S O A R 89

Space Station

Space Suit Test Program

Nasa - Jsc

Crew & Thermal Systems Division

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Space Station Preprototype Space Suit TEST PROGRAM

- Test Program Background
- Test Matrix Overview
- Evaluation Plan

Test Program Background

Background:

- To accomodate Space Station Freedom budget constraints, and without incurring management risk, Project Office:
  - Deferred EMU activity at Prime (Phase C/D) Contractor
  - Asked CTSD to continue supporting development activities

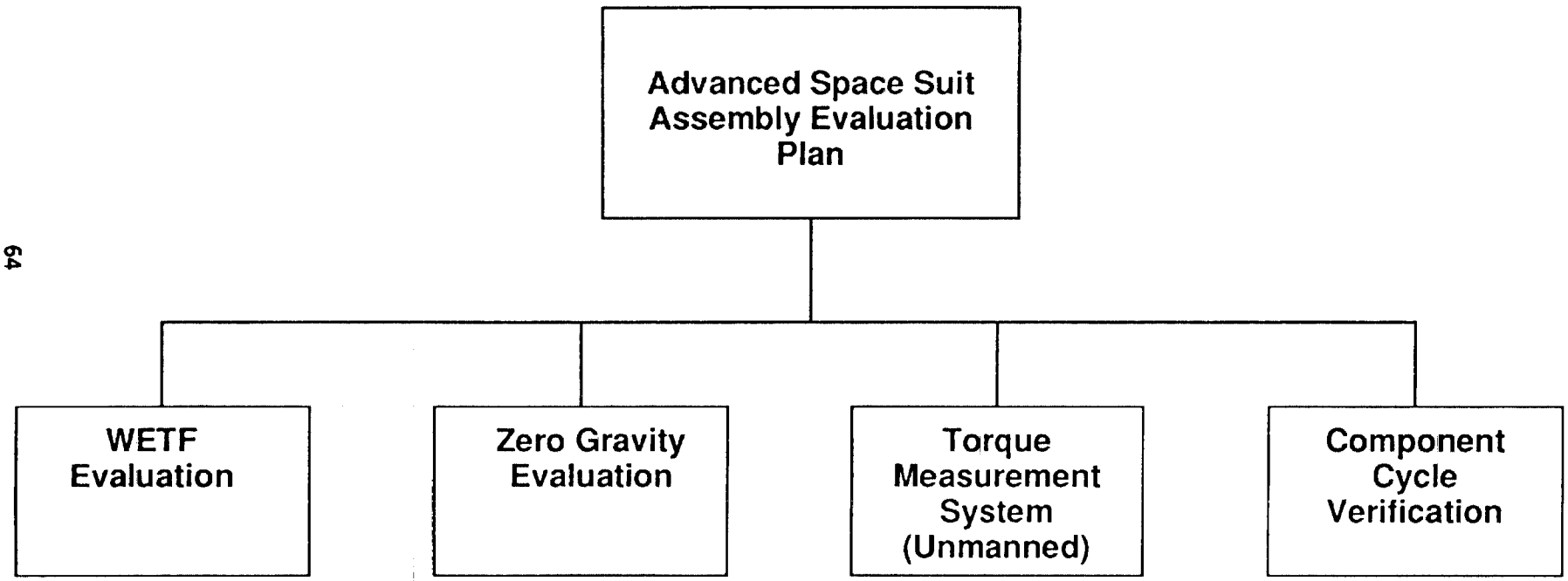
Goal:

- Develop best possible 8.3 psi space suit for Space Station FreedomProgram based on selected advanced suit technology

Objective:

- Establish quantitative measures of various performance characteristics as compared to Shuttle space suit:
  - Objective evaluations
  - Subjective evaluations
  - Typical task performance

ADVANCED SPACE SUIT ASSEMBLY EVALUATION ACTIVITIES



"Why" The Breadth of Program?

- **WETF Evaluation Activities:**
  - Simulation represents "hi-fidelity", real-time performance activities of actual EVA operations and tasks.
  - Establishes a "user" input comparison baseline developed over long-duration test excercises.
- **Zero-Gravity Evaluation (KC-135 Aircraft):**
  - Provides proper environment for don/doff evaluation activities.
  - Eliminates water inertia influencing factors.
- **Torque/Range Measurement (Unmanned)**
  - Establishes ultimate performance characteristics.
  - Provides absolute/non-subjective data-base.
- **Component Cycle Verification (Selected Joint Elements):**
  - Establishes design confidence level.
  - Identifies if design compromised due to material selection or fabrication/assembly process.

TEST MATRIX DESCRIPTION

SET-UP

PROCEDURES

REPRESENTATIVE DATA

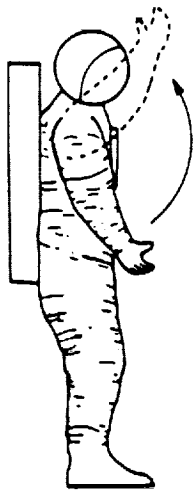
WETF
EVALUATION

OBJECTIVE EVALUATIONS

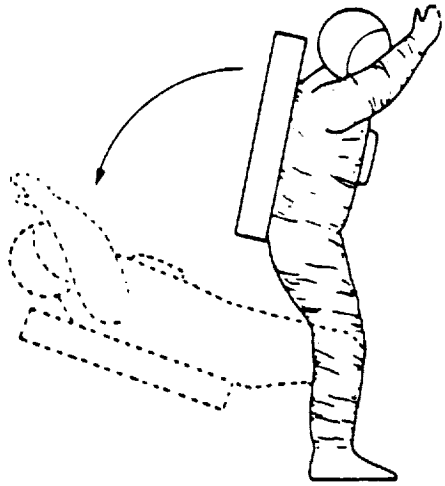
- MOBILITY (RANGE OF MOTION)
- REACH ENVELOPE
- MAXIMUM FORCE TRANSMISSION

SUBJECTIVE EVALUATIONS

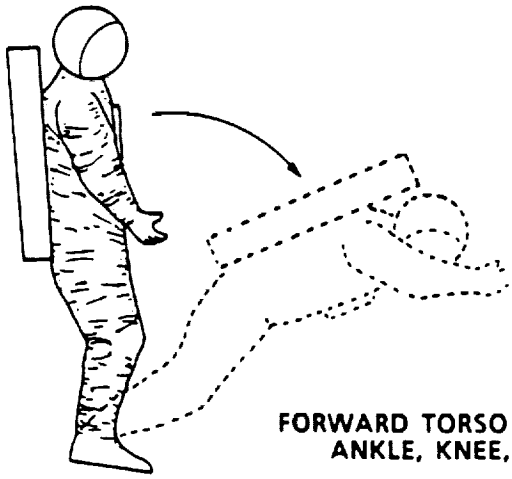
- MOBILITY (PERFORMANCE INDEX)
- EVA TASKS I
- EVA TASKS II



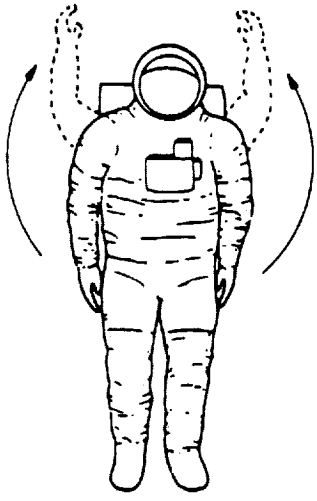
FORWARD AND UPWARD REACH FROM SIDE OF BODY (BOTH ARMS)



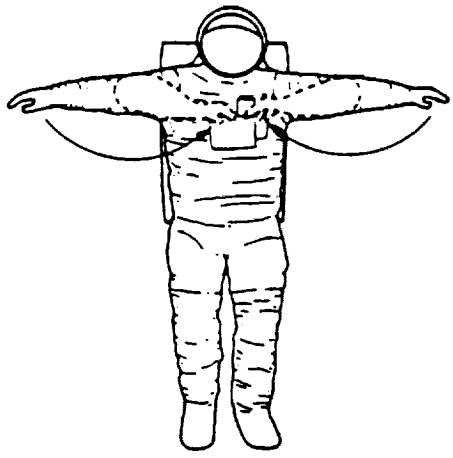
BACKWARD TORSO BENDING USING ANKLE, KNEE, AND TORSO



FORWARD TORSO BENDING USING ANKLE, KNEE, AND TORSO



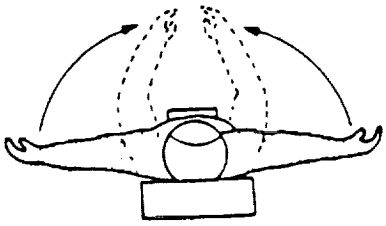
OVERHEAD REACH FROM SIDE OF BODY (BOTH ARMS)



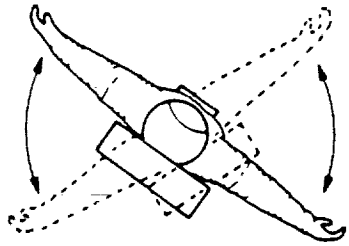
INBOARD CHEST REACH (BOTH ARMS)

WETF EVALUATION

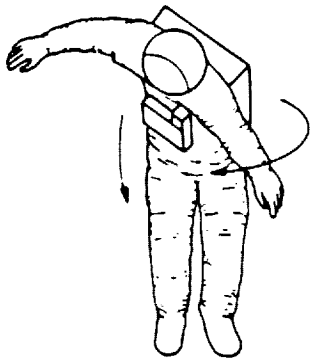
ACTIVITY	OBJECTIVES
MOBILITY	Objectively evaluate SSA performance by maximum joint angle measurement during various movements Subjectively evaluate SSA using performance index throughout motion Familiarize crewmember with SSA while performing isolated joint motions
REACH ENVELOPE	Objectively evaluate SSA by defining shape and volume of one and two handed functional reach envelopes Familiarize crewmember with integrated mobility of SSA
MAXIMUM FORCE TRANSMISSION	Objectively evaluate SSA by measuring maximum force transmission for movements 1) Frequently used during EVA 2) Defined for joint isolation Familiarize crewmember with SSA mobility under heavy work loads



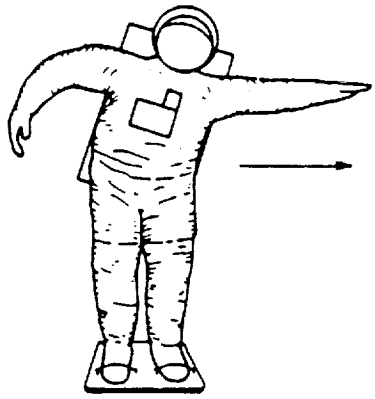
ARM SWEEPING MOTIONS (RIGHT TO LEFT, LEFT TO RIGHT)



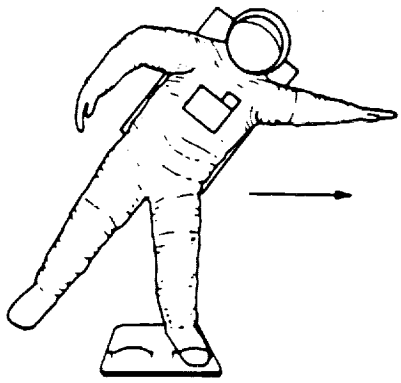
TORSO ROTATION (ARMS EXTENDED)



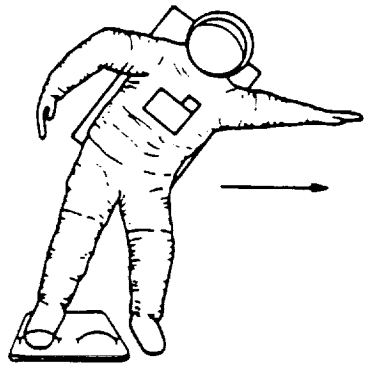
FORWARD TORSO BENDING WITH TORSO ROTATED



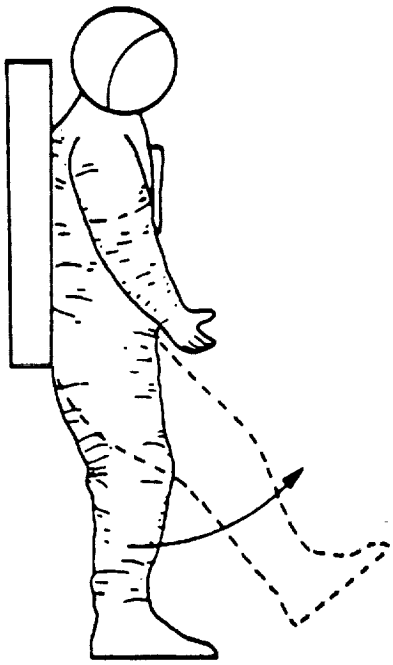
SIDE-TO-SIDE ANKLE FLEXION / REACH (RIGHT AND LEFT, BOTH FEET IN FOOT RESTRAINTS)



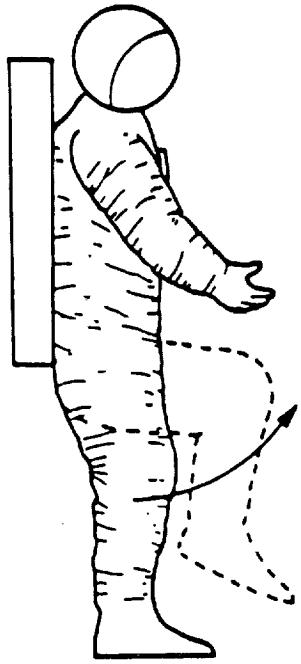
SIDE-TO-SIDE ANKLE FLEXION / REACH (RIGHT AND LEFT, ONE FOOT IN FOOT RESTRAINT)



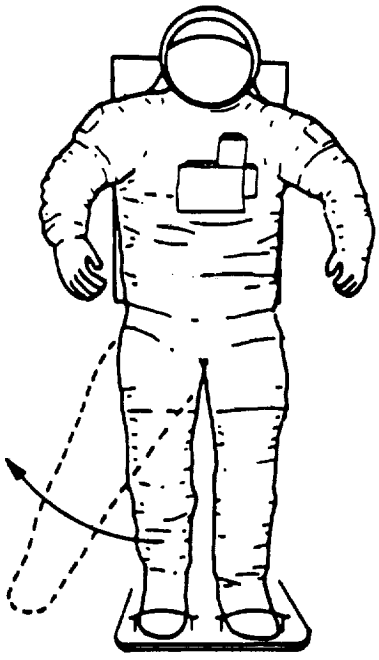
SIDE-TO-SIDE ANKLE FLEXION / REACH (RIGHT AND LEFT, OTHER FOOT IN FOOT RESTRAINT)



STRAIGHT LEG HIP FLEXION
(BOTH LEGS)

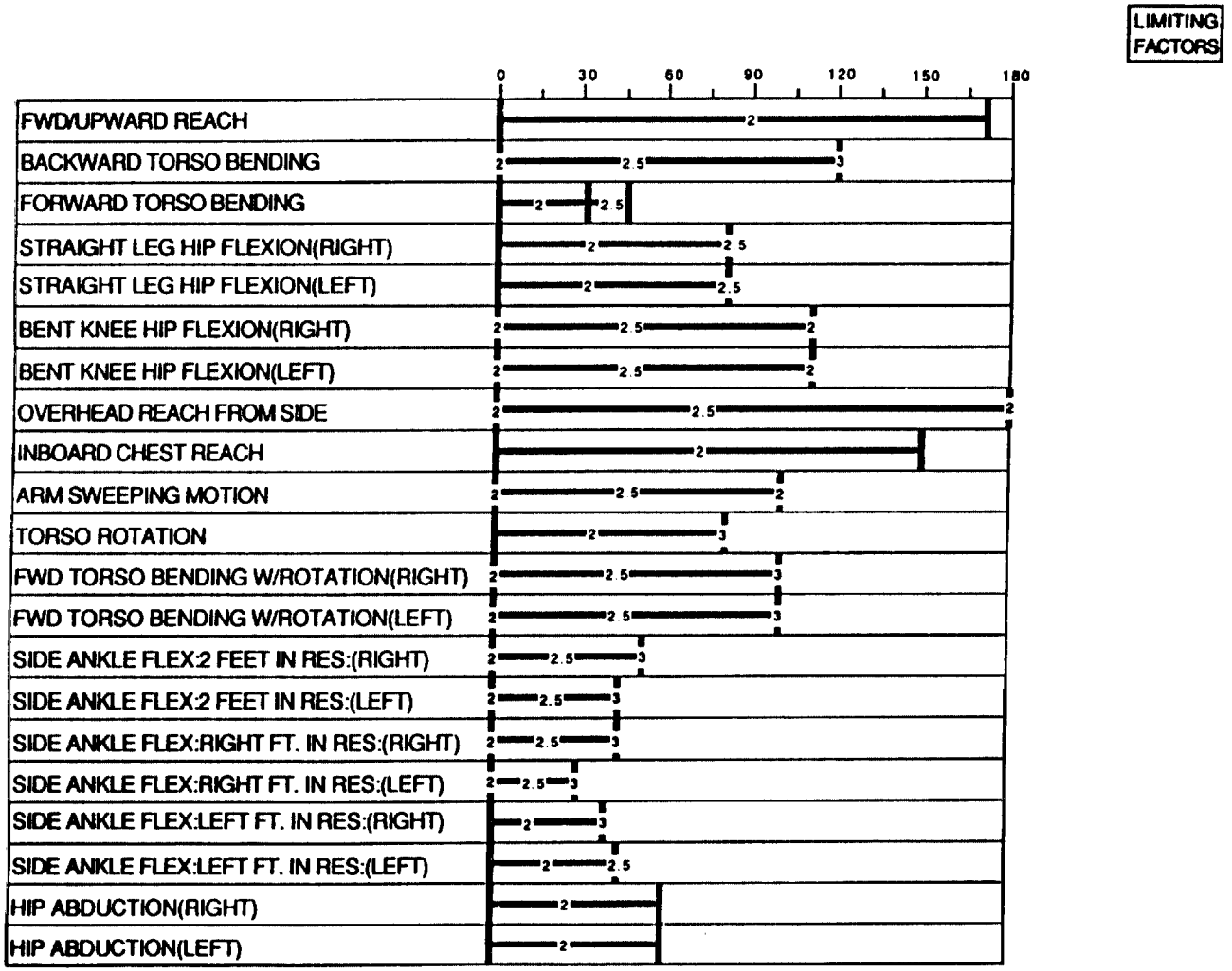


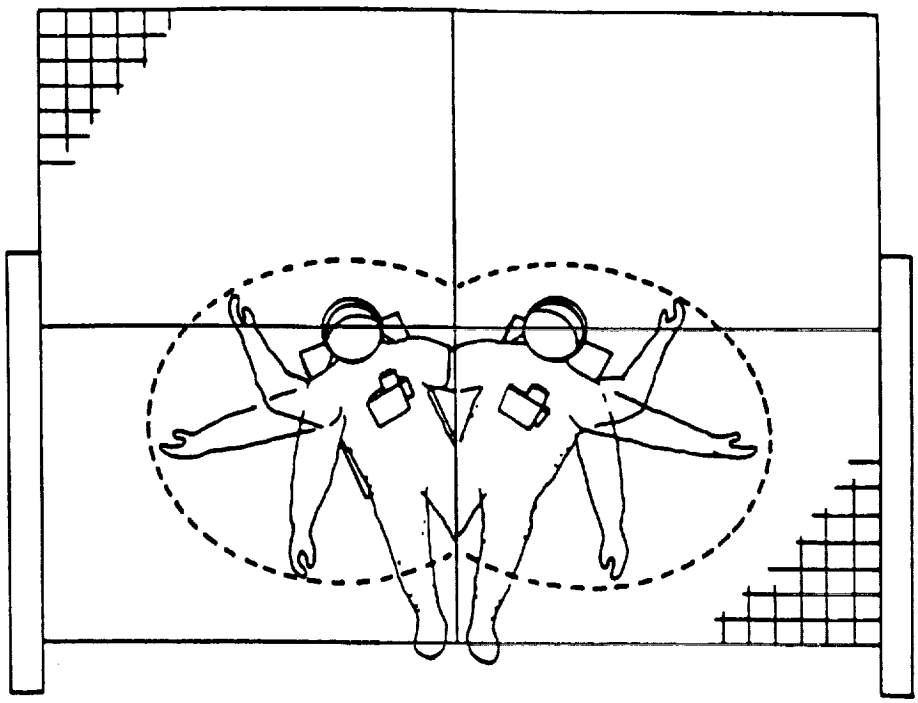
BENT KNEE HIP FLEXION
(BOTH LEGS)



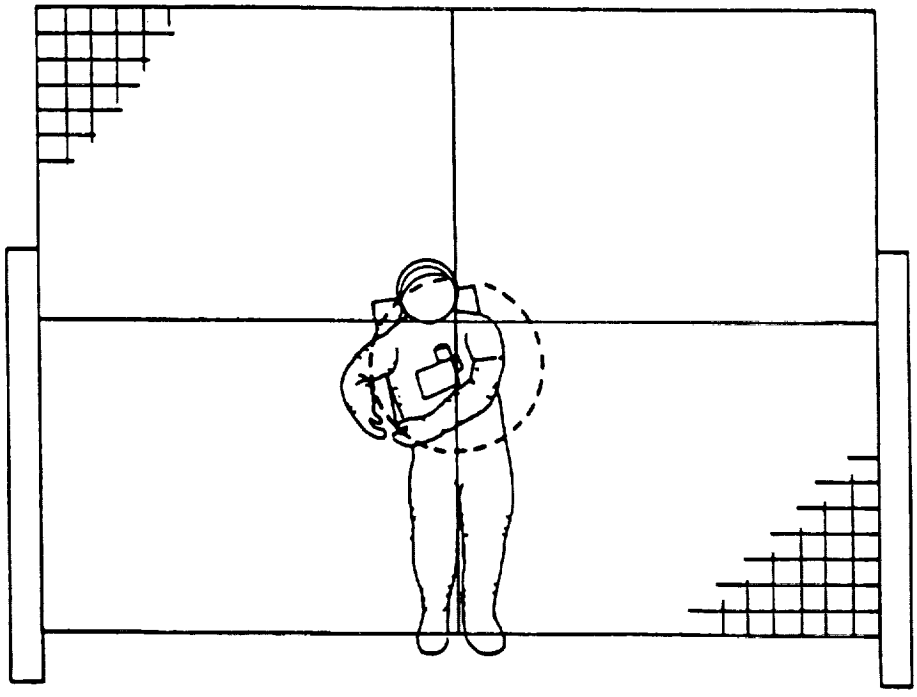
HIP ABDUCTION (BOTH LEGS)

SUIT MOBILITY EVALUATION

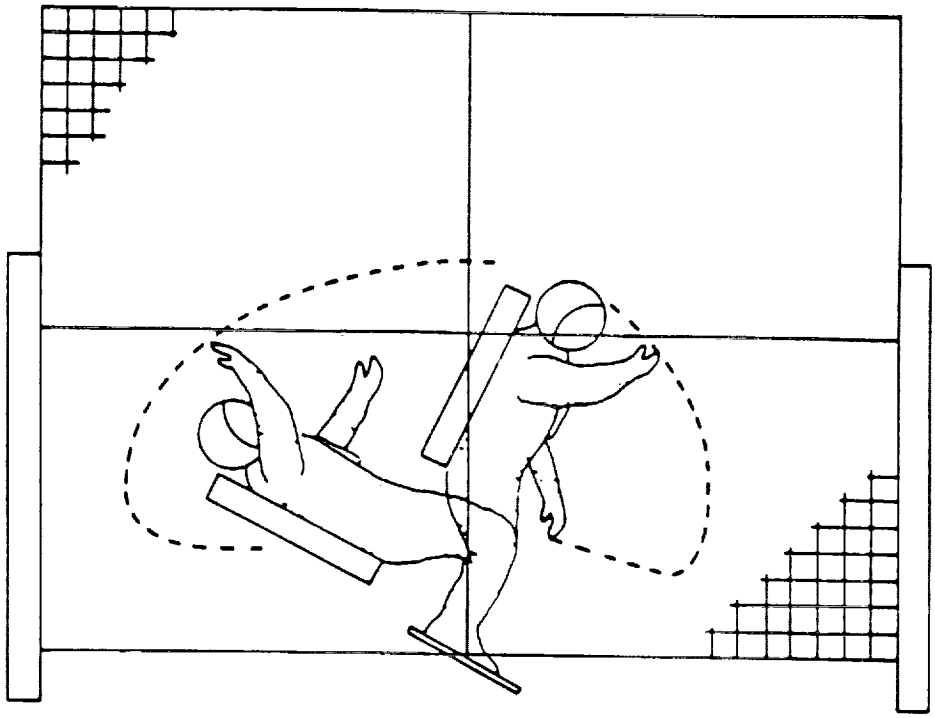




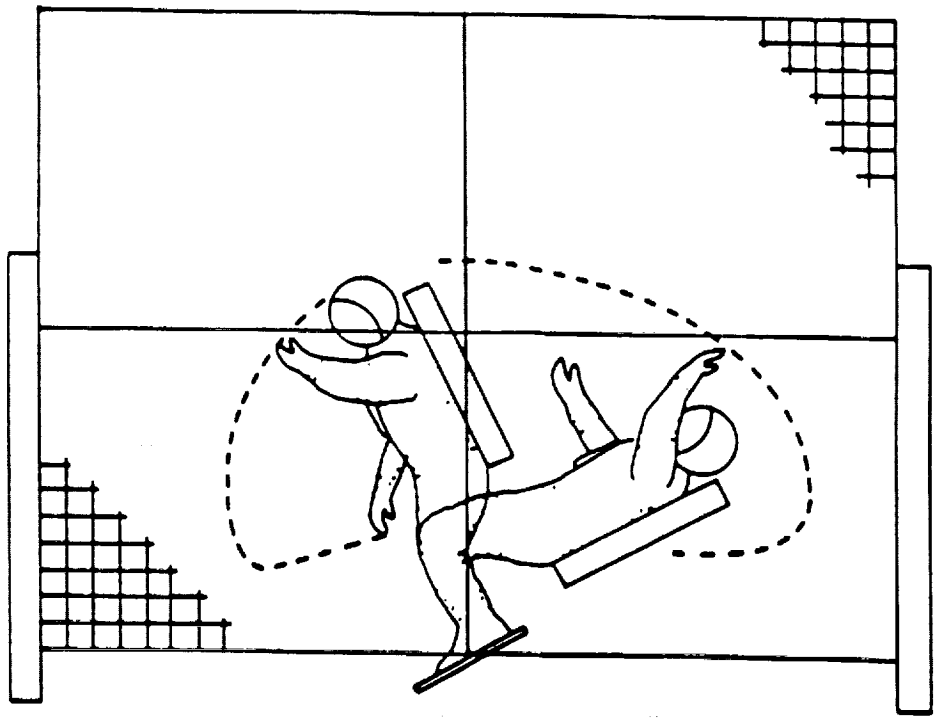
FRONT RIGHT- AND LEFT-HAND
REACH ENVELOPE



TWO-HAND REACH ENVELOPE



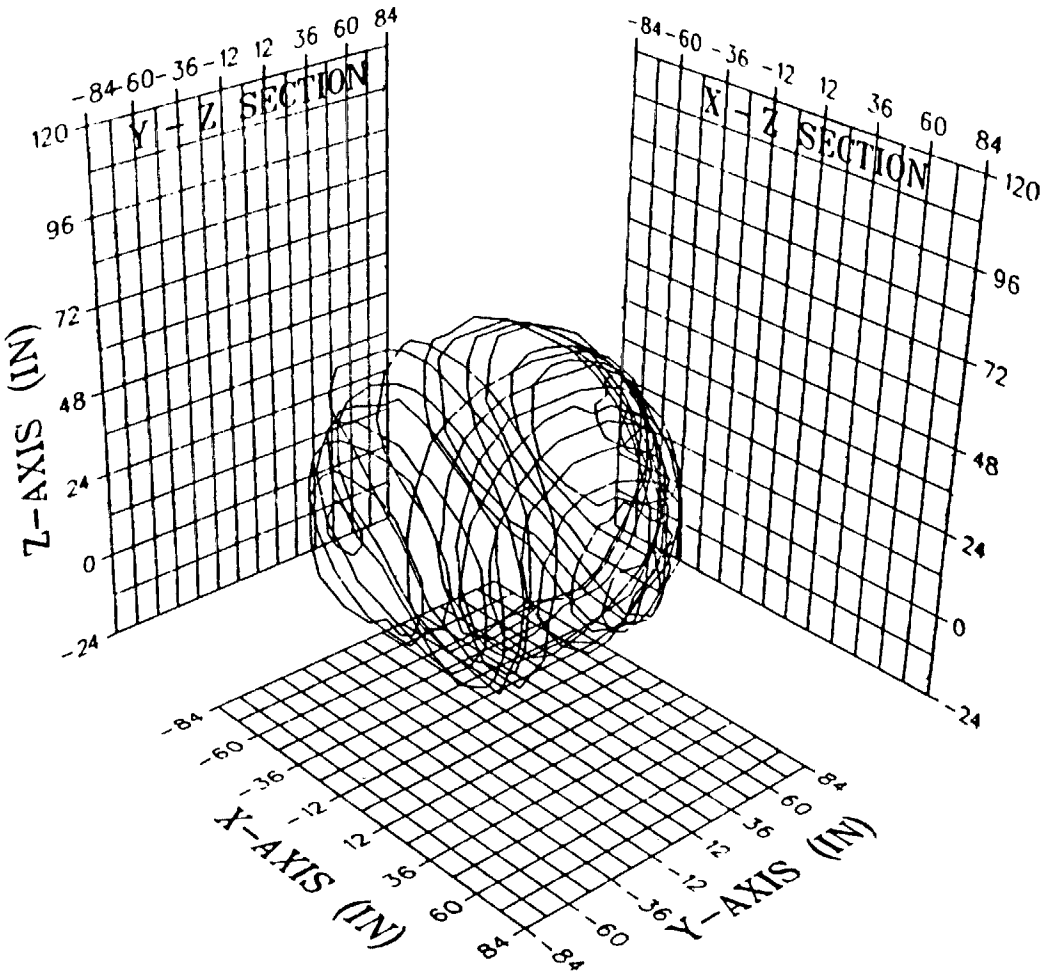
RIGHT SIDE ONE-HAND REACH ENVELOPE

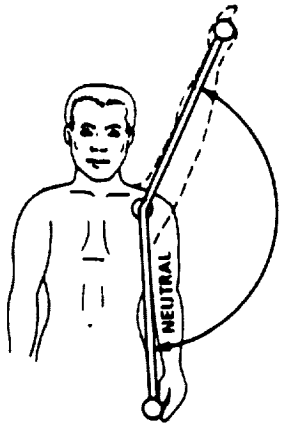


LEFT SIDE ONE-HAND REACH ENVELOPE

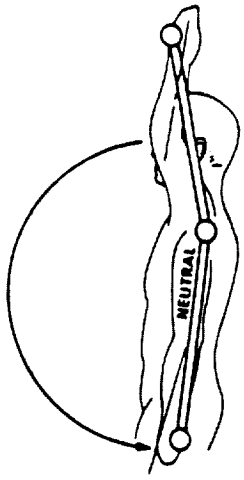
FUNCTIONAL REACH ENVELOPE

ONE-HANDED



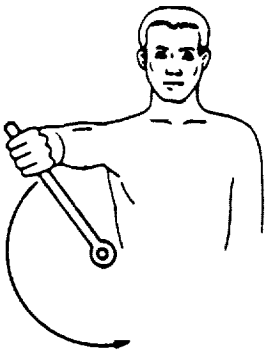


SHOULDER ABDUCTION

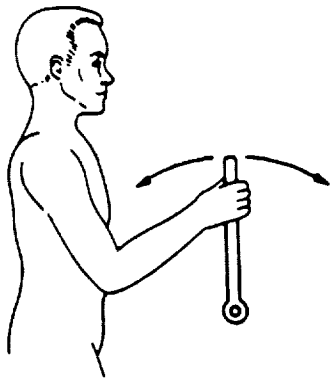


SHOULDER FLEXION

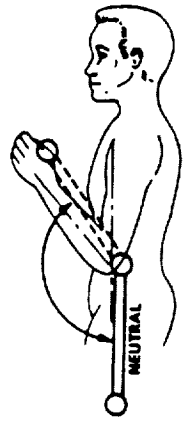
SHOULDER FLEXION/ABDUCTION
(combination of first two)



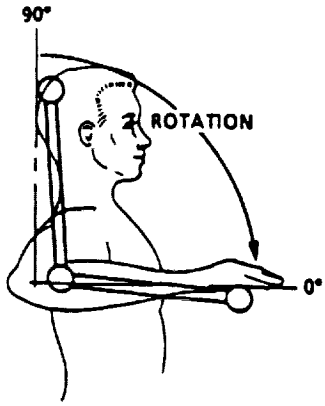
EVA RATCHET TOOL
CRANK



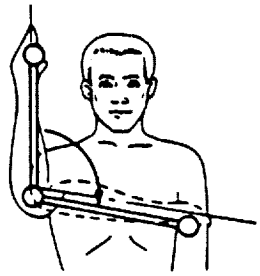
EVA RATCHET TOOL
PUSH / PULL



ELBOW
FLEXION / EXTENSION



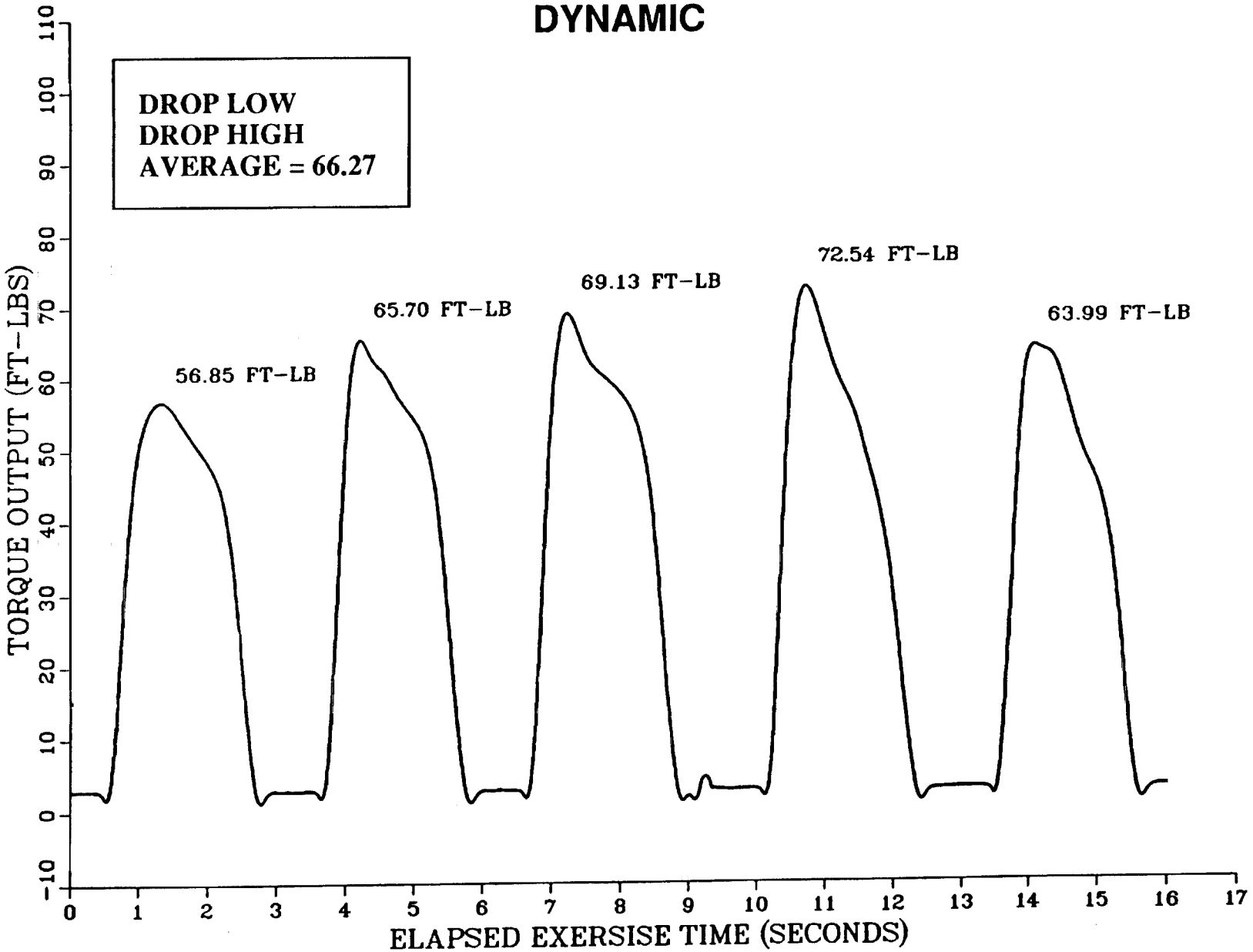
SHOULDER ROTATION
Y - AXIS



SHOULDER ROTATION
MEDIAL INTERNAL

SHOULDER FLEXION/ABDUCTION

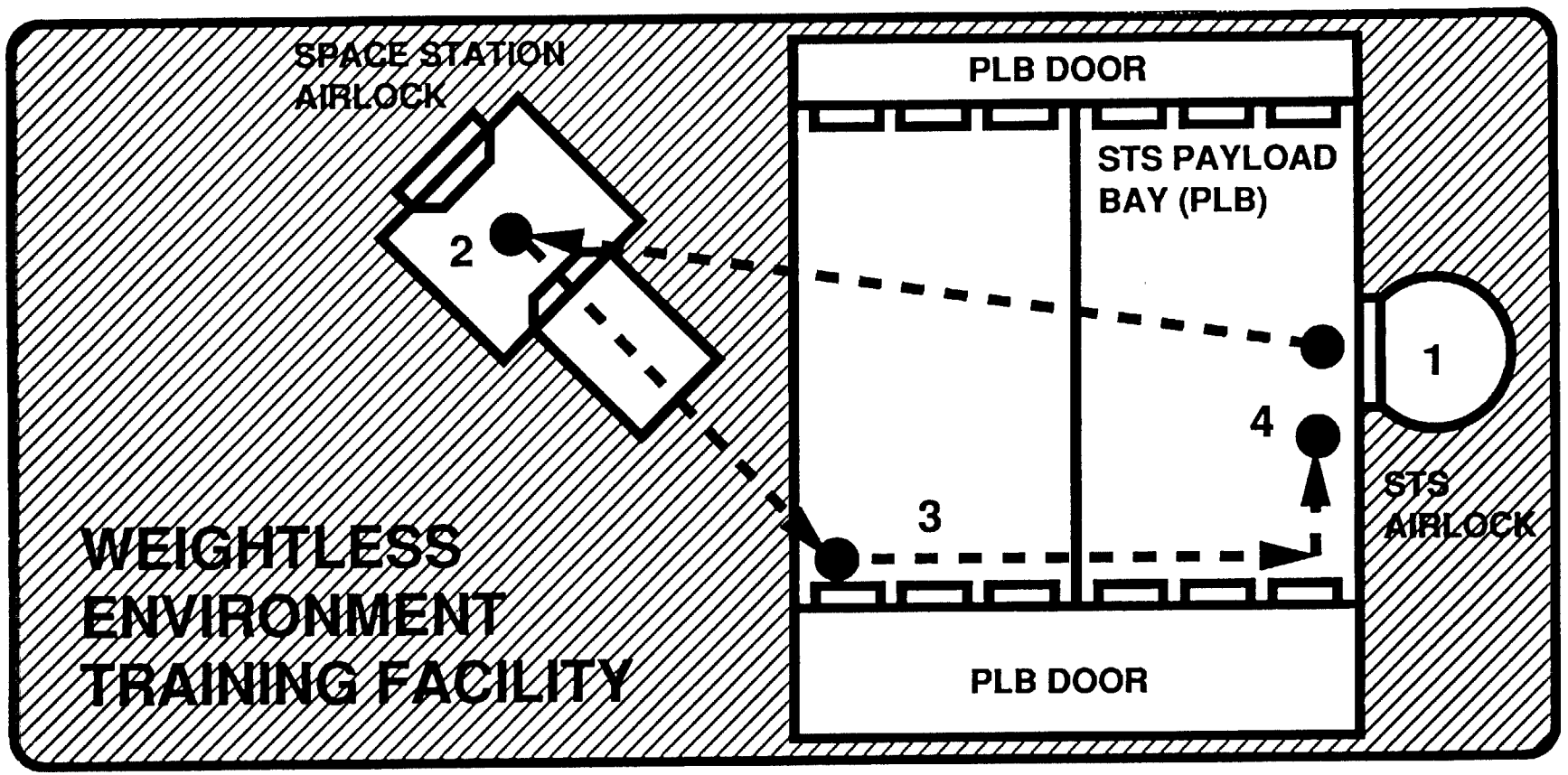
DYNAMIC



WETF EVALUATION (CONTINUED)

ACTIVITY	OBJECTIVES
EVA TASKS I	Subjectively evaluate SSA using Cooper-Harper rating scale while performing common EVA tasks Familiarize crewmember with SSA mobility as used on practical applications - precursor for EVA tasks II
EVA TASKS II (EASE/ACCESS)	Subjectively evaluate SSA using Cooper-Harper rating scale while performing EASE/ACCESS assemblies and disassemblies - best representation of unrestricted complex movements while performing typical Space Station assembly tasks

EVA TASKS I



1 STS AIRLOCK OPS
2 SPACE STATION AIRLOCK OPS
3 STS PAYLOAD BAY TRANSLATION
4 STS CONTINGENCY EVA OPS
WINCH
THREE POINT TOOL

KC-135
EVALUATION

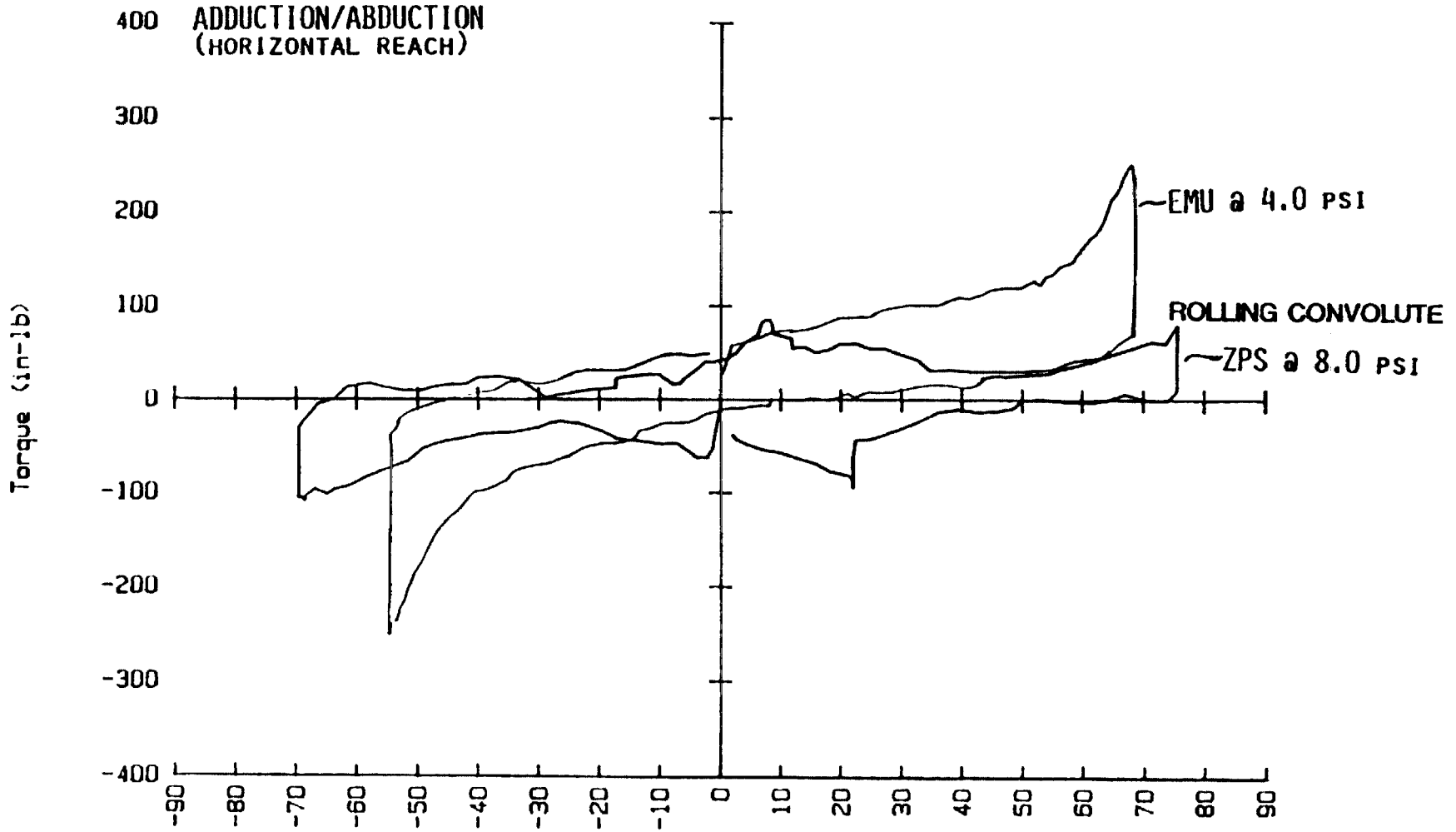
ACTIVITY	OBJECTIVES
DON/DOFF	Subjectively evaluate SSA don/doff operations using Cooper-Harper rating scale
TRANSLATION	Subjectively evaluate differences in SSA performance between neutral bouyancy (WETF) and zero - g - Ease of operation - Fit - Comfort

TORQUE / RANGE MEASUREMENT EVALUATION

ACTIVITY	OBJECTIVES
TORQUE VERSUS RANGE OF MOTION MAPPING	Objectively determine 1) Torque required to move the joint through a given range of motion 2) Maximum joint range of motion

SHOULDER JOINT COMPARISONS

(Torque vs. Angle)



-48°

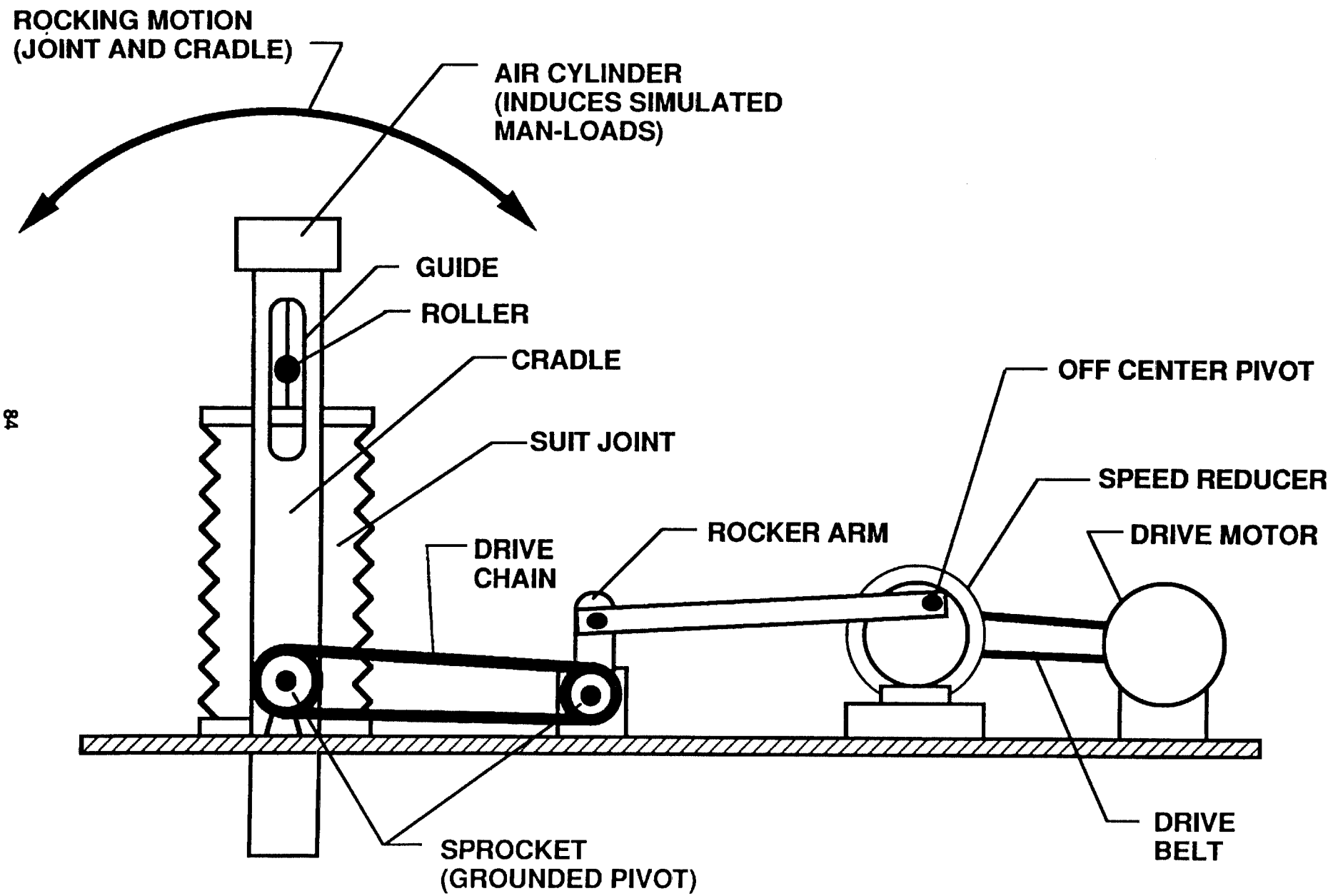
NUDE BODY RANGE

FORWARD - 182° - BACKWARD

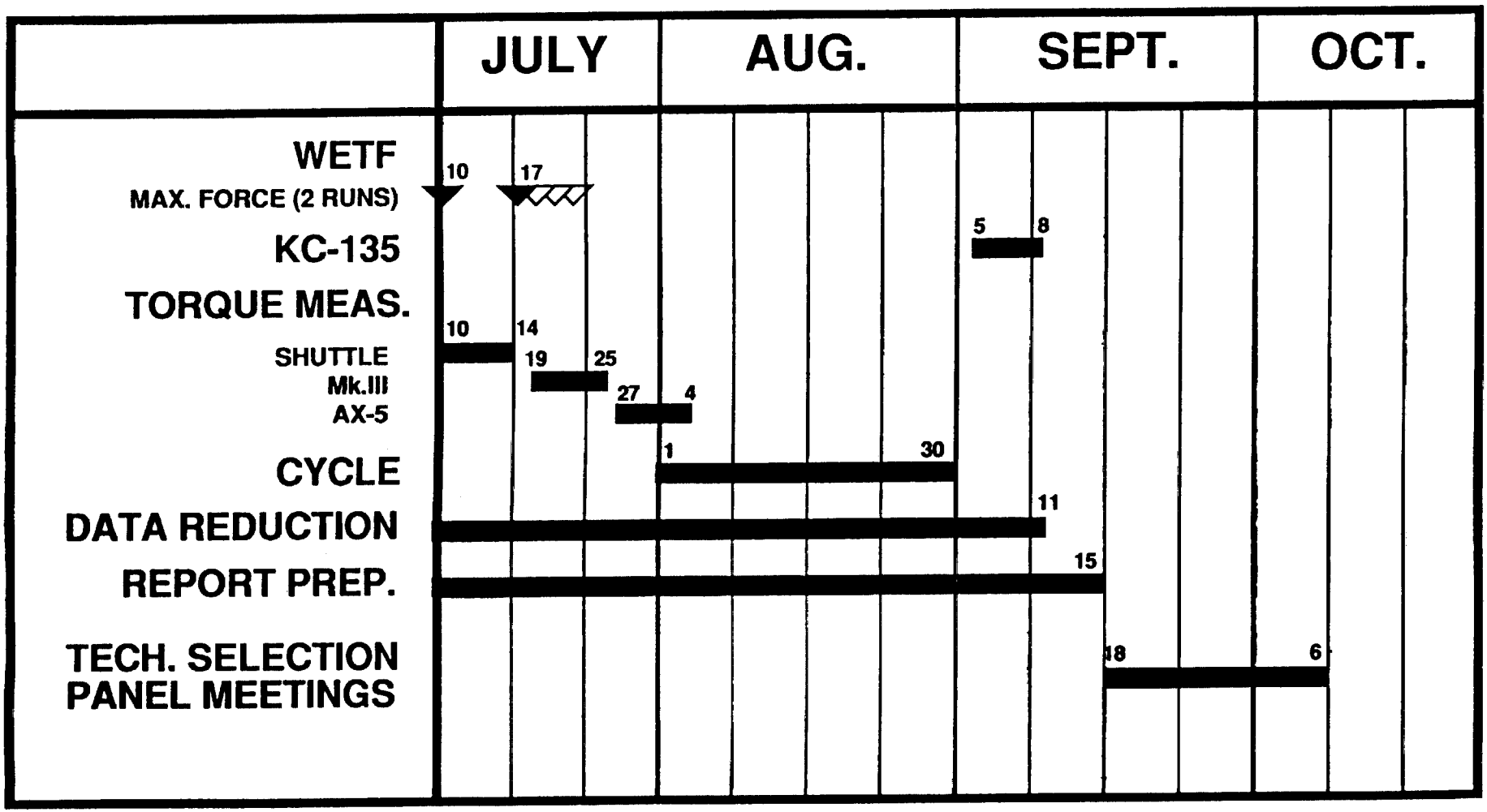
CYCLE VERIFICATION EVALUATION

ACTIVITY	OBJECTIVES
CYCLE JOINTS	Verify joint operational capability for one year on orbit life (plus a safety factor of two and based on 52 eva's per year)

SSA JOINT CYCLE MACHINE



SUIT TEST PROGRAM SCHEDULE



TASK COMPLETION MATRIX

MANNED TEST ACTIVITIES

	CREWMEMBER A			CREWMEMBER B			CREWMEMBER C			CREWMEMBER D		
WETF	STS	AX-5	Mk. III	STS	AX-5	Mk. III	STS	AX-5	Mk. III	STS	AX-5	Mk. III
SUIT MOBILITY												
REACH ENVELOPE												
MAX. FORCE												
EVA TASKS 1												
EVA TASKS 2												
KC-135	AX-5		Mk. III	AX-5		Mk. III	AX-5		Mk. III	AX-5		Mk. III

EVALUATION PLAN

EVALUATION PLAN COORDINATION MEETINGS

- ARC
- JSC
- Wk. Pkg. II Phase C/D Contractor (McDAC / LOCKHEED)

SELECTION CRITERIA PRIORITIES

TECHNOLOGY SELECTION PANEL

SELECTION PROCESS

SELECTION CRITERIA PRIORITIES

FIRST ORDER SELECTION CRITERIA MANNED PERFORMANCE

OBJECTIVE
- MOBILITY (RANGE OF MOTION)
- REACH ENVELOPE
- MAX. FORCE TRANSMISSION

SUBJECTIVE
- EVA TASKS I & II
- MOBILITY (PERFORMANCE INDEX)
- ZERO - G

SECOND ORDER SELECTION CRITERIA ENGINEERING TEST AND ANALYSIS

- TORQUE MEASUREMENT
- CYCLE VERIFICATION
- ENVIRONMENTAL PROTECTION

THIRD ORDER SELECTION CRITERIA PROGRAMMATIC ISSUES

- LIFE CYCLE COSTS

TECHNOLOGY SELECTION PANEL

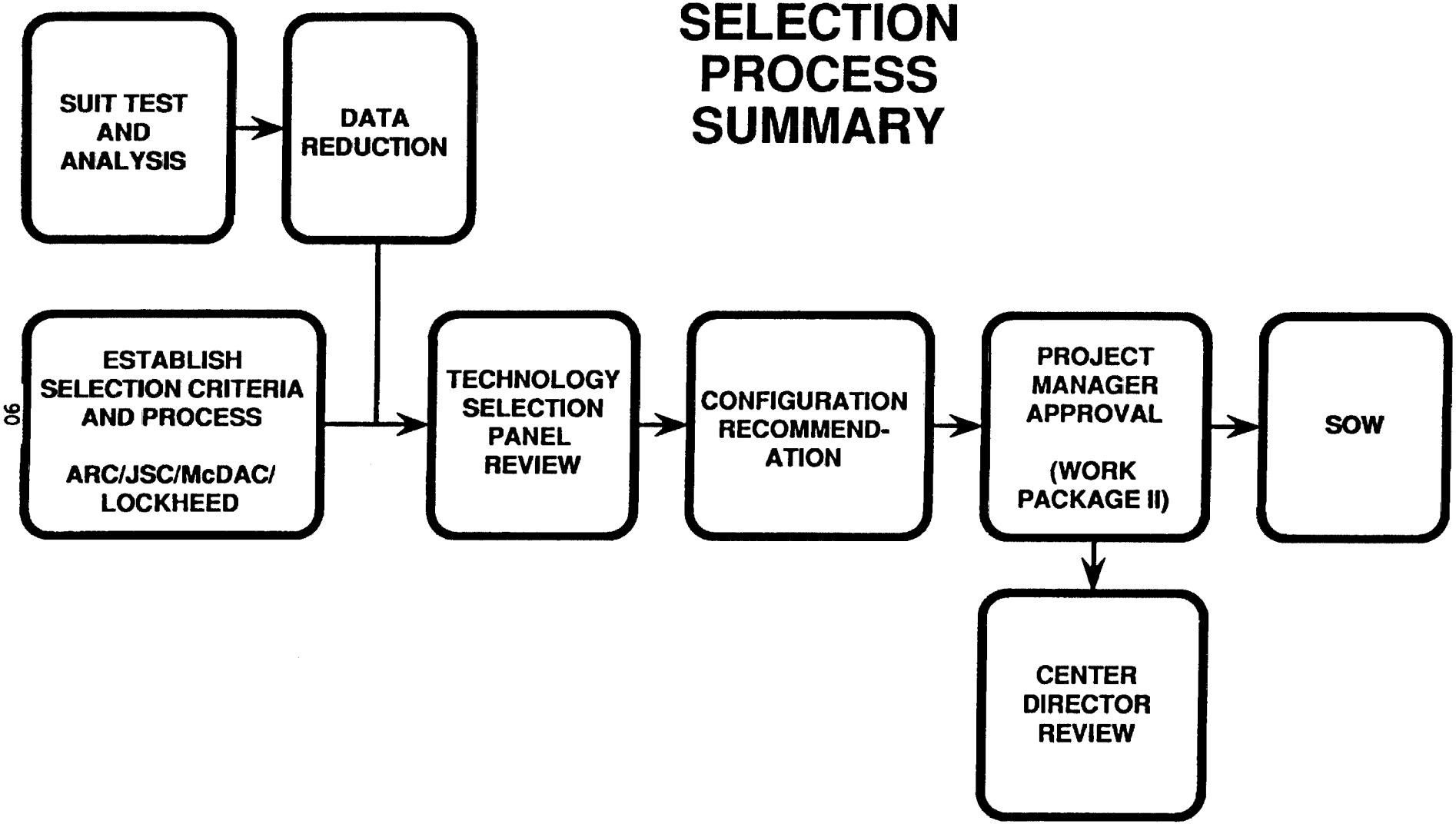
PURPOSE

- REVIEW ALL TEST DATA
- MAKE TECHNOLOGY SELECTION RECOMMENDATION

MEMBERSHIP

- CHAIR: EMU SYSTEM DEVELOPMENT MANAGER (SDM)
  - ROUEN
- TECHNICAL EXPERTS
  - KOSMO/JSC
  - VYKUKAL/ARC
- ASTRONAUT OFFICE
  - ROSS
- SPACE STATION PROJECT OFFICE (Wk. Pkg. II)
  - KISSINGER
- SYSTEMS ENGINEER
  - WEBBON/ARC
  - WEST/JSC
- PHASE C/D CONTRACTOR (Wk. Pkg. II)
  - RAFFAELLI/Mc DONNELL DOUGLAS
  - WILKINSON/LOCKHEED

TECHNOLOGY SELECTION PROCESS SUMMARY



AX-5 ADVANCED SPACE SUIT DESIGN OVERVIEW

Captain A. Reinhardt
NASA/Ames Research Center

(Paper not provided by publication date.)