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THE FLIGHT DEMONSTRATION PROGRAM AND SELECTION PROCESS

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Introduction:

In October 1983 the Office of Space Flight at NASA Headquarters established a new program office to: undertake a series of developments which would support program objectives of the Office of Space Flight; give younger NASA engineers "hands on" experience with the development of flight hardware; lead to new business for the Space Transportation System (STS); and stimulate present customers of the STS towards more efficient use of the unique capabilities of the space shuttle. The Flight Demonstration Program was initiated by undertaking the development of six demonstrations. The first of these demonstrations, the Orbital Refueling System was successfully flown on STS 41-C on August 29, 1984. The second and third Flight Demonstrations, EASE and ACCESS, were performed successfully on STS 61-B on November 29 and December1, 1985. These latter two demonstrations, are the subject of this Space Construction Conference. Therefore, no further discussions of EASE/ACCESS is included in this paper.

In the coming years these missions will be followed by demonstrations of a voice control system for the shuttle's closed circuit television system, an infrared intercommunications system, a plasma motor/generator proof of function demonstration, the implementation of a force feedback device on the shuttle's remote manipulator system, the transfer of super fluid helium on-orbit, a laser docking sensor and a small expendable deployment system.

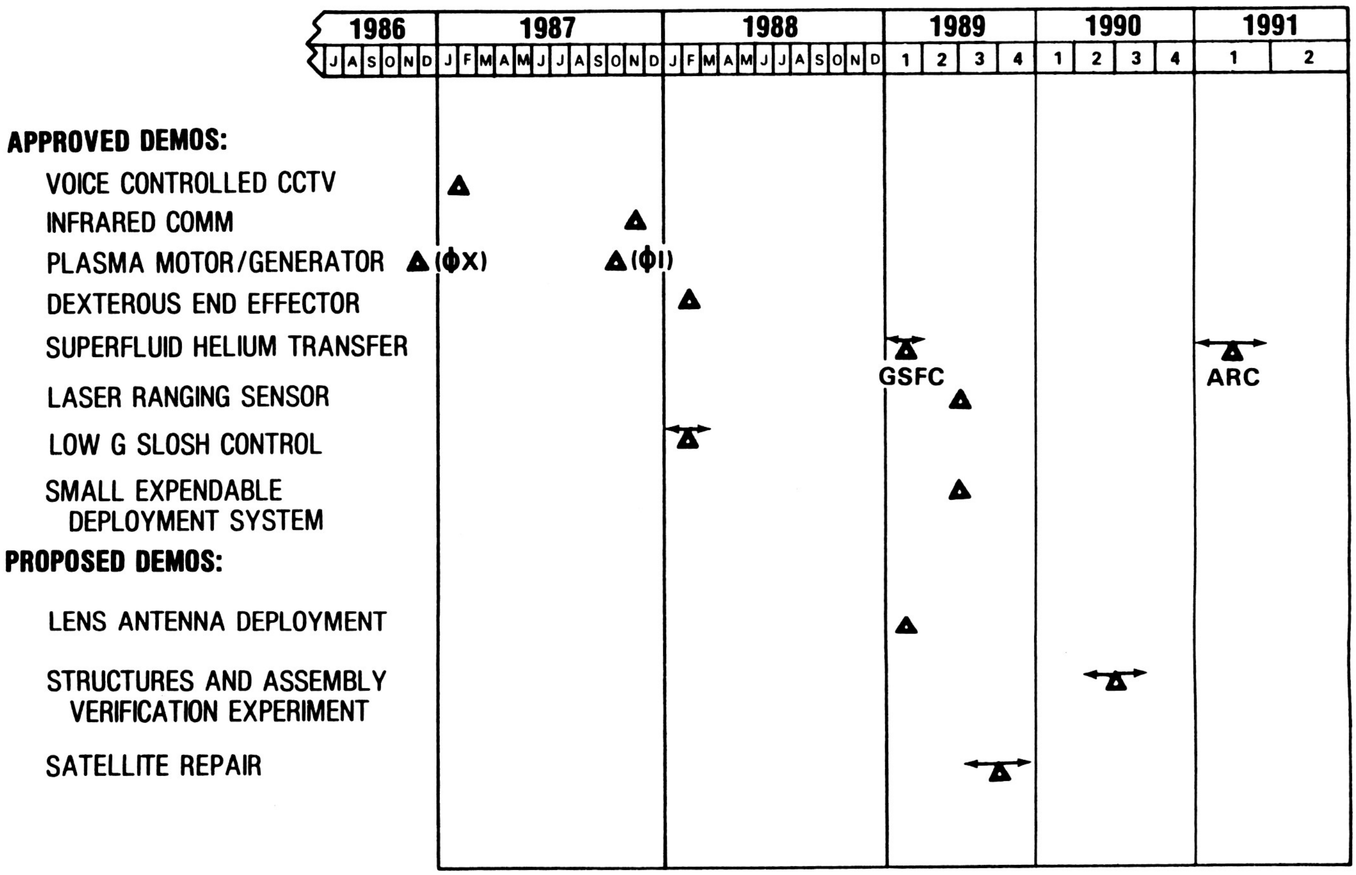
Flight Demonstrations are selected annually by the Flight Demonstrations Office in the Office of Space Flight. Responsive to a solication issued by the Flight Demonstrations Office, proposals for NASA funded Flight Demonstrations are submitted to NASA Headquarters in July of each year. These proposals undergo a peer review with the final selection announced by the Associate Administrator for Space Flight in October. The Flight Demonstrations Program also participates with the Department of Defense (DoD) in the management and manifesting of DoD Flight Demonstrations.

Typical areas of emphasis for Flight Demonstrations are:

Space Construction/Large Space Structure
Expendable Resupply
System Improvement
Satellite Servicing
Tether Applications

The proposed flight readiness dates for future OSF flight demonstrations are shown in Figure 1.

FLIGHT READINESS SCHEDULE FOR OSF FLIGHT DEMONSTRATIONS



Approved Flight Demonstrations

The Orbital Refueling System (ORS)

The Orbital Refueling System was the first Flight Demonstrations Program sponsored by the Office of Space Flight. The objectives of the ORS were to develop and demonstrate the equipment and procedures for a hydrazine fuel transfer system; to develop and demonstrate the tools needed to interface with existing satellites to accomplish fuel transfer; and to develop and evaluate specific procedures to refuel present satellites of the Landsat type.

The ORS consisted of five major categories: the structural subsystem; the fluid subsystem; the avionics subsystem; the thermal control subsystem; and the EVA tools. The ORS tankage unit (with its fuel tanks, piping, valving, heaters, and avionics) was mounted on a Mission Peculiar Experiment Support Structure (MPESS) in the cargo bay of the orbiter. In the demonstration configuration the ORS was capable of multiple transfers of approximately 200 pounds of hydrazine fuel. The ORS could be modified to deliver approximately 500 pounds of fuel to an orbiting satellite by a fuel line connected with a hydrazine servicing interface tool set. The ORS was interfaced to the Orbiter general purpose computer, and analog channels were available for data monitoring. Control of the ORS fuel transfer was from the Aft Flight Deck. During the ORS demonstration fuel was transferred through a fixed propellant bypass as well as through a fuel line connection established by an EVA crew member.

The EVA tools were the unique hardware items required to: permit access to the manual fill valve; provide redundant seals for crew safety; and control fluid flow to the satellite. The tool set consisted of seven items designed for satellite engagement, valve opening, and valve closing. The fuel transfer unit and valve, once engaged, became permanently attached to the satellite, thus providing a standard interface for refueling.

Force Torque Sensor

The goals of the Force Torque Sensor (FTS) Flight Demonstration are to demonstrate an enhanced capability of the shuttle Remote Manipulator System (RMS) in a zero "g" environment. The RMS/FTS system will measure and graphically display the forces and torques which are developed at the wrist joint of the RMS.

The RMS/FTS system design will intergrate new elements or components with existing shuttle subsystems. The new elements will include the Force Torque Sensor, the force torque sensor electronics, the sensor display subsystem, and the cabling and control panel. Existing shuttle subsystems that will be integrated with the RMS/FTS include the RMS, payload bay cabling, a closed circuit TV flight monitor, power and air conditioning.

The FTS housing will contain the FTS electronics and will be mounted as an integral part of the RMS. The FTS will be installed between the end of the RMS and the base of the standard end effector. The sensor display system will be located in the crew compartment and will comprise a microcomputer and graphics generator. The sensor display system will process signals from the FTS and resolve the forces and vectors will be graphically displayed on a Shuttle TV flight monitor.

Plasma Motor/Generator (PMG) Proof of Function

The objective of this experiment is to provide order-of-magnitude verification of the key physical processes involved in utilizing the Earth's magnetic field, the velocity of the shuttle and a conductor either to generate a voltage or a mechanical force (electrical generator or motor).

The results of this experiment would provide the first firm performance data to guide planning and development of hardware and experimental procedures for subsequent more extensive tests such as the Tethered Satellite System science experiments and engineering development systems. The primary uncertainty in operation of a PMG system lies in the performance of the plasma current "brushes" to complete the "armature" to ionosphere current path. The numerous variables involved in theoretical computation of the plasma physics processes result in considerable uncertainty in the results obtained. Only a direct measurement, in orbit, of the induced VXB voltage, current, coupling, and ionospheric circuit impedance can provide adequate verification that the calculated effects actually occur.

Initial verification of these fundamental issues can be obtained prior to the availability of the Tethered Satellite System by flying the 200 meter/10 watt experiment. Adequate voltage and separation from spacecraft wake effects will be achieved by the 200 meter wire, without having to deal with stabilization and retrieval systems credible zeroth-order demonstration of the hollow cathode plasma coupling vital to PMG performance will be achieved. The deployed wire and far end electronics package will be jettisoned at the completion of the experiment.

Voice Controlled CCTV Demonstration

The Voice Controlled System (VCS) is a voice-actuated control system which can be used to operate spacecraft equipment when the operator's hands (and eyes) are preoccupied with the operation of other systems. This increases the efficiency of crew operations. To demonstrate this technique, the VCS will be used by a crewman to operate the Orbiter television cameras while he is simultaneously using the Remote Manipulator System (RMS) to deploy or retrieve a payload. Since the cameras provide differing views of the payload bay and the payload during the deployment operation, normally the crewman has to remove his hands from the RMS control handles and shift his visual attention to the television control panel to select cameras and adjust their view and focus. By using the VCS, he will only have to speak certain control words into his headset to effect these tasks.

The VCS will provide control output for a command vocabulary of 100 discrete words or phrases. It will respond only to the voice of the crewman who has previously recorded his voice patterns into a memory module which is inserted into the VCS at the time of the operation.

All comands provided by the VCS will parallel those on the normal television control panel and can be overridden by the television control switches. A fail safe feature will be provided to automatically remove the VCS from the control circuits when power is removed from the VCS.

In addition to normal camera adjustments, the VCS will provide sequences of camera adjustments in response to a single command word input. These sequences of adjustments will automatically position the camera to predetermined operating conditions without requiring the attention of the crew.

Infrared Intercommunications

The Infrared Intercommunications (IR COMM) is a wireless means of communicating voice or data between two or more crewman or between crewmen and an associated wall-mounted unit which ties into the Shuttle or Space Station avionics. Information will be transferred by means of modulated infrared light radiated from tiny body-mounted diode light sources. This light will bounce off the walls and other objects in the cabin, essentially "flooding" the cabin volume and eliminating blind spots regardless of source location. The receiver will detect the light mounted anywhere within the cabin regardless of which direction the transmitter or receiver are pointed. This concept has been demonstrated both in a laboratory environment and the shuttle mock-up.

A deficiency of the presently used wireless (radio) crew communications unit is its inability to meet communications security requirements without the use of body-worn encryptors. Infrared Communications would provide that security. The IR light is effectively attenuated by the Shuttle windows; the optical energy will not interact with the electrical signals of the Orbiter wiring. An optical system would be small, wireless, and light-weight, having less of an impact on the crew. Multiple users can be readily accommodated by additional channels. In addition to providing secure communications for the crew, IR could provide the transfer of high rate biological data from the crew to a wall unit, thereby replacing the existing tape recorders. This would allow real time data analysis while maintaining full crew mobility.

The purpose of the flight experiment is to demonstrate the capability of the system to transfer voice and data without dropouts using the flooded volume technique. In addition, it will prove the adaptability of the system to a space vehicle environment which incorporates multiple users.

Superfluid Helium On Orbit Transfer

With this demonstration, we plan to transfer superfluid helium (at approximately 2°K) using 175 L dewars and under zero-g conditions.

The method to be used involves a porous plug thermomechanical pump--a simple electrical device that, due to the unique properties of superfluid helium pumps the superfluid by simply heating one end of the propus plug. The principle involved is the same as that used by the IRAS and COBE porous plug to contain superfluid helium within a dewar in zero-g.

Many current and proposed space flight projects include detectors, instruments (AXAF, COBE, LDR), and facilities (IRAS, SIRTF, GP-B) which are liquid helium cooled. For long lifetime instruments and facilities, the limiting factor is the depletion of the stored helium. For those facilities which, with refurbishment, are required to last more than 1 or 2 years (SIFTF, AXAF, LDR), a method of replenishing the liquid helium is required.

We believe that this demonstration is a natural follow-on for the hydrazine propellant refueling demonstration recently completed. The superfluid helium transfer will demonstrate another in-flight servicing capability for the shuttle.

We are currently setting up a laboratory transfer experiment at the GSFC. This experiment will further define the porous plug parameters relevant to the transfer of superfluid helium in zero-g.

Laser Docking Sensor

This proposed flight demonstration is designed to show the ability of the Laser Docking Sensor (LDS) to provide real time data as an aid in a manual docking procedure. Rendezvous and docking parameters along with a three-dimensional target attitude simulation will be available as a visual display provided by the flight qualified grid computer. The crew may use this data as their basis for performing the approach to the target. The LDS system will provide azimuth and elevation angles as well as range to retroreflectors placed in a known configuration on the target vehicle.

By knowing these parameters, a plane can be defined whose orientation represents the attitude (roll, pitch, yaw) of the target with respect to the sensor/active vehicle axes. This information, provided at a real time rate (about 3-5 Hz), will enable an optimum approach trajectory to be calculated and followed either manually, as a visual aid to the crew, or automatically, by providing the information to the existing onboard navigation computers.

The LDS comprises an illuminating laser source that will either scan over or flood the field of view. This will provide the high signal to noise ratio required to maintain the accuracy of the system. A retroreflector configuration will be attached to any target vehicle in a known configuration of known dimensions to allow the calculations of unambiguous attitude. Ranging will be accomplished by modulating the laser source in either a pulsed fashion (pulsed or chirped ranging) or a CW fashion (tone ranging). Present technology will provide range accuracy to approximately one percent of range. A receiver with accompanying optics will detect the modulated return from the retroreflectors.

The operational scenario will consist of scanning the full field of view until the retroreflectors are encountered. Each retroreflector, in turn, will be located in angle and range. The sensor will then enter the track mode which consists of performing small, fast dither scans over the last known location of each reflector. Reflector movements will be then detected to allow the calculation of attitude, angle, rate, range and range rate relative to the active vehicle.

Small Expendable Deployment System

This proposed tether applications Flight Demonstration will check-out and validate the Small Expendable Deployment System (SEDS) concept. In this demonstration the tether will be cut and allowed to reenter the Earth's atmosphere after use. The proposed system will have a 10 km long tether which will be used to boost a 350 pound end mass about 70 km above the shuttle's orbit. The tether will be housed in a Get Away Special (GAS) can and the entire system will be mounted on a Mission Peculiar Experiment Support Structure as a partial payload.

SEDS will weigh approximately 450 pounds including the end mass. The diameter of the kevlar tether will be 1.65 mm. The concept consists of kevlar wound on a spool and placed in a GAS can. The tether will unwind from the outside surface of the spool. For control of the deployment speed, tension will be applied to the tether via gas bags located between the spool and the GAS can walls. A gas supply and metering system will be needed to maintain the proper pressure in the bags. The speed of deployment will be measured using an optical turn counter and a clock. A converging-shaped structural frame built above a GAS can will protect the tether and serve as an exit path for the tether. A cutting tool located at the top of the frame will sever the tether when the experiment is completed.