Some Human Factors Considerations for Orbital Maintenance and Materials Transfer

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Scientific and tactical space missions will require support from units trained and equipped to perform a variety of extravehicular maintenance operations. The effective accomplishment of maintenance missions depends upon the extent to which man can adjust to the extravehicular space environment and his adjustment and performance are dependent upon the degree to which his sensory apparatus will continue to provide at least a basic repertoire of stimuli with which he is familiar. A preliminary task analysis was required to determine the performance levels of a human space-maintenance worker and to evaluate some of man's space-adaptive capacities. The preliminary analysis established certain tentative considerations expected to influence the maintenance mission. Basic among these were the following: shuttle vehicle design, design of vehicle upon which task will be performed, makeup of test, degree of automation involved in performance of task, accessibility of task area, techniques for task performance and effectiveness of tool design or modification. Certain basic assumptions were also enunciated; the worker would operate in an anthropomorphic suit and would possess the necessary motor skills and visuomotor coordination. The shuttle vehicle and the vehicle upon which the task would be performed would be joined by some sort of docking technique.

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The preliminary analysis established certain tentative considerations expected to influence the maintenance mission. Basic among these were the following:

- Shuttle vehicle design.
- Design of vehicle upon which task will be performed.
- Makeup of task.
- Degree of automation involved in performance of task.
- Accessibility of task area.
- Techniques for task performance.
- Effectiveness of tool design or modification.

Certain basic assumptions were also enunciated:

- The worker would operate in an anthropomorphic suit.
- The worker would possess the necessary motor skills and visuomotor coordination.
- The shuttle vehicle would be capable of motion in six degrees of freedom.
- The shuttle vehicle and the vehicle upon which the task would be performed would be joined by some sort of docking technique.

The preliminary task analysis also helped to establish a tentative statement of the range of missions anticipated for the space maintenance worker and this statement, in turn, permitted some definition of typical tasks the space maintenance worker might be expected to accomplish.

On the basis of these tentative statements and definitions an empirical investigation was initiated to permit observation of a human subject during his efforts to accomplish certain specified tasks under simulated space environment.

PROCEDURE

During this investigation each operation of each task was completed by a human subject in three environments: shirtsleeve, unpressurized suit and pressurized suit. The pressure-suit environment included three situations: working through an open hatch set into the shuttle at 90 degrees, working through an open hatch set into the shuttle at 45 degrees and working through fabric armpieces attached to a closed shuttle vehicle. A Mark IV suit was used for these experiments. Anecdotal records were maintained and the observations of the subject were recorded.

The subject attempted to accomplish the following tasks: (1) replacement of gasket on Agena engine starter-generator, (2) repair of meteoroid puncture, (3) replacement of fuel cell and (4) replacement of electrical switch.

Mockups were used for the Agena engine, the fuel cell and the switch.

The length of time and the tool force required for each task in each of the environments were measured.

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Techniques in the use of fabric armpieces with respect to (1) task accessibility, (2) tool and parts stowage, (3) tool and parts handling, (4) vision and lighting problems and (5) physical orientation were observed. Design features of the fabric armpieces were observed, as were the effects of abuse on the armpieces.

RESULTS AND DISCUSSION

An evaluation of the notes of the observer and the taped comments of the subject disclosed problem areas in anticipated space-maintenance operations. Among these were the configuration of the hatch in the shuttle, the capabilities of the pressure suit and the gloves, the design of the tools and the design of the fabric armpieces. Bolts, fasteners and lanyards caused problems for the subject too.

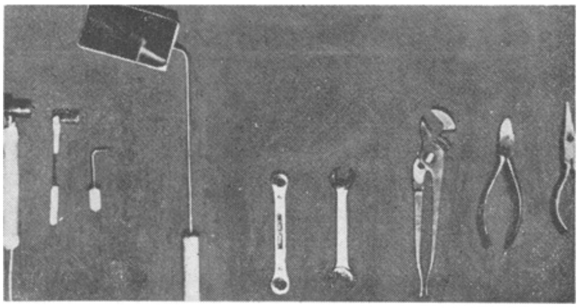

Fig. 1. Assorted standard tools used to perform the tasks.

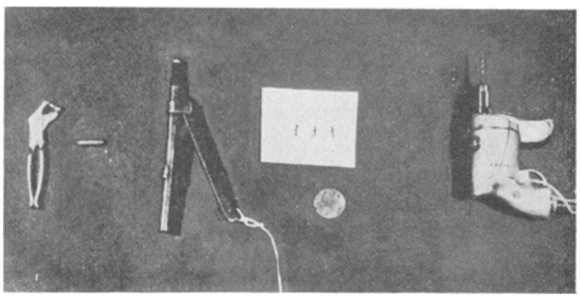

Fig. 2. Assorted standard tools used to perform the tasks.

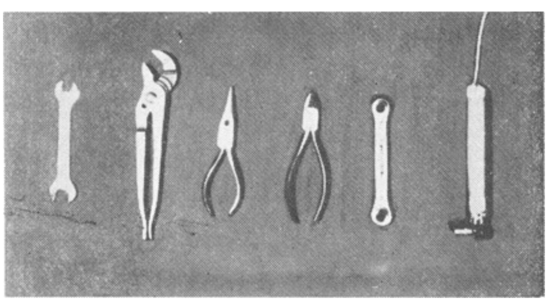

Fig. 3. Assorted standard tools used to perform the tasks.

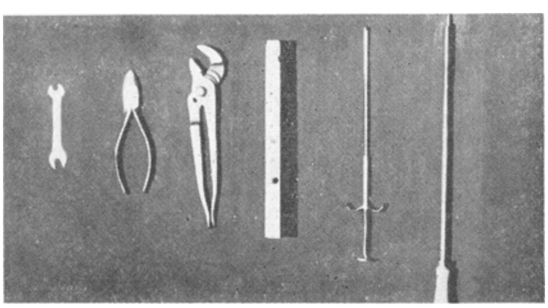

Fig. 4. Assorted standard tools used to perform the tasks.

The subject made recurring comments about fatigue from fighting the suit and frustration from aborted task efforts.

Tools: Assorted standard tools were used, including ratchet wrenches, end wrenches, flexible and rigid wrench extensions, cleco pliers, allen wrenches, power drills, rivet guns and Phillips screwdrivers. Tools used to perform the tasks are pictured in Figures 1 through 4.

Wire drift pins were used to help align work during reassembly operations and a long-handled mirror was used for close observation of the task object.

The ratchet wrenches were found to require some modification because the subject could neither hear nor feel the characteristic clicks. At times he exerted considerable energy without actually knowing if he was making appropriate progress while using this particular tool assembly. This tool should be modified to provide electronic sensing of the clicks and to notify the subject by varied audible tones or by varied patterns of vibration distinct enough to be sensed through the gloves.

All of the tools appeared to need modification to provide handle surfaces of greater diameter and to ensure retention of grip on the work object. Manual control of the retention device appeared necessary. The retention device would ensure contact with the work object, allow the user to rest periodically without jeopardizing the progress of his work and prevent loss of extracted bolts or fasteners.

Operation of a conventional drill (¼-inch chuck) quickly caused hand fatigue because of the weight and shape of the device. Addition of a front pistol-grip handle permitted one-handed operation with either hand and permitted easy shifting from one hand to the other.

The cleco pliers will require modification to prevent loss of the cleco fastener from the jaws of the tool. The present design requires that constant pressure be exerted by the worker to hold the fastener securely but, because of the awkardness of the gloves, the worker cannot effectively sense the degree of pressure necessary.

The blind rivet gun requires modification to prevent loss of the rivet from the front aperture since this tool requires two-handed operation by the subject during approach to the work object.

Suit: A suit that is not tailormade was found to add to the difficulty of performing maintenance tasks. Excessive suit adjustments required to make a suit fit properly restrict the movement of the man in the suit. It was concluded from these experiments that the suit used, which was not tailormade, is not satsfactory as a space-maintenance garment because (1) it is not sufficiently mobile at 3.5 psi, (2) the worker has to "fight" the suit to accomplish his tasks and (3) the ventilation is inadequate.

Gloves: Considerable improvement in the gloves is imperative to permit critical tactility, easy manipulation and better access to structurally restricted task areas. Finger length and size are critical factors and flexibility to permit small-detail finger manipulation is an essential requirement.

Two styles of gloves were used during the experiments. One style had a tendency to balloon excessively when inflated, thus inducing an appreciable amount of hand fatigue. The second style was more effective for space-maintenance use because they did not balloon as much.

Lanyards: It is essential that parts and tools be anchored to prevent their loss and the lanyard can perform this function adequately. However, lanyards tend to tangle and should be redesigned to provide a handle with the line attached to the handle at a swivel. It might be possible to construct a retractable lanyard that can be arrested at various lengths and easily released.

Access: The subject needed more working room, generally, which indicates a need for appropriate redesign to enlarge access to areas where maintenance problems are likely to occur. In most instances the subject was unable to get both hands into a task area at the same time and his visual observation of the work in progress ranged from difficult to impossible. The inability to get close enough to reach more than 18 inches into the work area was a handicap. The armpiece configuration was more restrictive than the open-hatch pressure-suited versions.

Bolts: Threaded bolts should be redesigned to provide for minimum thread area and a root diameter extension below the shortened threads, to permit use of the bolts as drift pins for alignment during reassembly operations. This arrangement would also serve to prevent cross-threading because it would aid in proper positioning of the bolts.

Lockwires: Since the gloves are sensitive to penetration the use of lockwires introduces a hazard. A spring device would probably be an effective substitute for lockwires.

Fabric Armpieces: The use of fabric armpieces prevented the subject from twisting his body to improve his contact with a particular work area. By removing one arm from the armpiece he could increase his reach but he was then restricted to one-handed work. When the subject used both armpieces his dexterity and coordination were hampered by the inflexibility of the fabric used in construction.

Observations of the fabric armpieces in use led to the following conclusions:

1. Armpieces should be oversized from the elbows back but close-fitting below the elbows to permit access to tasks in remote or restricted areas.
2. The shuttle view plate should overhang the chest area enough to permit downward observation but should not protrude excessively beyond the radius of the helmet.
3. The chestplate should be as narrow as possible and the arm bellows should meet at the center.
4. Arm ports should be set at an angle to each other.
5. Maximum shoulder freedom of movement should be provided by an accordion bellows design.
6. Armpieces should be designed so as to provide the same meteoroid protection the shuttle structure provides.

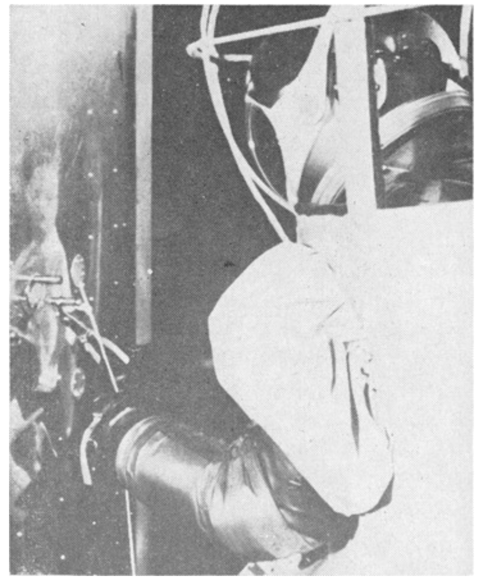

Fig. 5. Fabric armpieces in use as the subject repairs a meteoroid puncture.

Figure 5 shows a photograph of the fabric armpieces in use as the subject repairs a meteoroid puncture. Figure 6 depicts armpiece design features.

Hatches: The open-hatch configurations are more convenient for maintenance purposes than the fabric armpiece configuration. The hatches permit the worker to lean out and into his work and they permit more freedom of head and torso movement. The 45-degree hatch is more convenient than the 90-degree hatch because it facilitates movement of the shuttle vehicle to attain better proximity to the task.

Vehicle Movement: It is essential that the shuttle vehicle be capable of linear and rotary motion of at least one foot. Such movement capabilities are necessary to ensure effective observation and completion of the tasks by the worker. As a natural concomitant this

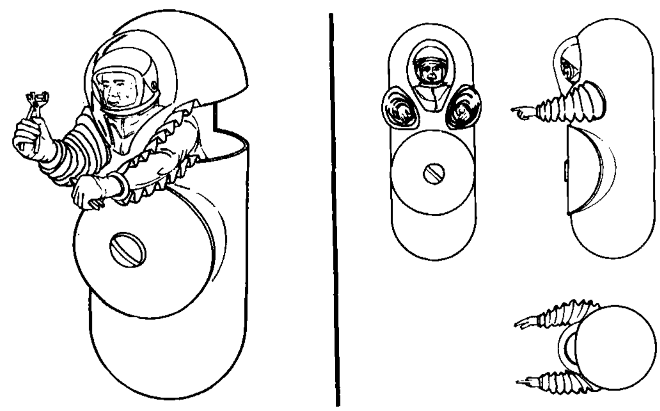

Fig. 6. Armpiece design features.

maneuverability would result in conservation of effort required to accomplish certain operations.

The method by which the two vehicles are tethered will influence controlled motion as well as vehicular restraint required for work to be done. The open hatch configurations would be a little less dependent on large relative motion than the configuration using the fabric armpieces.

Worker Frustration and Fatigue: Successful completion of some task operations was thwarted, at times, because of certain design features inherent in the vehicle being worked on and in the shuttle vehicle, because of the unsuitability of various tools and because of the physical restraint imposed by the pressurized suit. Frustration and excessive physical effort caused the subject to overheat and induced a marked degree of fatigue during relatively short operational periods.

Repeated attempts to accomplish even the smallest of tasks often led to frustration and fatigue because of task inaccessibility and suit and tool restraints. Typical symptoms of fatigue appeared as increased awkwardness in manual manipulation and an increased tendency to drop tools and fasteners. The subject consistently reported rapid development of feelings of fatigue in his hands, especially when the particular task required the use of tools with small handles or the operation of excessively long threaded parts.

TABULATED RESULTS

Tables I through V present tabulated time results and comments from each of the specified tasks.

CONCLUSIONS

Accumulated evidence strongly suggests a need for continued and imaginative investigation of psychophysiological and technical factors that may influence the accomplishment of space maintenance missions. At the same time it is apparent that speculation and simulated exercises are no substitute for real experience in the space environment. The following conclusions can be drawn from this attempt to define realistically some of the problems pertinent to the space maintenance missions:

1. The design of the shuttle vehicle should provide for maneuverability during the actual maintenance operation.
2. The 45-degree hatch appears to accommodate the space maintenance worker most conveniently.
3. Vehicles upon which space maintenance will have

TABLE I SUMMARY OF CUMULATIVE TASK TIMES* (MINUTES)

	CONTROL CONDITION		SHUTTLE/PRESSURIZED SUIT		
TASK	SHIRT-SLEEVE	UNPRESSURIZED SUIT	FABRIC ARMPIECES	HATCH 90 DEGREES	HATCH 45 DEGREES
1. REPLACE GASKET	19.9	38.5	ABORT	86.8	90.0
2. REPAIR METEOROID PUNCTURE	6.1	5.5	7.55	7.2	6.55
3. REPLACE FUEL CELL	14.8	19.4	48.0	49.4	37.4
4. REPLACE DAMAGED SWITCH	8.6	10.3	34.4	26.5	22.7

*DOES NOT INCLUDE REST PERIODS
(20 MINUTE WORK PERIOD – 20 MINUTE REST PERIOD)

TABLE III CUMULATIVE TASK TIMES (MINUTES) — TASK NO. 2 REPAIR METEOROID PUNCTURE

TASK REQUIREMENTS	CONTROL CONDITION		SHUTTLE/PRESSURIZED SUIT			STANDARD FASTENERS	FORCE DATA	TOOL REQUIREMENTS
	SHIRT-SLEEVE	UNPRESSURIZED SUIT	FABRIC ARMPIECES	HATCH 90 DEGREES	HATCH 45 DEGREES			
1. PLACE PREFABRICATED HOLE-PLUG ON PUNCTURE.	0.4	0.3	0.5	0.4	0.4	SOP	SOP	NONE
2. DRILL PILOT HOLE FOR CLECO FASTENER TO MATCH PREDRILLED PLUG-HOLES.	1.1	0.5	0.8	0.6	0.6	POWER DRILL	THRUST ACTION	POWER DRILL WITH TWO HANDLES
3. INSTALL CLECO FASTENER.	1.3	0.8	2.35	2.3	2.2	2 CLECO FASTENERS	THRUST ACTION	CLECO PLIERS
4. DRILL HOLES FOR FASTENERS TO MATCH PREDRILLED PLUG.	2.1	1.3	2.8	2.8	2.5	POWER DRILL	THRUST ACTION	POWER DRILL WITH TWO HANDLES
5. INSTALL BLIND RIVETS.	3.3	2.9	6.2	4.5	4.3	RIVETS	SQUEEZE FORCE	BLIND RIVET GUN
6. REMOVE TWO CLECO FASTENERS.	4.1	3.3	6.3	5.5	5.4	2 CLECO FASTENERS	SQUEEZE FORCE	CLECO PLIERS
7. STOW PLIERS.	4.6	3.7	6.4	5.6	5.45		SOP	CLECO PLIERS
8. INSTALL BLIND RIVETS.	6.05	5.3	7.5	7.15	6.5	RIVETS	SQUEEZE FORCE	BLIND RIVET GUN
9. STOW RIVET GUN.	6.1	5.5	7.55	7.2	6.55		SOP	RIVET GUN

TABLE II
CUMULATIVE TASK TIMES
(MINUTES)

TASK NO. 1
REPLACE GASKET ON STARTER GENERATOR

TASK REQUIREMENTS	CONTROL CONDITION		SHUTTLE PRESSURIZED SUIT			STANDARD FASTENERS	FORCE DATA	TOOL REQUIREMENTS
	SHIRT-SLEEVE	UNPRESSUR-IZED SUIT	FABRIC ARMPIECES	HATCH 90 DEGREES	HATCH 45 DEGREES			
1. SECURE SOLID CHARGE IGNITERS BY CUTTING LOCKWIRE & SEPARATING ELECTRICAL CONNECTORS; TWO IGNITERS PER START-CAN, 4 CONNECTORS & TETHER WITH LANYARD.	1.1	3.5	3.2	4.8	4.1	LOCKWIRE & ELECTRICAL CONNECTORS	CLOSED FORCE SQUEEZE ACTION	LOCKWIRE CUTTING PLIERS. CONNECTORS REMOVED MANUALLY BE TORQUING THE SCREW COLLARS
2. REMOVE TWO BOLTS FROM STARTER CAN ASSEMBLY CLAMPS & STOW BOLTS.	1.4	5.5	ABORT	8.7	10.5	2 BOLTS 3 8 IN. HEAD	14-15 LBS	SOCKET RATCHET WRENCH WITH EXTENSIONS & A BOXED RATCHET WRENCH
3. PLACE LANYARD ON STARTER CANS.	1.5	5.8		8.8	11.5	LANYARD		
4. REMOVE TWO BOLTS FROM STARTER CAN ASSEMBLY BRACKET & STOW BOLTS.	3.3	8.7		15.9	22.5	2 BOLTS 3/8 IN. HEAD	14-15 LBS	SOCKET RATCHET WRENCH WITH EXTENSIONS & A BOXED RATCHET WRENCH
5. DISCONNECT TWO FLEX HOSES FROM GAS GENERATOR INJECTOR.	5.1	10.2	ABORT	17.2	24.2	NUT 3 8 IN.	SMALL	TWO OPEN-END WRENCHES – ONE FOR HOLDING & ONE FOR TORQUING
6. REMOVE 10 BOLTS FROM TOP OF GAS GENERATOR INJECTOR AND STOW BOLTS.	6.7	16.9	ABORT	36.2	48.2	10 BOLTS		ALLEN WRENCH WITH EXTENSIONS WITH & WITHOUT RATCHET
7. REMOVE GAS GENERATOR STARTER ASSEMBLY & STOW.	7.2	17.5		36.8	48.8	NONE	NO FORCE REQUIRED TO SEPARATE ASSEMBLIES	A SCREWDRIVER OR A PRYING TOOL
8. REMOVE GASKET.	7.5	17.7		37.2	49.6	NONE	NONE	A SCREWDRIVER OR THIN BLADE IS NEEDED TO REMOVE GASKET FROM GROOVE
9. INSTALL NEW GASKET.	8.1	17.		37.3	53.1	NONE	NONE	
10. REPLACE GAS GENERATOR STARTER ASSEMBLY.	8.9	8.2		37.8	53.5	TWO DRIFT-PINS, 3.5 IN. LONG		TWO DRIFT PINS TO HOLD GENERATOR FOR BOLT POSITIONING
11. REPLACE 10 BOLTS ON GAS GENERATOR.	13.1	27.2	ABORT	56.4	72.6	10 BOLTS	TORQUING ACTION	ALLEN WRENCH WITH EXTENSIONS & RATCHET
12. CONNECT TWO FLEX HOSES TO GAS GENERATOR.	13.4	28.5	ABORT	58.1	74.8	NUT 3/8 IN.		TWO OPEN-END WRENCHS: ONE FOR HOLDING & ONE FOR TORQUING
13. REPLACE TWO BOLTS ON STARTER CAN ASSEMBLY BRACKET.	14.8	33.2		66.4	80.8	2 BOLTS 3/8 IN. HEAD	14-15 LBS	SOCKET RATCHET WRENCH WITH EXTENSIONS
14. REMOVE LANYARD.	15.1	33.5		66.6	80.9	LANYARD		
15. REPLACE TWO BOLTS ON STARTER ASSEMBLY CLAMPS & STOW BOLTS.	16.9	36.5		74.2	87.6	2 BOLTS 3/8 IN. HEAD	14-15 LBS	SOCKET RATCHET WRENCH WITH EXTENSIONS
16. REPLACE THE FOUR IGNITERS ON STARTER CANS.	19.9	38.5	ABORT	86.8	90.0*	ELECTRICAL CONNECTORS	CLOSED FORCE SQUEEZE ACTION	CONNECTORS REPLACED MANUALLY & TIGHTENED USING PUMP PLIERS BY TORQUING THE SCREW COLLARS

* THIS TASK WAS ACCOMPLISHED BEFORE THE 90° HATCH-CONFIGURATION TASK. HENCE, TOTAL TIMES WERE SLIGHTLY LONGER BECAUSE OF LEARNING CURVE.

to be performed should be designed to assure access to anticipated repair areas.

4. Slightly modified standard tools appear to be suitable for space maintenance operations; essential modifications would include enlargement of all handles, incorporation of a device to retain each tool on the work object and two pistol-grip handles on bulky tools.

5. Pressure suits must be tailormade and individually fitted and gloves must be designed to prevent ballooning and to ensure maximum tactility and flexibility.

TABLE IV
CUMULATIVE TASK TIMES
(MINUTES)

TASK NO. 3
REPLACE FUEL CELL

TASK REQUIREMENTS	CONTROL CONDITION		SHUTTLE/PRESSURIZED SUIT			STANDARD FASTENERS	FORCE DATA	TOOL REQUIREMENTS
	SHIRT-SLEEVE	UNPRESSURIZED SUIT	FABRIC ARMPIECES	HATCH 90 DEGREES	HATCH 45 DEGREES			
1. CUT LOCKWIRE ON ELECTRICAL CONNECTOR.	1.1	1.2	1.8	2.2	1.7	LOCKWIRE & ELECTRICAL CONNECTOR SCREW COLLARS	CLOSED FORCE SQUEEZE ACTION (BOTH HANDS)	LOCKWIRE CUTTING PLIERS
2. DISCONNECT ELECTRICAL CONNECTOR.	1.2	1.8	5.5	3.1	2.5	ELECTRICAL CONNECTOR, SCREW COLLARS	SQUEEZE ACTION	PUMP PLIERS
3. DISCONNECT FUEL LINE.	1.6	2.1	5.5	3.1	2.5	11/16 IN. FITTING	ROTATE AND PULL	OPEN-END WRENCH 11/16-IN. (PUMP PLIERS) 7/8 IN. OPEN-END WRENCH
4. DISCONNECT OXYGEN LINE.	1.7	2.5	5.5	3.1	2.5	11/16 IN. FITTING	ROTATE AND PULL	PUMP PLIERS OR 7/8 IN. OPEN-END WRENCH – 11/16 IN. WRENCH
5. DISCONNECT WATER LINE.	1.8	2.9	10.5	5.9	4.9	11/16 IN. FITTING	ROTATE AND PULL	OPEN-END WRENCH 11/16-IN. (PUMP PLIERS) OR 7/8 IN. OPEN-END WRENCH
6. REMOVE TOP FUEL CELL ASSEMBLY MOUNTING BOLTS; ATTACH CRANE LINE.	6.5	7.8	10.5	5.9	4.9	7/16 IN. BOLTS	RATCHET ACTION DOUBLE HEX HEAD	7/16 IN. RACHET WRENCH (SOCKET) AND/OR BOXED RATCHET WRENCH
7. REMOVE BOTTOM CELL ASSEMBLY MOUNTING BOLTS.	7.2	11.5	22.3	25.0	14.1	CRANE SLING & 7/16 IN. BOLTS	10-14 LBS DOUBLE HEX HEAD	7/16 IN. RACHET WRENCH (SOCKET) AND/OR BOXED WRENCH
8. REMOVE FUEL CELL.	7.2	11.5	23.2	21.6	20.5	CRANE SLING	PULL	SOP
9. REPLACE FUEL CELL.	7.6	11.5	23.2	31.4	22.1	7/16 IN. BOLTS	RACHET ACTION	7/16 IN. RACHET WRENCH
10. INSTALL MOUNTING BOLTS AT BOTTOM.	7.6	11.5	23.2	31.4	22.1	7/16 IN. BOLTS	RACHET ACTION	7/16 IN. RACHET WRENCH
11. REMOVE CRANE LINE AND INSTALL MOUNTING BOLTS AT TOP	8.8	17.5	39.1	41.8	30.7	7/16 IN. BOLTS	RACHET ACTION	7/16 IN. RACHET WRENCH
12. CONNECT WATER LINE.	8.8	17.5	39.1	41.8	30.7	11/16 IN. FITTINGS	SQUEEZE ACTION & TORQUE	OPEN-END WRENCH 11/16 IN. PUMP PLIERS
13. CONNECT FUEL LINE.	8.8	17.5	39.1	41.8	30.7	11/16 IN. FITTINGS	SQUEEZE ACTION & TORQUE	OPEN-END WRENCH 11/16 IN. PLIERS
14. CONNECT OXYGEN LINE.	13.6	18.6	45.7	47.1	35.6	11/16 IN. FITTINGS	SQUEEZE ACTION & TORQUE	OPEN-END WRENCH 11/16 IN. PUMP PLIERS
15. CONNECT ELECTRICAL CONNECTORS.	14.8	19.4	48.0	49.4	37.4	ELEC. CONNECTORS	THRUST	SOP

TABLE V
CUMULATIVE TASK TIMES
(MINUTES)

TASK NO. 4
REPLACE DAMAGED SWITCH

TASK REQUIREMENTS	CONTROL CONDITION		SHUTTLE/PRESSURIZED SUIT			STANDARD FASTENERS	FORCE DATA	TOOL REQUIREMENTS
	SHIRT-SLEEVE	UNPRESSUR-IZED SUIT	FABRIC ARMPIECES	HATCH 90 DEGREES	HATCH 45 DEGREES			
1. INSERT SHORTING PLUG (THRUSTER).	0.2	0.7	0.6	0.4	0.5	SHORTING PLUG (THRUSTER)	THRUST & TORQUE	NONE
2. REMOVE ACCESS PLATE FASTENERS.	3.3	3.6	12.9	10.1	6.1	PHILLIPS SCREWS	TORQUING ACTION	PHILLIPS SCREWDRIVER WITH 18 IN. HANDLE
3. ATTACH LANYARD TO ACCESS PLATE.	3.4	3.8	12.9.5	10.2	6.3	LANYARD	SOP	NONE
4. DISCONNECT MS CONNECTOR.	4.9	4.5	14.4	11.9	7.2	SCREW COLLAR	TORQUING ACTION	REMOVED MAN-UALLY BY TORQUING SCREW COLLAR
5. REMOVE SWITCH & STOW.	5.6	5.2	15.7	12.9	7.6	7/16 IN. BOLTS	SOP	
6. INSTALL REPLACEMENT SWITCH.	6.1	5.9	19.2	16.8	13.8	7/16 IN. BOLTS	TORQUING ACTION	7/16 IN. OPEN-END WRENCH
7. CONNECT MS CONNECTOR.	6.7	6.8	20.2	18.5	14.5	SCREW COLLAR	TORQUING ACTION	REPLACED MANU-ALLY BY TOR-QUING SCREW COLLAR
8. REMOVE LANYARD.	6.8	6.9	20.6	18.6	14.7	LANYARD	SOP	NONE
9. INSTALL ACCESS PLATE FASTENERS.	8.5	10.1	34.0	26.4	22.5	PHILLIPS SCREWS	TORQUING ACTION	PHILLIPS SCREWDRIVER 18 IN. HANDLE
10. REMOVED SHORTING PLUG & STOW.	8.6	10.3	34.4	26.5	22.7	SHORTING PLUG (THRUSTER)	TORQUE & REMOVE	NONE

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