Flying Space Shuttle Missions

During my years as an active Space Shuttle Astronaut, which were during the first half of the Space Shuttle Program, I had the privilege and great personal pleasure to fly three Space Shuttle missions. Early in the Shuttle Program, missions were generally of short duration, starting out at three to five days in length, and increasing steadily to a week to 10 days in duration. Eventually some Shuttle missions grew in length to 17-18 days, after a "Long Duration Orbiter" package was developed which provided the consumables to extend mission length. Later, after some missions could rendezvous with the Russian Space Station "Mir", and eventually with the International Space Station (ISS), the Space Shuttle could power down on its consumption of its own consumables, and use power, atmosphere, and maneuvering done by what it was docked to. This provided extra duration, but still mission length was limited to durations of about 17-18 days for other reasons. One concept that usually came into play when mission durations were being discussed was how much time had passed since the Commander's last practice of the Shuttle approach and landing sequence. Ground personnel were reluctant to go much beyond the 18-20 day number for that discussion, but many of the pilots thought that a very basic Shuttle approach and landing simulation hosted on the flight computers could allow missions of 30-40 days, as long as the Shuttle could be a "parasite" on the ISS, and conserve on-board consumables for entry and landing. We did not win that argument (for various reasons), and therefore mission durations never got beyond 17-18 days, with more common lengths of 10-14 days, later in the Shuttle Program. My three missions early in the Shuttle Program were 3, 5, and 8 days duration, totaling 16 days in space. What a glorious time those 16 days were, providing memories that will last my lifetime. I will provide in this story chapter descriptions of some of those memories, as I describe some of the specifics of each mission.

MISSION: STS 51C

(First completely dedicated Department of Defense support mission)

Use NASA Archives to find basic STS 51C Information:

1. Access the NASA web site: www.nasa.gov
2. Highlight the "Missions" heading at the top of the page, select "All Missions A –Z"
3. Scroll down to "S" and select "Space Shuttle"
4. In the search box (upper right), type "STS-51C," and click "search" symbol
5. Select "NASA-STS-51C" in the search results

To view some pertinent photos from STS 51C, follow this procedure:

1. Access the NASA web site: www.nasa.gov
2. Highlight "Galleries" heading at the top of the page, then select "Image Galleries"

3. On the Image Galleries page, locate the box labeled “NASA Image Library.” Click on the link “NASA Images” at the bottom of the box

4. In the search box at the top of the NASA Image and Video Library page, type in STS-51C, select “Images” and “videos” (below the box), then click “search” symbol

Personal Comments for STS 51C:

Since this was a dedicated Department of Defense (DOD) mission, everything about the mission was classified at a very high level. And since STS 51C was the first of this type of DOD mission, NASA was pretty much not accustomed to handling the classification aspects of everything about the mission, from start to finish. NASA operates its missions normally in the most open and inclusive ways possible, with the objective being to make sure everyone involved knows everything about the mission, and that they share their knowledge with everyone else. But STS 51C was totally opposite that attitude in all respects, starting with initial briefs on what the mission was, all the required parameters for the conduct of the mission, all the training sessions we had, and of course all the operations during the mission. I could not tell anyone what the mission was, what we were doing, when, or anything about what our simulations were about. Everything about the mission was conducted in secure facilities, and there were certainly no press conferences announcing to the public what was going to happen. I could not even talk to my wife, Diane, nor my kids, about what the mission was, when we would launch, or when they would go to Florida to watch the launch! I almost thought that they thought I was not really getting ready to fly my first mission, especially when all the other Astronaut families they knew were free to talk about everything about the missions coming up. Anyway, it was a bit of a bummer for one’s first mission. Since it was my first mission, my crew position was as the Pilot, which is the term NASA used to note the right seat of the flight crew, which was the normal assignment for the first mission. The first training flow was hectic, full of all the requirements someone flying a first Space Shuttle mission needed to accomplish, and all this training was made more complicated because of the classification requirements. But still, the knowledge that I was preparing to go into space made it all seem less intense, and I had waited some seven years from our class selection date to make the mission, so it was just fine to be going through the training flow. I also got to do EVA (Space Walk) training, because of the unique mission requirements. Normally, the Pilot and Commander did not get EVA training, so it was another unique set of training requirements I got to participate in.

What does it feel like to fly in a rocket that launches into space, especially in a vehicle that weighs 4.5 million pounds at liftoff, so thrust has to be more than that, or you don’t go anywhere! The Space Shuttle produced about 7.3 million pounds of thrust with its solid fuel boosters and main engines, so not only was that enough to liftoff, but it produced a liftoff that was immediate and rather robust in performance. The entire ascent from liftoff to main engine cutoff was about 8.5 minutes in duration, and during that time, the Shuttle reached a speed of about 17,500 miles per hour and gained a few hundred miles in altitude. If that sounds like quite a ride, it is! The first two minutes while the boosters are thrusting was the most dynamic, shaking, vibrating, turbulent ride I have ever experienced in any vehicle I have ever flown in. This being my first ascent, my feeling was like “I sure hope we are going in the right direction, because if we aren’t, I am not sure I could do anything about it because of the sheer power we were riding on. This was a complete new feeling for me in a flight situation, But, because of all the ascent training we had received, I do think we could have come close to hitting the engine cutoff flight path angle and speed, with a huge amount of luck! The second stage after the booster are jettisoned, was as smooth as glass, with a steady increase in “g” load until throttle down at 3 “g.” Three

“g” may not sound like much, but when it is through your chest, it builds up to quite a heavy feeling by main engine cutoff. And after main engine cutoff—weightlessness (zero g). The guerilla gets off your chest, you can breathe easily, and 60% of your mission training is no longer applicable!

It takes a few hours to learn how to operate efficiently in the weightlessness of space. Everything not restrained by something floats, including you as you unstrap and start to move around. Moving no longer involves using your legs to walk, but instead you move by pushing or pulling yourself to start moving, and then you float to a new location. Really cool! And a huge amount of fun. Once you get used to how to move, all actions start to get more logical. Living and working in weightlessness is one of the unique things about space flight that will remain in my memory for life. Another lifelong memory is the scenery and views of Earth from space, at the altitudes involved. The perspective is huge, and one has a very wide panorama always passing below, with different scenery on each successive orbit. The Earth is a beautiful place when seen from hundreds of miles up, and I never got tired of looking out the windows and taking pictures whenever the flight plan allowed some extra time.

Returning from space in the Shuttle Orbiter was much less dynamic than ascent, and takes about an hour to accomplish. The deorbit burn happens about half way around the world from the landing site, and during re-entry, the Orbiter was a spacecraft, then a combination spacecraft and aircraft, and finally an aircraft, but throughout the whole entry, it was a glider, and not a very good glider. Dissipating all the energy that went into getting to orbit required a well-engineered vehicle and a well-designed trajectory to be successful, and the Orbiter was superb. Going through the peak heating phase was especially interesting if it happened in darkness, as heat produced basically caused the Orbiter to be enclosed in a glowing sheath of ionized gas that filled the window frames with an orange glow. As the Orbiter went subsonic, the buffeting from moving shock waves stopped, and the Commander took over manual flying to landing. At manual takeover, altitude was around 45,000 feet, and from that point to touchdown was only about 3 to 4 minutes. The landing profile was a precisely controlled sequence of airspeeds, altitudes, dive angle, and distance to the runway, which we practiced hundreds of times in the simulators and the Shuttle Training Aircraft before flight, to make sure the one shot at landing would be successful. The short, sweet three day flight to space and back was a huge success for the mission, the Air Force, NASA and the crew, and I was proud to have been a part of it. And one of the first things that came to mind is “I hope I get assigned to another mission as soon as possible.”

MISSION: STS 31

(Primary mission was to launch and deploy the Hubble Space Telescope (HST) into a 330 nautical mile altitude, circular orbit around Earth)

Use NASA Archives to find basic STS 31 Information:

1. Access the NASA web site: www.nasa.gov
2. Under "Missions" heading (top of web page), select "All Missions A – Z"
3. Scroll down to "S" and select "Space Shuttle"
4. In the "search" box (upper right), type in "STS-31" and then hit "search"
5. Select "NASA-STS-31" in the search results

To view some pertinent photos from STS 31 use the following procedure:

1. Access the NASA web site: www.nasa.gov
2. Highlight "Galleries" at the top of the web page, then select "Image Galleries"
3. On the Image Galleries page, locate the box with label "NASA Image Library. Click on the link "NASA Images"
4. In the search box at the top of the "NASA Image and Video Library" page, type in STS-31, check "Images" and "videos" below the search box, then click "search" symbol
5. With the "sliding bars" that limit the year of search, position the bars so that only the year 1990 shows on both boundaries (bars overlap). Then click "adjust search" to get only STS 31 images from 1990.

Personal Comments for STS 31:

There were several major differences between my first mission, STS 51C, and the second mission, STS 31. Probably the most significant of those was that my crew position for STS 31 was as Commander of the mission. I must admit that that change alone altered my outlook toward all the training sessions we had, from classroom to simulations to Shuttle Training Aircraft (STA) sorties. As Commander, you are in charge of all actions, operations, maneuvers, performance of the flight plan, and flight safety while airborne (or in space). Of course we had the support of a large ground flight control team which was indispensable, and always tries to keep the flight crew on schedule, is available for any question the crew may have, and has so much more data than the crew, they can detect even the slightest off nominal performance or drifting of critical parameters, and can immediately advise the crew on appropriate actions to take. This close relationship between flight crew and ground control team was the essence of many successful missions and the myriad things that transpired each mission. The mission Flight Director on the ground was the "orchestra leader" for the whole team for the whole mission, and the relationship between "Flight" and his ground team and the Commander and his spacecraft team was of highest importance. This relationship evolves over the period of training for the whole team, and forms the basis for success. The mission Commander (of the Space Shuttle crew) was responsible to assign other members of the crew to specific areas of responsibilities that were in addition to the basic responsibilities of their crew positions. These would be payload responsibilities, who would do space walks, who would be the prime and backup Remote Manipulator (RMS—robot arm) operators, and many other common crew functions, as well as the flight specific responsibilities. I was especially attuned to the changes in my overall responsibilities as Commander, but as the training unfolded, those changes seemed to be very logical and easy to adapt to and train for and get your mind set to do those jobs and functions so that they were more of "second nature" behavior. I attribute that ease of transition from right seat to left seat in charge to my entire background and training to that point, including Cadet days at USAFA.

The other huge difference between first mission and second mission was the fact that STS 31 was not a classified mission. In fact, the "atmosphere" surrounding the Hubble Space Telescope deploy mission was so directly opposite the classified nature of STS 51C, it is actually hard to compare the two. NASA desired so much information exposure to the public for the Hubble mission, that it was almost a struggle to grasp the effort that was made to publicize the mission after the total lock-up on information release on STS 51C. But what a good thing the change turned out to be. We could talk about the mission and what was involved to anyone, and I could actually tell my family everything, and my relatives and friends as well. My wife and I were sent to the Paris air Show so I could give briefings on what we were doing, and what was expected of the Hubble Telescope after it was on orbit. One of our crew, Steve Hawley, was our resident astronomer on the crew, and was the "go to" person to answer all questions about expectations for the telescope and how much better Hubble would be than ground based telescopes. Our EVA crew spent hours training for contingency situations that might come up during deploy, and also developing the tools that would make the Space Walks more likely to succeed regardless of the malfunction being addressed. The whole process of training and preparing for the mission was so much more open and communication friendly that it was a joy to be a part of, and probably helped me personally to grasp the change to the Commander much easier and more thoroughly than if the sequence had been reversed.

The Hubble telescope was a large payload, filling the front 45 feet of the payload bay of the Shuttle, with just 15 feet or so space behind it. It weighed about 24,000 pounds, and was about 13 feet in diameter, so there was not a lot of leftover room or performance to get it to the desired orbit. Since the Hubble Telescope has no propulsion capability of its own (engines or control jets), the desire during our mission was to get the telescope to the highest orbit altitude we could, so that its decay would be very slow, and its pointing methods (momentum wheels and magnetic torque devices) would be as effective as possible, and its pointing accuracy as stable as possible. Therefore, after main engine cutoff in the ascent phase, the orbital maneuvering system (OMS) engines were used to get the "Discovery" to the highest circular orbit we could get from the fuel on board. That meant that raising orbit altitude and then performing the deorbit burn at the end of the mission basically used all of the OMS fuel available, with little or no margin left over. I never did get completely comfortable having no reserve OMS fuel after nominal deorbit burn, but we did have fuel in the reaction jet system, so there was some backup capability assuming entry consumption was not too far from normal.

The flight plan for the mission was to get on orbit with the Hubble Telescope, on day one check out all the systems and equipment needed for deploy, and then on day two, to actually pull the telescope out of the payload bay, activate various systems, and get its antennas and solar arrays extended, so that the Hubble could survive on its own power and communicate with the ground controllers. Both solar arrays had to be completely deployed to generate enough electrical power for the telescope to survive and function. All activity went off normally until the second solar array was being commanded to extend, and it stopped after a couple of inches of travel. We sent extend commands several more times with the same result. So the contingency procedure to send out the EVA crew with proper tools to manually crank open the second array was initiated. The EVA crew was suited, in the airlock, and had depressurized to 5 psi above vacuum, before we and the ground crew came up with a work-around. The ground controllers found that there was a software problem (isn't every problem these days a software problem?) in the computer routine that was extending the array, which caused the process to stop. Ground controllers bypassed that software, and the array extended on the next command. We were right at the end of the deploy window, so with all requirements met, we on the flight deck released the telescope and I initiated back away from Hubble. Our EVA crew was still "stuck" in the airlock and had not been able to do an actual space walk (everyone who trains for EVA wants to actually do one), and since they were the normal camera operators, the crew did not get on-board pictures of this very momentous event. Luckily, there was an IMAX camera in the payload bay that did get good video, so we were not totally embarrassed. After we released the telescope, we maneuvered to a position behind it a few miles, and followed it in orbit for a couple of days while the ground controllers continued to do their checkout, and while the flight crew did secondary experiments.

On the fifth mission day we initiated deorbit procedures, but with Edwards AFB as the landing site because of weather at Kennedy Space Center. However, there were extreme winds at Edwards AFB all night before the landing, but with just enough let up for us to get through the hour and five minute deorbit and landing before the winds increased again to out of limits conditions. Because of the crazy wind conditions, we encountered a large wind shear just a couple thousand feet above touchdown and lost some 30 knots of airspeed instantaneously. For a large, heavy, stubby winged glider with an L/D of somewhere around 3.5 to 1, that is not good! We stretched the final approach, and landed slower than desired, but touched down on the runway! Total success, I must say! Next question, "When can I fly again?"

MISSION: STS 46

(Primary objectives: deploy the Eureca Satellite, and deploy and recover the Thethered Satellite System (TSS))

Use NASA Archives to find basic STS 46 information:

1. Access the NASA web site: www.nasa.gov
2. Highlight the "Missions" heading (top of web page), and select "All Missions A – Z"
3. Scroll down to "S" and select "Space Shuttle"
4. In the search box (upper right), type in "STS-46" and then hit search
5. Select "NASA-STS-46" in the search results

To view some pertinent photos from STS 46 use the following procedure:

1. Access the NASA web site: www.nasa.gov

2. Highlight “Galleries” at the top of the home page, then select “Image Galleries”

3. On the Image Galleries page, locate the box with label “NASA Image Library.” Click on the link “NASA Images”

4. In the search box at the top of the NASA Image and Video Library page, type in “STS-46,” and put a check in the boxes for “Images” and “Videos.” Then click “search” symbol

5. With the sliding “bars” that limit the year(s) of search, adjust each bar so that the year of search is 1992 on both ends of the scale (bars overlap). Then click on “adjust search” to limit the search to only STS 46 in 1992

Personal Comments for STS 46:

The STS 46 mission was one that was quite different from both of my previous missions because of the two primary mission objectives involved, and because of the heavy sponsorship of the European Space Agency. The first objective, in terms of flight plan execution, was the deployment of the European Space Agency (ESA) developed Eureca Spacecraft. This payload was a small deployable satellite bus, with several experiments mounted on it which could use the power and cooling supplied by the bus during an extended period of on-orbit operation after we deployed it on STS 46. The flight activities to lift the satellite out of the payload bay of “Atlantis” and extend solar arrays and perform other activation procedures was not complicated, and had been done several times with other Shuttle payloads. We did have some issues with the data handling system during the activation, which ended up delaying the deployment for a day. This problem was solved and Eureca was deployed, and remained in orbit for about 10 months, and was retrieved by another Shuttle mission and returned to ESA. Training for this deployment was normal and well understood by our crew and training team. The same was not true for operation of the Tethered Satellite System (TSS). TSS was flying for the first time, and there was almost no training that had been developed for how to proceed. Most of what existed was in the form of theory on how the tethered satellite, the tether itself, and orbital mechanics effects would all interplay with each other during our deploy attempt. None of the operations we were going to perform had ever been performed by a manned mission, and the 20 kilometer (12.5 miles) tether was the longest attempted deployment. Theory “said” that the satellite would have to be pushed away from the cradle, and so small air jets were included to help get the satellite away from the Shuttle as the tether unwound from the reel. At about 500 meters, again by theory, there would be enough gravity gradient force to keep the tether tight for the remainder of the deployment. Training for the operation of the mechanisms and ops sequences was quite well understood, but when it was time to move into mission training and deal with potential malfunctions, the process turned more toward addressing theory and what might happen, rather than being able to come up definite scenarios on how the tether and satellite would behave. In other words, we guessed a lot on many aspects of training for TSS operations. During the actual attempt to deploy the satellite, the reel jammed at about 256 meters of total distance from the Shuttle, and we could not get it to go further, although we tried many times to keep the deploy of the satellite going. During training, the crew was informed of several conditions that if any of them happened, we should be ready to “cut the tether and run” by maneuvering the Shuttle out of the way of a possible rebounding satellite! For a normal deploy, none of them would happen. But when the reel jammed at 256 meters, we were right in the middle of what was believed to be an unstable zone. But the satellite and tether were stable while we were not trying to clear the jam, and as soon as we tried to do anything to clear the jam, the satellite and tether motion got pretty wild. Eventually, it was decided

that we would wind the tether back up and pull the satellite back in to the cradle, and stow all the telescoping tower holding the cradle. We learned a great deal about tethered satellite operations, which was all applied to a re-flight of the system about three years later. One unique part of the mission was that we had to use two-shift operations on board, since we could not have all crew members sleep at the same time with the tethered satellite deployed. That gave the off duty crew time to try out the sleep compartments on the middeck which were a privacy improvement over the normal sleeping "bag" used in single shift ops. For this mission I was the Commander again, so the basic syllabus for standard training was quite familiar and gave me more insight into some of the procedures than the first exposure. The crew was the largest I had flown with as there were seven crew members onboard. We truly had an international crew as well, with our payload specialist from Italy, a mission specialist from Switzerland, and five U.S. crew members, one of whom was from Costa Rica originally. A really nice result of having both our payloads sponsored by the Europeans was that there were some visits to Europe for training and then a very nice post mission "thank you tour" when we visited several of the countries that had been a part of the mission. It was tough duty, but someone had to do it! Our landing occurred at the Kennedy Space Center after 8 days on orbit and some of the most interesting "flying" of any of the three missions.

After the thank you tour of Europe, and after the series of debriefs the flight crew did with all the ground teams (this was a standard practice for all missions), I was assigned to the position of Deputy Chief of the Astronaut Office, which involved a good deal of administrative work as well as occasional simulation opportunities, and I was trying to see if I might be assigned to fly the first servicing mission to the Hubble Space Telescope, which was being put together to fix a number of items on the Hubble Telescope that had come up in the couple of years after STS 31. But it turned out that such an assignment was not in the cards, and about the same time an opportunity came up for transitioning out of the Active Astronaut business, and into a Space Shuttle Program Management position at the Kennedy Space Center in Florida. I had begun to think about life after being an Astronaut, and some of my family had been dropping hints about maybe it was time to think about other work as well. So I took the job in Florida, but had to leave the Astronaut Office, retire from the Air Force, move to Florida, and become a Civil Servant (luckily at the SES level), all in about four months in the summer of 1993. I had some very mixed emotions about doing all of that, but it turned out to be a very good move for me. The job and work in Florida was super great, the people I got to know even better were outstanding, and being the NASA Manager for Launch Integration was rewarding and quite stressful. The white hair of today comes from that job, rather than the all the jobs leading up to it!

All the Best to USAFA Class of 1967!

Loren Shriver

USAFA Class of 1967

(Story #5)

Loren J. Shriver