Space Station

The Role of Mock-Ups in the Development of Orbital Replaceable Units (ORU)

5-65

Human Productivity Working Group
Ames Research Center – NASA
March 2, 1984

Gary A. Johnson
Crew Systems

Large Modular Orbital Replaceable Unit (ORU)

5-66

ORBITAL REPLACEABLE UNIT - ORU

- AN ORU IS ANY UNIT SPECIFICALLY DESIGNED FOR REPLACEMENT WHILE IN ORBIT
- TYPES:
  - COMPONENT (E.G., SOLAR ARRAYS, CMGS, INDIVIDUAL ELECTRONIC BOXES, ANTENNAS)
  - MODULAR - A COLLECTION OF RELATED UNITS IN SINGLE PACKAGE FOR TO OPTIMIZE MAINTAINABILITY (E.G., BATTERIES, THERMAL CONTROL PUMP PACKAGE, SELECTED GROUPS OF ELECTRONIC BLACK BOXES) - MAY HAVE INTEGRAL COLDPLATE
- NUMBER AND RATIO OF TYPES IS A FUNCTION OF THE PARTICULAR SPACECRAFT (I.E., SPACE STATION, SPACE PLATFORM, LEO FREE FLYER, GEO FREE FLYER)

LARGE MODULAR ORU APPLICABILITY

- MAINTENANCE
- GROWTH
- UPGRADING
- ASSEMBLY

LARGE ORU REPLACEMENT TESTS

PURPOSE:

TO DEVELOP AND VALIDATE HARDWARE DESIGN AND OPERATIONS FOR ON-ORBIT REPLACEMENT OF LARGE MODULAR ORU'S. THESE TESTS WILL PROVIDE GENERIC DATA FOR ANY SPACECRAFT IN WHICH LARGE ORU'S ARE AN OPTION, SUCH AS SPACE STATIONS AND SPACE PLATFORMS

TEST METHODS:

- 1-G TESTS - SHIRTSLEEVE SUBJECTS WITH SIMPLE PENDULUM AND COUNTERBALANCE SUSPENSION - NO RMS (AT TRW)
- NEUTRAL BUOYANCY TESTS - PRESSURE-SUITED SUBJECTS WITH PARTIAL SP FRAME, RMS, MFR, AND MMU (AT MSFC)

5-69

LARGE ORU REPLACEMENT TESTS

OBJECTIVES:

1-G TESTS:

- O VERIFY MECHANICAL OPERATION OF ORU STRUCTURAL, FLUID AND ELECTRICAL CONNECTIONS
- O PRELIMINARY EVALUATION OF HANDLING, GUIDING, ACCESS FEATURES
- O DEVELOPMENT OF NEUTRAL BUOYANCY TEST PROCEDURES

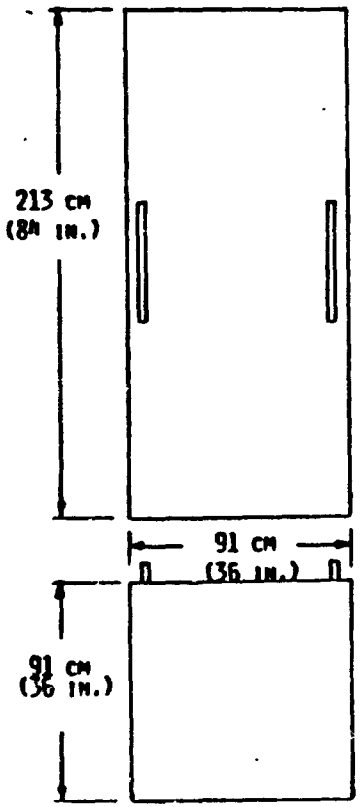
NEUTRAL BUOYANCY TESTS:

- O DEVELOP AND VERIFY ORU/EVA/RMS/MFR/MMU INTERFACES
- O VERIFY HANDLING, INSERTION, AND REMOVAL OF LARGE HIGH DENSITY MODULES
- O VERIFY MANUAL OPERATION OF STRUCTURAL, FLUID AND ELECTRICAL ATTACHMENT MECHANISMS
- O VERIFY ACCESS, VISION, TORQUE, FEEDBACK, AND SAFETY PARAMETERS
- O OBTAIN TASK AND TASK ELEMENT TIMES
- O DEVELOP AND VERIFY BODY POSITIONS AND BODY RESTRAINTS
- O VERIFY COMPATIBILITY OF CREW SAFETY TETHERING AND EQUIPMENT TETHERING OPERATIONS WITH ORU OPERATIONS
- O VERIFY FUNCTION OF MODULE ALIGNMENT GUIDES
- O INVESTIGATE TEMPORARY PARKING OPERATIONS

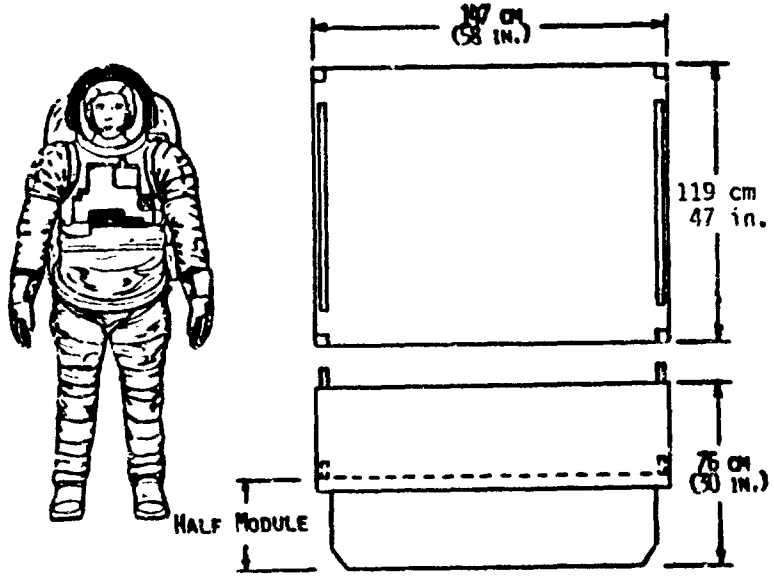
APPROACH USED TO DEVELOP ORU REPLACEMENT OPERATIONS

- UTILIZE RESULTS FROM SPACE TELESCOPE AND OTHER PROGRAMS TO AVOID UNIQUE SOLUTIONS
- ANALYSIS AND ENGINEERING LAYOUTS OF OPERATIONS/PROCEDURES
- 1/20 SCALE MODEL EVALUATION
- 1-G (UNSUITED) TESTS USING FULL SCALE FOAM-CORE MOCKUP OF ORU AND FRAME SEGMENT
- 1-G (UNSUITED) TESTS USING FULL SCALE NEUTRAL BUOYANCY TEST UNIT
- NEUTRAL BUOYANCY TESTS WITH SUITED SUBJECTS AT NASA/MSFC

MODULAR ORU



SPACE TELESCOPE
SCIENTIFIC INSTRUMENT
800 POUNDS



SPACE PLATFORM
ORU
200 TO 1500 POUNDS

5-72

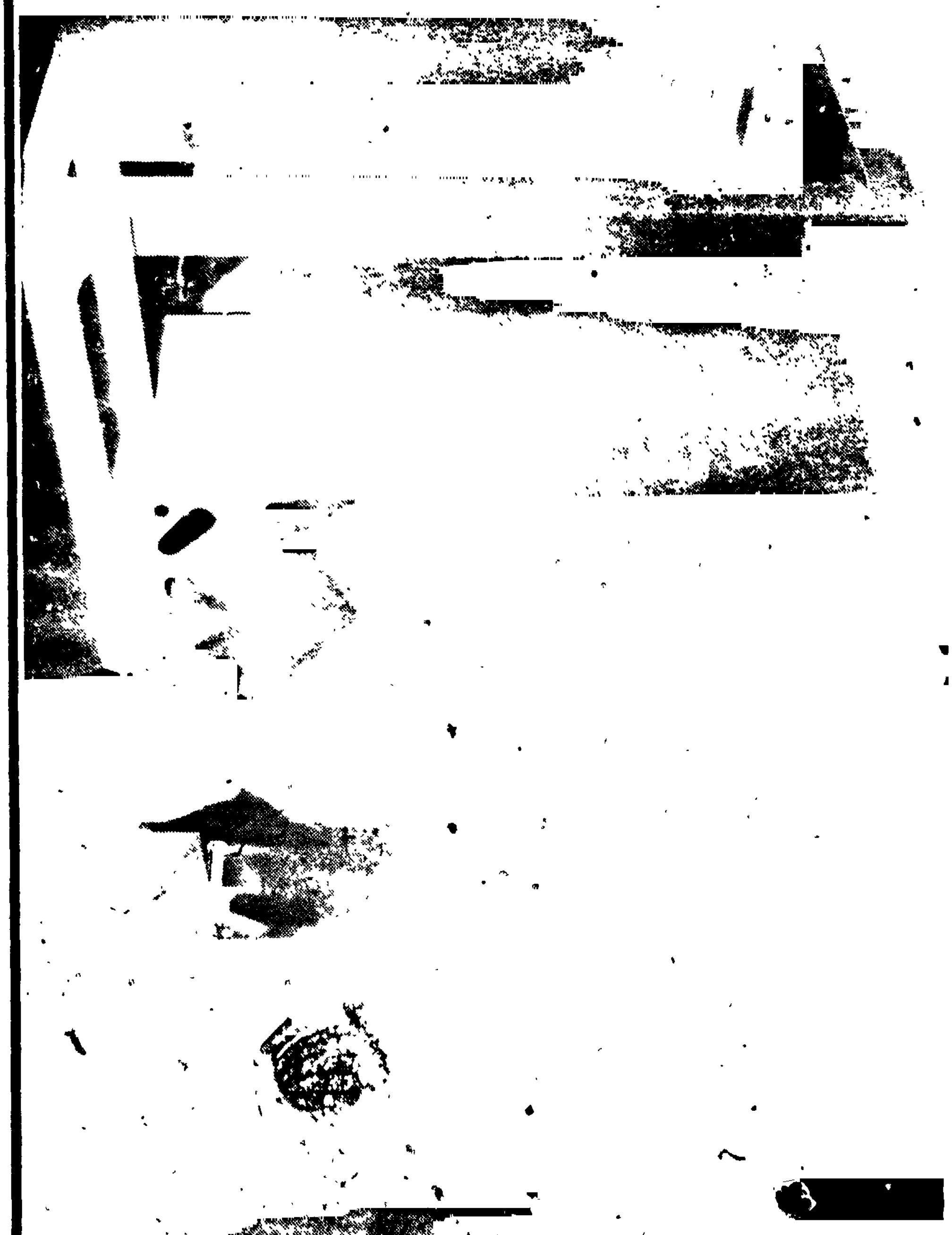
8

ORIGINAL PAGE IS
OF POOR QUALITY

PORT ORU REPLACEM

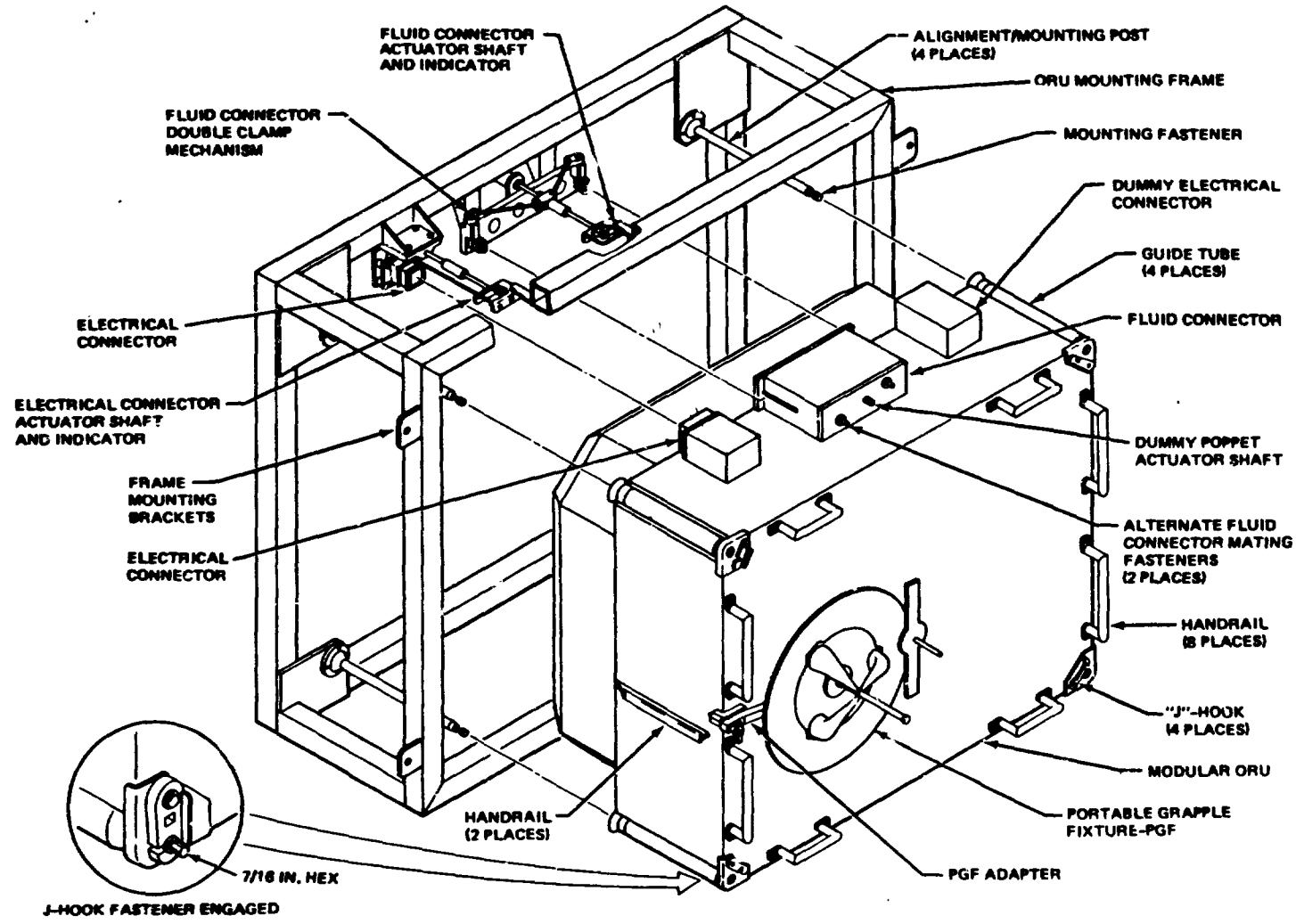
PROGRAM MANAGEMENT DIVISION

ORIGINAL PAGE IS
OF POOR QUALITY



MODULAR ORU MOCKUP

MODULAR ORU AND ORU MOUNTING FRAME

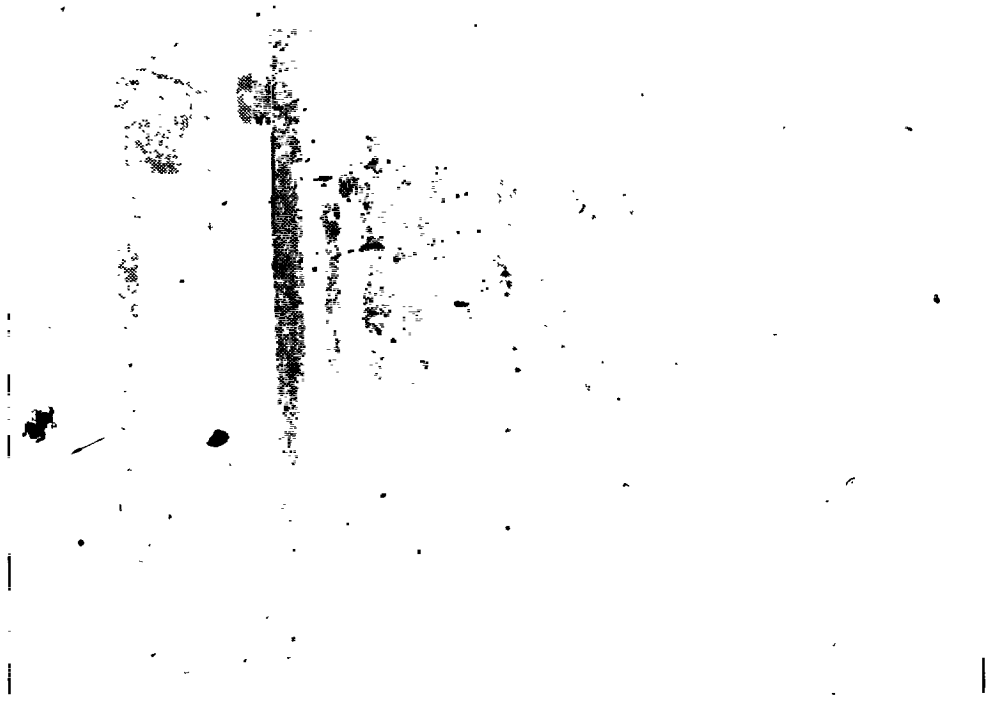


12

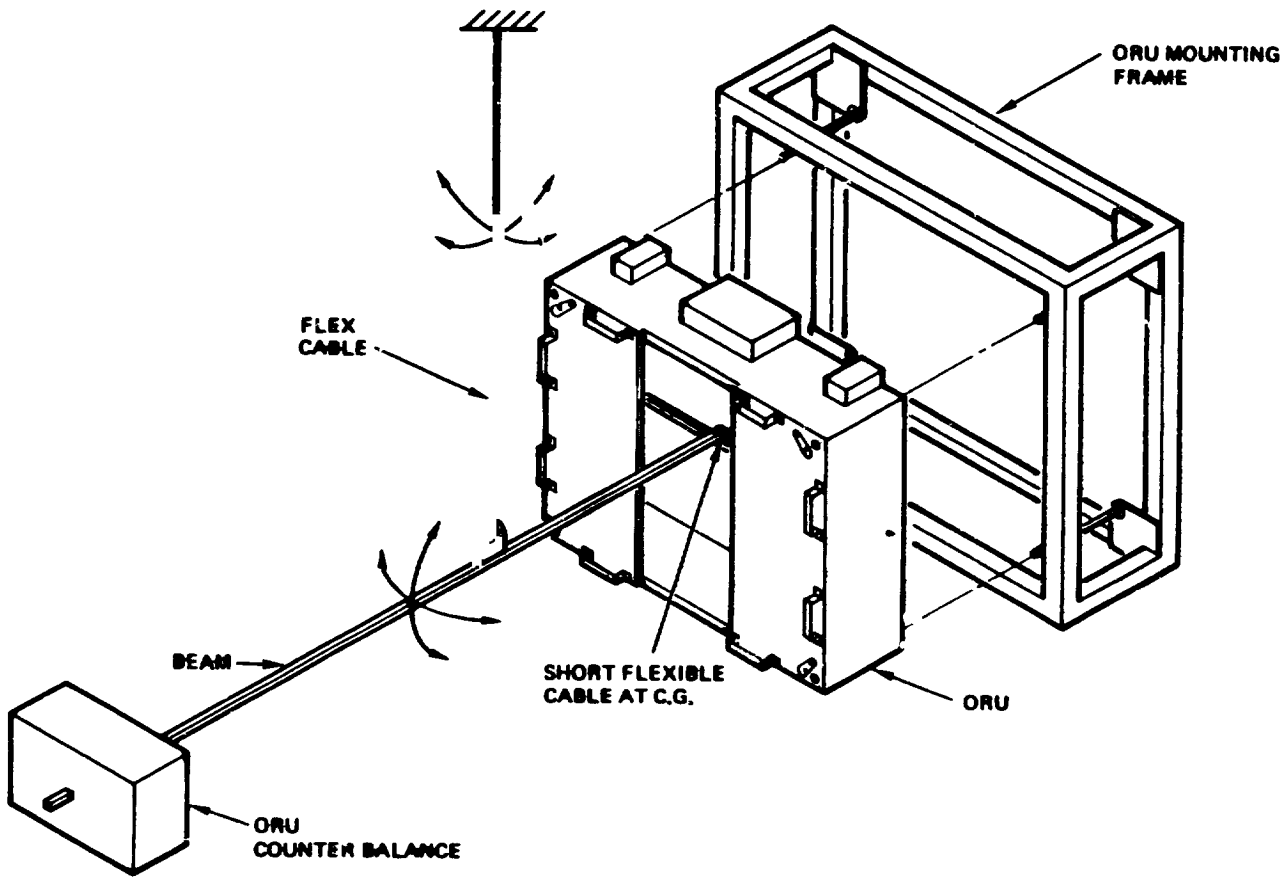
ORU HARDWARE AND OPERATIONS
DESIGN FEATURES

- VISIBILITY/ACCESS COMPATIBLE WITH SUITED CREWMEN
- ADAPTER PROVIDED FOR PORTABLE RMS GRAPPLE FIXTURE FOR MODULE TRANSFER
- STANDARD NASA HANDHOLDS AND FOOT RESTRAINTS
- SHARP CORNERS, EDGES AND PROTRUSIONS ELIMINATED
- ALL LOOSE EQUIPMENT TETHERED
- STANDARD MUSHROOM RATCHET WRENCH USED FOR ALL FASTENERS AND ACTUATORS (7/16" HEX - DOUBLE-PLUS HEIGHT)
- "J"-HOOK FASTENERS (TEMPORARY RESTRAINT INHERENT)
- NO ENGAGEMENT OF THREADED FASTENERS (BASELINE)
- RUNNING FRICTION IN ALL TOOL OPERATED FASTENERS AND ACTUATORS
- ALIGNMENT GUIDES FOR MODULE
- STATUS (MATE/DEMATE) INDICATORS FOR FLUID AND ELECTRICAL CONNECTOR
- OPERATION MARKINGS FOR ACTUATORS
- ADAPTER PROVIDED FOR DOCKING MMU TO ORU WITH ROTATION JOINT FOR ADDRESSING TASKS

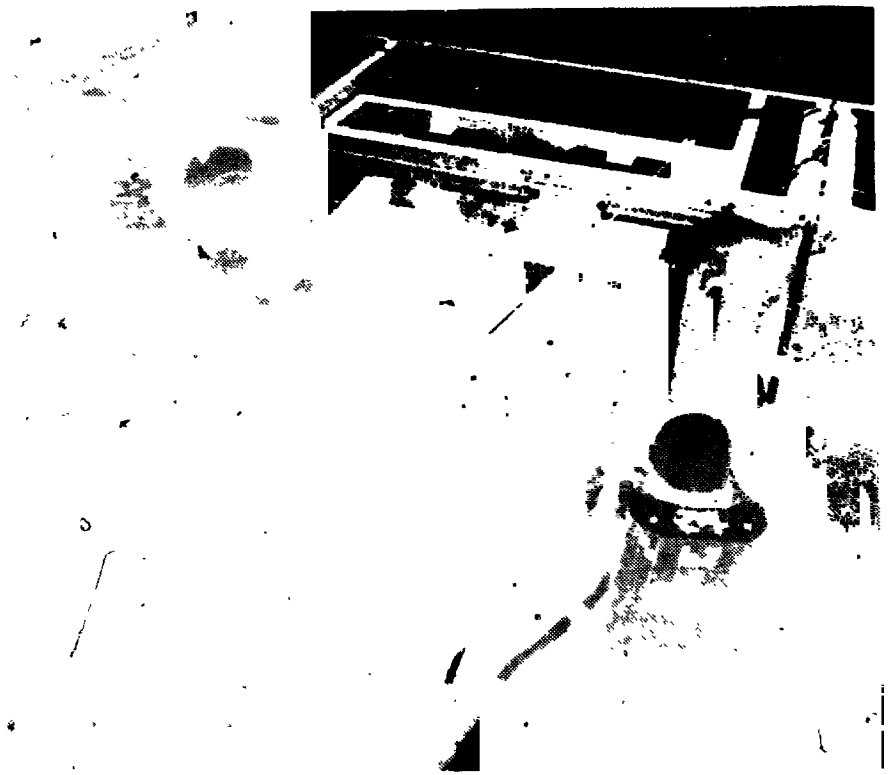
MODULAR ORU NEUTRAL BUOYANCY TEST UNIT



MODULAR ORU
1-G PENDULUM TEST

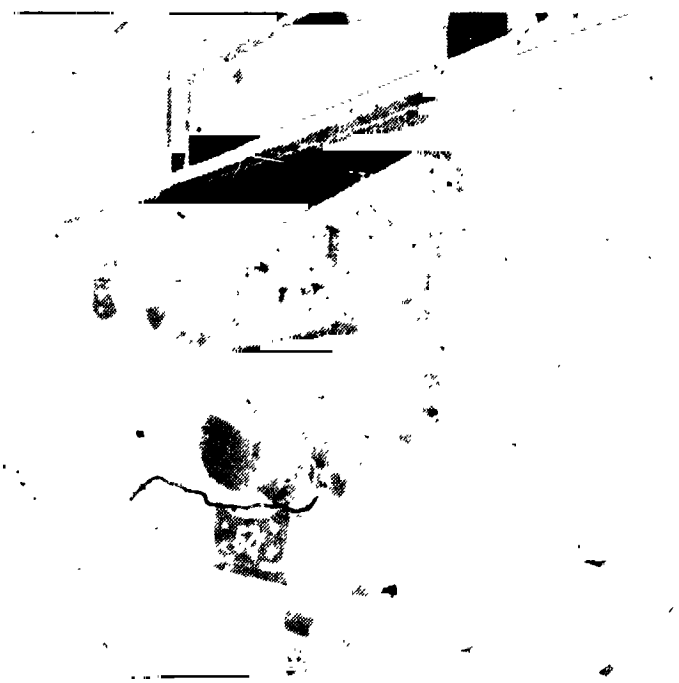


INSTALLATION OF MODULAR ORU USING PORTABLE FOOT RESTRAINTS



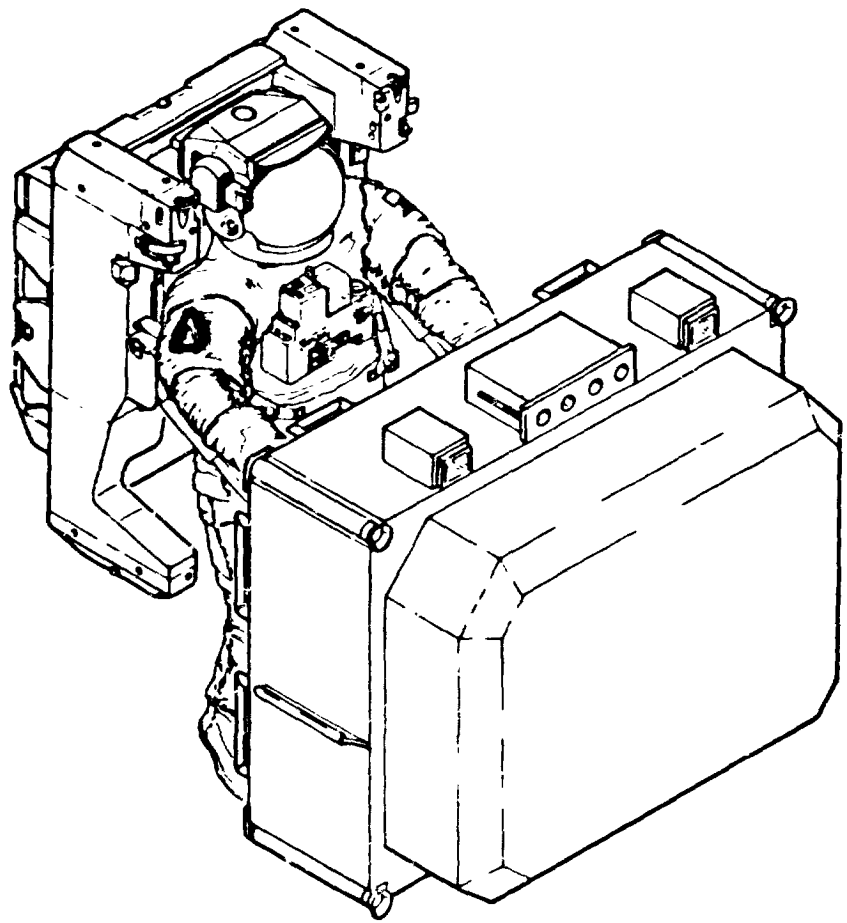
REMOVAL OF MODULAR ORU USING MFR

INSTALLATION OF ORU USING MMU



ROTATING MMU TO ADDRESS ORU FASTENERS

MANNED MANEUVERING UNIT (MMU) WITH MODULAR ORU



NEUTRAL BUOYANCY TEST RESULTS

- ALL THREE MODES (PFR, MFR, MMU) FEASIBLE FOR REPLACEMENT OF LARGE MODULES
- MFR MODE MOST EFFICIENT - WHERE RMS ACCESS IS AVAILABLE
- POST/TUBE ALIGNMENT IS EFFECTIVE - NO BINDING
- J-HOOK MECHANICAL FASTENERS - EASY TO OPERATE AND PROVIDE TEMPORARY RESTRAINT
- HAND TOOL DRIVEN ELECTRICAL AND FLUID CONNECTOR MATE/DEMATE MECHANISMS ARE EFFECTIVE
- TETHER APPROACH FOR PARKING IS FEASIBLE -
- ALL OPERATIONS ARE COMPATIBLE WITH A7L TEST SUIT - SHUTTLE PRESSURE SUIT WOULD ENHANCE OPERATIONS
- FOOT RESTRAINTS ARE MORE EFFECTIVE AND SAFER THAN HANDHOLDS-ONLY, FOR LARGE MODULE HANDLING - ONE CREWMAN IN FOOT RESTRAINT IS ADEQUATE
- TORQUE (25 FT/LBS) AND NUMBER OF TURNS (3-5) ON FASTENERS AND HEX DRIVES COMPATIBLE WITH RATCHET WRENCH/HANDHOLD APPROACH
- ONE INCH HEX HEIGHT PREFERRED OVER "DOUBLE-HEIGHT" (1/2 IN.) - BETTER TOOL STABILITY

S-84

NEUTRAL BUOYANCY TEST RESULTS (CONT)

- ONE-MAN OPERATIONS ARE FEASIBLE FOR ALL THREE MODES BUT TWO-MAN OPERATIONS ARE PREFERRED FOR MODULE CONTROL IN PFR MODE
- MMU/ORU/PRESSURE SUIT INTERFACES CAN BE DEVELOPED IN NBF - FREE FLYING DYNAMICS NEED COMPUTER AND 6 DOF SIMULATION
- ANALYTICAL AND MOCKUP DETERMINATION OF FOOT RESTRAINT LOCATIONS IS EFFECTIVE
- SOME DIFFICULTY IN MATING ALTERNATE FLUID CONNECTOR BOLTS - LEARNING CURVE
- TASK TIMES
- UTILIZATION OF FOAM-CORE MOCKUPS ARE VERY EFFECTIVE IN DEVELOPING HARDWARE AND PROCEDURES
- SIMPLE COUNTERBALANCE PENDULUM (1-G) TESTS ARE EFFECTIVE IN PRELIMINARY TESTING OF ALIGNMENT AND ATTACHMENT HARDWARE FOR LARGE MODULES
- NEUTRAL BUOYANCY TESTS SHOULD INCLUDE SAFETY TETHERS, MINI WORK STATION (MWS) AND WORK TETHERS TO ENHANCE FIDELITY
- SIGNIFICANT AMOUNT OF GENERIC DATA ON EVA,RMS, MFR, AND MMU OPERATIONS OBTAINED

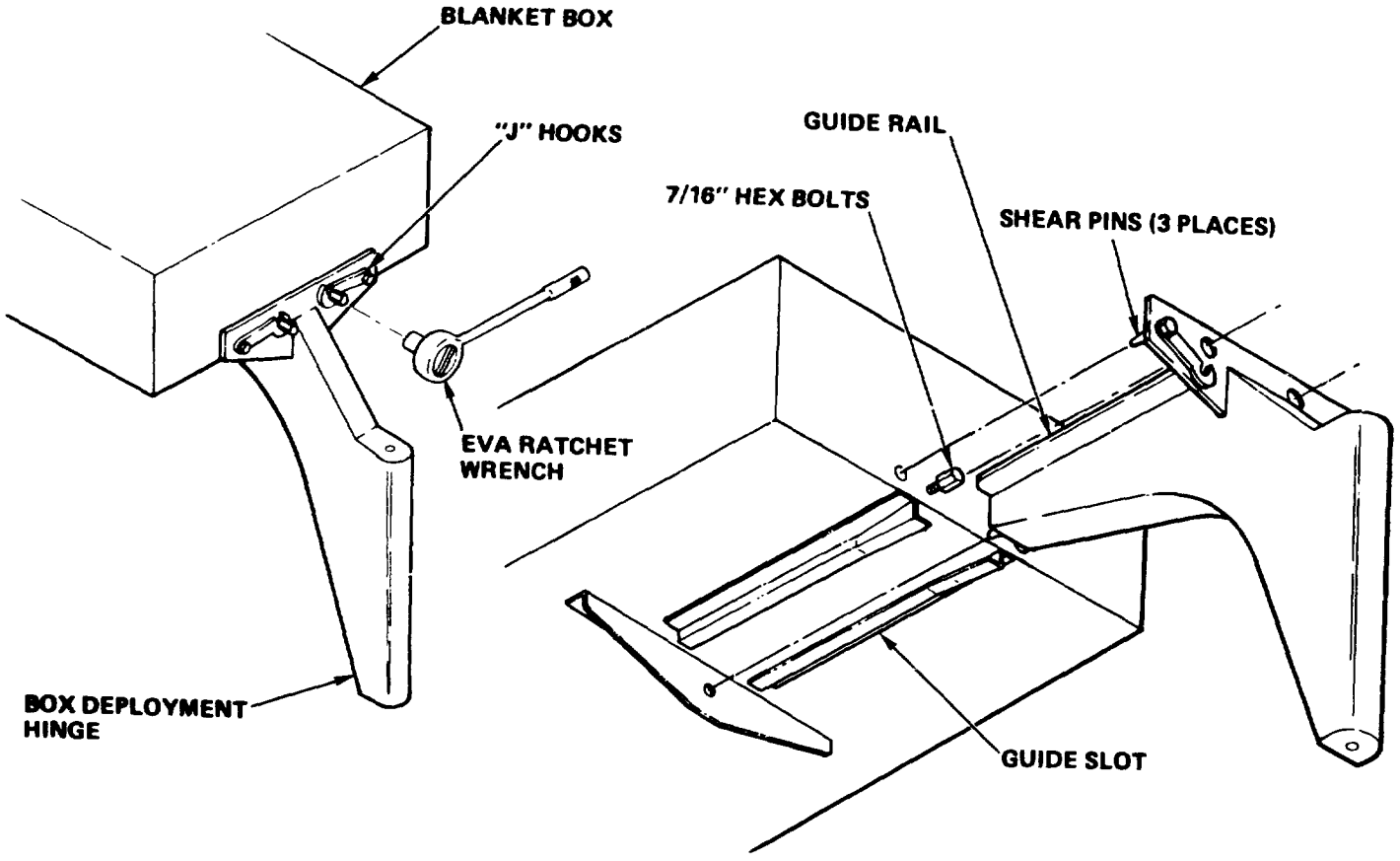
Solar Array Subsystem

SOLAR ARRAY MOCKUP

ELECTRICAL CONNECTOR MATING

ORIGINAL PAGE IS
OF POOR QUALITY

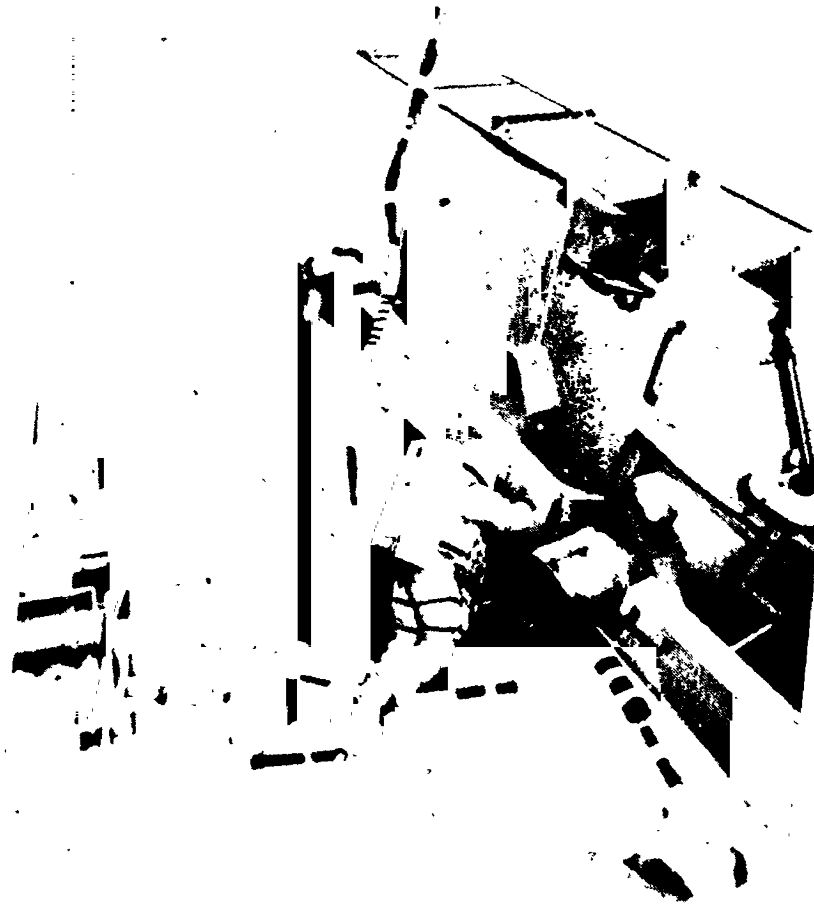
BOX TO WING MECHANICAL INTERFACE



ORIGINAL PAGE IS
OF POOR QUALITY

S/A BOX REMOVAL
CREWMEN AT BOTH ENDS

NEUTRAL BUOYANCY TEST
BLANKET BOX CHANGEOUT USING MANIPULATOR
FOOT RESTRAINT



1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM 86673		

4. Title and Subtitle	5. Report Date
PROCEEDINGS OF THE SEMINAR ON SPACE STATION HUMAN PRODUCTIVITY	April 1985
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Compiled by Marc M. Cohen and Erika Rosenberg*	85011
	10 Work Unit No.
9. Performing Organization Name and Address	11 Contract or Grant No.
Ames Research Center, Moffett Field, California 94035 *San Jose State University, San Jose, California	
	13. Type of Report and Period Covered
12 Sponsoring Agency Name and Address	Technical Memorandum
National Aeronautics and Space Administration Washington DC, 20546	14. Sponsoring Agency Code

15 Supplementary Notes

Point of contact: Marc M. Cohen, Ames Research Center, MS 239-C, Moffett Field, CA 94035, (415) 694-5385 or FTS 464-5385

16 Abstract

As NASA prepares plans to develop a space station, one of the major human factors study tasks is to develop an approach to crew safety. NASA has always been a leader in the field of safety consciousness and recognizes that safety will be the key to reliability and human productivity in the space station.

In evaluating safety strategies, it is also necessary to recognize both qualitatively and quantitatively how this space station will be different from all other spacecraft. It is recognized that the major difference between a space station and previous spacecraft is the role of human factors and extra-vehicular activity (EVA). In the project, a model of the various human factors issues and interactions that might affect crew safety is developed.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Space station Crew safety Internal contamination Space architecture	Unlimited Star category: 54

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Uncl	Uncl	741	A99

*For sale by the National Technical Information Service, Springfield, Virginia 22161