PROJECT DOCUMENT COVER SHEET

~~PRELIMINARY~~

BONE AND MUSCLE CHANGES DURING
PROLONGED SPACEFLIGHT

Principal Administrator:
Lawrence F. Dietlein, M.D.

Principal Investigator:
Harry O. Wheeler, Ph.D.

REPORT NUMBER	DATE
DB-51-67-M052	4-6-67

PREPARED BY:	H. O. Wheeler, Ph.D, Biomedical Specialties Branch
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APPROVED:	(PROGRAM OFFICE)

NO. OF PAGES

REVISIONS					CHG. LETTER
DATE	PREPARED BY	APPROVALS			
		BRANCH	DIVISION	PROGRAM OFFICE	

PRELIMINARY

REPORT NUMBER DB-51-67-M052

MSC FORM 151A (JUL 66)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

EXPERIMENT IMPLEMENTATION PLAN

FOR

MANNED SPACE FLIGHT EXPERIMENTS

TITLE BONE AND MUSCLE CHANGES DURING PROLONGED SPACE FLIGHT

(Confine to total of 30 letters, numerals, spaces, punctuation marks, etc.)

MO52
EXPERIMENT NUMBER

April 6, 1967
DATE

NASA FORM 1347 JAN 67

EXPERIMENT IMPLEMENTATION PLAN

FOR

TITLE ______________________________ Exp. No. ______________

This Plan contains the following:

SECTION I	Experiment Summary (copy) (The original is forwarded by separate correspondence to Headquarters sponsoring office for signature and MSFEB submission)
SECTION II through IV	Experiment descriptive information (Same as sections II through IV of the Experiment Proposal Form but updated to reflect current status)
SECTION V	Experiment Development Approach
SECTION VI	Experiment Integration Approach
SECTION VII	Experiment Programmatic Information

The information contained in this document was prepared and coordinated by the Experiment Development Center and the Payload Integration Center.

SIGNATURE: ______________________________

____
DATE

Experiment Development Center

SIGNATURE: ______________________________

____
DATE

Payload Integration Center

THIS DOCUMENT WILL BE SUBMITTED TO THE MSFEB FOR EXPERIMENT APPROVAL. IT IS NECESSARY THAT ALL SECTIONS BE COMPLETED.

EXPERIMENT IMPLEMENTATION PLAN
FOR
MANNED SPACE FLIGHT EXPERIMENT

1. Title of Experiment

BONE AND MUSCLE CHANGES DURING PROLONGED SPACEFLIGHT

Experiment No. M052

2. Sponsorship

Sponsoring Program Office (SPO)	OMSF, Space Medicine
Principal Investigator(s) (PI)	Approved H. O. Wheeler
	Date 6-1-67
PI Institutional Affiliation	NASA, MSC Biomedical Research Office, DB
SPO Manager	S. P. Vinograd, M.D.

3. Development

Experiment Development Center	Approved ______ Robert F. Thompson, MSC
	Date ______
Director of Medical Research and Operations	Approved ______ Charles A. Berry, M.D.
	Date ______
Center Experiments Manager	Approved L. F. Dietlein, M.D. Lawrence F. Dietlein, M.D.
	Date June 2, 1967

4. Integration

OMSF Flight Program Office	ML
Payload Integration Center	Approved ______ Leland F. Belew, MSFC
	Date ______

5. Approval (Headquarters use only)

Sponsoring Program Office Approval ______ Date ______

Flight Program Office Approval ______ Date ______

Approved for Flight Assignment ______ Date ______

Program Office
Associate Administrator

Date ______

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION **EXPERIMENT SUMMARY** MANNED SPACE FLIGHT	DATE PREPARED 4-6-67

TO *(Transmit Original Copy)*	FROM *(NASA or DOD Sponsoring Office)*
EXECUTIVE SECRETARY **MANNED SPACE FLIGHT EXPERIMENT BOARD**	SIGNATURE

PART I — **ADMINISTRATIVE**

1. TITLE *(Confine to total combination of 30 spaces, punctuation marks, letters, numbers, etc.)*	2. EXP. NO.
BONE AND MUSCLE CHANGES DURING PROLONGED SPACE FLIGHT	M052

3. PRINCIPAL INVESTIGATOR

A. FULL NAME	B. INSTITUTION	C. PHONE
Harry O. Wheeler, Ph.D.	Biomedical Research Office Houston, Texas	HU3-4251

4. OFFICE OR CENTER	5. CONTACT NAMES
SPONSORING PROGRAM OFFICE	
FLIGHT PROGRAM OFFICE	
DEVELOPMENT CENTER	
INTEGRATION CENTER	

6. MSF/MSFB ACTIONS
(To Be Completed by Executive Secretary, MSFEB, only.)

A. ACTIVITY OR RESULTS	B. DATES
COMPATIBILITY REVIEW AUTHORIZED	
COMPATIBILITY REVIEW BY	
MSFEB RECOMMENDATION	
FLIGHT PROGRAM ASSIGNMENT	
FLIGHT MISSION ASSIGNMENTS	

C. ADDITIONAL MSF/MSFEB COMMENTS

NASA FORM 1339 JAN 67 — REPLACES NASA FORM 1067, JUL 65, WHICH IS OBSOLETE.

NASA FORM 1347 Jan 67

PART II	TECHNICAL INFORMATION

1. OBJECTIVE

See Page 2.1

2. SIGNIFICANCE *(Relationship to technical discipline, reference previous experiment data, results, etc.)*

See Page 2.2

3. DESCRIPTION *(Outline approach, briefly describe equipment. Include sketch and/or block diagrams, whenever possible, as an attachment to this form.)*

See Page 2.3

PART III	ENGINEERING INFORMATION		
1. WEIGHT		**2. SIZE**	
LAUNCH	RETURN	LAUNCH	RETURN
3. POWER		**4. DATA RECORDING**	

5. SPACECRAFT INTERFACE

See Page 2.4

6. SPECIAL CONSTRAINTS *(e.g. environmental, equipment lifetime, etc.)*

See Page 2.5

NASA FORM 1339 JAN 67

NASA FORM 1347 Jan 67

PART II - TECHNICAL INFORMATION

1. Objective.- Measurement of changes in musculoskeletal status during orbital space flight is the primary objective of this experiment; concomitant objectives are evaluation of water, electrolyte and possibly steroid changes. Previous bed-rest immobilization studies have shown significant increases in calcium excretion and development of a negative calcium and nitrogen balance (output exceeds intake). This experiment is expected to confirm or possibly modify these ground-based predictions and Gemini results.

2. <u>Significance</u>.- Musculoskeletal deterioration cannot be tolerated by the human body for indefinite periods of time. Identification of rates and levels of actual deterioration will allow accurate specific countermeasures to be taken. Such measures may include exercises and diet supplement.

PART II - TECHNICAL INFORMATION (CONTINUED)

3. Description.-

The experiment has three phases: (1) Preflight, 15 days maximum, (2) Inflight, up to 60 days, and (3) Postflight, 15 days maximum, preferably beginning immediately postflight. These are described in SECTION II, TECHNICAL INFORMATION, Item No. 4. EXPERIMENTAL APPROACH.

PART III - ENGINEERING INFORMATION -

5. Spacecraft Interface.- Major hardware components and their operating locations are: (1) CM-Urine Sampling and Volume Measurement System (USVMS); (2) CM-Specimen Mass Measurement Device (SMMD) (M056 equipment to be adapted); (3) OWS-USVMS; (4) OWS-SMMD (use equipment on board for M056); (5) OWS-Body Mass Measurement Device (BMMD) (use equipment installed for M058); (6) Provisioning of inflight food is considered operational requirement except experimental food of M487; and, (7) OWS-Waste Management System (WMS)-Provided as part of M487. Operation of SMMD and dryer portion of WMS support, M052.

PART III - ENGINEERING INFORMATION (SUMMARY)

6. Special Constraints.-

OPERATIONS SUPPORT:

No constraints are to be placed upon trajectory.

PRE- AND POSTFLIGHT:

Monitor diet, fluid intake, eliminations, blood samples, and bone densitometry. Time required: Normal personal hygiene time increased by one third; eating time unaffected; fluid intake between meals requires extra 15 seconds between meals.

INFLIGHT:

Record diet and fluid intakes; record, measure and sample urine and fecal eliminations; measure body mass on BMM device and record.

PART IV — OPERATIONAL REQUIREMENTS

1. CREW ACTIVITIES *(Include brief profile of crew tasks preflight, inflight, and postflight.)*

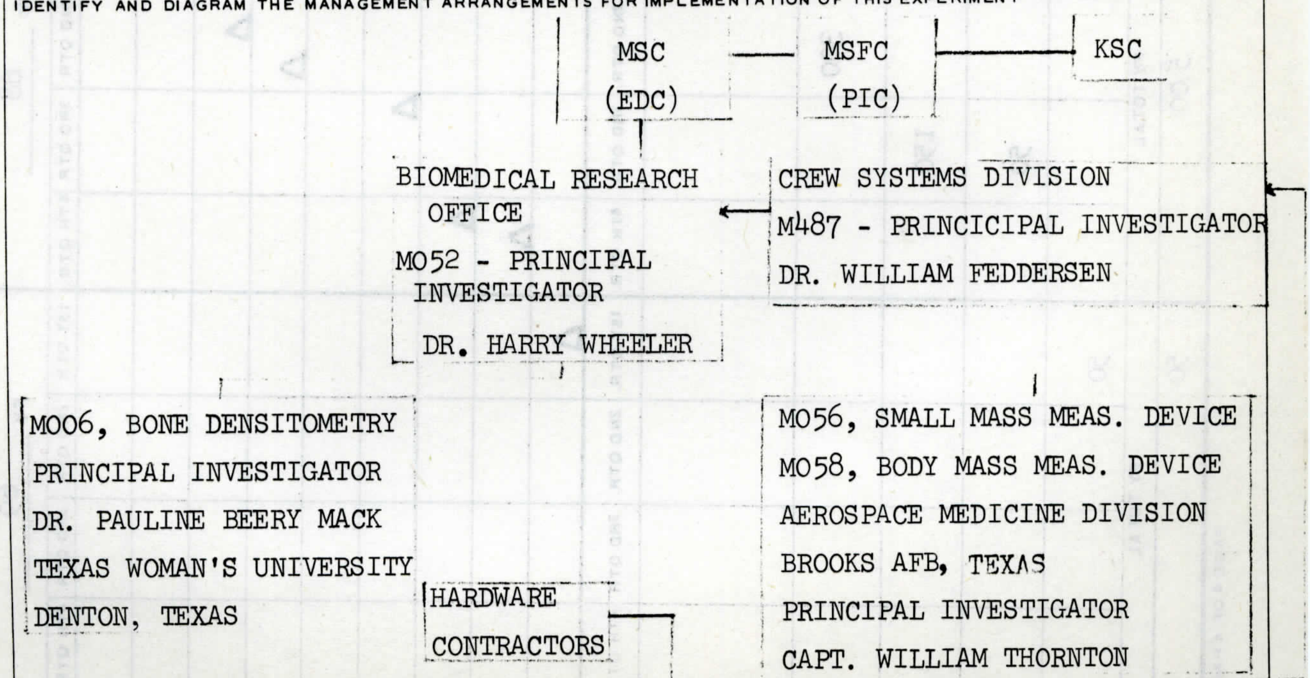
See Page 3.1

2. FLIGHT SUPPORT *(Include communications, tracking needs, recovery requirements, etc.)*

3. SPECIAL REQUIREMENTS *(e.g. trajectory, spacecraft stabilization, unusual pre-launch support or recovery techniques, airlock, EVA, fuel, etc.)*

PART V — MANAGEMENT

IDENTIFY AND DIAGRAM THE MANAGEMENT ARRANGEMENTS FOR IMPLEMENTATION OF THIS EXPERIMENT



PART VI — SCHEDULE AND RESOURCES REQUIREMENTS

1. SCHEDULE OF MAJOR MILESTONES

Pacing Item: USVMS

Milestone	FY 67 1ST QTR.	FY 67 2ND QTR.	FY 67 3RD QTR.	FY 67 4TH QTR.	FY 68 1ST QTR.	FY 68 2ND QTR	FY 68 3RD QTR.	FY 68 4TH QTR.	FY 69 1ST QTR.	FY 69 2ND QTR.	FY 69 3RD QTR.	FY 69 4TH QTR.
APPROVED FOR FLIGHT			Δ									
HARDWARE CONTRACT				Δ								
ICD COMPLETE						Δ						
DESIGN COMPLETE						Δ						
DEP COMPLETE												
PROTOTYPE DELIVERED							Δ					
QUALIFICATION TESTING COMPLETE								Δ				
FLIGHT HARDWARE DELIVERED								Δ				
INSTALLATION AND CHECKOUT COMPLETE									Δ			

2. FUNDING REQUIREMENTS

FUNDING REQUIREMENTS	FUNDING SOURCE	FY 67 1ST QTR.	FY 67 2ND QTR.	FY 67 3RD QTR.	FY 67 4TH QTR.	FY 68 1ST QTR.	FY 68 2ND QTR.	FY 68 3RD QTR.	FY 68 4TH QTR.	FY 69 1ST QTR.	FY 69 2ND QTR.	FY 69 3RD QTR.	FY 69 4TH QTR.
DESIGN, DEVELOPMENT, FABRICATION & TESTING (MOCK-UP, PROTOTYPE & SUPPORT EQUIPMENT)					300								
FABRICATE, TEST & DELIVER (FLIGHT HARDWARE)							300						
SUPPORTING STUDY EFFORT								150					
SPACE VEHICLE INSTALLATION AND CHECKOUT								50					
DATE ANALYSIS & PUBLICATION										50			

TOTALS	FY 67 FY TOTAL	FY 68 FY TOTAL	FY 69 FY TOTAL
TOTALS	300	5.00	50

PART IV - OPERATIONAL REQUIREMENTS.-

1. CREW ACTIVITIES:

Pre- and postflight: Monitor diet, fluid intake, eliminations, blood samples, and bone desnitometry. Time required: Normal personal hygiene time increased by one third; eating time unaffected; fluid intake between meals requires extra 15 seconds between meals.

Inflight: Record diet and fluid intakes; record, measure and sample urine eliminations; record fecal eliminations; measure body mass on BMM device and record. Collect in OWS 7 days of fecal eliminations (demarcated by appearance in stool of ingested food dye marker) and return for postflight analyses.

SECTION II - TECHNICAL INFORMATION

1. OBJECTIVES

Briefly define experiment objectives.

See Page 5.1

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2. SIGNIFICANCE

Explain the value of the experiment. Indicate anticipated gains from the project and, where so, how these may relate to future effort.

See Page 5.2

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3. DISCIPLINARY RELATIONSHIP

Provide information on the following (with references as appropriate):

a. Brief history of related work.

b. State of present development in the field.

See Page 5.3

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4. EXPERIMENT APPROACH

Information provided in this section should:

a. Fully describe the experiment concept.

b. Outline the method and procedures for carrying out experiment.

c. Define the measurements to be made and ranges of numerical values expected.

d. Describe method for analysis and interpretation of data.

e. Present prime obstacles or uncertainties which can be anticipated.

f. Explain the significance of the astronaut in performing the experiment.

See Page 5.4 thru 5.6

SECTION II - TECHNICAL INFORMATION (Cont'd)

5. BASELINE OR CONTROL DATA

Specifically identify support studies or concurrent investigations that must be conducted to augment the flight investigation.

SECTION II - TECHNICAL INFORMATION.-

1. OBJECTIVES:

Measurement of changes in musculoskeletal status during orbital space flight is the primary objective of this experiment; concomitant objectives are evaluation of water, electrolyte and possibly steroid changes. Previous bed-rest immobilization studies have shown significant increases in calcium excretion and development of a negative calcium and nitrogen balance (output excees intake). This experiment is expected to confirm or possibly modify these ground-based predictions and Gemini results.

Assessment of the alteration in musculoskeletal status during orbital space flight is the primary objective of the OWS experiment. Concomitant objectives are evaluation of water, electrolyte, and possibly steroid changes.

Investigators have long recognized that chronic confinement may result in metabolic alterations such as losses of calcium and phosphorus to the point of osteroporosis, urinary tract stone formation, and loss of muscle mass and strength. Several bed-rest immobilization studies have shown that in healthy young adults urinary calcium excretion increases two to threefold within five weeks after confinement. The same individuals may enter into a state of negative nitrogen balance (output exceeds intake). Quantitative X-ray studies of the bones have demonstrated concomitant demineralization with bed-rest immobilization.

The preceding observations have led some investigators to predict that prolonged exposure to both confinement and weightlessness during space flight can eventually produce deleterious alterations in the physiological and biochemical integrity of the flight crew. As of the time of preparation of this form, Gemini pre- and postflight X-rays have suggested loss of mineral from peripheral bones; and the Gemini M007 experiment has demonstrated a trend for negative metabolic changes which may have been ameliorated by inflight exercise.

2. SIGNIFICANCE:

Musculoskeletal deterioration cannot be tolerated by the human body for indefinite periods of time. Identification of rates and levels of actual deterioration will allow accurate specific countermeasures to be taken. Such measures may include exercises and diet supplement.

3. DISCIPLINARY RELATIONSHIP:

Debilitating diseases have long been known to cause severe calcium and nitrogen losses (negative balance), but it is only in recent years that evidence has been presented demonstrating that in normal healthy individuals the lack of activity, e.g., bed rest for two or more weeks, can per se promote excess calcium and nitrogen excretion. In these bed rest experiments, modification of the direction of gravitational forces on the skeletal system may also be a contributory factor in the observed deconditioning; therefore, it has been predicted that prolonged exposure of the human organism to both immobilization and subgravity would produce deleterious changes in the physiological and biochemical integrity of organ systems that are normally under the influence of gravitational force and exercise. Significant but preliminary biomedical data on this problem were obtained on the Gemini 7 orbital flight.

Although Gemini 7 is the longest manned mission to date, the losses in bone mass were markedly less than those observed in the two previous flights of four and eight days' length. The losses from the hand phalanges tended to be lower than observed in the crews of the Gemini 4 and Gemini 5 missions, but they were greater than the losses exhibited by bed rest subjects.

We believe that the vast improvement in the retention of bone mass by the Gemini 7 astronauts may be attributed, at least in part, to the fact that they consumed a substantial portion of their food fortified with calcium, and they performed routine isometric and isotonic exercises.

It should be stated that the bone losses in these orbital flight studies are by no means indicative of skeletal pathology. In the studies conducted thus far, the bone mass returns to preflight level within a relatively short period of time postflight.

4. EXPERIMENTAL APPROACH:

The experiment has three phases: (1) Preflight, 15 days maximum, (2) Inflight, up to 60 days, and (3) Postflight, 15 days maximum preferably beginning immediately postflight.

The results of the M007 experiment on Gemini 7 indicate a need for a postflight phase at least equivalent in duration to the preflight phase.

Experimental parameters which must be measured or controlled and which interface with the astronaut are:

a. Body Weight: Pre- and postflight phases only. Daily upon arising (after micturition). Inflight: Body mass measurement (daily in OWS).

b. Diet: Calcium intake must be made as constant as possible within a range of 800 - 1000 mg/day.

(1) Pre- and Postflight: The pre- and postflight diet will be a calcium controlled metabolic diet calculated, prepared, and cooked under the direction of a metabolic dietitian and one assistant. Both menus will daily provide approximately 100-110 grams protein and approximately 95 grams fat per day, thus approximating the inflight menu in nutrient composition. No restriction will be made on smoking or chewing gum, but particular care must be taken to avoid the swallowing of toothpaste (high in calcium content). The success of this experiment is dependent of the extent and quality of nutrient intake information. It is proposed that the menus prepared by the dietetic staff in the MSO Building at Cape Kennedy and onboard the recovery vessel be followed by the crew as meticulously as possible. It is not the intent of the experiment to constrain unrealistically the astronauts' food intake or eating habits; it is imperative, however, that detailed records be kept concerning all food consumed. Pre- and postflight menu planning will be coordinated with the crew to reflect preferences. The postflight diet for use on the recovery vessels will be developed on the same basis. An attempt is being made to stabilize crew intake of nutrients and allow for adaptation to a diet very similar in nutrient composition to that of the inflight diet. Aboard the recovery vessel the specially prepared diet will be available. For pre- and postflight diets, preweighed servings will be provided. No limit will be placed on the quantity of calories to be ingested to maintain body weight. The crew will be urged to keep plate-waste at a minimum, because this waste will have to be weighed and consumption record corrections made accordingly. Although it is not mandatory that the astronaut "clean his plate," complete consumption is to be encouraged. The intent is to maintain constancy of input in order that the output data can be meaningfully interpreted as being reflective of the space flight experience.

4. EXPERIMENTAL APPROACH (Continued):

(2) The Inflight Diet: The inflight diet will be the Apollo type menu of freeze dehydrated and otherwise dried or processed foods of known composition. A record of food consumed will be maintained. The interface with the M487 experimental feeding system must be considered.

c. Fluid Intake:

(1) Pre- and Postflight: Ad libitum but quantity must be recorded. Graduated beverage containers will be provided pre- and postflight. Water intake can be approximated by using a personal reusable drinking cup and a daily log on which "number of time filled" can be recorded, or by employing some other type of water measuring device.

(2) Inflight: The water measuring devices (WMD) for drinking and food reconstitution will be utilized and consumption by each crewmember recorded. The Gemini/Apollo WMD is envisioned. The crewmember will log the counter readings at each usage.

d. Specimen Collection:

(1) Pre- and Postflight: Pre- and postflight urine and stool specimens must be collected. Facilities for separate urine and stool collection will be provided at several permanent locations at Cape Kennedy (e.g., crew quarters, mission simulator, VAM, launch pad) and on primary recovery ships. Appropriate containers in an insulated carrying case for use up to 6 hours at other unpredictable locations will be made available. Since a site to process collected samples will be established in the MSO Building and onboard the recovery carriers, permanent-type collection facilities can be installed at convenient locations and personnel made available for the pickup of samples.

(2) Inflight Urine: Engineering constraints may not permit all micturitions to be collected; therefore, the urine collection system will consider a means of measuring the total 24-hour voidings of each subject, and collecting a minimum aliquot (200 cc) of each void or 24-hour pool. Provisions will be made for identifying the astronaut and time of micturition. Two to four sample bags per man per day will be stowed onboard unless experience and stowage constraints dictate otherwise.

(3) Inflight Stools: While in the OWS (estimated flight day 14 thru 27 on AAP 2) the wet and dry weight of stools will be determined by mass measurement for a minimum seven-day period. The containers will be labeled for terrestrial return at the termination of the AAP 2 mission or during a revisit mission. Otherwise the mass of

4. EXPERIMENTAL APPROACH (Continued):

all stool specimens in the CM and OWS will be measured and recorded, but need not be returned for postflight analyses.

e. Blood:

(1) Pre- and Postflight: Two samples of venous blood, approximately 50 ml each, will be withdrawn during preflight medical examination. Postflight blood samples (50ml) will be obtained onboard the recovery carrier; one sample to be obtained as soon as possible postflight, and the others 24 and 72 hours later.

(2) Inflight: None.

f. The following information concerning the collection, preservation and storage of specimens is given in a separate document available on request:

(1) Blood:

(a) Parameters to be examined and amount of blood required for each parameter.

(b) Treatment and storage (technical procedures).

(c) Collection protocol (technical procedures):

1 Preparation
2 Equipment
3 Technique

(2) Urine: As above.

(3) Food: As above where applicable.

g. A bibliography pertaining to this experiment is available upon request.

SECTION III - ENGINEERING INFORMATION

1. EQUIPMENT DESCRIPTION - See Pages 7.1 thru 7.3

This section should:

a. Provide a narrative description of the experiment hardware. Include block diagram. Discuss expected performance, e.g., dynamic range, intrinsic noise sources, input and output characteristics, limitations, etc.

b. List required equipment, including test models, flight hardware, spares, ground support equipment, etc.

c. Give state of equipment definition, i.e., conceptual, design, breadboard, prototype, flight hardware, etc.

2. ENVELOPE

Provide a geometrical sketch of each separate assembly of flight hardware, giving dimensions and configuration, and number them for later identification.

3. WEIGHT AND SIZE - See Page 7.4

Give the estimated weight and size of the completed experimental hardware (including unique cabling, plumbing and support structure).

Submit in the following format:

EQUIPMENT ITEM	WEIGHT	VOLUME STORED	VOLUME OPERATION	DIMENSIONS STORED	DIMENSIONS OPERATION	SHAPE STORED	SHAPE OPERATION
Assembly 1							
Assembly 2							
Assembly 3							
Etc.							
TOTAL							

4. POWER

Power requirements should be provided for each assembly or component identified in Item 3 above. Information should be provided in the following format:

POWER	Standby	Average	Maximum
TOTAL POWER:			
POWER CONSUMED BY SEPARATE ASSEMBLIES			
USVMS Assembly #1	0	Intermittent	35 w
DRYER Assembly #2	0	Unknown	Unknown
SMMD (M056) BMMD (M058) Assembly #3	Self-contained		

If power consumption is not constant, requirements should be furnished in sufficient detail so that power profiles can be determined.

5. SPACECRAFT INTERFACE REQUIREMENTS - See Page 8.1

Include the following:

a. Required or desired location.

b. Mounting requirements.

c. Spacecraft subsystem support requirements (electrical, communications, environmental, guidance, etc.).

d. Special mechanical linkage or control requirements.

6. ENVIRONMENT CONSTRAINTS

a. Estimate the environment extremes or limits within which satisfactory operation of the equipment is possible. Complete the format below.

TOLERANCE LIMITS

Constraint \ Assembly or Unit	1 USVMS	(See M487) 2 DRYER	(See M056) 3 SMMD	(See M058) ETC. BMMD
Thermal				
Stored				
Operational				
Atmospheric Pressure	+ 10 + 45 25 Psia to 1 x 10^{-6} MM Hg			
Relative Humidity	15% to 100%			
Air Movement Rate	20% to 100%			
Atmospheric Composition				
Contaminants				
Acceleration (Storage)	0 to 7g			
Positive				
Negative				
Transverse				
Acceleration (Operation)	0 to 1g			
Positive				
Negative				
Transverse				
Vibration (Storage)	20 to 100 cps - linear increase (log by log plot) from 0.001g^2/cps to 0.075g^2/cps			
Random				
Sinusoidal				
Vibration (Operation)	100 to 500 cps - constant at 0.075g^2/cps			
Random	500 to 1000 cps - linear decrease (log by log plot) from 0.75g^2/cps to 0.015g^2/cps			
Sinusoidal				
	1000 to 2000 cps constant at 0.015g^2/cps 30g			

SECTION III - ENGINEERING INFORMATION.-

1. EQUIPMENT DESCRIPTION:

Major hardware components and their operating locations are: (1) CM-Urine Sampling and Volume Measurement System (USVMS); (2) CM-Specimen Mass Measurement Device (SMMD) (M056 equipment to be adapted); (3) OWS-USVMS; (4) OWS-SMMD (use equipment onboard for M056; (5) OWS-Body Mass Measurement Device (BMMD) (use equipment installed for M058); (6) Provisioning of inflight food is considered operational requirement except experimental food of M487; and, (7) OWS-Waste Management System (WMS) - Provided as part of M487. Operation of SMMD and dryer portion of WMS support, M052.

a. Urine Sampling and Volume Measurement System (USVMS): This unit will consist of a calibrated volume measurement system installed for convenient access and use by crewmembers. Volume will be taken by each crewmember and recorded. A 200 cc sample is to be retained for each 24-hour period. Similar units are required for integration with the CM Waste Management System and with the OWS Waste Management System. Design details have not been finalized.

b. Specimen Mass Measurement Device (SMMD): Aerospace Medicine Division, Brooks AFB, Texas has developed a device which uses a linear spring/mass pendulum, the period of which is electronically determined by the mass of the body being measured. A digital readout is logged. This experiment M056 device will be installed and operated in the OWS in support of experiment M052. A duplicate requirement exists in the CM.

c. Body Mass Measurement Device (BMMD): This device is identical, in basic principle, to item B., above. However, the device above is small in size and measurement capacity, but the BMMD is large enough to accomodate an astronaut who assumes a sitting position on the pendulum platform. This device has also been developed by Aerospace Medicine Division, Brooks AFB, and is to be installed in the OWS in support of experiment M052.

d. Dryer: This device in combination with the USVMS and fecal collector constitutes the Waste Management System (WMS) of experiment M487 in the OWS. The dryer is to be used for the drying of urine and fecal specimens for the purpose of water removal so that mass of residual solids and evaporated water may be determined and specimen constituents can be stabilized.

e. Quantities Required: (See Page 7.2)

SECTION III - ENGINEERING INFORMATION.-

1. EQUIPMENT DESCRIPTION (Continued):

e. Quantities Required:

ITEM:

REQUIRED FOR:	Urine Sampling and Volume Measurement System (USVMS)	Specimen Mass Measurement Device (SMMD)	Body Mass Measrurement Derice (BMMD)	Dryer	
MASS MOCKUP	1 CM 1 OWS	1 CM (1) OWS	(1) OWS	(1)	
TRAINING	1	(1)	(1)	(1)	
QUALIFICATION	1	(1)	(1)	(1)	
FLIGHT	1 CM 1 OWS	1 CM (1) OWS	(1)	(1)	
BACKUP	1	(1)	(1)	(1)	

Note: (1) indicates items assigned to other experiments. Refer to page 7.3.

SECTION III - ENGINEERING INFORMATION.-

1. EQUIPMENT DESCRIPTION (Continued):

f. Spacecraft Interface Requirements:

(1) Command Module:

(a) Urine Sampling and Volume Measuring System (USVMS) must be integrated into the waste handling system.

(b) Specimen Mass Measuring Device (SMMD) must be stowed in CM and provisions must be made for mounting the device.

(2) OWS:

(a) Urine Sampling and Volume Measuring System (USVMS) must be integrated into the waste handling system.

(b) SMMD and BMMD of experiments M056 and M058 will be used.

(c) Dryer is part of experiment M487 waste management system.

(3) Life support is not required.

(4) Data handling requirements are not needed.

2. Weight and Volume: The total estimated weight of the experiment hardware is 21. pounds. The total estimated volume of the equipment 1.3 cubic feet. Inside the stowage box, the equipment will require 1.3 cubic feet, and may be consolidated with other experiments for storage.

EQUIPMENT ITEM	WEIGHT (POUNDS)	VOLUME STORED	(CUBIC FEET) OPERATIONAL	DIMENSIONS (INCHES) STORED	DIMENSIONS (INCHES) OPERATIONAL	SHAPE [4]
USVMS	13.5 $(13.5)^3$	1.0 $(1.0)^3$	1.0 $(1.0)^3$	Integrated with: CM - WMS OWS - WMS	T.B.D.	Unknown-Cyl
SMMD	8.0 CM $(8.0\ \text{OWS})^1$	0.3 $(0.3)^1$	0.5 $(0.5)^1$	6x8x10	6x14x10	Rectangular
BMMD	$(38.0)^2$	$(13.9)^2$	$(27.8)^2$	20x30x40	20x60x40x	Rectanglar
DRYER	$(20/0\#)^3$	$(1.0)^3$	$(1.0)^3$	Integrated with OWS WMS	T.B.D.	Rectangular
Total	21.5 (66.0)	1.3 (15.2)	1.5 (29.3)			

Notes:
1. Value to be assigned to M056
2. Value to be assigned to M058
3. Value to be assigned to M487
4. Shape - Stored - Operation

5. SPACECRAFT INTERFACE REQUIREMENTS:

A. COMMAND MODULE:

1. Urine Sampling and Volume Measuring System (USVMS) must be integrated into the waste handling system.

2. Specimen Mass Measuring Device (SMMD) must be stowed in CM and provision must be made for mounting the device by wall or floor bracket.

B. OWS:

1. Urine Sampling and Volume Measuring System (USVMS) must be integrated into the waste handling system.

2. SMMD and BMMD from other experiments to be used.

3. Dryer should be integrated into Waste Management System.

C. Life support is not required.

D. There are no data handling requirements.

SECTION III - ENGINEERING INFORMATION (Cont'd)
(Tolerance Limits, Cont'd)

Noise Light Tolerance Intensity Wave Length Radiation Tolerance RFI EMI	N/A				

b. If the experiment can possibly cause interference with other equipment, indicate the nature and range of the potential outputs.

CONTAMINANTS	OUTPUT RANGE				
Vibration Random Sinusoidal Noise Light Radiation RFI EMI	Potentially None				

7. DATA MEASUREMENTS REQUIREMENTS - See also Page 9.1

State the expected data and measurement characteristics in the format specified below where applicable. Include additional or different information as necessary.

PARAMETER TO BE MEASURED		PARAMETER 1	PARAMETER 2	PARAMETER 3
EQUIPMENT ITEM USED		USVMS ASSEMBLY 1	See EIP for M056 and M058 ASSEMBLY 2	See EIP for M487 ETC.
EXPECTED VALUES OF PARAMETER	UNITS (METERS, GMS., ETC.)	Milliliters		
	AVERAGE	300		
	RANGE	50-800		
MEASUREMENT CHARACTERISTICS	HOW OFTEN (E.G. TIMES PER DAY)	5/man		
	DURATION OF EACH	Variant		
	TOTAL NUMBER IN MISSION	15/day		
OUTPUT SIGNAL OF INSTRUMENT	TYPE (DIGITAL, ANALOGUE)	Digital		
	FREQUENCY RANGE, LOW TO HIGH (CPS., HZ.)	N/A		
	AMPLITUDE RANGE (E.G. O-5 VOLTS)	Unknown		
	INSTRUMENT RESOLUTION (% TOTAL SCALE)	± 2½%		
READ-OUT REQUIREMENTS	NO. OF CHANNELS	One		
	SAMPLING RATE (TIMES PER SEC., ETC.)	N/A		
	TELEMETRY (CHECK IF NEEDED)	N/A		
	RECORDER (CHECK IF NEEDED)	N/A		
TIME IDENTIFICATION METHOD	(SPACECRAFT CLOCK OR OTHER)	S/C Clock GET		

7. DATA MEASUREMENTS REQUIREMENTS (Continued):

a. There is no requirement for automatic data accumulation, recording, or transmission.

b. The following discussion and table describe the parameters of investigation. The inflight data requirements consists of logged entries and eliminations and entries of mass and volume measurements.

3. SPECIFY PARAMETERS TO BE MEASURED INCLUDING NUMERICAL VALUES EXPECTED AND OUTLINE THE RESEARCH PROGRAM:

The experiment is designed to determine the catabolic activity of bone and muscle during exposure to the weightless and operational conditions within the Saturn IV-B laboratory. The premise is that, based on the results of immobilization studies, weightlessness and confinement will result in a loss of the principal constituents of bone and muscle which may be ameliorated by optimal exercise and dietary regimens.

In order to assess the magnitude and rate of alteration in nitrogen, creatinine, calcium, phosphorus, sodium, sulfur, potassium, magnesium, and chloride metabolism, and steroid excretion, it is necessary to obtain preflight, inflight, and postflight specimens of the following:

1. Urine, for a period pre- and postflight and continuously inflight.
2. Feces, for a period pre- and postflight.
3. Blood, pre- and postflight.
4. Water balance, output measured as urine, intake by an operational metering procedure.

Each astronaut will serve as his own control in establishing baseline or control data in the experiment. Constraints of astronaut preflight training permitting, a preflight metabolic control phase of 15 days will be obtained. A postflight 15 day control phase will also be obtained. The Apollo flight for which this experiment is tentatively planned is scheduled for 30 to 60 days. Related data from M-7 (Gemini metabolic study) and M 007 (Apollo metabolic study) will be available for comparative purposes.

The primary independent experimental variable which must be isolated is the diet. The exact amount and composition of all ingested foods and liquid must be known. The calcium intake during the pre- and postflight experimental periods must be established at constant levels. Three factors may be cited for this requirement with respect to bone:

1. The need for standardization, since fecal calcium particularly varies directly with intake. (Once established, this parameter can be considered a constant for a given individual, since inflight fecal sampling is not feasible.)
2. Previous related metabolic studies have been carried out at these dietary calcium levels.
3. The inflight Apollo type diet will furnish calcium in this range. Day to day constancy of intake, although programmed, will necessarily be less rigid inflight.

Levels of physical activity will be governed by the regular pattern established by the crew.

The collected data will allow calculation of selected excretion rates and comparison with pre- and postflight baseline control data.

Pre- and postflight bone densitometry studies will be accomplished following the current M006 protocol; three preflight films of hand and foot and four postflight films of hand and foot will be required.

Parameters to be measured are shown in Table I.

(Attach additional sheets if necessary, identifying items by number.)

Item 3.

TABLE I

Parameters	Sample	Range	Sample Size
Calcium	Serum (1)	4.5-5.7 mEq/l	0.5 ml
	Urine (2)	0.1-0.4 g/24 hr	10.0 ml
	Feces (1)	0.3-1.3 g/24 hr	1.0 ml
	Food (2)	0.8-1.0 g/24 hr	1.0 g
Phosphorus	Serum (1)	2.5-4.8 mg%	0.5 ml
	Urine (2)	0.8-1.5 g/24 hr	1.0 ml
	Feces (1)	0.9-1.7 g/24 hr	1.0 g
	Food (2)	1.4-1.55 g/24 hr	1.0 g
Magnesium	Serum (1)	1.52-2.4 mEq/l	1.0 ml
	Urine (2)	4.1-16.4 mEq/24 hr	1.0 ml
	Feces (1)	0.12-0.36 g/24 hr	1.0 g
	Food (2)	0.14-0.22 g/24 hr	1.0 g
Sodium & Potassium	Serum (1)	135-143mEq/l	0.1 ml
	Urine (2)	150-197mEq/24 hr	0.5 ml
	Food (2)	2.5-3.5 g/24 hr	1.0 g
Chloride	Serum (1)	98-110 mEq/l	1.0 ml
	Urine (2)	10-15 g/24 hr	1.0 ml
Total Nitrogen	Urine (2)	10-18 g/24 hr	1.0 ml
	Feces (1)	0.7-2.1 g/24 hr	1.0 g
	Food (2)	14.0-17.6 g/24 hr	1.0 g
Creatine	Urine (2)		
Creatinine	Urine (2)	1-1.5 g/24 hr	1.0 ml
Alkaline Phosphatase	Serum (1)	1-6 Bod. Units	0.5 ml
Total Protein	Serum (1)	6.2-8.5 g%	0.15 ml
Albumin	Serum (1)	4.5-5.5 g%	0.1 ml
Globulin	Serum (1)	1.5-3.5 g%	0.1 ml
Hydroxyproline	Urine (2)	1.5 mg/24 hr	5.0 ml
Routine Clinical Urinalysis	Urine (2)	N. A.	5.0 ml
Hydroxyproline	Serum (1)		5.0 ml
Free		0.01-0.2 MM/ml	
Bound		0.14-0.19 MM/ml	
Urea	Urine (2)	25-35 g/24 hr	1.0 ml

(1) Pre- and postflight

(2) Continuous; i.e., preflight, inflight (CM and OWS), and postflight

TABLE I (Continued)

Parameters	Sample	Range	Sample Size
Amino Nitrogen	Urine (2)	100-150 mg/24 hr	2.0 ml
Osmolality	Urine (2)	50-1200 mOsm/l	2.0 ml
17-Hydroxycortico-Steroids	Plasma (1)	2-18 mg%	5.0 ml
Vasopressin	Serum (1)	______	2.0 ml
Catecholamines	Urine (2)		25.0 ml
Epinephrine		3-35 µg/24 hr	
Norepinephrine		25-135µg/24 hr	

(1) Pre- and postflight

(2) Continuous; i.e., preflight, inflight (CM and OWS), and postflight.

SECTION IV - OPERATIONAL REQUIREMENTS

1. SPACECRAFT ORIENTATION REQUIREMENTS

Orbital parameters, spacecraft attitude control requirements, pointing accuracy, and stability tolerances should be outlined in format below:

a. Describe maneuvers. N/A

b. Type of orbit. N/A

c. Orbit parameters: perigee, apogee, period, inclination. N/A

d. Lighting constraints. Normal CM and OWS lighting

e. Time of month, time of day, phase of moon, etc. N/A

f. Number of measurements required. N/A in this context

g. Time per measurement. N/A in this context

h. Orbital location during measurements. N/A

i. Spacecraft pointing accuracy: pitch, roll, yaw. N/A

j. Allowable spacecraft rate: pitch, roll, yaw. 10^{o}/hr. for each

---

2. ASTRONAUT TRAINING - See pages 11.1 thru 11.7

Outline the special skills and training requirements of the flight crew to support the experiment. Include EVA and communications training. A schedule for these training activities, showing the time required of the flight crew and supporting personnel and facilities, should be included.

---

3. ASTRONAUT PARTICIPATION PLAN - Not available at this time - See Summary Page.

Those requirements, other than training, which involve crew personnel should be specified, indicating whether activity is pre-flight, in-flight, or post-flight. Describe the following in chart form:

a. The task for each crew member.

b. The time required for each task.

c. The equipment used in performing each task.

d. A schedule showing when each task is performed (i.e., launch - 10 days, launch - 5 days, first orbit, second orbit, etc.).

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4. PRE-LAUNCH SUPPORT - See Page 13.1

This section should provide the following information:

a. Preliminary shipping and handling procedures.

b. Preliminary installation and checkout procedures.

c. Facilities (labs, office space, etc.).

d. Test equipment (bench test equipment, special test sets, simulators, etc.).

e. Services (fuel, chemicals, power, etc.).

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5. FLIGHT OPERATIONAL REQUIREMENTS - See Page 12.1

Those operational requirements which do not directly involve the flight crew should be presented. Communication needs, tracking needs, and special techniques, such as restrictions in the use of control thrusters at stated times, should be delineated. If the support of network range stations is required, it must be explained. Indicate any special skills required of ground personnel.

Describe all real time operational support requirements necessary to conduct the experiment such as uplink command data needed to control the experiment, special communications requirements with either the crew or the ground controllers, or specific data needed by the experimenter for execution of the experiment.

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6. RECOVERY REQUIREMENTS - See Section IV, Item 7, Data Support Requirements, Page 13.1

State what equipment must be recovered, its size and weight, special handling techniques, and other constraints. Also any special equipment to be used on recovery ships, such as for x-ray, photographic, or laboratory work.

7. **ASTRONAUT TIME REQUIREMENT SYNOPSIS**

PREFLIGHT TIME	IN-FLIGHT TIME	POSTFLIGHT TIME
$2\frac{1}{2}$ hrs/wk in addition to time usually required for eating and elimination	30 min/day in addition to time required for eating and elimination	$2\frac{1}{2}$ hrs/wk in addition to time usually required for eating and elimination

8. **DESCRIBE THE PREFLIGHT AND POSTFLIGHT REQUIREMENTS ON THE ASTRONAUT**

Flight crewmembers will receive a 60-minute indoctrination in addition to the Preflight Briefing. This time allocation is provided to allow for a more thorough orientation of the astronauts and for familiarization with the experimental protocol and equipment.

Crewmembers are required for the collection of baseline experimental data during the preflight control period when total urinary and fecal output will be recovered from each astronaut. Balanced diets will be prepared and served in the astronauts' quarters at Kennedy Space Center.

The inflight phase of this experiment requires little additional crew time (30 minutes per day estimated). The diet will consist of Apollo-type food. Twenty-four hour urine output for each astronaut will be collected, and aliquots removed for vacuum drying or other processing and returned to earth for assay.

The postflight phase allows observation of the readjustment of calcium, nitrogen and electrolyte metabolism to a 1 G environment. Demands upon the astronauts are identical with those of the preflight protocol, and the total time involved is also about the same.

Typical inflight time lines (See following pages).

(Attach additional sheets if necessary, identifying items by numbers.)

PRELIMINARY

TIME LINE ESTIMATE

M-052 - BONE AND MUSCLE CHANGES DURING PROLONGED SPACEFLIGHT

GENERAL:

The requirements of this experiment revolve around crew eating and personal hygiene activities. At no time is more than one crewmember required to perform any phase of the experiment.

PRE- AND POSTFLIGHT (15 DAYS):

1. Diet and fluid intake is continuously monitored.

2. All eliminations are identified and collected.

3. Body weight is measured daily each morning upon arising.

4. Blood samples (2 pre and 2 post) and bone densitometry (3 pre and 4 post) at pre- and postflight physicals or specified intervals.

Time: Normal individual personal hygiene time is increased by one-third. Eating time is unaffected (intake recorded by dietician). Recording of fluid intake between meals requires 15 seconds per drink.

INFLIGHT (ENTIRE FLIGHT DURATION):

1. Diet and fluid intake is continuously monitored. Food residue is measured by mass measurement (5 minutes per crewmember per day).

2. All urine eliminations are identified, measured, and aliquots taken. Operation time of USVMS*, including logging is estimated 10 minutes per crewmember, four times per 24-hour period.

3. Fecal eliminations in CM** are logged--time per crewmember, 2 minutes.

4. In OWS*** fecal eliminations are logged. In addition, all waste aliquots (urine and fecal) are dried (WMS)****. A seven day fecal collection period with return of samples is requested. The processing of waste for drying requires the use of the specimen mass measurement device. All this equipment is part of the M-487 Habitability experiment except for the recording of events and storing of required specimen for return to earth. Time: Twenty (20) minutes per crewmember per day is considered chargeable to the M-052 experiment.

* Urine Sampling and Volume Measurement System; ** Command Module; *** Orbital Workshop; **** Waste Management System in M-487.

5. In the OWS,* daily body mass will be measured on the body mass measurement device. Time: Five (5) minutes per crewmember.

LIST OF PROPOSED INFLIGHT EQUIPMENT

M-052 - BONE AND MUSCLE CHANGES DURING PROLONGED SPACEFLIGHT

1. CM - Urine Sampling and Volume Measurement System (USVMS).
2. CM - Specimen Mass Measurement Device (SMMD).
3. OWS - USVMS.
4. OWS - SMMD.
5. OWS - Body Mass Measurement Device (BMMD).
6. Provisioning of inflight food is considered operational requirement except experimental food of M-487.
7. OWS - Waste Management System (WMS) - Provided as part of M-487. Operation of SMMD and dryer portion of WMS support, M-052.

DATA MEASUREMENT REQUIREMENTS INFLIGHT

M-052 - BONE AND MUSCLE CHANGES DURING PROLONGED SPACEFLIGHT

1. Access to GET* event timer in CM and OWS.
2. Individual - daily - M-052 logs.

* GET - Ground Elapsed Time.

M-052 - BONE AND MUSCLE CHANGES DURING PROLONGED SPACEFLIGHT

INFLIGHT TIME LINE TABLE

MINUTES Exp. Total Per Man	Time for Event	Typical Activity Time Line
00:00		
00:10	00:10	USVMS #1 - Log
Nominal	Alloted:60	Eat - Drink - Log
00:15	00:05	SMMD of Waste Food
00:17	00:02	Drink - Log
00:27	00:10	USVMS #2 - Log
Nominal	Alloted:60	Eat - Drink - Log
00:32	00:05	SMMD of Waste Food
00:34	00:02	Drink - Log
00:44	00:10	USVMS #3 - Log
Nominal	Alloted:60	Eat - Drink - Log
00:49	00:05	SMMD of Waste Food
00:59	00:10	USVMS #4 - Log
00:60	00:01	Record GET - - Defecations
		Additional Requirements in OWS
01:05	00:05	Daily Body Mass
01:20	00:15	Prepare and Load WMS Dryer (EXP M-487) - Once daily
01:25	00:05	Empty WMS Dryer - Log and Retain Seven-Day Fecal Collection Period - Log All Defecations

M-052 - BONE AND MUSCLE CHANGES DURING PROLONGED SPACEFLIGHT

INFLIGHT TIME LINE TABLE - BASED ON TYPICAL CM&OW DAY

24-HOUR CLOCK		SP	CP	P
00:00	06:00	Sleep (OWS)	Work (CM)	Work (OWS)
(02:50	03:00)	----------------------	USVMS #1* Log	USVMS #1* Log
06:00	06:10	USVMS #1*- Log	----------------------	----------------------
06:10	06:15	BMMD	----------------------	BMMD
06:15	07:15	Eat - Drink - Log	Eat - Drink - Log	Eat - Drink - Log
07:15	07:25	----------------------	SMMD - Food Waste - Log	SMMD - Food Waste - Log
07:25	12:00	Work or Exp.	Work or Exp.	Work or Exp (Load WMS Dryer 15 mins)
(07:20	07:30)	----------------------	USVMS #2 - Log	USVMS #2 - Log
(11:50	12:00)	USVMS #2 - Log		
12:00	13:00	Eat - Drink - Log	Eat - Drink - Log	Eat - Drink - Log
13:00	21:00	Work	Sleep (OWS)	Sleep (CM)
(18:00	18:10)	USVMS #3 - Log	----------------------	----------------------
21:00	21:10	----------------------	USVMS #3 - Log	USVMS #3 - Log
(21:10	21:15)	----------------------	BMMD	----------------------
21:10	22:10	Eat - Drink - Log	Eat - Drink - Log	Eat - Drink - Log
22:10	22:20	USVMS #4 - Log	SMMD - Food Waste - Log	SMMD - Food Waste - log
22:20	06:00	Sleep	Work or Exp.	Work or Exp.
(22:20	22:25)	----------------------	(Empty WMS Dryer)	----------------------
(22:25	22:35)		USVMS #4 - Log	USVMS #4 - Log

* Defecation + Log (Assume one per day.)
USVMS: Urine Sampling and Volume Measurement System Operation
SMMD: Operation of Specimen Mass Measurement Device (One crewmember does total effort.)

M-052 - BONE AND MUSCLE CHANGES DURING PROLONGED SPACEFLIGHT

INFLIGHT TIME LINE TABLE

MINUTES Exp. Total Per Man	Time for Event	Typical Activity Time Line
00:00		
00:10	00:10	USVMS #1 - Log
Nominal	Alloted:60	Eat - Drink - Log
00:15	00:05	SMMD of Waste Food
00:17	00:02	Drink - Log
00:27	00:10	USVMS #2 - Log
Nominal	Alloted:60	Eat - Drink - Log
00:32	00:05	SMMD of Waste Food
00:34	00:02	Drink - Log
00:44	00:10	USVMS #3 - Log
Nominal	Alloted:60	Eat - Drink - Log
00:49	00:05	SMMD of Waste Food
00:59	00:10	USVMS #4 - Log
00:60	00:01	Record GET - - Defecations
		Additional Requirements in OWS
01:05	00:05	Daily Body Mass
01:20	00:15	Prepare and Load WMS Dryer (EXP M-487) - Once daily
01:25	00:05	Empty WMS Dryer - Log and Retain Seven-Day Fecal Collection Period - Log All Defecations

M-052 - BONE AND MUSCLE CHANGES DURING PROLONGED SPACEFLIGHT

INFLIGHT TIME LINE TABLE - BASED ON TYPICAL CM&OW DAY

24-HOUR CLOCK		SP	CP	P
00:00	06:00	Sleep (OWS)	Work (CM)	Work (OWS)
(02:50	03:00)	-----------------------	USVMS #1* Log	USVMS #1* Log
06:00	06:10	USVMS #1*- Log	--------------------	--------------------------
06:10	06:15	BMMD	--------------------	BMMD
06:15	07:15	Eat - Drink - Log	Eat - Drink - Log	Eat - Drink - Log
07:15	07:25	----------------------	SMMD - Food Waste - Log	SMMD - Food Waste - Log
07:25	12:00	Work or Exp.	Work or Exp.	Work or Exp (Load WMS Dryer 15 mins)
(07:20	07:30)	----------------------	USVMS #2 - Log	USVMS #2 - Log
(11:50	12:00)	USVMS #2 - Log		
12:00	13:00	Eat - Drink - Log	Eat - Drink - Log	Eat - Drink - Log
13:00	21:00	Work	Sleep (OWS)	Sleep (CM)
(18:00	18:10)	USVMS #3 - Log	--------------------	------------------------
21:00	21:10	----------------------	USVMS #3 - Log	USVMS #3 - Log
(21:10	21:15)	----------------------	BMMD	------------------------
21:10	22:10	Eat - Drink - Log	Eat - Drink - Log	Eat - Drink - Log
22:10	22:20	USVMS #4 - Log	SMMD - Food Waste - Log	SMMD - Food Waste - log
22:20	06:00	Sleep	Work or Exp.	Work or Exp.
(22:20	22:25)	-----------------------	(Empty WMS Dryer)	------------------------
(22:25	22:35)		JSVMS #4 - Log	USVMS #4 - Log

* Defecation + Log (Assume one per day.)
USVMS: Urine Sampling and Volume Measurement System Operation
SMMD: Operation of Specimen Mass Measurement Device (One crewmember does total effort.)

M-052 - BONE AND MUSCLE CHANGES DURING PROLONGED SPACEFLIGHT

INFLIGHT TIME LINE TABLE - BASED ON TYPICAL CM DAY

24-Hour Clock		SP	CP	P
00:00		Sleep	Work	Work
02:50	03:00	--------------------	USVMS #1* Log	USVMS #1* Log
03:00	04:00	--------------------	Eat - Drink - Log	Eat - Drink - Log
04:00	04:05	--------------------	--------------------	SMMD of Waste Food - Log
04:05	06:00	--------------------	Work	Work
06:00	06:05	USVMS #1 Log	Work	Work
06:05	07:00	Eat - Drink - Log	Work	Work
07:00	07:10	--------------------	USVMS #2 - log	USVMS #2 - log
07:10	12:00	Work	Work	Work
12:00	12:10	USVMS #2 Log	USVMS #3 - log	USVMS #3 - log
12:10	13:10	Eat - Drink - Log	Eat - Drink - Log	Eat - Drink - Log
13:10	13:20	--------------------	--------------------	SMMD of Waste Food - log
13:20	21:00	Work	Sleep	Sleep
(16:00	16:10)	(USVMS #3*) - log	Sleep	Sleep
20:50	21:00	USVMS #4 - Log	USVMS #4 - Log	USVMS #4 - Log
21:00	22:00	Eat - Drink - Log	Eat - Drink - Log	Eat - Drink - Log
22:00	06:00	Sleep	Work	Work
(23:00	23:10)	--------------------	(SMMD of Waste Food)	--------------------

* Defecation + Log (Assume one per day.)
USVMS: Urine Sampling and Volume Measurement System Operation
SMMD: Operation of Specimen Mass Measurement Device (One crewmember does total effort.)

5. FLIGHT OPERATIONAL REQUIREMENTS:

Requirement limited to experiment representative monitoring progress and real time communication with MCC flight surgeon in event communications with crew is required.

7. DATA SUPPORT REQUIREMENTS - See Page 13.1

Describe the facilities for gathering pre-flight control data or indicate where this must be accomplished (e.g., a local hospital or other facility in close proximity to the launching site, within the facilities of the launching site, etc.). Present any special requirements for data handling including real time, or near real time, support, retrieval and forwarding of the data to a given data collection center.

The experimenter should indicate requirements for computer analysis, provide information on the operational parameters to be measured, such as attitude, rates, and fuel consumption, and include any special instructions on data processing or disposition and disposal of experimental equipment.

9. DISCUSS PREFLIGHT AND RECOVERY FACILITIES REQUIRED AND DATA HANDLING PROCEDURES

The astronaut kitchen facilities in the MSO Building at Cape Kennedy should be adequate to meet the SIVB needs, provided that the number of additional regular meals served to individuals not on study is not excessive. A metabolic dietitian and one assistant briefed in the special requirements for the astronauts will supervise the preparation of food for the pre- and postflight phases. One 14 cu. ft. refrigerator and one 14 cu. ft. freezer will be placed in the kitchen area for the storage of pre-weighed foods and other controlled composition foods.

A small laboratory or portion of an existent laboratory with approximately 112 square feet of floor space will be required for the storage and preservation of specimens for analysis. This area must be furnished with a 3X10 foot combination laboratory bench and sink. A refrigerator and two freezers having a total volume of 30 cu. ft. will be used for specimen storage. These facilities were under development for the M007 experiment in the MSO Building.

The kitchen, storage, and laboratory facilities of the primary recovery ship will be utilized during the postlanding data collection. No attempt will be made to outfit or staff ships in the contingency landing areas. Controlled diet food for the recovery ships will be pre-weighed and prepared at Cape Kennedy and served on shipboard by a nutritionist member of the study team. A small working area in the clinical laboratory aboard is required for the preserving of urine and feces for shipment. Both inflight and postlanding specimens will be flown to the analytical laboratory when the vessel reaches port.

The data derived from the experiment will be reduced and transferred to punch cards for computer analysis.

The statistical method to be applied to the data will be analysis of variance and/or co-variance.

(Attach additional sheets if necessary, identifying items by number.)

SECTION V - EXPERIMENT DEVELOPMENT APPROACH - See Page 15.1

This section should provide the guidelines and ground rules to be followed in preparing the reliability, qualification and test specifications to be followed during the development of the experiment hardware. Existing NASA directives, policies, and procedures, with any special instructions, shall be followed where applicable.

In formulating these guidelines, the reliability, qualification and test program should be consistent with the magnitude and complexity of the experiment and with the importance of the experiment to the primary mission objective. All experiment equipment, systems and subsystems must be designed, constructed and tested to standards adequate to prevent compromise of crew safety or vehicle performance and to ensure a high probability of successfully accomplishing the experiment in space. Close coordination is essential between the Payload Integration Center and the Experiment Development Center in preparing these guidelines to ensure that the requirements of the experiment, as well as the flight program, are adequately satisfied.

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1. RELIABILITY PROGRAM

   Identify the principal elements of the reliability program for the experiment.

---

2. APPLICABLE PUBLICATIONS

   Cite the applicable R&QA Publications which will be followed.

---

3. QUALIFICATION PROGRAM

   Specifically identify the qualification guidelines by which the experiment will be developed.

---

4. TEST PLANS

   Provide specific test plans for the development, acceptance and qualification of the experiment equipment.

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5. DOCUMENTATION

   Identify the documentation that will be required to validate the R&QA program.

SECTION V - EXPERIMENT DEVELOPMENT APPROACH

The experiment equipment and associated hardware will be controlled and measured against acceptable standards of workmanship and design to assure system operational integrity and minimum degradation of experiment objectives. Such standards and measurements will be verified by implementing in-process inspection techniques and Government monitoring of qualification tests, including certification histories, as required.

Preparation of the final R&QA Program will be closely coordinated with the payload integration center to insure adequate provisions for flight safety and experiment success.

An important phase of the qualification program will be manned tests designed to prove the physiological suitability of the devices.

See also Section II, Technical Information, Page 5, Item 4.

SECTION VI - INTEGRATION APPROACH

This section must present the plan for meeting the requirements of the preceding Sections II, III, and IV. Sufficient detail is necessary to define the complete integration requirements and to assess the experiment/spacecraft compatibility. The information shall include, but not necessarily be limited to, data pertinent to the following areas:

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1. EXPERIMENT LOCATION - See Page 17.1

   Selection of the experiment locations for storage and operation during the various phases of the mission, such as launch, orbit, and reentry, shall be described.

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2. INSTALLATION AND STRUCTURAL MODIFICATIONS - See Page 17.1

   Identify the spacecraft modifications, including structural, plumbing and wiring, necessary to accommodate the experiment.

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3. SPACECRAFT SUBSYSTEMS - See Page 17.1

   Determine the modifications needed to supply the experiment with the storage and operational requirements, such as power, environmental control, data measurement and recording or transmission facilities. Provisions for spacecraft guidance and navigational requirements shall also be included.

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4. EXPERIMENT OPERATION - See Page 17.1

   Describe the provisions for operating the experiment, such as control panels, displays, linkages for experiment control, etc.

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5. EXPERIMENT CONSTRAINTS - See Page 17.1

   Describe the means for accommodating the experiment constraints required by Section III.

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6. PRE AND POST LAUNCH SUPPORT - See Page 17.1

   Discuss the provisions for providing pre- and post-launch items, such as facilities, test equipment, services, etc.

SECTION VI - INTEGRATION APPROACH (Cont'd)

7. ASTRONAUT TRAINING EQUIPMENT - See Page 17.1

Describe the plan for providing identified astronaut training equipment, such as simulations, training units, and special equipment.

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8. SPECIAL SERVICES - See Page 17.1

This part should describe the provisions for communication network support, recovery requirements, special data handling, etc.

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9. ASTRONAUT PERFORMANCE - See Page 18.1

Assess the astronaut capability to perform the experiment.

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10. REAL TIME FLIGHT OPERATIONAL SUPPORT - See Page 18.1

Describe the plan for providing the real operational support required by the experiment including the following areas:

a. Telemetry data.

b. Command data uplink.

c. Voice data, both to the crew and ground controllers.

d. Any other special requirements identified to conduct the experiment.

SECTION VI- INTEGRATION APPROACH.-

1. EXPERIMENT LOCATION:

Information at this time is limited to that presented in Section III, Item 1.

II. INSTALLATION AND STRUCTURAL MODIFICATIONS:

This cannot be defined at this time.

III. SPACECRAFT SUBSYSTEMS:

Information at this time is limited to that presented in Section III, Items 3, 4, and 5.

IV. EXPERIMENT OPERATION:

Information concerning operating procedures for all required hardware is unknown pending design information from contractors yet to be selected.

V. EXPERIMENT CONSTRAINTS:

This information cannot be provided until sufficient data concerning the Orbital Workshop can be provided by Marshall Space Flight Center.

VI. PRE- AND POST LAUNCH SUPPORT:

Information at this time is limited to that presented in Section IV, Item 7.

VII. ASTRONAUT TRAINING EQUIPMENT:

Experimental equipment needed for astronaut training should be provided by the equipment contractors.

VIII. SPECIAL SERVICES:

Information at this time is limited to that presented in Section IV, Items 5 and 7.

IX. ASTRONAUT PERFORMANCE:

No problems are envisioned.

X. REAL TIME FLIGHT OPERATIONAL SUPPORT:

Information at this time is limited to that presented in Section IV, Item 5.

SECTION VII - PROGRAMMATIC INFORMATION

1. MANAGEMENT ARRANGEMENTS

This section should designate the elements at the Payload Integration Center (PIC) and the Experiment Development Center (EDC) responsible for the development and implementation of the experiment. Further, it should identify the relationship between the PIC, EDC, the principal investigator and all other organizations including contractors involved in implementation of the experiment. A diagram detailing this management structure should be included. Specific areas to be covered include:

a. Assignment of experiment management responsibility in terms of its systems, subsystems and flight objectives.

b. A description of the management organization for the experiment. Clearly indicate the individuals to be assigned responsibility for management, and identify their lines of authority and responsibility and any specific authority limitations.

c. A description of the responsibilities and relationships to NASA of any external organizations involved in the experiment.

d. A description of any permanent advisory bodies, such as standing committees and evaluation groups.

e. An assessment of possible international requirements of the experiment or opportunities for international cooperation, stating whether or not existing overseas facilities are likely to be used or additional facilities needed. Describe support of any kind by foreign organizations or governments which will be advantageous.

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2. MANAGEMENT REPORTING

Provide a description of the procedures to be used in reporting status of the experiment implementation. Identify the principal reports to be prepared and describe their nature, frequency and distribution. Include reports used at the installation level to manage program effort between all Centers and organizations including contractors.

SECTION VII - PROGRAMMATIC INFORMATION (Cont'd)

3. PROCUREMENT ARRANGEMENT

This section will summarize necessary procurement plan arrangements and procurement activity as follows:

a. List each planned contract or subcontract effort for each phase of the experiment.

EXPERIMENT PHASE	AGENCY PERFORMING WORK	TYPE	CENTER MONITORS & TECHNICAL ADMN.

b. List the planned schedule for each procurement activity.

EXPERIMENT PHASE	WORK STATEMENT COMPLETE	RFP RELEASE	AWARD CONTRACT	SUBCONTRACT REVIEW COMPLETE

c. Provide the following information relative to experiment hardware contract activity.

(1) Role of the Principal Investigator (PI) as prime contractor or technical consultant.
(2) Capability of the PI's institution to manage the work involved.
(3) Willingness of the PI to entertain competitive procurement in his hardware development efforts.
(4) Provisions for providing requirements of hardware commonality between previously qualified flight hardware and that which is now proposed.
(5) Provisions for providing the interface requirements of the proposed experiment hardware and other experiments contained in the common payload package (if applicable).

SECTION VII PROGRAMMATIC INFORMATION (Cont'd)

4. SCHEDULE AND RESOURCE REQUIREMENTS -- DEVELOPMENT SCHEDULE

Major Milestones	PLANNED DEVELOPMENT SCHEDULE											
SPACECRAFT MODULE SUMMARY	FY ______				FY ______				FY ______			
	QUARTERS				QUARTERS				QUARTERS			
	1	2	3	4	1	2	3	4	1	2	3	4
Experiment Approval (MSFEB)												
CCA Issued												
PI Contract Let												
Hardware Contract Let												
Integration Specification Issued												
ICD Complete												
DEP Complete												
Mockup Delivered												
Prototype Delivered												
Crew Training Unit Delivered												
Quality Testing Completed												
Flight Units Fabrication & Delivery												
Acceptance Test Complete												
Ground Support Equipment Delivered												
Installation & Checkout												
Shipped to Launch Site												
Flight Analysis Complete												
Final Report												

5. FUNDING REQUIREMENTS

Provide the funding requirements of the experiment by quarter as indicated on the following page (Quarterly Funding Requirements). The total funds necessary for completion of the experiment will be estimated, both for in-house and contract effort. The funding should be broken into the areas indicated on the sheet and should identify the source of funding for each area. The amount of detail and the selection of elements of work breakdown and cost categories to be used will depend upon the complexity and particular nature of the experiment; however, the general objectives of the fund estimate presentation should be to facilitate validation of the completeness and reasonableness of the fund estimate, as well as to provide a historical point of departure for meaningful revision of fund estimates as experiment assumptions and/or pricing factors change.

SECTION VII - PROGRAMMATIC INFORMATION (Cont'd)
Quarterly Funding Requirements (Dollars in Thousands)

ITEMS	FUNDING SOURCE	FY ____				FY ____				FY ____				FY ____				TOTALS
		QUARTERS				QUARTERS				QUARTERS				QUARTERS				
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
DESIGN																		
Exp. Hardware																		
Training Equip.																		
Checkout Equip.																		
SUPPORT EQUIPMENT																		
Mock-up																		
Engineering Test units																		
Fabrication																		
Assembly																		
Test																		
Prototype																		
Fabrication																		
Assembly																		
Test																		
Training Units																		
Fabrication																		
Assembly																		
Test																		
Checkout Equipment																		
Fabrication																		
Assembly																		
Test																		
FLIGHT EQUIPMENT																		
Flight Unit																		
Fabrication																		
Assembly																		
Testing																		

SECTION VII PROGRAMMATIC INFORMATION (Cont'd)
Quarterly Funding Requirements (Dollars in Thousands) (Cont'd)

ITEMS	FUNDING SOURCE	FY ____				FY ____				FY ____				FY ____				TOTALS
		QUARTERS				QUARTERS				QUARTERS				QUARTERS				
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Spares																		
Fabrication																		
Assembly																		
Testing																		
SUPPORT STUDIES																		
SUPPORT FACILITIES AND SERVICES																		
TRAVEL																		
VEHICLE INTEGRATION																		
Vehicle Modif																		
Installation																		
Checkout																		
DOCUMENTATION																		
Major Documentation																		
Def. Exp. Plan																		
Rel. Predictions																		
Qual. Test Rept.																		
Failure Analysis																		
etc.																		
Periodic Reports																		
Briefings & Reviews																		

SECTION VII PROGRAMMATIC INFORMATION (Cont'd)
Quarterly Funding Requirements (Dollars in Thousands) (Cont'd)

ITEMS	FUNDING SOURCE	FY ____				FY ____				FY ____				FY ____				TOTALS
		QUARTERS				QUARTERS				QUARTERS				QUARTERS				
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
PUBLICATION Data Reduction Analysis Reporting																		
YEARLY TOTALS																		
GRAND TOTAL																		

6. MANPOWER - See Page 29.1

a. In-house manpower estimates are to be shown for each center and/or installation, and categorized insofar as possible by systems and subsystems, and by fiscal year for the life of the experiment. The experiment totals should be resummarized to reflect for each system (and by fiscal year) the manpower effort required within each center and/or installation in its conduct of:

(1) Research and development, and

(2) Experiment and system management, including contractor monitoring.

b. The contract manpower estimates are to be shown in a similar manner to the in-house estimates.

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7. FACILITIES - See Page 29.1

All major facilities and lab equipment (including those of contractors and other Government agencies) essential to the experiment in terms of its systems and subsystems, are to be indicated, distinguished insofar as possible between those already in existence and those that will be developed in order to execute the experiment. The outline of existing facilities should indicate their scheduled availability. The outline of new facilities should indicate the lead time involved and the planned schedule for construction, modification, and/or acquisition of the facilities.

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8. EXPERIMENT RESULTS - See Page 29.1

a. Specify the channels and facilities to be used for retrieving raw data, processing them into usable records, and transmitting them to the experimenter and other appropriate users.

b. List the technical reports required for

(1) "Quick Look" records

(2) Data reports

(3) Preliminary analysis

(4) Technical notes/memoranda (NASA and contractor)

c. Indicate the planned schedule for release of the above technical information to

(1) Headquarters sponsoring program offices

(2) The news media

(3) The scientific and technical community

See Page 29.1

SECTION VII - PROGRAMMATIC INFORMATION (Continued).-

6. MANPOWER:

a. Inhouse (Man Months)

	FY67	FY68	FY69	TOTAL
R&D (NASA/MSC)	6	12	6	24
Experiment Management	3	6	12	21
b. Contract (Man Months)	0	36	48	84

7. FACILITIES: (See Page 13.1)

Baseline data will be obtained at NASA/MSC and NASA/KSC; and by contract. These studies will provide applied criteria and will implement the pre- and postflight phases of the experiment.

Mockup and training equipment will be needed for astronaut training.

8. EXPERIMENT RESULTS:

a. Data Handling - Experiment data logs are to be handcarried to the Biomedical Research Office, MSC, after retrieval from spacecraft. Analytical data will be provided to BRO/MSC as soon as available on pre-, inflight and postflight specimens.

b. Technical Reports - One quick look report to be made by principal investigator within one month of flight termination.

Preliminary analyses to be made by the participating investigator.

Copies of preliminary and final reports to be distributed to MSC, Headquarters sponsoring office, and MSFC.

c. Public Information - As applicable.

Presentation at Apollo Application Experiment Conferences as required.