommodate subsequent discussions pertaining to the crew skills, mix and more specific duties for particular missions." This suggested that the thinking was to assign crewmembers with a medical background to a medical mission, astronomers to astronomy missions etc., training certain crews to fly specific mission profiles, such as deployment of a series of payloads (TDRS, comsats), or focusing on particular skills, such as EVA servicing, Remote Manipulator System (RMS) operations and so on. **[10]**

[3] In reality, there was no such thing as a 'typical mission' for the Shuttle. While each mission flown may have looked similar, they were all highly individual.

Part of this long-term planning, according to the memo, included the early application of a definitive nomenclature and formal description of duties, to create training plans and subsequent flight operations and procedures. The suggestions put forward in this 1972 memo, a decade prior to the first Shuttle crews flew missions, are detailed in Table 2.1.

Table 2.1: SPACE SHUTTLE FLIGHT PERSONNEL NOMENCLATURE AND DUTIES [FEBRUARY 1972] ALL PAYLOAD CLASSES

Crew Nomenclature	Flight Dynamics - Aero	Flight Dynamics – Space	Flight Procedures	Flight Plan	Booster Subsystems	Orbiter Subsystems	Emergency Procedures	Payload Subsystems	Payload Instruments	Payload Operations	Rendezvous	Docking	Orbital Mechanics	EVA	Network
Commander	1	1	1	1	1	1	1	2	3	2	1	1	1	2	1
Pilot	1	1	1	1	1	1	1	1	3	2	1	1	1	2	1
Mission specialist	2	2	2	1	-	2	1	1	2	1	2	2	2	1	2
Payload specialist	-	-	3	2	-	-	2	2	1	2	-	-	2	3	3
Passenger/observer	NOT CONSIDERED AN ACTIVE CREW MEMBER														

Adapted from attachment to March 7, 1972 memo from Crew Training and Simulation Division [from the NASA JSC History Collection; copy held in AIS files] Key:
1. Primary training and responsibility
2. Direct support responsibility, specialized training
3. Operational support

In an April 1972 attachment to the memo, the preliminary duties identified for each position on the Shuttle crew were assigned as follows: **[11]**

The *COMMANDER* would be in command of the flight and responsible for the overall space vehicle, personnel, payload flight operations and vehicle safety. They would be proficient in all phases of the vehicle flight, payload manipulation, docking, and subsystem command, control and monitor operations. A commander would also require knowledge of payload and payload systems as they related to flight operations, communication requirements, data handling and vehicle safety.

The *PILOT* would serve as second in command and hold duties essentially equivalent to those of the Commander.

The *MISSION SPECIALIST(S)* would be responsible for the interface of payload and Orbiter operations and management of payload operations. The MS (and there may be more than one on each flight) would also need to be proficient in vehicle and payload subsystems, flight operations and payload communications data management.

The *PAYLOAD SPECIALIST(S)* would be responsible for the application, technology and science payload/instrument operations. They would have a detailed knowledge of payload instruments, operations, requirement, objectives, and supporting equipment.

The *PASSENGERS/OBSERVERS* which, according to the document, meant "anyone who has no direct part in Shuttle operations." Though not detailed in this document, they would (presumably) have to undergo Shuttle briefings, safety, and crew equipment training sessions to become part of 'a crew' and thus be safe to fly with.

Even at this early stage, MS and PS assignments were being applied to some of the long-term planning charts and documents.

On July 25, 1972, North American Rockwell (later Rockwell International) was named as lead contractor for the design, development and construction of the Orbiter element of the Space Shuttle stack. It was stated at that time that the first manned orbital flight of the Shuttle was planned for 1978 and that 445 flights were projected to be completed by 1990[4].

Meanwhile, NASA was already evaluating who might be suitable for its next astronaut intake, and were in fact planning to go much further than just eliminating the jet-pilot training qualification that the Scientist-Astronauts had needed to acquire for its next class of astronauts. On July 29, just four months after Louden's letter in the *New York Times*, and four days after Rockwell was named leading contractor, NASA Administrator James C. Fletcher spoke in Baltimore, Maryland, at the annual meeting of the National Technical Association (NTA)[5]. In his speech, Fletcher informed the audience that NASA planned to expand opportunities for black and minority groups from within the space agency, including possible flights on the Shuttle: "We are planning now for Shuttle flights," he stated, adding that "it will carry minority and women scientists into orbit." **[12]**

By 1973, several astronauts had been working in development and support roles for the Space Shuttle for some time. This was part of a restructuring of all departments in the Astronaut Office to take into account expected retirements once the Skylab and Apollo-Soyuz Test Project (ASTP) phases had been completed, while at the same time utilizing the talents of those who remained, in particular the Scientist-Astronauts. On December 7, 1973, in support of the pending retirement of the Apollo-Saturn spacecraft system and the introduction of the

[4] Less than a year later, on April 2, 1973, NASA HQ had refined the Shuttle flight manifest to show six orbital flights in 1978, 15 in 1979, 24 in 1980 and 40 in 1982, increasing to 60 each year from 1983 to 1987, and then dropping to 28 in 1988. This was still clearly an over-optimistic goal, as over the next decade funding remained a challenge, and qualifying the systems proved much more time consuming than first envisaged.

[5] The NTA was a non-profit organization aimed at aiding members of the black and other minority groups to prepare for technical or scientific careers.

Space Shuttle, the eleven remaining Scientist-Astronauts in the office were reassigned either to the Science or the Application of Life Science directorates. Though more changes were forthcoming, many of the Scientist-Astronauts assumed support roles in the emerging development of Space Shuttle payloads and experiments, most notably in Spacelab, the European contribution consisting of a pressurized science module and unpressurized support pallets to be flown in the payload bay of the Shuttle. Spacelab was designed to be operated by a 'science' crew made up of NASA astronauts and 'guest' foreign astronauts from member countries of (from 1975) the European Space Agency (ESA). To aid this development, a series of ground and airborne simulations of Spacelab missions were conducted during the mid- to late-1970s that provided valuable information on how the orbital Spacelab missions might be planned, prepared and flown, as well as the roles and responsibilities the science crewmember could hold on those missions. **[13]**

Fig. 2.8: One of the promoted advantages of the Space Shuttle over previous American crewed spacecraft was the extra room available. This image shows an almost empty middeck and airlock. After the four OFT missions, the middeck on real missions was rarely so devoid of equipment.

Fig. 2.9: Meal times 1970s style, illustrating the multi-cultural and mixed gender crews often portrayed in these concept images as the search for a new class of astronauts was pursued.

Defining the roles

The flying capability of the Orbiter indicated the two main designations almost immediately. With two pilots seated on the flight deck, the left seat would be occupied by the lead pilot, assisted from the right-hand seat by his 'co-pilot', as is traditional in large commercial, military or transport aircraft. For the Shuttle, that meant the Commander (CDR) on the left and the Pilot (PLT) on the right. With an expected crew compliment of between 4–6 additional crew members, depending on the mission, the designations of the other astronauts were defined by the specialty skills required, hence MS or PS. This evolution took countless memos, matrixes and meetings over a period of time and is highlighted here in another example from the JSC Space Shuttle Archive. The on-going topic of Shuttle crewing was discussed in a meeting held at JSC on October 24, 1972, between members of the Engineering Directorate (Mail Code E), Flight Operations (Mail Code C), and personnel from simulator contractor Ling Temco Vought, who created a baseline for further discussion. This baseline was summarized as:

- A *basic* crew would consist of two NASA astronauts: CDR and PLT.
- A maximum of four additional crew members, including NASA astronauts as MS, and non-career PS, as required.

- Total maximum in-flight personnel (crew (CDR, PLT, MS, PS) and 'passengers') would be no more than 10.
- Two crewmembers (MS, and CDR or PLT) would conduct EVAs.
- Responsibility for the crew assignments were listed as:
  - CDR or PLT were responsible for all activities affecting the Orbiter, including operation of the Remote Manipulator System.
  - MS would be responsible for Orbiter/payload interface and payload/instrument operation
  - PS would be responsible for application, technology and science payload or instrument operation.
  - Passengers [undefined in the document at that time] would have no responsibility for Space Shuttle or payload operations, raising the question of their purpose (for example, artist, politician, foreign dignitary, celebrity, etc.).

The document generated from that meeting also defined an early study of the initial STS flight crew assignments. For the six orbital test flights prior to commencing the operational phase, only a two-person *basic* crew (CDR/PLT) would be flown, after which the crew complement would expand as required. When the full operational period began, a flight rate of 60 missions per year was projected. There was also a suggestion for *two* crews to be assigned to each mission (prime and back up, and by flying only a *basic* crew, both astronauts in each crew would be trained and equipped to complete any EVA required).

The prediction for subsequent operational flights was for a *basic* crew annual flight rate of between 4–6 missions *each year*, with the MS flying 3–4 missions per year. If the low rate for the *basic* crew and high rate for the MS astronauts (minimum of two) were taken into account (i.e., a team of four astronauts flying four missions each year as a unit) then at the least *15 crews would be in training each year, totaling 60 astronauts* [author italics]. This was without taking into account natural attrition (retirement from active status), down time (proficiency training, vacation or illness), injury, or loss of life.

Using this 1972 format to surmise a 'typical' Shuttle mission, planned for an average of seven days (some less, others more), meant that a crew could be back in the training cycle every two or three months. Having the same crew flying with similar payloads could be both advantageous and disadvantageous to training, and raises the question of the desire and motivation of the crew to fly such repetitive missions so frequently. In reality, it was found that such a rate was highly impractical, financially prohibitive and operationally impossible, as training for an 'average' Shuttle flight was found to take many months. The option of rapid turnaround was investigated early in the program, however.

A decade later, in 1982, astronaut Bob Crippen was interviewed for JSC *Roundup* and was asked this very question. The interviewer suggested that such a rapid turnaround would represent a couple of weeks of jubilation in flying the mission, a week of debriefing and one day of rest, followed almost immediately by months of training for the next flight. Crippen admitted that the crew rotation system remained a work in progress even in 1982, but as flight rates increased it was expected that the crew turnaround time would decrease, though it was still far from decided if this was a path NASA would take. There had indeed been some planning done in the Astronaut Office about what the ideal gap between flights should be, what additional training, if any, would be required to fly a similar mission, or whether generic crews would be implemented in the future, but this was still being hotly debated. By the early 1980s, it was found that it took about 12 months to train a Shuttle crew, though it was hoped this could be reduced to a turnaround of between 3–6 months. This was still being worked on two years later when Crippen was assigned to his fourth mission, his second of 1984. Around this time, a DOD stand-by crew had been created, reflecting the delays in the program and changes in launching classified payloads. This 'launch-ready' crew had to be ready to go at short notice, but in the end was not utilized in that role. The 1986 *Challenger* accident, program changes and hardware delays finally put paid to this idea of a defined crew flying multiple missions based on short turnaround training. On some missions, however (e.g. Space Radar Laboratory; Spacelab Life Science; Atlas; Hubble Servicing), at least one crewmember from an earlier crew was assigned to the next flight in the series to help with the payload and training preparations. **[14]**

In a second document, a rough draft (undated but filed with the above 1972 memo) of 'job descriptions' for Shuttle crewmembers suggested as early as 1972 that "all crewmembers that will fly will be highly trained individually as capable of contribution to the success of the operational or scientific missions being flown." The document then went on to suggest that the Shuttle had the capacity to fly two or more crewmembers that were "not directly responsible for the safe return of the vehicle," thereby utilizing their expertise instead on training in Orbiter-to-experiment operations. This would vary mission by mission, between payload and availability, but three levels of 'Shuttle crew training' were being defined for the Shuttle vehicle and payloads/experiments as early as 1972.

For example:

Shuttle Pilots: Both the CDR and PLT (the flight deck crew; collectively referred to here as 'the pilots') would have intensive knowledge of the Shuttle vehicle and spaceflight operation in general.

- The CDR retained primary responsibility for safety of the vehicle and entire crew.

- The Orbiter could be operated by the CDR and PLT without additional assistance (the workload experienced during ascent and entry across the four Orbital Flight Tests (OFT) contributed to the decision to assign an MS as a Flight Engineer (FE), to assist the CDR and PLT from the first operational mission, STS-5).
- The pilots were to be responsible for system operation, fault isolation and necessary maintenance on the vehicle and its systems.
- In support of the payload, the pilots would ensure operation of the fuel cells and management of consumables, as well as distribution of power to support the payload and experiments.
- The pilots would be responsible for opening the payload bay doors, deploying the payload, grappling satellites and payload stowage.
- The pilots may also support payload operations in a limited manner without requiring additional training, such as gathering of data in multi-shift operations.
- The PLT may act as 'buddy' during EVA operations, performing as IV (Intra-Vehicular) assistant and safety observer to the MS performing the EVA while the CDR monitors the EVA from inside the Orbiter. (In the early days of the program, participation in EVAs had been suggested as part of the role of a Shuttle Pilot, but their increasing responsibility and workload dictated that they should instead fulfill a support role for both planned and contingency spacewalks.)

Creating the criteria

Plans for selecting the next group of astronauts were therefore challenging, not only because the program they would be chosen for was unlike any that had preceded it, but also because the established method of selecting top test pilots as candidates, or selecting suitably qualified scientists to be trained as jet pilots before assigning them to a mission, needed to be changed.

Flying experience would always be a required skill for those assigned to land the Orbiter on a runway at the end of the mission, but for the majority of the Shuttle mission profile, the emphasis would be on scientific and operational activities in orbit, and this would require a new breed of astronaut. NASA was also under pressure to be seen to include suitably qualified female and minority groups, and doing so meant that the selection process would take longer than the earlier intakes. Therefore, the program to select what would become NASA's next astronaut group actually began five years before they were announced, during a two-day meeting in September 1972. This was not even at a NASA field center, but away from the glare of publicity and the media.

At the Peaks of Otter Lodge, located in the Blue Ridge Mountains north of Roanoke, Virginia, the directors of the NASA field centers associated with the

manned space flight program gathered to discuss developing a plan to define the requirements for a new group of astronauts to train specifically for the Space Shuttle, as well as the timeline for such a plan. They were guided by Jim Fletcher, who indicated right from the start that full consideration should be given to including minority groups and female candidates. Leading this effort would be the Manned Spacecraft Center in Houston, Texas (MSC; renamed the Lyndon B. Johnson Space Flight Center – JSC – in 1973, in memory of the 36th U.S. President who died early that year). Over the next four months, MSC would create a range of staffing plans for Space Shuttle astronauts, to be presented to Dale Myers, the Associate Administrator for Manned Spaceflight, by February 1, 1973. The creation of these plans would be based upon the most accurate and up-to-date projections for the number and frequency of projected Shuttle flights, as well as an estimate of the need for pilots to fly the vehicle over the first few years during the test and early operational phases.

The Shuttle program had only just been authorized, so it was still many years away from the first flight, and as NASA already had a cadre of veteran and rookie astronauts from earlier groups, it was expected that at least some of these men would still be available to crew the first few test flights to qualify the system for operational missions. In addition, past experience allowed officials at Houston to realize that there was no immediate need to employ a new group of astronauts at this point, as a long wait for a flight opportunity would diminish their enthusiasm. The precedent was the departure of several of the Scientist-Astronauts from the 1965 and 1967 selections before they had flown a mission. There was also the limitation of training equipment to be considered and indeed the lack of a defined training program, which was still under development. Added to this was concern that over-training and maintaining proficiency would be detrimental if a new group was selected too soon and was forced to wait for years before achieving their first space flight.

Therefore, it was announced in June 1973 that the new selection would not take place for five years (1978), when the opportunity for them to fly the Shuttle was expected to be much closer. In the meantime, the current astronauts would be employed filling roles in support of the design, development and testing of the Shuttle hardware and procedures (see below). Dr. Fletcher, commenting on these discussions, said that NASA had no problem in recruiting, but now was not the time, and that serious consideration would be given to recruiting female and minority astronauts in the future. **[15]**

A few months later, in October 1973, timely results from a five-week experiment held at Ames Research Center, Moffett Field, California, designed to determine female qualifications for space flight, unsurprisingly found that women were as physically fit for weightless flights as men. Eight Air Force nurses had endured two weeks of total bed rest and their post-test results were comparable to those of male volunteers. It represented a step in the right direction for the future. **[16]**

The following month, the latest ongoing efforts to define the activities that a Shuttle crew might be expected to be involved with during the orbital phases was uncovered in another memo (later researched by the authors). This was the result of ongoing in-house studies at JSC and revealed how complex the topic had become when compared to the memo of March 1972, just 20 months previously. **[17]** In this memo, the crew complement was stated to be directly influenced by the complexity of the Shuttle missions, the types and numbers of payloads flown, the skills of the crewmembers, and the proposed duty cycle. In reviewing the progress to date, the memo stated that "crew cross-training will most likely be mission dependent." The attached matrix (see Table 2.2) of crew functions circa 1973 showed a level of cross-training. The document was recommended to be used for planning purposes, but with the caution that "as the Shuttle and payload designs mature, and the subsystems and operational criteria/constraints evolve, it is expected that this matrix will be updated," as it inevitably was… several times.

Over the following months, the staff at JSC continued to review and revise plans concerning a new group of astronauts. The emphasis at this time was, logically, for Pilot astronaut candidates, as mastering flying and landing the vehicle was prioritized in the objectives of the Approach and Landing Test (ALT) and OFT programs. As with Apollo, it seemed that science would have to wait until the

Table 2.2: SPACE SHUTTLE OPERATIONS CREW FUNCTION MATRIX

	Shuttle Flight Operations											Manipulator Operations				Rendezvous/ docking operations				
Flight personnel	Flight dynamics - aero	Flight dynamics - space	Rendezvous/station keeping	Guidance, navigation, control	Shuttle system management	Safety of flight monitor/control	Emergency procedures	Flight procedures	Mission flight plan	Shuttle consumables management	Network communications	Payload bay doors	Payload restraints	Manipulator controls	CCTV/direct viewing	Orbiter attitude/translation control	Docking target/COAS	docking systems controls	Direct viewing	Monitor/control rendezvous sensors
Commander	P	P	P	P	P	P	P	P	P	P	P	B	B	B	B	P	P	P	P	P
Pilot	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	B	B	B	B	B
Mission specialist	S	S	S	S	S	S	P	F	S	F	S	S	B	S	S	F	-	-	S	S
Payload specialist	-	-	-	-	-	S	P	F	S	F	S	-	F	-	F	-	-	-	F	-

(continued)

Table 2.2: (CONTINUED)

Flight personnel	Orbiter/ payload interface				Payload operations								Habitability			
	Interface support & consumables management	Safety of flight c&w/control	Communications management	Subsystem maintenance/repair	Payload operations & monitoring	Experiment annunciation, monitoring & control	Experiment senor maintenance/repair	Payload data management	Activity scheduling	Autonomous payload consumables management	EVA/IVA	Vehicle attitude control	Food preparation and cleanup	Equipment stowage/unstowage	Waste management	Sleep and exercise
Commander	S	P	S	F	F	S	F	F	S	F	S	P	P	P	P	P
Pilot	B	P	B	F	S	S	F	F	S	S	P	P	P	P	P	P
Mission specialist	P	P	P	P	B	B	B	B	P	P	P	B	P	P	P	P
Payload specialist	S	S	S	B	P	P	P	P	B	P	F	F	P	P	P	P

Key:
PARTICPATION
P Prime,
B Back Up,
S Support,
F Familiarization

ORBITER UPPER FLIGHT DECK STATIONS
• Forward
- Flight operations
• Aft Area of Upper Flight Deck
- Orbiter/Payload Operations
- Payload Operations
- Rendezvous/Docking/Manipulator

REF: NASA-S-73-3208; -3209 & -3210 dated June 11, 1973

test program was completed and the orbital vehicle was certified to fly. As test pilots had the most appropriate skills for that task, the priority was to define new Pilot astronaut selection requirements, focusing more on operational experience rather than test piloting skills and on devising a suitable training program to address that change and requirements.

By 1974, the Shuttle design had been decided upon. Gone were the huge fly-back booster and the liquid-fueled rocket boosters that replaced it. Also gone were hopes of using the Shuttle to construct and supply a large, 50-crew space station. Instead, more modest plans were being designed for the Shuttle; to deploy and repair satellites, dispatch space probes across the solar system, conduct short science missions in a pressurized laboratory in the cavernous payload bay, support the interests of national security in a series of secret missions for the U.S. Department of Defense (DOD), and in using the transportation system, its components and resources, to promote the benefits of developing new commercial ventures in space. To attain these bold, far-reaching plans, the 'Shuttle' vehicle now consisted of the reusable delta-winged Orbiter, launched by means of a (one-flight) External Tank (ET) fueling three exchangeable main engines on the Orbiter, and assisted by twin recoverable Solid Rocket Boosters (SRB). This design was a far cry from the originally envisaged grand plan of the Space Task Group just five years previously, but would still require a new class of astronauts to fly and operate it.

A status report update

In the spring of 1974, the Committee on Science and Astronautics released a new status report, featuring briefings from various NASA field centers and primary Shuttle contractors on the state of Apollo-Soyuz, the planned (and subsequently abandoned) Space Tug and the Space Shuttle. With the final Skylab mission recently recovered after a record 84 days in space, progress toward the joint flight with the Soviets underlined that this would be the final time Americans would venture into orbit until the advent of the Shuttle. Progress in the Shuttle program was presented in the report and a lot had changed in two years, most notably the reduction in the overall weight of the Orbiter. The former 170,000 lbs. (77,112 kg) dry weight was now revised to 150,000 lbs. (68,040 kg) thanks to a 40-point weight reduction program. This included taking 24 inches (60.9 cm) out of the crew compartment, and moving the EVA airlock into the crew compartment as the central payload bay area was reduced by 14 inches (36 cm). Just one RMS (the Shuttle's Canadian-built Remote Manipulator System robotic arm) was planned instead of the original two, now moved to the port longeron (left side) but with provision to add the second on the opposite longeron if required (which it never was). These seemingly small adjustments affected the internal volume inside the crew module and the facilities provided for the crew.

Aaron Cohen, NASA's Orbiter Project Office Manager, explained to the Committee that "the Orbiter cabin arrangement is well defined. In fact… we've got a group of people out at Rockwell to freeze the design on the Orbiter display

and flight control for the Pilot station and the Payload Specialist station." In the accompanying presentation diagram (dated 1973), the four seats on the flight deck illustrated the aft starboard MS workstation, the central docking station and the payload monitoring station. There were provisions for up to six seats on the mid-deck, to accommodate the maximum of ten crewmembers (only for emergency/space rescue modes). Interestingly, in a later briefing, the labeling of a similar diagram identified the CDR seat in the front left (port) position, the PLT at front starboard (right), an MS seat at aft starboard (behind the PLT) and a 'Payload Monitor' in the central seat behind and between the CDR and PLT (which, from STS-5 in 1982 through to the end of the program in 2011, would be assigned to the MS-2/FE).

The overall mass of a payload is always a major consideration in trying to launch anything into space, or indeed return it to the ground, with weight reduction programs featuring in the development of every spacecraft over the years and continuing to this day. Payload mass therefore has a direct influence on the crew complement flown. A standard Shuttle crew of four, together with their equipment and provisions for a flight of seven days, on average, was a significant contribution to this mass. The addition of more crewmembers affected this calculation and had knock-on effects across other areas, most notably environmental control and life support. Consumables were baselined at 28 man-days total (4 crew x 7 days) but the storage areas were sized for 48 man-days, with allowance for a contingency mission extension capability built in while still remaining within the total launch mass capability and the vehicle's Center of Gravity (CofG) calculations for ascent and landing. As early as 1974, there were studies into longer missions. If a 30-day mission was flown, this would add a significant amount to the overall weight of consumables and the volume required in the payload bay for extra cryo-tank kits (which eventually became the Extended Duration Orbiter – EDO – package for missions of up to 17 days, flown for the first time in 1992). The desire was to fly an average of seven persons for seven days on every mission to maximize the return, but the balance between achieving this and the limits of available power, consumables and capabilities was a factor in assessing payload manifests and assigning the suitable crew complement to support them. In addition to the difficulties of launching, flying and returning a mission into space**,** it was also expensive in terms of budget and manpower, so no mission would be flown for longer than necessary. **[18]**

On June 5, 1974, Dr. John E, Naugle, NASA's Deputy Associate Administrator, confirmed in a press briefing on the status of the transportation system in Washington D.C., that the construction of the first Orbiter was underway, the ALT remained on schedule for 1977 and that the first manned OFT was being planned for 1979. At the same briefing, Elwood W. Land Jr., of the Space Shuttle

Systems Office, stated that a core of about 25 active astronauts could be maintained (in training) to fly a proposed rate of *one orbital mission each week* [author italics].

The view from JSC

In September 1974, MSC Director Christopher C. Kraft wrote a letter to John F. Yardley, NASA Associate Administrator for Manned Spaceflight, stating that the feeling at JSC was that there were an adequate number of pilots available already in the Astronaut Office, based on current estimates (such as those mentioned by Naugle), who could cover prime and back-up crew assignments in the ALT and OFT programs, and probably for the first few operational missions. He added that the Center would *not* be actively seeking replacement pilots before 1982.

Experience from past selections in the 1960s had shown to the management at JSC that it took a *minimum* of 20 months between the first advert appearing in the press calling for new astronauts and one of the successful applicants actually flying in space. This suggested that the call for new pilot astronauts would not go out much before 1980, when there would be an estimated 20 positions open for new candidates. This figure was derived from estimated natural attrition rates of about two pilots each year and the (rather optimistic) expectation that by then *each* pilot would be flying no more than *six missions a year.* It was also assumed that back-up assignments would no longer be required following the OFT program, as there would be a sufficient pool of pilots available to step into a vacant crew position should the need arise. There was also the fact, largely overlooked in published accounts at the time, that the training system and resources would not be able to cope with duplicating the number of crew expected to be in training. The primary crew would therefore be priority, with a pool of suitability prepared crewmembers following generic, support and proficiency training until called upon to join a flight crew.

For the first Shuttle missions, Kraft believed that the unique stability and control demands on a Shuttle flight deck crew during launch, entry and the various abort profiles would require pilots with considerable flight test experience. As the program evolved and flight experience and maturity in the systems was demonstrated, then the strict piloting requirements could be relaxed for new astronaut selections, he thought, without impacting safety or heightening the risks. Kraft also expressed his desire to include the current Scientist-Astronauts (chosen in 1965 and 1967) as crewmembers on the early flights of the Shuttle, which was logical given their decade of involvement in the program and the range of developmental work many of them had accomplished. The four remaining members of

the 1965 selection had flown a single mission each, while all those still active from the 1967 class were still awaiting their first mission, though all had passed a USAF jet pilot course prior to acceptance into the team and had maintained their proficiencies in the years since. Despite this, Kraft informed Yardley that studies at JSC assumed that the Scientist-Astronauts would be assigned as MS on the Shuttle, rather than as pilots.

This is a contentious issue. As qualified jet pilots with (at the time) nearly a decade of experience in flying jets with NASA, it could be argued that their assignment as a Shuttle PLT would be an option, perhaps on a dedicated science mission, but it was not to be. Despite the fact that Scientist-Astronaut Story Musgrave would eventually log more flight time in the T-38 than any of his pilot colleagues, not one MS (Scientist-Astronaut or otherwise) flew as PLT or CDR on a Shuttle mission. By contrast, two of the 1978 pilot astronauts (Griggs as MS-1 on STS-51D and Nagel as MS-2 on STS-51G) flew as MS on their first space flights. Unfortunately, Griggs was killed before he could make a second space flight, but Nagel progressed to the PLT and CDR seats on his next two missions. Whatever the reasons – and astro-politics certainly played a part – pilots retained the command of the Shuttle flight deck until the end of the Space Shuttle program in 2011. Some MS were eventually assigned as commanders from the 1990s, but for the payload not the vehicle. Subsequently on the International Space Station (ISS), non-pilot astronauts would take command of long expeditions on that facility, though not of the vehicles which carried them to or from the station.

In 1974, Chris Kraft at JSC was very clear about the future direction that NASA should take in selecting new pilot astronauts. They needed to be highly motivated and personally dedicated individuals, while the missions offered should be challenging but safe. It was important to keep the time gap between selection and flight relatively short, and if NASA did this then retaining pilots would not be a problem. Kraft informed Yardley that he would review and update this assessment annually. In the meantime, a definite plan for future crewing would be created by March 1975 that included a detailed review of the currently-proposed role of both the PLT and the MS on a Shuttle crew, as well as the criteria to be used in selecting these personnel, the training methods and requirements to prepare them for Space Shuttle flights, and the staff levels required to support the first three years of (orbital) flight operations.

This was the first detailed planning to include the MS. In reply, Deputy Administrator George Low expressed his concern that the emphasis had been mainly on the pilots, stating "I think an even more important subject is the acquisition of scientists and others who will fly the Shuttle, *but not as pilots* [author italics]."

Fig. 2.10: A collection of artist's impressions highlighting the variety and scope of missions the Shuttle program was planning to fulfill.

Scientist-Astronaut's role

On November 18, 1974, NASA asked the Space Program Advisory Council (SPAC) to study the role that Scientist-Astronauts could fulfill within the Shuttle program. As a number of them were already heavily involved in the development of Spacelab-type missions, experiments and procedures, the advice from the Council only underlined the importance of their early involvement. It was highly recommended that the current Scientist-Astronauts could be a valuable asset in the development and execution of experiment and payload integration issues, for Spacelab-type missions, between the Principle Investigators (PI) and the Astronaut Office. It was also suggested that they could serve as the primary experiment operator for dedicated Spacelab missions. **[19]** At this time, the on-going debate remained about what to term the non-pilot crewmembers on a Shuttle mission. From the ground-based Spacelab simulations, the term "Experiment Operator" was coined, which evolved over the next few years into the more defined roles fulfilled by the MS and PS.

In a response to the SPAC findings, Louis C. Haughney, Geophysics Program Manager of the Airborne Science Office at NASA Ames, suggested drawing upon the broad experience of the Scientist-Astronauts, feeling that it would be worthwhile considering them as managers for the Spacelab flights and assigning them early in the planning process[6]. Then, when the flight was manifested, the Scientist-Astronaut could become a full time manager of that mission, working in close cooperation with the other MS assigned to the flight crew. During the mission, the 'senior' Scientist-Astronaut could serve as an on-orbit flight director responsible for all Spacelab systems relating to the experiment package, working with a back-up Scientist-Astronaut assigned as Assistant Mission Manager who would coordinate ground activities. Though this was not exactly the way things turned out, it did create the concept of a science crew working the payload and scientific objectives and an Orbiter crew handling the Space Shuttle systems. During the 1970s, the designation of Senior Scientist-Astronaut was commonly used until they merged into the collective MS designation and role. A decade and a half later, in January 1990, these ideas evolved into the role of Payload Commander (PC), with members of the Thirty-Five New Guys (TFNG) becoming the first assigned to this role. In 2002, NASA introduced the designation of NASA Science Officer onboard the ISS, to coordinate research primarily on the U.S. segment. **[20]**

The future crewing plan

By March 1975 this plan was in place, but with recommendations to expand the next selection to encompass applications from a wider field of experience than those first considered. This included JSC employees with initiative and ambition, even if they had no flying skills or had not scientifically qualified through the National Academy of Science (NAS). The plan supported the idea that there was no immediate urgency in selecting a new group, but reasoned that within the next ten years many of the current astronauts in the office would have turned 50 and would probably be looking to retire.

It is clear that the process to define the criteria needed for a new group was painfully slow, but it had to be. From the start, deciding to broaden the criteria to enable a much wider segment of the U.S. population to apply meant that those selected would require an extensive – and thereby longer – training

[6] An in-depth background to the participation during the 1970s of the Scientist-Astronauts in the simulated ground and airborne Spacelab development 'missions' is covered by the authors in their 2007 title **NASA's Scientist-Astronauts** [pp. 283–331]. While connected to the development of Shuttle MS, this falls outside the scope of this current work.

program based at JSC Houston in order to attain the suitable qualifications required to fly. It was hoped that this new, positive, flexible approach to the selection criteria would encourage minority and female candidates to apply, though there was no guarantee of this. As authors Atkinson and Shafritz noted in their 1985 book: "This concept was compatible with the idea of permitting current NASA personnel who were not astronauts to enter the program," and that, "some of those selected might never reach flight readiness, but the training, evaluation and counseling could minimize this risk, unless a candidate simply lost interest or decided that an alternative career would be more personally beneficial." **[21]**

One of the most debated items in establishing the selection criteria was the minimum educational qualifications for the MS; that of a doctorate or equivalent in engineering, life or physical sciences or mathematics. This was seen not as a barrier to candidates, but as a way of refining the number of applicants to make the whole system more manageable, as well as the fact that such applicants would have several years of academic and practical (teaching) experience behind them. Chris Kraft thought that not requesting an advanced degree would be a mistake. JSC desired a doctorate, while Headquarters suggested a minimum of a BSc degree. Kraft wrote on March 12, 1976 that if an advanced degree was not stipulated, then "In my opinion… the number of people that will apply will be almost impossible to deal with."

The original selection plan

It was quickly realized that the selection would be an intensive program on several levels over a considerable period of time, but if necessary could begin as early as June 1975. After allowing three months to file applications, the screening of those applications could begin in the fall of 1975. After a series of medicals, further interviews, and security and background checks, the announcement of a new group of astronauts could be made by the first or second quarter of 1976. Expecting an intake of 20–25 pilot and MS candidates, it was envisaged at the time that the candidates would arrive at JSC in the summer of 1976 and then begin a program designed to enhance their qualifications over a period of *three to six years*. In the period after training, the Ascans could either be reassigned to different NASA field centers to gain an insight into other branches of NASA, be allowed study for higher academic qualifications, or work in different branches at JSC, such as Mission Control or Aircraft Operations. Then, depending on attrition rates among the veteran astronaut and the individual progress of each Ascan, the candidates would be phased back into the program as fully qualified (but unflown) astronauts. NASA also revealed at this time that the intention was to continue subsequent astronaut selection programs at regular intervals.

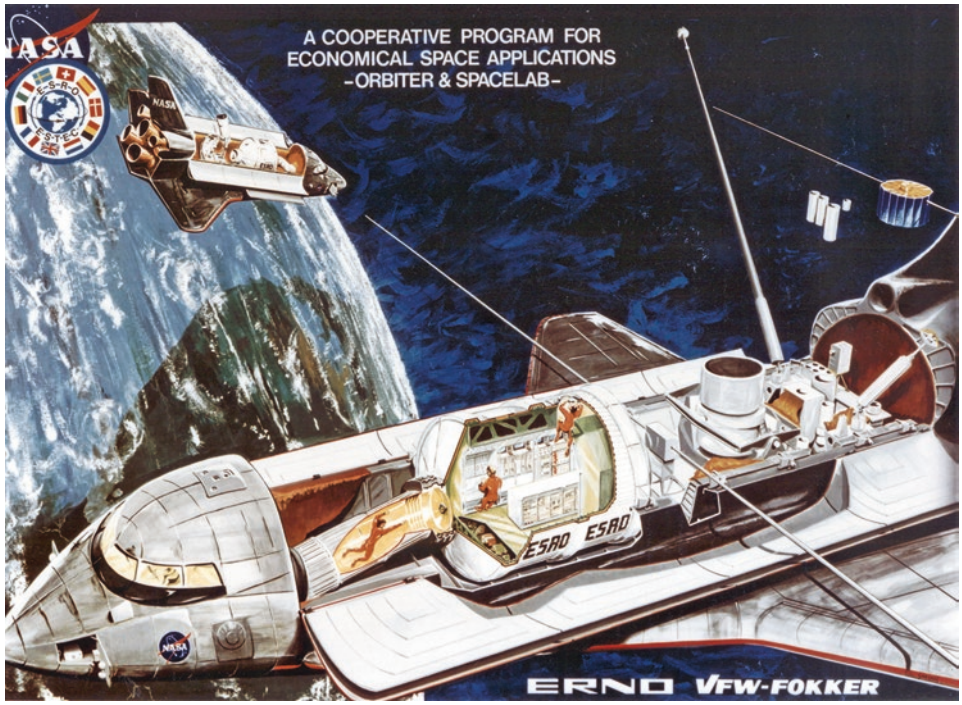

Fig. 2.11: A cooperative venture with the Europeans resulted in Spacelab, and the opportunity to fly invited Payload Specialists and passenger/observers into orbit alongside the NASA career astronauts.

Reality hits home

This was all fine on paper and in planning documents, but difficulties in developing the Shuttle pushed the first flight back several times. As a result, JSC was not that enthusiastic about bringing in another group of scientists to train as astronauts while many of those selected a decade earlier were still waiting for their first flights. In addition to the very evident technical and hardware issues facing the program, NASA also had to answer public feedback from minority groups and Congress. But it took time. The plan to select the pilots took two years and the plan for the MS took another year, to the end of 1975. On top of this, the specific provisions for female and minority applicants were not finalized until early 1976.

Finally, in March of that year, a definitive plan emerged to recruit a new group of astronauts and the Group 8 Astronaut Selection Board was created. It consisted of senior management, scientific and pilot personnel from JSC, together with Dr. James H. Trainor from Goddard Space Flight Center as a scientist representing the scientific community. The board held their first meeting on March 24, 1976.

In the spring of 1976, it was felt that the Astronaut Office and the Science and Applications Branch should participate in the forthcoming ASSESS II airborne mission to define the function and role of the MS. **[22]**. Maintaining that the MS should be "professionally knowledgeable in the prime discipline of the mission to which he was assigned," the Science and Application Branch saw the role as "in-flight integration of experimental objectives and overall for the successful completion of the experiment mission objectives and to reduce training loads."

On March 3, 1976, the *Chicago Tribune* reported a *Baltimore Sun* article that NASA was formally about to announce the acceptance of women into the astronaut corps that July. Though the 'exact' number of new astronauts was not disclosed, the prediction was fairly accurate in stating that women would "form part of a group of 15 Mission Specialists." A program of screening, evaluation and physical examination would be completed within the next year, and the candidates chosen by the end of 1977, to start training in July 1978 and expected to be operational by 1980. **[23]**

Following a three-day meeting between NASA and ESA officials two months prior to issuing the call for Space Shuttle astronaut candidates, John F. Yardley, Assistant Administrator for Manned Spaceflight, informed the press at a Paris news conference on May 15, 1976, that current Shuttle planning envisaged 200 missions in the project, some of which would take three NASA and four European crewmembers on space science missions lasting between a week and a month. He reported that in addition to the 30 astronauts available for the program, the agency would soon select 30 more, including women. Strangely, he also suggested that participants might be selected from the USSR, although no such offer had been indicated or planned for. The schedule at the time envisaged 600 Shuttle missions over a 12-year period from 1980, with a fleet of five Orbiters flying 60 missions each year. A three-person NASA crew would consist of CDR, PLT and an MS, together with up to four PS. The PS could expect to fly one or two missions, but NASA career astronauts could be expected to fly up to 20 or 30 times in their career. **[24]** Two months later, on July 8, NASA issued its call for 15 pilots and 15 MS, to be selected by the end of 1977.

On May 20, 1976, Eugene Kranz, the Deputy Director of Flight Crew Operations, wrote a memo addressed to a number of JSC directorates concerning a recent ASSESS and Shuttle planning meeting held at NASA HQ in Washington D.C. Kranz voiced his frustration at the deep-rooted disputes between field centers regarding science and engineering objectives on the Shuttle program, which had carried over from the Apollo program. "Again, history is repeating itself," he wrote, especially referring to the question of science objectives on the engineering test flights under the OFT program, intended to establish the data that proved the Shuttle system worked as designed *before* committing major scientific payloads or programs to the flights. Kranz was at the receiving end of some flak for this approach in stating that science working groups had "never satisfied the need to be

involved" in the preparation of what he termed "a real mission." It was becoming clear, at least for the Astronaut Office, that crew assignments for the first missions under the OFT program would be filled by veteran pilots from the earlier groups. Noting that the exact role of the MS was still in debate, Kranz stated that "the Mission Specialist job description and functions are not recognized by some branches of NASA, and even some of the personnel at the Office of Space Flight are unclear as to the intent in this area." He also suggested that more work was required in this area across the agency, which was interesting as NASA began advertising for its first group of Shuttle astronauts to train as MS just a couple of months later.

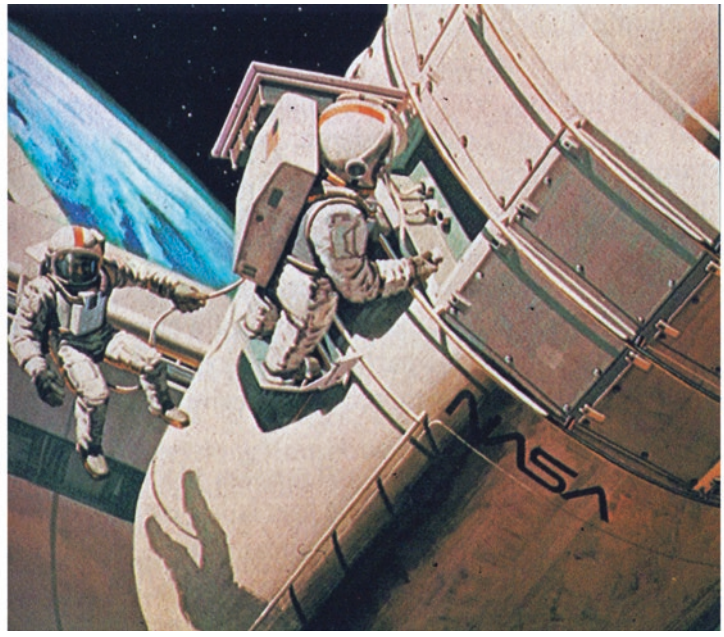

Fig. 2.12: Satellite servicing and maintenance was a major factor in promoting the benefits of the Space Shuttle system. Together with system reusability, a balance of national defense missions, exclusive scientific research and developing commercial opportunities were all highlighted as program priorities.

But how many?

Funding was one issue that required consideration before requesting new astronauts, both in terms of training costs and whether the funds and facilities were in place to support the process, despite the fact that the Shuttle was still some years from launch. Balancing the administrative plans and budgets against the reality was

a fine line and a delicate issue. There were many questions to be answered: How many astronauts would be required? What would be the most productive balance between current astronauts and new candidates? When would the systems and facilities be in place to support the training? And for how long could veteran and new astronauts be expected to remain active? This last point would be an important factor when timing the new Ascan selection and training programs to replace departing astronauts without affecting the crewing roster or flight schedule.

One question which had to be addressed before deciding on the number of new astronauts to select was to determine how many of the veteran astronauts had chosen to remain to support the early flights. In addition, there were four astronauts not directly working in the Astronaut Office but on special assignment elsewhere, who had been assured that they could return to active flight training should they desire it and advised that training would commence for the OFT in 1977. These four, all detailed to Washington D.C., were Joseph P. Allen (unflown Group 6 Scientist-Astronaut), who was Assistant Administrator for Legislative Affairs at NASA Headquarters; William A. Anders (Group 3 pilot astronaut; LMP Apollo 8), currently serving as Chairman, Nuclear Regulatory Commission; Russell L. Schweickart (Group 3 pilot astronaut; LMP Apollo 9), serving as Director, User Affairs, Office of Applications, NASA HQ; and John L. Swigert (Group 5 pilot astronaut; CMP Apollo 13), who was on the Committee on Science and Astronauts, U.S. House of Representatives. In June 1976, James Fletcher wrote to each of them advising that a new recruitment drive would be announced the following month, and that he needed to know if they planned to return to NASA and the Astronaut Office. Each was eligible for assignment on OFT, but needed to advise the administration by July 1, 1977 as to whether they would be returning to the Astronaut Office in January 1978. These four did not have a significant impact on the selection of the 1978 group, with only Joe Allen electing to return and the other three formally withdrawing from the astronaut program in the interim, as did former Skylab 4 Commander Jerry Carr and Apollo 17 CMP Ron Evans.

Following a paper trail

There are scores of documents, memos, charts and plans filed in the STS archive boxes at the JSC History Office, and we have sampled just a few to illustrate how crew definitions, roles and requirements evolved many times during the years leading up to the first Shuttle flights. Even some of those produced as late as 1980 forecast that *when* shuttle flights exceeded 20 missions per year (which it would never come close to in its 30-year history), the core 'three-person crew' teams (CDR, PLT, MS) would be recycled intact within a year to make the most of the training process. If this plan had come to fruition, the manifests of 22 missions annually would have required at least 11 four-person crews, or 44 individual astronauts, in training *each year*. Clearly, had this occurred, it would have been a massive undertaking that would have been challenging to maintain and would have

placed enormous strain on resources and capabilities. Reading these documents with the benefit of hindsight, their necessity for minimum and maximum long-term planning is obvious, but with the real-time difficulties encountered during the 30-year program, even overlooking the two tragic accidents with *Challenger* and *Columbia*, it is difficult to see how the program could ever have sustained this rate, even in the best-case scenarios without any setbacks, failures or delays. These plans are useful for reference, in understanding how things changed as new documents superseded the previous versions, and how different the actual program became during its lifetime.

The 1980 planning forecasts would later be used to justify the selection of a further (ninth) astronaut group later in 1980, and annually after that. This was well before any of the TFNG had been assigned to their first mission or ventured anywhere near a Shuttle on the launch pad.

PIONEERING SPACE SHUTTLE ASTRONAUT ASSIGNMENTS (1969–1980s)

Before we review the backgrounds of the 1978 selection and discuss their early assignments in more detail, we summarize here the support assignments held by 'veteran' astronauts of previous selections who, over more than a decade, pioneered and refined the training and crew duties assigned to the new astronauts once their Ascan program had been completed. The TFNG may have been the pioneers of the Ascan training program and fulfilled early ground support roles for the first Shuttle mission, but their path was made much easier by the dedicated work of some of NASA's 'original' astronauts, many of whom would never get the opportunity to fly on the vehicle they had worked so hard to make a reality.

To remain or to depart?

In the spring of 1972, the Space Shuttle had become a realistic proposition. Apollo had landed men on the Moon five times and was about to end the program with its sixth landing mission. Many of the 'veteran' astronauts who had flown the earlier missions on Mercury, Gemini and Apollo to attain this success had long since retired, or were planning to do so very soon. The trio of three-man Skylab crews had been announced in January of that year and were in training, and with just a single, joint docking mission with the Soviets in 1975 on the manifest, but not yet crewed, the short-term flight opportunities were zero.

As the search for new astronauts began a year after ASTP, the hope was still to orbit the Shuttle by 1978 or 1979 at the latest, but difficulties in developing the new technology and hardware, especially the three main engines, pushed this into the early 1980s. By then, most of the astronauts who had been selected during the first decade of NASA had long gone, frustrated by such a long wait for a flight

seat, unwilling to endure months of training and simulations, or expressing a desire to pursue new challenges. The size of the NASA astronaut corps was significantly diminished. For some, after flying to the Moon, a seat on the Shuttle could never replace the magic of that lunar trip. For others, any space flight was a *good* one as long as things went well, and so they decided to stick it out and wait for a seat on the Shuttle. However, the limited availability of astronauts to crew the expected increase in missions after the test program, and the ever-aging original population of astronauts, meant that NASA needed to instigate a wider search to bring in a new generation of astronauts.

Over a decade had passed since the last selection of astronauts by NASA in 1967. It had been nearly two decades since the first group of seven had been chosen, and a decade since seven transferred from the cancelled USAF Manned Orbiting Laboratory (MOL). When the Group 8 candidates arrived at JSC in January 1978, there were very few of the original 73 astronauts left from the first seven groups chosen between April 1959 and August 1969. It was also a very different NASA. The work may not have made the headlines, but since 1969 a cadre of astronauts had fulfilled a variety of important, often mundane roles in the early development of the Shuttle vehicle, systems and procedures, helping to define the role of 'the astronaut' in the program. These included: evaluating the early designs of the controls, displays and equipment they intended to use during a mission; the roles they would employ in flying the vehicle; deploying and retrieving satellites; operating scientific equipment; performing EVA; and servicing satellites. Their work was significant in defining the criteria that would prepare Shuttle pilots or MS, or what should be expected from a PS or Observer. Often overlooked, these assignments were far reaching and are an integral part of the story of Group 8 and beyond, thanks to their input and participation in Shuttle support roles years before the Shuttle became a reality. It is a similar story today, as current astronauts participate in simulations of lunar and Martian missions and crew activities, train in extreme environments and offer their experience to mission development and for future flights they will never participate in.

Some of the veterans from the early selections, who remained at JSC long enough to see the creation of a Shuttle branch of the Astronaut Office and the start of vehicle development and testing, occupied managerial rather than flight positions. From the original Group 1 selection (1959 Mercury astronauts), **Donald K. 'Deke' Slayton** flew on the 1975 ASTP docking mission after having been medically grounded for 16 years, then went on to serve as manager of the ALT and OFT programs between 1975 and 1982. Only one member of the second selection in 1962 remained in the Office. Gemini and Apollo veteran **John W**. **Young** had assumed the role of Chief Astronaut from Alan Shepard after America's first astronaut had retired in 1974. Young would remain in that position for the next 13 years, taking breaks only to train for his two Shuttle missions, before assuming an administrative role until leaving NASA in 2004. Two astronauts from the third selection

in 1963 remained at NASA during the late 1970s. Apollo and Skylab commander **Alan L. Bean** had focused on Shuttle training issues since 1975 and subsequently served as Chief Astronaut in Young's absence while he flew STS-1. Bean was the Group 8 and 9 training supervisor prior to retiring from the program in 1981 to pursue a career in painting. Gemini and Apollo veteran **David R. Scott** had left the Astronaut Office in 1972 but was subsequently appointed Director of Dryden Flight Research Center in California during the ALT program, finally resigning from NASA shortly after that series of flights had been completed in October 1977.

From the late 1960s, many of the active astronauts who were between crew assignments, or at the end of their astronaut careers, were assigned to the Space Shuttle Program Office. On October 17, 1969, *MSC Roundup* reported that Mercury and Gemini astronaut **L. Gordon Cooper** had been named as Assistant for the Shuttle Program Flight Crew Operations Directorate (FCOD) at MSC. In this position, he was responsible for the flight crew training program, astronaut input into the design and engineering, and was the directorate representative in hardware development and tests of the Space Shuttle, though it is doubtful if his heart was really in his new assignment. Officially still active, he lost the command of an Apollo lunar mission to fellow Mercury astronaut Alan Shepard and elected to leave the agency in July 1970. Gemini and Apollo astronaut **Edwin E. 'Buzz' Aldrin** worked on defining the early designs of the Shuttle as part of "theoretical committees for a manned booster," an idea he rejected. Another Gemini and Apollo veteran, **Richard F. Gordon**, who had lost his own Apollo lunar mission due to budget cuts, became Chief of Advanced Programs in August 1971, working on the design and development of the Shuttle until he left the agency in January the following year. In November 1976, Apollo 9 astronaut **Russell L. Schweickart** worked as Assistant for Payload Operations in the Office of Planning and Program Integration, Space Shuttle Office at JSC, where he helped define polices for Shuttle payload operations until he decided to leave the agency in the summer of 1977.

Several astronauts of the fifth (1966) pilot selection worked on a variety of early Shuttle development issues in one form or another. Between November 1975 and March 1978, former ASTP crewmember **Vance D. Brand** worked on mission planning and studied the entry phase of the Orbiter for OFT, for which he was assigned in 1978. Skylab 4 commander **Gerald P. Carr** was Head of the Shuttle Design Support Group at JSC from May 1974 until leaving NASA in 1977. He worked on payload support (mission phase), crew station hardware, RMS development and evaluation of emergency egress procedures. In 1973, Apollo 16 LMP **Charles M. Duke** was assigned as a Technical Assistant to the Manager for Shuttle Orbiter Integration, and later as Deputy Manager for Advance Planning STS. As he explained in his 1990 autobiography *Moonwalker,* these were mostly paperwork assignments combined with a lot of meetings. Former X-15 pilot **Joe H. Engle** was assigned to the Shuttle Program Office in 1971, shortly after losing the Apollo 17 LMP position to geologist Jack Schmitt. He became involved with

mission phase control and display hardware, and served as a liaison for the Shuttle Training Aircraft (STA). He also worked hard on the preparations for test flying the Orbiter in ALT, for which he was selected in 1976. Apollo 17 astronaut **Ronald E. Evans** joined the Astronaut Office Shuttle Development Branch in July 1975 and became responsible for operational aspects of the OFT Ascent Phase. Apollo 13 LMP **Fred W. Haise** joined the Shuttle Development Branch in April 1973 as Technical Assistant to the Manager of the Shuttle Orbiter Project, working towards a test flight assignment on ALT in 1976. **Don L. Lind** was busy with Shuttle development assignments during 1974 and 1975. After a one-year sabbatical, he returned to JSC in the fall of 1976 and was assigned to the Operational Mission Development Group responsible for the development of payloads for OFT and early operational missions.

Skylab 3 astronaut **Jack R. Lousma** worked on Shuttle Development from July 1975 until 1978, assigned to cockpit layout issues in the design support team prior to being named to the OFT training group. Apollo 16 CMP **Thomas Kenneth 'Ken' Mattingly II** joined the Shuttle project in 1973 and was assigned a variety of roles, including Head of the Operation and Engineering Support Group until 1978. He then became the Technical Assistant to the Manager of OFT (Deke Slayton) and also worked on Extravehicular Mobility Unit (EMU) issues for several years. **Bruce McCandless** was instrumental in the development of the Shuttle Manned Maneuvering Unit (MMU), following on from his work on the Skylab demonstration astronaut maneuvering unit in 1973. He also worked on developing EVA equipment and procedures, the prelaunch and ascent phases, in developing crew input for the Inertial Upper Stage (IUS), and in evaluating servicing methods and procedures for the Large (later Hubble) Space Telescope. Skylab 4 pilot **William R. Pogue** worked on Shuttle development from June 1974, on the launch and abort mission phase and the pilots' handbook, until he left the agency in 1975, returning for short time in 1977. One of his lasting commitments, before leaving again in 1978, was to argue in favor of keeping the new Ascans in the Astronaut Office rather than, as he wrote in 2011, having them "farmed out" to different NASA field centers to gain experience while awaiting their first crew assignments. Apollo 14 CMP **Stuart A. Roosa** worked on crew training issues from January 1973 until leaving the agency in 1976. Apollo 13 CMP **Jack L. Swigert** had an early Shuttle assignment in 1971, using the Lockheed simulator for "flying and landing" a delta-shaped lifting-body Shuttle configuration, along with Group 7 astronauts Gordon Fullerton, Hank Hartsfield, and Don Peterson, before leaving the Astronaut Office in 1973 and NASA altogether four years later. Apollo 15 CMP **Alfred M. Worden** was also briefly assigned to Shuttle development issues at JSC from May 1972 until he transferred to NASA Ames in California in August that year, where he put his test pilot and astronaut experiences to good use including on various Space Shuttle vehicle simulations. Finally from this group, Skylab 2 pilot **Paul J. Weitz** worked on crew station design hardware and Earth resources

issues, as well as completing underwater zero-g simulations of contingency EVAs related to forthcoming Spacelab missions. He also became technical coordinator, Shuttle Support Office and remained active long enough to command an early Shuttle mission.

Of the remaining active members of the 1965 Scientist-Astronaut selection, Skylab 4 science pilot **Edward G. Gibson** had originally left NASA after his Skylab mission in 1974 and worked as consultant for ERNO West Germany on Spacelab development between 1976 and 1977. He returned to NASA as Chief of MS Selection and Trainer for the 1978 Group, and served as a member of the 1978 selection board. He was assigned as the ascent Capcom for STS-1 and in line for an early flight as an MS, but resigned for a second time in 1980. Skylab 2 science pilot **Dr. Joseph P. Kerwin** worked on Shuttle crew station design, controls and medical monitoring from 1974. He took part in the selection of the new MS in 1977 and as their first training supervisor in 1978. He then worked on planning operational missions, including the role of the astronaut in rendezvous, satellite deployment and retrieval, and RMS operations.

Several members of the second Scientist-Astronaut selection chosen in 1967 were still at JSC a decade after their selection, all unflown. Many fulfilled a number of key roles in Shuttle development while awaiting their first space flight on the Shuttle. **Joseph P. Allen** was nominated as a candidate for airborne simulation of Spacelab missions (ASSESS) and worked on Spacelab development, and payload support crew station controls and displays for the physical sciences. **Anthony W. England** returned to the Astronaut Office in 1979 after a seven-year absence and was assigned to the Operations Mission Development Group, working in hardware and experiments for the Spacelab 2 mission. He also worked on developing the Shuttle computers and software. **Karl G. Henize** was first assigned to Shuttle development issues in 1974. His assignments included participation in ASSESS simulations, Shuttle-borne astronomy payloads, payload support and handling, and assisting in the development of crew station controls and displays for physical sciences. His work on the Spacelab 2 payload had begun in 1977. **William B. Lenoir** worked in Shuttle development from 1974 on payload crew station controls and displays for the physical sciences, payload deployment and retrieval systems and procedures, development of the Extravehicular Mobility Unit (EMU) and Portable Life Support System (PLSS), and supporting the OFT series. He also worked on Powersat studies, man's role in the remote sensing of the Earth, and trained on using the RMS. **F. Story Musgrave** also began Shuttle development work in 1974, in payload support crew stations controls and displays for the life sciences. He worked on the design and development of all Shuttle EVA-related equipment, including the PLSS airlock suits, toolkit and MMU. He participated in ground simulations of Spacelab missions, and early design and development work on the Shuttle Avionics Integration Laboratory (SAIL). **Robert A. Parker** became involved in early designs of Spacelab from 1973 and worked in the Payload

Operations Working Group, which involved meetings and negotiations between representatives of NASA and ESA. He also worked on payload support and crew sciences, served as chief Scientist-Astronaut, participated in an ASSESS flight and was a member of the MS selection board during 1977. **William E. Thornton** worked on Shuttle development from 1974, mainly in payload support crew stations controls and displays for life sciences. He completed Spacelab ground simulations and, realizing that his first space flight might be several years away, applied unsuccessfully for a seat as PS for Spacelab 1. He also worked on deployable payloads, but mainly became deeply involved in monitoring crew health on orbit, developing techniques and procedures to investigate those phenomena.

Of the seven transfers from MOL in 1969, **Karol J. Bobko** was assigned to development issues on the program almost as soon as he joined NASA. From 1975, he was assigned as support crew and alternate Capcom/chase pilot for ALT. He then worked on OFT preparation and mission definition issues and as lead astronaut, test and checkout at KSC, for the first launch of *Columbia*, defining the roles which became known as the Cape Crusaders. **Robert L. Crippen** was assigned to the Shuttle branch in 1975, where he worked on OFT mission phase hardware and software integration and became a lead in the Shuttle General Purpose Computer and OFT training. From 1973, **C. Gordon Fullerton** worked on development issues concerning recovery, mission phase and control and displays, prior to his assignment to ALT in 1976. **Henry W. Hartsfield** worked on flight control and simulation hardware in the Shuttle Development Office from February 1974 to April 1981. As a member of the OFT astronaut support group, he was involved in the development of entry flight control systems and associated interfaces. **Robert Overmyer** joined the ALT team after completing his support work on ASTP in the summer of 1975. He flew the first flight of the (converted Gulfstream) STA in October 1976 and alternated as Capcom and chase pilot during the 1977 ALT program. During 1979/1980, Overmyer served as the Deputy Orbiter Manager for OV-102 *Columbia* during its preparations and processing for the STS-1 flight. **Donald H. Peterson** was assigned to Orbiter systems, including mission phase, navigation, and communications and tracking hardware, as well as for Orbital Maneuvering System (OMS) or Reaction Control System (RCS) issues, from May 1972 until December 1981. In addition, he served as a member of the OFT Group (missions), responsible for engineering support, man/machine interface and safety assessment for the OFT program. Finally, **Richard H. Truly** was assigned to ALT duties immediately after completing his support work on ASTP in 1975.

Senior astronauts who also flew the Shuttle

A total of 23 astronauts from the earlier selections flew as MS, PLT or CDR in the first decade of Shuttle missions between April 1981 and December 1990, a decade in which all of the 1978 members flew at least their first Shuttle mission and many their second or third, bridging the gap between those eras.

No astronaut from the first selection (1959) remained active to participate in the early orbital missions, although John Glenn did return in 1998, aged 77, to fly one mission (STS-98) as a PS. From the second selection (1962), John Young would command the first mission in 1981 and the first Spacelab mission in 1983. No one from the 1963 selection flew on the Shuttle, and only one (Scientist-Astronaut Owen Garriott) from the fourth selection completed one mission, the first Spacelab flight in 1983.

From the fifth selection in 1966, seven astronauts flew on the Space Shuttle: Vance Brand (3 missions); Joe Engle (2 missions); Don Lind (1 mission); Jack Lousma (1 mission); Ken Mattingly (2 missions); Bruce McCandless (2 missions); and Paul Weitz (1 mission). Seven members of the second Scientist-Astronaut selection in 1967 (Group 6) also flew Shuttle missions: Joe Allen (2 missions); Tony England (1 mission); Karl Henize (1 mission); Bill Lenoir (1 mission); Story Musgrave (6 missions); Bob Parker (2 missions); and Bill Thornton (2 missions).

After losing the opportunity to fly on the USAF MOL program, all seven who transferred to NASA in 1969 went on to fly Shuttle missions: Karol Bobko (3 missions); Bob Crippen (4 missions); Gordon Fullerton (2 missions) Hank Hartsfield (3 missions); Bob Overmyer (2 missions); Don Peterson (1 mission); and Dick Truly (2 missions).

Passing the baton

These veteran astronauts lent their experience to very early Shuttle development issues, mainly from the early 1970s, as can be seen from the brief explanations of the varied roles they fulfilled over many years prior to the vehicle even flying in the atmosphere, let alone in orbit. Though the 1978 group were the first chosen specifically to train for and fly the Space Shuttle, almost a decade of work had already been completed in establishing the roles the crew would perform, input into the design and development of crew-related systems and procedures, and in identifying where further input was required.

When the 1978 candidates participated in the pristine syllabus of the newly-created Ascan training program over just 12 months instead of the expected two years, their individual capabilities were evident and reinforced the decision to select them in the first place. Following the completion of the Ascan program, and in part to further challenge and prepare them for space flight, the whole group were given various technical roles in support of the first orbital flight of the Shuttle. But this was by no means virgin territory. While many of the astronauts from the 1959–1969 selections who had forged the path from the design boards to the launch pad were now retired, their input, achievements and dedication made the transition from Ascan to astronaut much smoother for the TFNG. They would now participate in support roles in a rapidly developing program, just months prior to both the Shuttle's first flights into orbit, and also their own.

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