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1995 (32nd) People and Technology - The Case
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Apr 25th, 2:00 PM - 5:00 PM

Paper Session I-A - Evaluation of Space Shuttle and Orbiter Capabilities

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Evaluation of Space Shuttle and Orbiter Capabilities

John W. Young
NASA Astronaut



32nd Space Congress
People and Technology – The Case for Space
April 25-28, 1995

COLUMBIA LIFT-OFF 12 APRIL 1981

About 13 years ago, we launched the Space Shuttle. As launch vehicles go, its performance has been incredible. Its launch reliability (66 of 67) is 98.5%. To support Space Station Assembly and Operations, we must increase Space Shuttle launch performance by adding over 13,000 additional pounds of payload to the 51.6-degree inclination orbit. This will allow us to haul payloads of over 40,000 pounds to support Space Station Assembly missions at altitudes up to 220 nautical miles. Potential weight-to-orbit improvements are many. Every pound possible is being investigated. For example, we are building a new Aluminum Lithium External Tank to gain about 7,500 pounds of payload to orbit. Seven new ascent trajectory design and steering software upgrades will gain us almost 1,600 pounds of payload to orbit. We intend to use actual crew weights as the crew person is "spiced" at 200 pounds.

Many of you know about the Space Shuttle and what makes it operate. It is people. This paper is about what people in space have done



to provide the United States and our international partners with unique operational capability to do what no other spacefaring Nation can do. The Space Shuttle and its trained, capable flightcrews are a great combination for expanding the human space exploration envelope.

SOLAR MAXIMUM MISSION SPACECRAFT RETRIEVAL ATTEMPT

The general rule of operating practice in the Space Shuttle in the retrieval, repair, refurbish, refuel, and redeploy business is to do the job as follows. First we use Intravehicular activity—to rendezvous with the objective. Then we use the robot arm—the Remote Manipulator System to grapple and retrieve the machine. Finally, we perform Extravehicular Activity to do all the things that only humans can do including the real-time, unplanned fixes. However, because we had this new Manned Maneuvering Unit, we decided on Solar Maximum Mission to demonstrate the use of its capability first.

Wearing that Manned Maneuvering Unit, "Pinky" Nelson attempted to retrieve the 4,790 pound Solar Maximum Mission Spacecraft. The attempt failed because we did not know



the correct configuration of the payload attach point. This lesson continues to be re-learned in space exploration all too frequently.

SOLAR MAXIMUM SATELLITE REFURBISHMENT

When the payload mechanism incompatibility caused us to fail to retrieve Solar Max, Bob Crippen kept station on the satellite and Jerry Hart snared it with the Remote Manipulator arm and placed it on the Flight Support System. As seen above, "Pinky" Nelson and "Ox" Van Hoften repaired and refurbished the Solar Maximum Mission Spacecraft.



IN-SPACE REFUELING

Dave Leestma and Kathy Sullivan operated the Orbital Refueling System and proved in-space refueling of hydrazine. When the Gamma-Ray Observatory needs refueling, we are ready to do that job.



COMMUNICATIONS SATELLITE RETRIEVAL

The Manned Maneuvering Unit proved its value. Dale Gardner used the Stinger Adapter to retrieve this failed communications satellite. The satellite weighed over 1,200 pounds.



HANDLING AND CONTROLLING MEDIUM SIZED COMMUNICATIONS SATELLITES

Dale Gardner and Joe Allen transferred the handling and control of one of the 1,200 pound communications satellite that they retrieved on the STS-51A mission.



COMMUNICATIONS SATELLITE CONTINGENCY REPAIR ATTEMPT

Dave Grigs and Jeff Hoffman worked in Space to attach the “fly swatter” to the Remote Manipulator System. The “fly swatter” was designed and built in real-time to activate the LEASAT-3 communications satellite operate switch.



SATELLITE REPAIR ATTEMPT

The Remote Manipulator System used the real-time designed “fly swatter” to activate the LEASAT operate switch. It did not work, but, if we cannot fix what is broken out there, we should have no business exploring space with humans. Humans are unique; they do *not* quit and they *never* give up.



SATELLITE CAPTURE FOR REPAIR

“Ox” Van Hoften and the capture of that previous pesky LEASAT-3 communications satellite for repair. It is not clear who has control of what in this view.



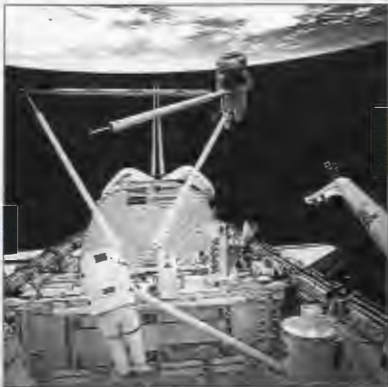
LARGE SATELLITE HANDLING AND CONTROL

Bill Fisher and “Ox” Van Hoften repaired the LEASAT-3 Communications Satellite. They showed us that, when properly restrained, two EVA crewpersons could control and repair this giant satellite which weighed 15,190 pounds! What are the limits of mass a properly trained crew person can control in space? We do not know yet.



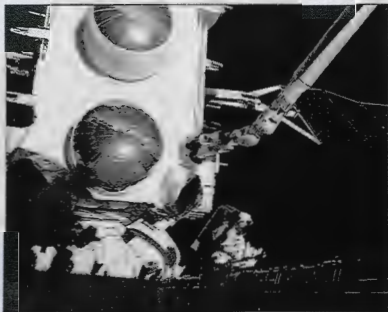
SPACE CONSTRUCTION IN LOW EARTH ORBIT

The Experiment of Structures in Extravehicular Assembly shows that EVA crew people could put the Space Station together rung-by-rung. The inverted tetrahedron of 6-foot beams was assembled and disassembled several times by Jerry Ross and Woody Springer. Also practical, this method of space construction is an inefficient use of human resources in space unless there is no other way.



REAL-TIME SATELLITE SAVING

During a contingency EVA, Jay Apt and Jerry Ross deployed the antenna on the Gamma Ray Observatory, thereby saving that great observatory. Amazing discoveries from the Gamma Ray Observatory have made astrophysicists go back to the drawing boards (or wherever they go).



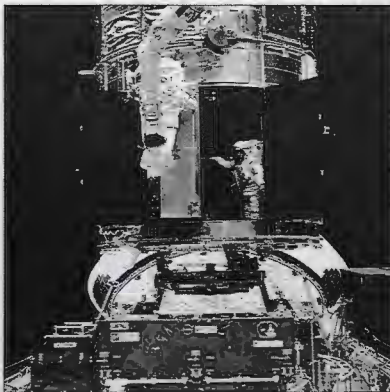
INTELSAT VI RETRIEVAL

The Intelsat VI repair team of Tom Akers, Rick Hieb, and Pierre Thuot grappled, positioned, and controlled the 8,900-pound satellite. The decision to have three persons in space set up to retrieve the satellite was a brilliant real-time idea of the flightcrew. Only 3 pounds of force were necessary to move the satellite by hand. Therefore, three humans could control the satellite at 120 degrees apart but two at 180 degrees apart would have had control problems when attaching the satellite capture bar.



CORRECTIVE OPTICS SPACE TELESCOPE AXIAL REPLACEMENT

The STS-61 EVA team installed the Corrective Optics Space Telescope Axial Replacement on Space Telescope. This telephone booth size optical correction module allows the Space Telescope to see much better than "spec" in space. Some scientists believe it can see to the edge of the Universe. Tom Akers, Jeff Hoffman, Story Musgrave, and Kathy Thornton performed five periods of EVA and completely reserviced and repaired the Space Telescope.



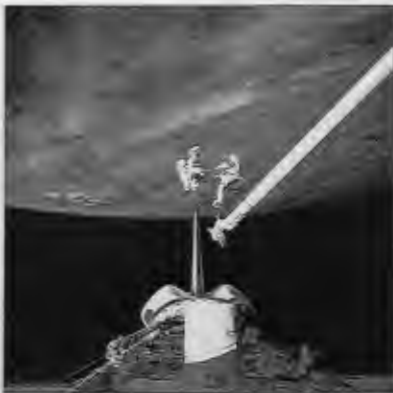
SPACE TELESCOPE SOLAR ARRAY REPAIR

The Space Telescope repair team also repaired the Solar Arrays. At present, Space Telescope is being recognized by astronomers as a prime telescope. The Space Telescope's amazing findings include finding a more precise number for the Hubble Constant—and the age of the Universe. Instruments have been proposed for its next servicing mission that have the potential to revamp human thought processes. For example, one instrument has the potential to discover the planets around the nearer stars.



DEMONSTRATING THE SIMPLIFIED AID FOR EVA RESCUE

The Simplified Aid for EVA Rescue (SAFER) was demonstrated by Mark Lee and Carl Meade. SAFER has many future practical applications such as Orbiter in-space repairs and docked Orbiter EVA crew or Space Station EVA crew rescue.



LAPTOPS IN SPACE FOR SITUATIONAL AWARENESS, SYSTEM INFORMATION, AND VEHICLE CONTROL

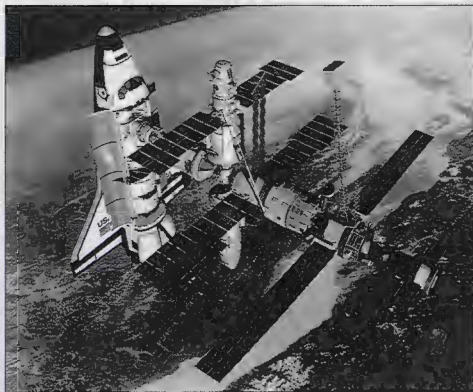
This computer was the first Space Shuttle Laptop. Now, by using direct communications paths from the Orbiter and its payloads, we can provide laptop computer control in Orbiter. Laptop computer programs supported the STS-63/ Mir-1 rendezvous and proximity operations. Up to seven laptops have been carried on the Orbiter. These better information pathways allow incredible improvements in situational awareness, crew performance, and efficiency. We can overcome 25-year old cabin display inefficiencies without replacing those instruments. With respect



to the use of these computers on Orbiters, the technology is in its infancy. These laptops have the potential to become the faster, better, and cheaper way to operate the Orbiter fleet.

PHASE I ORBITER/MIR DOCKING

The Phase I Shuttle Mir program is scheduled for the Shuttle/Mir dockings. The missions will include three extravehicular activities. One of the extravehicular activities is planned for a joint Russian-US EVA with the potential for four people working in space.



PHASE II INTERNATIONAL SPACE STATION ASSEMBLY

This view shows the partially constructed International Space Station orbit. Space Shuttle flightcrew operational experience with hardware retrieval, refurbishment, and repair, and working in space, has provided our flightcrews with the operational background that they must have to successfully assemble the Space Station using the Orbiter, its Remote Manipulator System, and the Extravehicular capabilities.



THE INTERNATIONAL SPACE STATION

The engineering artist's view is this completed International Space Station. If the Russian Space Station experience is any guide, a more realistic picture would show two astronauts, with SAFERS attached, working on some part of the Space Station to repair or replace its equipment.



THE IMPROVED PERFORMANCE SPACE SHUTTLE

The Space Shuttle Program has demonstrated the capability to perform useful resupplying, repair, and recovery of satellites. This performance has provided the flightcrews with the operational experience that will allow us to build the Space Station. This machine can deliver to the place in orbit, where they are needed, five or more crew members fully trained to use the robotic arm—the Remote Manipulator System—and perform Extravehicular Activity, and when necessary, replan and redo the job needed in real-time. When upgraded, the machine will deliver all this capability and about 63,000 pounds to 100-nautical mile orbit at 28.5-degree inclination. To do an equivalent mission with Single-Stage-to-Orbit launch vehicle would require about two Titan IVs and two Single-Stage-to-Orbit launch vehicles. Arriving at the same place in space at the same time with four vehicles, the rendezvous, docking, remote manipulator, and extended EVA crew capabilities will



be very expensive. Someone could figure which set of machines will be faster, cheaper, and better for an equivalent mission. My bet is the single launch vehicle Space Shuttle and its crew is the equipment for the job. And, I doubt that any faster, better, cheaper comparison is even close.

LUNAR EXPLORATION POTENTIAL

In 30 years of human space operations, we have demonstrated that humans launched to space and their robotic helpers are well suited to the exploration and discovery of the other places in the solar system. This paper points out that proven space explorations by humans with their motivation and resourcefulness will help us tremendously in our operations on other places besides Earth. The MOON could well be our next stop. Payload to orbit in the Space Shuttle is the key. With the upgraded Space Shuttle our Nation will have the capability to put giant payloads into orbit. A couple of docked Orbiter payload stages could well allow us a limited capability to put up a small high-tech, pre-packaged MOON base. On later Shuttle missions, we could then send human crews to continue the exploration of our nearest neighbor. We have a long way to go to explore



this Final Frontier. The sooner we get started with this scientific discovery, and technology creating business, the better off we will all be.

