# SHUTTLE INFORMATION AND COMPARISONS

# OF SHUTTLE WITH SKYLAB

PREPARED BY

THE LIFE SCIENCES DIRECTORATE

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# SPACE SHUTTLE SYSTEM DESCRIPTION, GENERAL CAPABILITIES AND CREW FUNCTIONS

- SYSTEM DESCRIPTION

The Space Shuttle Flight System is composed of the Orbiter, an External Tank containing the ascent propellants to be used by the Orbiter main engines, and two solid Rocket Boosters (SRB's).

- GENERAL CAPABILITIES

The SRB's and the Orbiter main engines fire in parallel, providing thrust for lift-off. The Orbiter main engines continue firing until the vehicle reaches the desired sub-orbital conditions where the External Tank is jettisoned. The orbital maneuvering subsystem (OMS) is fired to place the Orbiter in the desired orbit. The Orbiter delivers and retrieves payloads, conducts orbital operations, and returns to a land base in a manner similar to that of high-performance aircraft. The Orbiter is a reusable vehicle designed to operate in orbit for missions up to 7 days duration. However, the Orbiter is being designed so as not to preclude missions of longer duration up to 30 days from being accomplished.

- CREW FUNCTIONS

The Orbiter crew consists of the commander and pilot. Additional crewmen which may be required to conduct Orbiter/payload operations are a mission specialist and one or more payload specialists. The functional descriptions assume that two crewmen (commander and pilot) are always required to operate and manage the Orbiter. The remainder of the crew (mission and payload specialists) will be a function of the mission requirements. Detailed responsibilities of the mission specialist and payload specialist(s) will be tailored to meet the requirements of each individual mission. The crew size will be a function of the mission complexity and duration. The duties of the crew are:

Commander. The commander will be in command of the flight and will be responsible for the overall space vehicle operations, personnel, and vehicle safety. He will be proficient in all phases of vehicle flight, docking, and Orbiter and attached payload support systems. He will be responsible for the on-orbit operation and management of attached payload support and Orbiter systems. He may support/perform specific payload operations if appropriate and at the discretion of the payload sponsor.

Pilot. The pilot will be second in command of overall space vehicle operation and will be equivalent to the commander in proficiency and knowledge of the vehicle and attached payload support systems and operations. He will be responsible for on-orbit operation and management of attached payload support and Orbiter systems. He will normally perform the payload deployment/retrieval operations via the remote manipulaton system and will be the second crewman for EVA operations. He may support/perform specific payload operations if appropriate and at the discretion of the payload sponsor.

Mission Specialist. The Mission Specialist will be proficient in payload (experiment) operations. He will have a detailed knowledge of the payload operations, requirements, objectives, and supporting equipment. He will be knowledgeable of Orbiter and attached payload support systems and will be the prime crewman for EVA operations. He will be responsible for the coordination of overall Orbiter operations in the areas of flight planning, consumables usage, and other activities affecting payload operations. He may perform special payload handling or maintenance operations via the Remote Manipulator System. At the discretion of the payload sponsor, he may assist in the management of payload operation, and may in specific cases serve as the payload specialist. Because of training requirements and mission responsibilities, he should be selected by NASA on a career basis.

Payload Specialist. The Payload Specialist will be responsible for the attainment of the payload (experiment) objectives. The Payload Specialist will be an expert, proficient in payload (experiment) operations. He will have a detailed knowledge of the payload instruments (and their subsystems), operations, requirements, objectives and supporting equipment. He will be responsible for the management of payload operations and for the detailed operation of particular instruments or experiments. He must be knowledgeable of certain Orbiter systems, e.g., accommodations, life support, hatches, tunnels, caution and warning systems.

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR MISSION CHARACTERISTICS

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Mission Autonomy | Minor degree | High degree | 1) Skylab crews found that ground control of all mission details was not desirable and that the crew could accomplish more with some flexibility in the flight plan. Shuttle planning is directed to give the crew more autonomy.<br>2) The concept of payload specialists assigned to the crew should give them the expertise to exercise this autonomy efficiently. |
| Crew Size | 3 - Commander, Scientist Pilot, and Pilot | 4 (reference) - Commander Pilot, Payload Specialist, Mission Specialist | Shuttle can carry more than the basic crew if needed for specific payloads (up to 7 with Spacelab mission). |
| Mission Length | 28 days<br>59 days<br>85 days | 7 days, with growth to 30 days | |
| Orbital Characteristics | Fixed orbit ($50^{o}$ inclination, 210 nautical miles circular orbit) | Variable inclination and orbital altitude | |
| Launch Site | Kennedy Space Center only. | Kennedy Space Center (NASA) and Vandenberg Air Force Base | |
| Recovery | Command Module only - water landing | Earth landing strip fixed recovery sites identical with launch sites. | Skylab recovery ships, mobile medical laboratories, and elaborate logistics provisions will not be needed for Shuttle. |
| Abort Effect | Probable loss of revisit capability | Safe mission termination through all mission phases; recovery of orbiter and payload for later reuse. | |
| Payload Characteristics | Multi-disciplined | Principally payloads dedicated to a single disciplinary area; moderate amount of mixture of disciplines is feasible. | Considerable planning integration to obtain all objectives scheduled for the Skylab Program. |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR MISSION CHARACTERISTICS

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Data Management | Dependent on telemetry and ground processing.<br>–<br>Delayed feedback to the orbiting vehicle, if any. (predominantly open loop). | Autonomous within flight vehicle throughout flight phase | Shuttle experiment results should be enhanced by onboard data management capability |
| Experiment Return | Very limited capability (weight and volume limitations). | Normal mode of operation is to return the payload (except for satellites and deep space probes.) | This simplifies many experiments by reducing photography and crew observations. Also helps in anomaly resolution if any occur so that future experiments can be improved. |
| Mission Evolution | Limited | Unlimited | Skylab revisits were limited to two only and mission changes were limited due to weight and volume payload capability of the revisit Command Modules. Shuttle program can be continually revised so that later missions can profit by every lesson learned on earlier missions. |
| Payload Ownership | Mostly government (NASA plus some DOD, university and foreign) | Can be owned by industry, universities or other institutions, both U.S. and foreign. | Ownership by other than NASA is feasible due to the concept of the payload and also the concept of multiple independent experiments on one payload pallet. Shuttle payload costs should be greatly reduced due to the re-usability of both the orbiter and the payloads. |
| Safety Standards | Manned Space Flight Certification | Space Shuttle System: Manned Space Flight Certification Standard<br>–<br>Payloads: Commercial Industry and airline standards | Experiment costs should be reduced with the utilization of Shuttle standards. |
| Microbial Contamination | Rigid Inflight Hygienic Procedures | • Moderate procedures;<br>• Controlled by mission-to-mission refurbishment | This should enable Shuttle crews to have more time for productive work or rest. |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR MISSION CHARACTERISTICS

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Rendezvous and Docking | Absolutely necessary for crew transfer from Command Module to Workshop | Variable constraint; dependent on type of mission flown.<br>–<br>No planned crew transfer unless a rescue operating mode is designated. | |
| Deployment and Retrieval of Unattached Payloads | None | Objectives for special missions | |
| Venting Effects | Impacted operation of attitude control system | Minimal impact, if any | Mission dependent. Shuttle vents all the time unless stored. |
| Load Factors | Launch stress only for experiments in the Orbital Workshop. | Not to exceed 3-g's. | |
| Communications | Less than 20% average coverage per day | Same without communications satellite (except for polar orbits). Greater than 90% average daily coverage with communications satellite 2-way air/ground TV. | No Tracking and Data Relay Satellite antenna – 15%<br>One Tracking and Data Relay Satellite antenna – 40 to 60%<br>Two Tracking and Data Relay Satellite antennae – 85 to 100% |
| Payload Constraints | Fixed to launch configuration with minor alterations via visit-to-visit resupply.<br>–<br>Mostly internal with passively mounted external experiments.<br>–<br>Considerable crew involvement. | Fixed for each mission<br>–<br>Variable from mission-to-mission<br>–<br>Attached or free flying capability<br>–<br>• Manual<br>• Automated<br>– Active<br>– Passive<br>• Combined operating modes for attached payloads | |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR ENVIRONMENTAL FACTORS

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Atmospheric Composition | 70% $O_2$<br>30% $N_2$<br>< 5 mm Hg $CO_2$ | 80% $N_2$<br>20% $O_2$<br>< 7.6 mm Hg $CO_2$ | 5.0 mm nominal |
| Atmospheric Pressure | 5.0 psia | 14.7 psia | |
| Operating Environment | Shirtsleeve | Shirtsleeve | |
| EVA Prebreathing | Not necessary | Will be necessary | Shuttle cabin will be 14.7 psia with 80% $N_2$. Skylab workshop and Apollo CM was at 5.0 psia. |
| Flammability | Extensive material screening | Extensive material screening | Shuttle atmosphere with 80% $N_2$ plus zero-g effects makes flame propagation less of a problem than normal earth environment. |
| Outgassing | Material testing | Material testing | Shuttle atmosphere will be the same as on earth so there will be much less tendency for outgassing of nonmetallic materials. |
| Liquid Waste Disposal | Vented overboard via trash compartment | To be determined | |
| Solid Waste Disposal | Left in orbit (except for M071 dried samples). | To be determined | |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR MISSION OPERATIONS

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Experimenter Support | "Off-Line" | "In-Line" | Experimenters to have an in-line mission role during flight following either a direct interface with the Flight Director or through a Principal Investigator technical interface. |
| Support to Experimenter | Involvement through NASA Principal Coordinating Scientist (PCS) | Continuous direct involvement with payload integration center | In Skylab, NASA was responsible for providing experiment hardware and software support; in Shuttle these functions shall reside with the individual experimenters. |
| Logistics Support | NASA | Mixed | NASA will provide logistics support to the experiment carrier interface. Logistics from the interface to the experiment will be experimenters' responsibility. |
| Experiments Planning | Experimenter with Operations Center | Experimenter direct with payload | Experimenter to establish protocol and crew procedures for experiment and to provide support to the payload center for coordinating these functions in the mission plan. |
| Experiments Training | NASA PCS Coordination | Flight Operations Management | Training interface with crew coordinated by payload center. |
| Mission Data Support | NASA PCS Coordination | Direct interface between experimenter and flight operations management | Coordination with flight operations to establish the formats in which experiments data will be submitted to experimenter. |
| Flight Experiments Anomaly Corrective Action Support | NASA PCS's and Project Engineers | Experiment and Support Staff | |
| Mission Management and Control: | | | |
| - Ascent Phase | | | |
| • Payload Monitoring | Ground | Onboard - Prime<br>Ground - Backup | |
| - On-Orbit Phase: | | | |
| • Payload Monitoring Prior to Activation | Ground | Onboard - Prime<br>Ground - Backup | |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR MISSION OPERATIONS

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| - On-Orbit Phase: (cont'd) | | | |
| • Activation, Checkout, and Deployment | Onboard | Onboard - Prime<br>Ground - Backup | (Limited by Station Contact) |
| • Subsystems Operations in Support of Payloads | Onboard and Ground | (Spacelab Support)<br>Onboard - Prime<br>Ground - Backup | |
| • Payload Performance Monitoring | Mixed | (Spacelab-Mixed) | Responsibilities vary for payload; preferred mode is onboard prime. |
| • Payload Subsystems and Experiment Operations | Onboard | Onboard - Prime<br>Ground - Backup | Ground will have real-time command capability - application sensitive to experiment complexities, man/machine interactions, degree of automation, etc. |
| • Free Flyer Payload (while in vicinity of host vehicle) | Not applicable | Ground - Prime<br>Onboard - Limited | Orbiter will have limited status monitoring while near vicinity of free flyer; possibly limited commands (engine safe command, attitude control deactivation) |
| • Attached Payload Operations (no manned experiments involvement) | Onboard | Mixed - Onboard and Ground Control | Requirements may vary between payloads. |
| • Consumables Management | Ground | Onboard - Prime<br>Ground - Monitor | Ground has monitoring and prediction capability (automated and manual). Strongly related to activity scheduling function. |
| • Activity Scheduling | Ground | Mixed<br>Preferably onboard management | Varies with payload complexity and degree of ground interfaces (coordination of network, Experimenter support, etc.). |
| • Radiation Monitoring/Prediction | Ground | Onboard - Prime<br>Ground - Monitor | Ground to have premission and real-time monitoring and projection capability - manage major decisions. |
| • Communications Scheduling and management | Ground | • Voice<br>- Onboard-Prime<br>- Ground - Monitor<br>• Data<br>- Ground-Prime<br>- Onboard-Backup | Total daily orbital coverage dependent upon orbital altitude and addition of communication satellite(s).<br>Telemetry data recording to be an automatic onboard function with manual override. Ground will command data dumps per flight plan, or upon onboard request. |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR MISSION OPERATIONS

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| - On-Orbit Phase: (cont'd) | | | |
| • Data Management (Payload Data) | Mixed | Mixed | Onboard personnel will have capability for automatic and manual control of editing and recording of experiments data. Ground will schedule sites and network for orbiter support and format data for Experimenter. |
| • General Concept | Ground had continuous command and control | Ground to have executive level control - inflight mission support to be analogous to aircraft enroute and terminal traffic control | |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR PAYLOAD OPERATIONS MANAGEMENT

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Experiments Concept | Independent experiments | • General laboratory<br>• "Suitcase" carry-on<br>• Automated<br>• Passive | Orbiter experiments bay to have fixed interfaces for fit and functions |
| Operations Policies | Host Site | Host Site | With experiment owner participation during operations |
| Payload Characteristics | Multi-disciplined | Approximately 50% single discipline and 50% mixed | Mission dependent |
| Experiment Development | NASA | Experimenters | Dependent on funding source |
| Flight Constraints | Manned space flight certification standards | Industrial standards and NASA flight safety standards | |
| Ultimate NASA Role | Total responsibility | Host responsibility | All experiment costs chargeable to experimenter and payload center allocatable to these areas. |
| Experiment Selection and Payload Development Integration | NASA Program Offices | To be established | Experiment assignment of each flight will be based on a long-range Experiment Implementation Planning Committee which will consist of NASA national and/or international scientists. |
| NASA Relationship to Experimenter for Collected and Processed Data | Owner and Host | Host only | In Skylab, NASA retained one copy of all data obtained during mission phases. Unless special agreements are reached with NASA, NASA distributes all data to experimenters. When NASA retains data, experiment costs may be fully chargeable to NASA or shared between NASA and experimenter. |
| Payload Contingency on Ground | Delay Flight Schedule | Remove or fly degraded schedule | Contingency payloads available for flight if payload needs to be removed. |
| Laboratory Ownership | NASA | NASA, with assignment to payload centers | Ownership may be only for period of usage - then recycled to perhaps another discipline. |
| Special Flight Equipment Ownership | NASA | Experimenter | |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR PAYLOAD OPERATIONS MANAGEMENT

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Baseline Equipment and Payload Carrier Checkout Equipment Ownership | NASA | NASA-Host Site | |
| Special Checkout Equipment and Special Software | NASA | Experimenter | |
| Opportunity for a Major Experimenter to fly with his experiment | No | Yes | |
| Flight Hardware Interface Verification Testing | NASA | NASA-Host Site | For payload to orbiter interface and payload module to payload module interfaces only. |
| Flight Hardware Performance Testing | | | |
| • General Lab | NASA | NASA | For safety related items and common equipment items. |
| • Special Hardware | NASA | Experimenter and Payload Center | |
| Management of Reports of Experiment Findings | NASA | Experimenter and experimenter sponsor | |
| Support Services | Central NASA control | NASA-Host Site | As required, charged to payload owner |
| Support Facilities | Host Site | Host Site | As required, charged to payload owner |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR CREW HEALTH CONSIDERATIONS

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Clinical Health Status Monitoring during pre- and postflight phase | Rigidly disciplined for fixed pre- and postflight periods | Periodic and routine throughout a crewman's flight status assignment. | Considerable numbers of candidate crews and passengers pool must be monitored for their crew health status. Their health status will have to be matched with their training and mission objectives of particular mission. |
| Work/Rest Cycle Constraints | Yes | Yes | Autonomy on Shuttle permits crew flexibility. |
| Biorhythm Adjustments | Necessary | Minimal | Skylab recovery constraints, extensive deactivation timeline, and long medical protocol after recovery forced sleep period shift (and then a subsequent readjustment). |
| Scientist Physiological Training | N/A | Yes | |
| Astronaut Physiological Training | Yes | Yes | |
| Inflight Diagnostic and Therapeutic Resources | Extensive - all crewmen | One or two selected crewmen for each mission. | |
| Inflight Physical Conditioning | Extensive | • Moderate for short duration missions<br>• Extensive for longer duration missions | |
| Baseline Physiological Data Collection | Extensive | Extensive only for life sciences mission. | Possibly only for crewmen who would be subjects for medical experiments in twice-a-year Spacelab missions. |
| Crew Health Assessments | Prime objective, but data system was principally for experiments | Limited | |
| Crew Clinical Training | Extensive course for all crewmembers | Only a few selected crews will be trained. | Short missions such as are planned for Shuttle may reduce possibility of serious medical problems, but possibility of accidents and hazards may be higher in the Shuttle due to multiple crews and repeated use of the same vehicle. |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR CREW HEALTH CONSIDERATIONS

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Crew Health Stabilization | Mandatory | To be determined | |
| Diets | Rigidly regulated (experiment requirement) | Principally pantry style; moderate menu constraints | |
| Clinical Health Status Monitoring During Flight Phases | Mandatory | Most probably limited to transitional flight phase; all other on a standby basis unless a specific experiment is involved. | |
| Criteria for Each Mission Termination | Real-time decisions | Real-time decisions | |
| Operational Hazards | • Fire<br>• Radiation<br>• Depressurization<br>• Toxicity<br>• Disease and Injury | Same plus landing hazards | |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR LIFE SCIENCES OPERATIONS DOCUMENTATION

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| Level 1, Headquarters Program Requirements Documents | Yes | Yes | |
| Level 2, Center Level Program Definition, Requirements, and Specifications | Yes | Yes | Mission operations documentation will attend to each type of payload carrier: spacelab, pallet, etc. |
| Level 3, Center Level Supporting documents including functional operations documents. (only Life Science Directorate functional documents are listed). | | | |
| 1. Medical Requirements Document | Consolidated Mission Clinical/ Experiment requirements | Independent clinical and experimental requirements | Clinical requirements are expected to remain stable from mission-to-mission<br>Experimental scope will change from mission-to-mission |
| 2. Medical Operations Plan | Same as above for Operations Plans | • Flight operations medical plan<br>• Spacelab pallet, etc., experiment operations plans | Experiment operations plans will be prepared for each combination of experiments designated for each type of payload carrier. |
| 3. Flight Crew Health Stabilization Plan | Yes | Unknown | |
| 4. Medical Operations Reporting Plan | Yes | No | To be included in the operations plans under heading #2. |
| 5. Biochemical/Clinical Lab Operations Support Plan | Yes | No | This becomes an experimenter responsibility if he has such a requirement. |
| 6. Medical Data and Calibration Management Plan | Yes | No | See accommodations handbook - heading #10 below. |
| 7. Mobile Laboratory Operations Plans | Yes | No | Shuttle Orbiter will land at launch site - host site will provide medical facilities. |
| 8. Mobile Laboratory Maintenance Plan | Yes | No | Same as above. |
| 9. Biomedical Specimen Recovery Logistics Plan | Yes | Yes | Rather than being a NASA plan, it will be an experimenter's plan so that he can interface with host site. |

COMPARATIVE OPERATIONAL CHARACTERISTICS BETWEEN SKYLAB AND SHUTTLE
FOR LIFE SCIENCES OPERATIONS DOCUMENTATION

| PARAMETER | SKYLAB | SHUTTLE | COMMENT/RATIONALE |
|---|---|---|---|
| 10. Accommodations Handbooks | No | Yes | These handbooks will be available from each host site interfacing with the experimenter. It will explain host site operating policies, equipment interfaces, available facilities, support services, etc., and advise the user of his responsibilities to the host. |