PHYSIOLOGICAL EFFECTS OF MAGNETIC FIELDS

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1. Introduction
   a. Motivation for research
   b. Definition of "high" and "low" intensity fields
2. Effects of Low Intensity Fields
   a. Animal exposures
   b. Human exposures
   c. Some proposed mechanisms
3. Effects of High Intensity Fields
   a. Animal exposures
   b. Human exposures
   c. Some proposed mechanisms
4. Conclusions

   Research needs in
   1) possible zero-g and magnetic field synergism
   2) determination of true mechanism of magnetic field effects
   3) long-term primate exposures for more dependable interpolation to expected human reactions

Human sensitivity to mag field .1-.3 mOe c 2-3 sec Rocard ('64) - Bad [illegible]
[illegible] inhibition of muscle contraction. [illegible]

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NON-IONIZING RADIATION

PHYSIOLOGICAL EFFECTS OF ~~LIGHT ENERGIES~~

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I. Introduction

Figure 1 presents the electromagnetic spectrum, including the portion that can cause ionization. All such emanations have certain characteristics and relations that are similar: they are a means by which energy is transmitted; they travel in straight lines and at the speed of light; they can be bent or focused; and they have the relation that a given frequency times the wavelength for that frequency is equal to the speed of light.

The wavelength of a given emanation determines its specific characteristics and, therefore, whether it will be classified as an x-ray, ultraviolet, infrared or microwave.

A further characteristic of electromagnetic radiation is that the energy delivered is directly proportional to the frequency. The energy comes in small units or quanta and is often measured in electron volts. One MeV (1,000,000 electron volts) is equivalent to the energy required to lift 1 milligram $1/10^6$ centimeters or 0.01 micron (about the height of a red blood cell lying flat). The thermal energy or motion of molecules at room temperature is about 1/30 eV. About 34 eV are required to produce an ion pair. This energy level is reached in the short-wave-length ultraviolet range and with long-wave-length or "soft" x-rays. All forms of electromagnetic radiation with wavelengths longer than the shortwave ultraviolet cannot produce ionization. On the other hand, lower energy levels in the range of 10-15 eV are sufficient to produce chemical reactions such as photosynthesis.

U-V – primary source sun – also arc lamps, electric arcs etc. + reflected sources
– effects – Table I (go I 1-2 ev)

SNOW BLINDNESS

INSIDIOUSNESS OF UV

SKIN CA + Skin Aging

Cumulative Effects? – Yes ī CA + Aging

U-V are really very soft X-rays

Intensity does not influence penetrability!

Energy does [i.e. shorter wave lengths (energy) penetrate more].

VISIBLE

II. Ultraviolet Radiation

The major natural source of ultraviolet radiation is the sun which emits U.V. in the range of 1,400 to 3,900 Å. Man-made sources include electric arcs used for lights, welding arcs, plasma jets or arcs, germicidal lamps and special lamps used to simulate solar radiation.

The amount of ultraviolet reaching the earth's surface from the sun depends on a number of factors. The position of the sun in the sky is one of these, and therefore, the amount received at a given site will vary with latitude, season of year and time of day. The elevation above sea level is also important. At higher elevations there is more U.V. Air pollution or clouds (water vapor) can reduce the amount that reaches the earth's surface.

Ultraviolet radiation is readily shielded. This weak penetrating ability limits the usefulness of U.V. as a bactericidal or vericidal material, and also allows the human body to protect itself from ultraviolet radiation by increasing the thickness of the stratum corneum--this, with tanning, offers considerable protection from U.V.

Some selected biologic effects of U.V. are presented in Table 1. It should be emphasized that the U.V. from sunlight or from artificial sources is not entirely safe. As with ionizing radiation, biologic manifestations do not appear until sometime after exposure. If the exposure is sufficiently great, there may be marked systemic effects such as fever, nausea and malaise. Apparently the aging effect of the skin bears a high correlation to the accumulated exposure to ultraviolet. In the areas with greatest exposure, premalignant or malignant changes are also most likely to develop.

Visible light – Narrow band

– Effects are direct or indirect

indirect – too little lighting →

– glare → ACCIDENTS

– reflection →

direct – eclipse of sun

→ Retinal burn & blindness or permanent [illegible]

– LASERS or MASERS

– extreme intensities → holes in retina or [illegible]

– don't feel it until after damage done.

– kind of death ray

III. Visible Light

This covers the relatively narrow band of 4000 to 8000 Å that is perceived by the human eye. The hazards of this type of radiation may be divided into direct and indirect. The former result from the radiation itself, such as retinal burns due to looking at the sun during an eclipse with inadequate filtration; the latter from personal injury caused by accidents produced by inadequate quality of illumination due to glare, high contrast or too low levels of lighting.

The retinal burn due to direct penetration and focusing of intense levels of light can produce atrophy of an area of the retina. Since in viewing eclipses or other potentially intense light sources the viewer uses the macula, the injury will be produced in the part of the retina that has the greatest concentration of cones and is used for fine and precise vision. Considerable disability can therefore occur.

Within the range of visible light are the recently developed devices called optical masers or lasers. Such units emit beams of light with remarkable properties. Because of their spatial coherence, laser beams have extremely small divergence or are highly collimated. They are therefore highly directional and can be focused to a spot whose diameter is close to one wavelength of the emitted light. As a result, enormous power densities are possible.

The hazard from laser beams results when a part of the body is placed in the beam. The high-power densities can quickly produce a burn, with destruction of tissue, before any sensation of burning more Δ effect ... absorbed

I-R – Short + long

→ Heating
– penetrates skin → Burns or Thermal Stress
– → cataracts – Lens can't lose heat ← lack of vascularity
– can shield c̄ shiny reflective shields
  – spot cooling to compensate
  – special glasses dark glasses c̄ metallic oxides ...
  – then for both UV + IR
  – education
– can sense it before it gets too bad – usually

Result of Long Term low Dose ? ?
Unknown.

is felt. The devices must be well shielded to prevent scattered radiation, and there should be no reflecting surfaces on which the beam could impinge and then be redirected. Burns have been produced at distances of up to one half mile from a source.

IV. Infrared

Infrared radiations have longer wavelengths than the visible range and are the radiations we "feel" when one holds his hands up to a fire or a hot stove. Their range is from 8000 to 1,000,000 Å. The range of 8,000 to 14,000 Å is referred to as short infrared, and the others as long infrared radiations. The wavelength emitted depends upon the temperature of the body. All objects radiate infrared radiations to other objects with a lower surface temperature.

The sensation of heat is quickly detected and can therefore give adequate warning that extreme conditions may exist. The radiation does not penetrate deeply into tissues. Heating of the body takes place as a result of heat absorption in the surface layers of the skin. Dilation of the capillary bed of the skin occurs, and the heat in the skin is removed by the blood or evaporation of moisture.

The fundamental action of infrared is heating. Sufficient heating can take place to cause burns of the skin, cataracts in the lens of the eyes or retinal burns. The iris in the eye appears to absorb the radiation and increase the heating effect of the lens. The lens is particularly sensitive because it has a poor heat-dissipating mechanism.

V. Microwaves

Microwaves encompass a wide range of wavelengths, from 0.01 to 3,000 centimeters. These wavelengths are used in radar, television, Microwaves – Wide range

Effects – [illegible] or Instantaneous

→ Heating Effect – [illegible]

– Radar & Oven ranges [illegible]

– [illegible] Reported → [illegible] Reported

– prob. due [illegible] – Reversible.

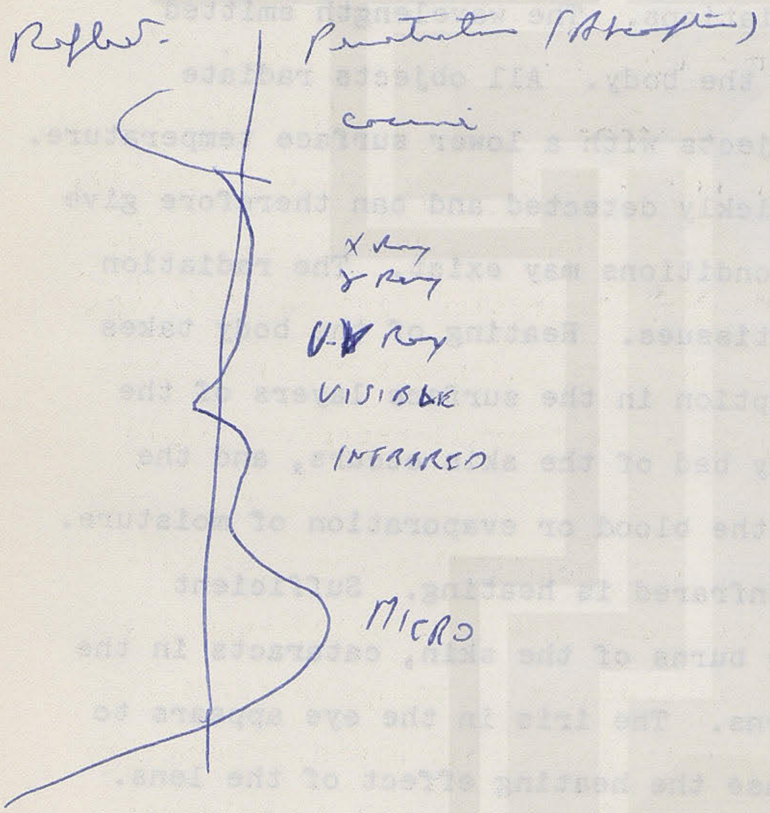
– Headache? Other Sx? – [illegible]

– Pregnancy had ↑ incidence of Mongolism [illegible] RADAR

[illegible] – Observation only

[illegible] for age of mothers.

– Heat is PROBLEM – [illegible] chief problem.



shortwave radio transmitters and diathermy. They are also used to fire photoflash bulbs remotely and can ignite dry steel wool. The energy levels are well below those needed to cause ionization. The effects of microwaves appear to be more complex than simply a heating effect, although most of the changes can be attributed to this phenomenon.

The effects of microwaves on the human body vary with the wavelength (or the frequency). At the lower frequencies (longer wavelengths), the body is transparent to the radiation. As the frequency increases, the body absorbs more and more power until a maximum is reached at about 300 megacycles per second. This is in the ultrahigh-frequency (UHF) television range. With further increase in frequency, less and less power is absorbed, and finally, at 10^4 megacycles per second, the skin acts as a reflector. Penetration at the point of maximum energy absorption (100 to 1000 megacycles per second) is potentially the most hazardous because there is little or no heating of the skin where thermal receptors would be stimulated.

The eye and the testes appear to be potentially the most vulnerable parts of the body. The eye, with its poor blood supply , particularly around the lens, is susceptible to cataract formation in the microwave range that can penetrate to that depth. Temporary sterility can be induced from the heating effect. It is unlikely, however, that it would be more than temporary. For these effects to occur, a man would have to be directly in the beam and close to the source. Persons most likely to be exposed would be workers on or in the vicinity of the transmitting wave guides. Table 2 contains a summary of the effects of microwave radiation on man.

SAFE LEVELS

UV - described - wave length

CA - Albino mice - 2,950 - 3300 Å range

6.3 - 8.4 x 10^8 ergs/cm^2

(15-20 small cells)

IR - No levels

Individual backs off

MICRO -

10 milliwatts/cm^2 - max./working day

20-30 milliwatts/cm^2 gen accepted but

some more sensitive > others.

∴ settled on 10

24 hours - 1 milliwatt/cm^2

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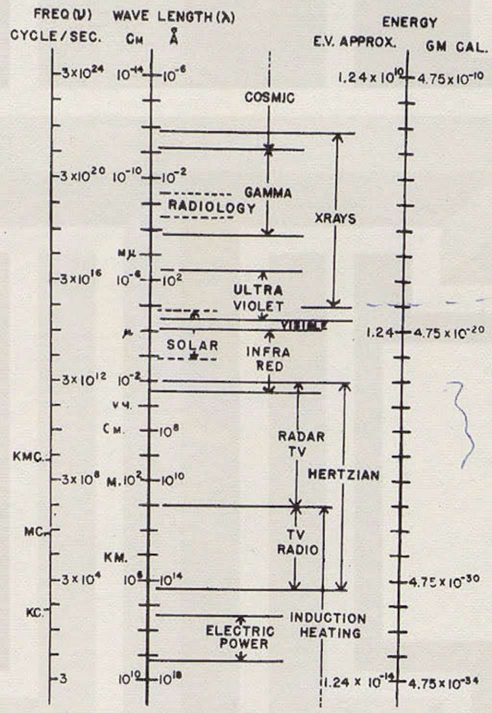

FIGURE 1. *The Electromagnetic Spectrum.*

TABLE 1. *Summary of Some Biologic Effects of Ultraviolet Radiation.*

EFFECT	RADIATION
Ionization	100 Å range – overlays with "soft" x-ray
Germicidal	2600 Å maximum – effect falls rapidly at shorter or longer wavelengths; effective range associated with absorption band of nucleoproteins
Carcinogenic	2000-4000 Å – maximum effect 2900-3200 Å
Ozone production	In germicidal range
Photosensitization	Wavelength at which this occurs varies with absorption characteristic of chemical compounds involved
Pigmentation	2800-3200 stimulates formation of melanin – little tanning; 3000-6500 Å, maximum 3600-5000 Å oxidizes preformed melanin – tanning
Thickening of stratum corneum	In solar range 3000-4000 Å
Degeneration of collagen	Parallels cumulated exposure in solar range 3000-4000 Å
Keratoconjunctivitis	Greater effect at shorter wavelengths – 0.15 x 10^6 ergs at 2880 Å will produce effect
Antirachitic	Ergosterol to vitamin D; 1 international unit of vitamin D formed from ergosterol when 900 ergs 2490 to 3130 Å absorbed
Erythema	2967 Å 25,000 μ W, sec/cm.^{2} minimal amount of power to produce erythema at this wavelength, which is wavelength of maximum sensitivity; erythema can be produced by shorter or longer wavelengths (within a limited range) but more power is necessary; with extremely short wavelength U.V. there is overlap with soft x-rays, & skin erythema results from effects of ionization.

Short wave length

Blocked by ozone of dust.

↑ Skin sensitivity to UV

Thiazine

(Chlorpromazine)

Thalomine

Oral Antidiabetics

Strawberry Rot

Factors

Pigment in Skin

Proteins – Porphyrin, etc

TABLE 2. *Summary of Effects of Microwaves on Human Beings.*

FREQUENCY *megacycles/sec.*	WAVELENGTH *cm.*	BAND* OR SOURCE	SITE OF ACTION	EFFECTS
>10,000	<3	ku k ka	Skin	Skin reflects or absorbs only in superficial layers; no effect or minimal.
10,000-1000	1-30	X C S (radar)	Skin	
		L	Lens of eye	Cataracts
1,200-150	25-200	UHF–VHF (radio & television); shortwave diathermy.	Internal organs	Damage, internally, due to overheating & interface phenomena
<150	>200	Industrial dielectric heating equipment		Body transparent No effects

Threshold limits:
- 10 m watts/cm.² — Potentially hazardous
- 1-10 m watts/cm.² — Safe for occasional exposure
- <1 m watt/cm.² — Safe for indefinitely prolonged exposure

*Letters refer to generally accepted symbols for the various wavelengths.

UTILIZATION OF ELECTROMAGNETIC ENERGIES

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INTRODUCTION

Establishing the rationale for nonencumbering measurements in the role of electro-magnetic energy.

Since the potential applications to specific measurements are greater in scope than time allows for this presentation, the remainder of thetalk will concentrate on specific applications of biotelemetry, oculometry, oximetry, and aerosol measurements. Extensions of these techniques will be considered.

Biotelemetry offers the capability of eliminating the normal tether to provide enhanced subject freedom during monitoring. A multi-channel biotelemetry system using FM/PAM modulation techniques is described. This biotelemeter offers the advantage of processing and transmitting a wide variety of biosignals with minimum increase in power consumption over single channel telemeters.

An electro-optical device capable of measuring eye position, eye pointing direction, pupil size, and blink occurrence will be described. Basically, the instrument remotely measures the centroid of the pupil and the corneal highlight. Based upon the geometry of the eye, eye pointing data is derived. This measurement instrument is basically an active multiplexed tracking system and its method of operation is described.

A two-color oximeter for measuring blood oxygenation in the vasculature of the retina and the theory of operation is described.

The applicability of electro-optical devices to remote physiological sensing is summarized. In the environmental measurement area, electro-optics can plan a major role in monitoring of the atmosphere. Instruments using infrared and ultraviolet radiation can be developed to measure major and trace gases. In addition, particulates in the atmosphere are being measured using optical techniques. The theory and operation of an aerosol particle analyzer is described.

PRINCIPLES OF BIODYNAMICS

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A. DEFINITIONS

1. Biodynamics:

Knowledge of the effects of mechanical force on living tissues; in particular, the physiological and anatomical changes in a living body or in any of its parts resulting from exposure to mechanical stress.

2. Biodynamic Factors of Mechanical Stress:

Force:
- a. Magnitude
- b. Area of distribution
- c. Orientation
- d. Duration
- e. Rise time
- f. Dwell
- g. Decay
- h. Dynamic load factor
- i. Relative displacement of anatomical structures
- j. Tension, compression, torsion and shear force components
- k. Frequency characteristics

3. Biodynamic Response Factors:

a. Acute, immediately reversible anatomical and physiological effects, not injurious.

b. Acute, persistent anatomical and physiological effects with signs and symptoms of injury, including:

(1) Pain, anxiety, neurocirculatory shock, concussion; correlated with changes in vital signs and physiological reactions;

(2) Abrasions, contusions, petechiae, ecchymoses, hematomas, tears and ruptures of skin, membranes, hollow viscera and solid organs;

(3) Strains, sprains or dislocations of joints;

(4) Fractures of bones and cartilages;

(5) Other similar reversible effects.

c. Chronic, irreversible anatomical and physiological effects related to disabling injuries, including:

(1) Survived permanent impairment of function in an organ or structure of the body.

(2) Amputation, avulsion, scarring or other irreversible anatomical damage.

d. Fatal injury from immediate or delayed effects of irreversible impairment of function or anatomical damage, including:

(1) Hemmorhage
(2) Hypoxia, strangulation
(3) Circulatory obstruction
(4) Destruction of vital nerve centers (cardiac, respiratory)
(5) Combined effects of multiple injuries
(6) Cardio-vascular shock
(7) Decapitation or evisceration

B. RESEARCH IN BIODYNAMICS

1. Accident and Injury Analysis:

   a. Falls
   b. Vehicular and aircraft crashes
   c. Sports and combat injuries (football, boxing, skiing, parachuting, hand-to-hand combat)

2. Experimental Methods:

   a. Exposure of instrumented subjects to simulated:

      (1) Aircraft crash
      (2) Motor vehicle crash
      (3) Subsonic and supersonic seat ejection
      (4) Space cabin landing impacts
      (5) Localized impact such as hammer blows to head, chest or abdomen

   b. Exposure of instrumented subjects to real time:

      (1) Parachute opening shock
      (2) Seat and capsule ejection
      (3) Space cabin launch, re-entry and landing

   Subjects for experiments include human volunteers, anesthetized primates, bears, swine, dogs, guinea pigs, and anthropometric dummies, and cadavers.

   c. Mathematical models for computer crash simulation.

   d. Real time and simulation testing of impact and crash protection devices.

3. Results:

   a. Tabulated and graphic data from accident and injury analysis.

   b. Tabulated and graphic data from experimental investigations.

   c. Correlations of mechanical force factors and their anatomical and physiological effects.

   d. Modification of mechanical force effects by protective measures.

   e. Limiting factors of mechanical force exposure with and without protective measures.

   f. Application of results to human protection from exposures to mechanical force.

C. DISCUSSION OF PRINCIPLES

1. Interaction of mechanical force variable factors relative to physiological and anatomical reactions.
2. Incremental sequence of tissue and organ vulnerabilities to mechanical force effects.
3. Resonant response to single impact pulse of varying rise time, magnitude and duration measured in living subjects.
4. Propriotonic muscle tension restraint modulation of live subject response to mechanical force; impact anticipation reflexes.
5. Isovolumetric containment protection from impact force.
6. Problem areas for future research.

GENERAL BIODYNAMICS, NOISE AND VIBRATION

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In monkeys — after 60 days immobilization & WTL — Breaking Strength of Bones & Shearing Resistance of Tendons from Bone ↓ 50% !!

The word biodynamics has evolved as the unifying term describing the dynamic mechanical properties of living systems and the effects of various force environments on these systems. The breakdown of the force environments into sustained acceleration, hypodynamics, impact, vibration, acoustics, blast, etc., has its justification more in historical reasons, simulation techniques and practical requirements than in a basic systematic approach to the mechanisms involved. Considerable work on the mechanical properties of bone and soft tissue and on the dynamic response of the human body structure has led to mathematical models applicable to the whole biodynamics field, which have their practical application for explaining physiological, pathological and behavioral findings, for predicting the body's response to force environments not yet experienced and for protection engineering. The observation of these modeling and dimensional scaling laws is particularly important in interpreting and extrapolating animal data with respect to their meaning regarding the effect of the same force environment on humans.

Airborne noise and structure-borne vibration are the more or less periodic higher frequency components of the total mechanical force and pressure environments encountered in space vehicle operations while sustained acceleration, static pressure changes, impact and blast make up the static and transient components. There are three sources of airborne noise: (1) noise from the propulsion system, increasing in intensity with the

Below 80 db no problem. Above 80 db → change of normal pattern of hearing. EEG — marked changes thrust of the engine and containing increasing amounts of low frequency energy as the diameter of the rocket exhaust is larger; (2) boundary layer noise, increasing with dynamic pressure (q); and (3) noise from equipment carried inside the vehicle. This latter noise is the only source to be considered while the spacecraft is outside the atmosphere. Structure transmitted vibrations are caused by unstable forces for the engines or irregular aerodynamic forces acting on the vehicle (buffeting).

The estimated or measured noise and vibration environments are compared to human safety and performance criteria to determine if the required crew performance can be assured. If the environmental stresses appear too high, one or a combination of the following measures is taken to provide the degree of crew protection required: reduction of the noise or vibration energy at the source, isolation of the subject from the environment and additional personal protective equipment. Laboratory simulators are available to produce the operational noise spectra (electro-dynamic speaker systems, sirens) and vibration spectra (one- or several-degree-of-freedom shake tables) required for realistic human factors testing and biological research work.

Noise (20 to 20,000 cps) affects man primarily through the organ of hearing. (Table 1) At extremely high noise intensities instantaneous injury to the middle and inner ear can occur. At lower intensities long-time noise exposure can result in temporary, or finally in permanent hearing loss. This reduction in hearing acuity is caused by damage to some of the receptor nerve cells in the inner ear. Even at relatively low intensities noise can interfere with the speech communication vital to performance. It also can be the source of annoyance. Quantitative criteria for these various effects are available and being used in system design. Protective equipment is available when necessary. Non-auditory effects of noise involve other organs than the auditory system but are important usually only at extremely high intensities. All effects of noise depend not only on the intensity but also on the frequency spectrum of the noise; noise control measures also are strongly frequency dependent.

Vibrations in the frequency range below 100 cps are those most troublesome for man. (Table 2) Unfortunately, this is also the range where vibration control by isolation is most space- and weight-consuming. The effects on man of vibrations in this region are strongly frequency dependent; mechanical resonances of various body parts and organs can occur at certain frequencies and amplify the effectiveness of the input energy with respect to the particular body region. There is, for example, a resonance of the thorax and abdominal viscera in the 3 - 6 cps range and a resonance of the head compared to the shoulders around 30 cps (for the sitting subject). The first resonance can lead to pain symptoms at relatively low vibration acceleration levels, thus limiting physiological tolerance of the subject. The head resonance can result in blurred vision and decreased performance capability on exposure to relatively low levels in this frequency range. These are simplified examples to demonstrate how the body's dynamic response influences critically the physiological and performance tolerance limits. Human tolerance and performance limits depend in detail on the direction of application of the vibration, the body position and support, the exposure time, and many other factors. Only approximate criteria are available in this area and additional research to clarify the various mechanisms of biological action is required.

Sonic Boom → No Physiologic Damage until 925 to 720 lb/ft² no — which is huge (eardrum rupture) 2160 # Lung Damage all far beyond range.

In actual flight, noise and vibrations are experienced in combination with other environmental stress factors, a fact requiring conservative application of the available criteria which have to date been derived from results of only one stressor at a time.

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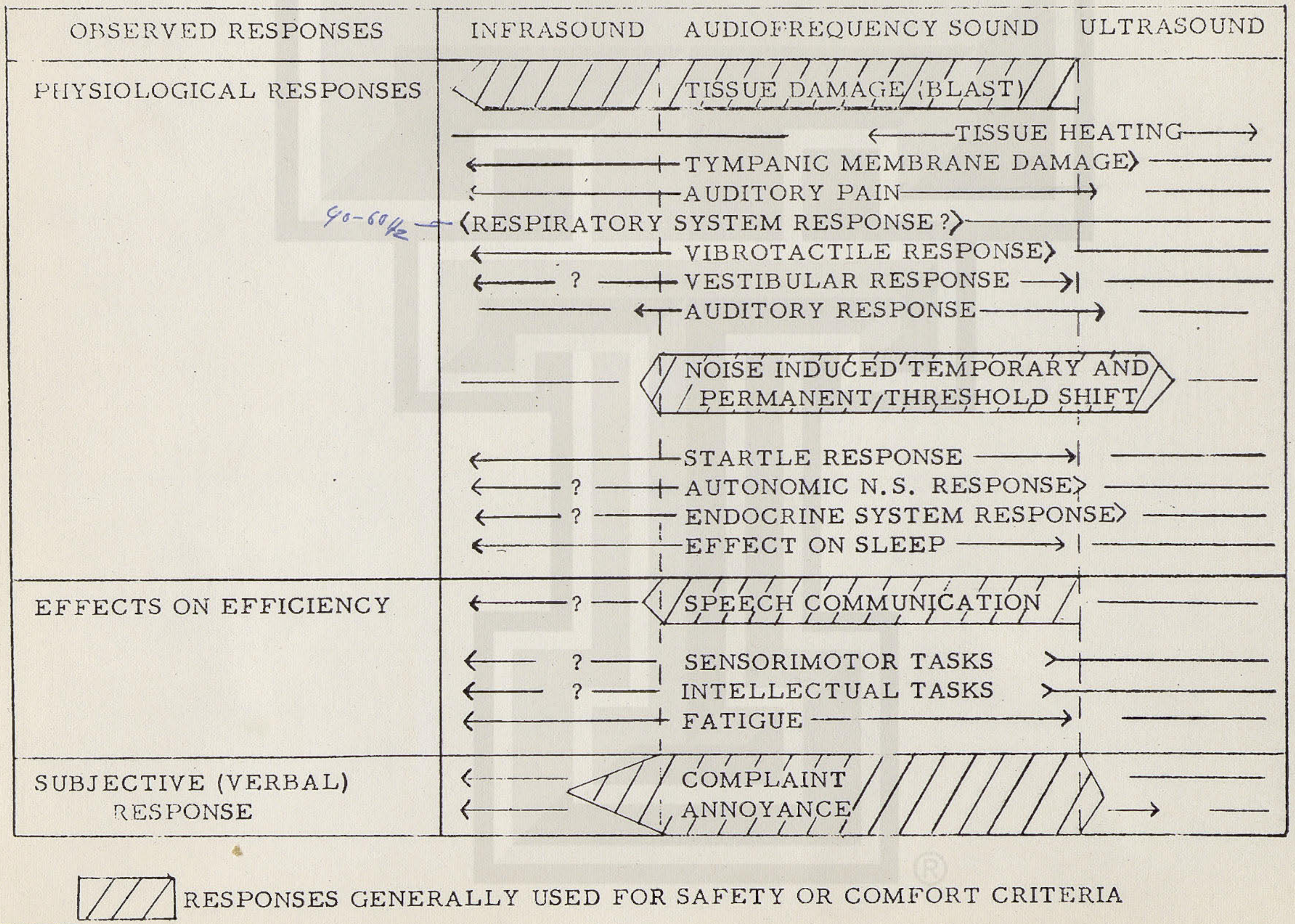
Smaller animals much more sensitive to blast than man. Converse is true of vibration.

TABLE I

HUMAN REACTIONS TO AIRBORNE NOISE AND IMPULSES



RESPONSES GENERALLY USED FOR SAFETY OR COMFORT CRITERIA

TABLE II

HUMAN REACTIONS TO VIBRATIONS

OBSERVED RESPONSES	VIBRATIONS: 1 cps — 100 cps — 1000 cps
PHYSIOLOGICAL RESPONSES	←TISSUE DAMAGE→
	PAIN
	←HEATING→
	←REFLEX DISORDERS→
	CARDIOVASCULAR, ←RESPIRATORY→, ENDOCRINIC } RESPONSES
	⟨VESTIBULAR RESPONSES⟩
	←VIBRO-TACTILE SENSATIONS→
EFFECTS ON EFFICIENCY	⟨SENSORIMOTOR TASKS, SPEECH COMMUNICATION, VISUAL ACUITY⟩
SUBJECTIVE (VERBAL) RESPONSES	←FATIGUE - - - - →
	←COMPLAINT→
	ANNOYANCE

[////] RESPONSES USED BY SOME FOR TENTATIVE SAFETY AND COMFORT CRITERIA

PHYSIOLOGIC FACTORS IN ATMOSPHERE SELECTION

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The selection of atmospheres for manned space vehicles involves several areas, including physiology, engineering, and mission planning. Obviously, from a physiologic point of view, an atmosphere has to be capable of sustaining life, should produce no irreversible physiologic effects, and must support crew performance. These characteristics are, of course, important in any system and are not unique to manned spacecraft. There are, however, other factors that must be taken into consideration in discussing physiologic factors that influence atmosphere selection, with the most notable of these being the demands that the mission *per se* places upon the choice of a spacecraft environment. It is within this context, i.e., the relation of physiologic factors to mission demands, that this presentation primarily will be directed.

The most critical demand the mission will make, from an atmosphere selection point of view, is that of a continuing increase in mission duration. This increase, from mission durations measured in hours in 1961 to those that will be measured in months in 1975-1980, requires that we give detailed attention to the environment, including such factors as total cabin pressure, choice of a diluent gas, need for a diluent gas, reliable limits for carbon dioxide partial pressures, and acceptable levels of trace contaminants.

In addition, the demands that are to be made on the crew by the mission requirements must be seriously considered. For example, the programming of frequent extra-vehicular activity will greatly influence the decision regarding total cabin pressure and choice of diluent gas. Also, the ability to terminate a mission due to equipment failure or malfunction must influence our thinking in considering the atmosphere for manned space flight. Finally, the physiologic state of the crew throughout the mission must be considered, particularly in determining acceptable tolerance limits for non-nominal operations.

ENGINEERING ASPECTS OF ENVIRONMENTAL CONTROL/LIFE SUPPORT SYSTEMS

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Introduction

The utilization of man in space had been largely subjugated to a relatively minor role by the technical problems associated with the spacecraft itself as a transportation vehicle. The success of the GEMINI program and the current status of the Apollo is evidence that the transportation system is in a relatively high state of development. Thus, man's role in space can now be increasingly emphasized.

Economically, an increase in man's direct role in space requires longer duration missions, and longer duration missions generate a number of unanswered questions. What will be the effect of long duration confinement on man's health and performance? Will artificial gravity be necessary? How should crew interactions be structured to maximize mission success? What new life support equipment will be required to make long duration missions a practical undertaking?

Solutions to these and other questions have been, and are being, actively pursued through Industry and NASA and University research. This life systems activity covers three key areas of manned space flight. (1) Human Research, (2) Human Engineering and (3) Life Support and Protective Systems Engineering. I will be addressing myself to Life Support and Protective Systems Engineering.

The challenge of long duration manned space missions lies in the development of regenerative life support and astronaut protective systems which can (1) minimize large quantities of expendables, (2) safely collect, sample and dispose of human wastes, (3) monitor and control trace contaminants, and (4) provide more sophisticated crew quarters and personal hygiene facilities. In this session we will examine with you this related technology area developments in the next 5 to 10 years.

CREW SUPPORT SYSTEMS IN MANNED SPACE FLIGHT

Edward L. Hays
Crew Systems Division
NASA Manned Spacecraft Center
Houston, Texas

I. <u>Spacecraft Environmental Control Systems</u>

- A. Introduction and Background
- B. Mercury Environmental Control System (ECS)
- C. Gemini Environmental Control System (ECS)
- D. Apollo CSM ECS
- E. Apollo Lunar Module ECS

II. <u>Space Suit and Extravehicular Life Support Systems</u>

- A. Historical Including Mercury Space Suit
- B. Gemini Space Suit
- C. Gemini Extravehicular Activity Life Support Packs and Support Hardware
- D. Apollo Extravehicular Mobility Unit (EMU)
  - 1. Apollo Space Suit
  - 2. Apollo Portable Life Support System – 4800 BTU TOTAL AVAIL.
- E. Advanced Space Suit Concepts

III. <u>Crew Provision Equipment</u>

- A. Survival Equipment
- B. Potable Water System
  - 1. CSM
  - 2. LM
- C. Waste Management Systems

IV. <u>Description of Crew Provisions Items for Apollo Spacecraft</u>

MANUAL CONTROL

Laurence R. Young
Associate Professor
Department of Aeronautics and Astronautics
Massachusetts Institute of Technology

I. Models of the human operator: linear, optimum, information theory

- A. Compensatory tracking
- B. Pursuit and precognitive tracking

II. Describing functions

- A. Quasi-linear models, remnant
- B. Crossover model
- C. Table of pilot models vs. plant dynamics, input
- D. Limits of controllability

III. Pilot opinion

IV. First and second order handling qualities

V. Complex piloting tasks

- A. Transmission delays
- B. Multi-axis
- C. Multi-loop
- D. Intermittent displays and sampling
- E. Nonlinearities

VI. Adaptive characteristics

- A. Failure detection and identification
- B. Models for manual adaptive control

COMPENSATORY (ERROR)
PURSUIT – [illegible] [illegible]
PRECOGNITIVE
For leading target etc. Pre-programmed commands

Ref. Luxenberg & Kuehn "Display System Engineering" McGraw-Hill 1968

DATA DISPLAY

Laurence R. Young
Associate Professor
Department of Aeronautics and Astronautics
Massachusetts Institute of Technology

I. Display Modes

A. Visual

B. Audio

C. Tactile

II. Display requirements

A. Variables needed

B. Link values and grouping

C. Range, accuracy, bandwidth

D. Digital vs. analog

III. Display techniques

A. Inside-out vs. outside-in

B. Compensatory vs. pursuit

C. Preview

D. Quickening

E. Predictor

F. Phase plane

IV. Integrated displays

A. VTOL example

B. Contact analog

V. Heads up displays

VI. Peripheral displays

VII. Cathode ray tube technology

A. Basic CRT, electromagnetic vs. electrostatic

B. Multigun CRT's

C. Storage tubes

D. Shadow mask

E. Beam shaping and character generation tubes

F. Projection CRT

G. Chromatron

H. Kaiser-Aiken thin tube

I. Cathodes

J. Phosphors

K. Optical Diode

MAY COVER LATER

VIII. Other visual display technology

A. Electroluminescent

B. Holographic

IX. Three dimensional displays and computer graphics

GROUP DYNAMICS IN LONG DURATION SPACEFLIGHT

Joseph F. Kubis, Ph.D.
Department of Psychology
Fordham University Graduate School
New York, N.Y.

I Group Functioning and Group Interaction as Critical Issues.

II Relevant Concepts

- Group Dynamics
- Isolation
- Confinement
- Spaceflight Duration
- Spacecrew Size

III The Individual in the Group

- Isolation Studies
  - Arctic Groups
  - Antarctic Scientific Expeditions
  - Nuclear Submarines
- Confinement Studies
  - Simulation
  - Nuclear Submarines
- Gemini and Apollo Flights

IV Group Processes in Confinement and Isolation Situations

- Personal Interaction
- Differentiation: Task, Role, Status
- Leadership Functions
- Groups Under Stress
- Group Cohesiveness
- Group Composition

V Personal Space - An Exploratory Experiment

SPACECRAFT HABITABILITY

Raymond Loewy
Chairman, Raymond Loewy/William Snaith, Inc.
New York

I. Introduction

A. Brief description of the function of the Industrial Designer

B. Our role in the Space Program

II. Habitability Studies for the Saturn I OWS

To explain our working procedure we have selected two areas of the Saturn I OWS crew quarters:

(Slides)

A. Food Management Compartment

B. Waste Management Compartment

III. Planning for Advanced Space Stations

(Slides)

A. Effects Coriolis force imposes on crew quarters planning

B. Concepts for full utilization of inner spaces in zero G

IV. Conclusion

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM

NASA LIFE SCIENCES REVIEW

Presented to the Three Associate Administrators

on

Wednesday, February 19, 1969

by

S. P. Vinograd, M.D.
Space Medicine, Manned Space Flight

MEDICAL EXPERIMENTS PROGRAM

The medical and behavioral experiments program is a group of activities directed toward the evaluation of changes in human function and capabilities which may be induced by space flight. The objectives of the program exist as two categories, each having its own projected application or purpose (Fig. 1).

The first is geared toward manned space flight. Its four objectives express the intention to determine as precisely as possible man's medical and behavioral responses, functional limitations, and supportive requirements in space flight. The information gained is applied to the planning of future manned space flight missions and programs. Effective planning and judicious manned versus unmanned tradeoffs will continue to be strongly dependent upon how well these objectives are fulfilled.

The second category of objectives is oriented toward earth based medical science. Its purpose is to advance medical research by carrying out well-conceived experiments designed to utilize the unique environmental characteristics of space for scientific information, whether or not the resulting data will be any way applicable to manned space flight. As an example, any physiological function which might be considered to be gravity dependent in some respect is potential subject matter for profitable investigation in the space environment.

The four objectives given in the first category are a general statement of the questions which the program is attempting to resolve. The specific questions being pursued have been formulated and arranged in order of priority. A representative list of top priority questions follow as Appendix A.

The program which has been designed to meet these objectives consists of two primary areas of activity: Experiment Management, the support of the experiments, themselves, during definition and development; and Ground Based Research and Development, the effort to develop integrated flight laboratory equipment, new and improved medical evaluative techniques to enhance our inflight capability, and to obtain ground based data, all of which are essential elements supporting the flight medical experiments effort.

The program can be further characterized by certain of its more important concepts. An enumeration of these might serve to convey a more complete picture of this effort (Fig. 2). First, experiment principal investigators are not limited to NASA personnel. Because the space program is both national and scientific in nature, because the mounting of experiments aboard space flights is extremely expensive, and because flight opportunities are relatively infrequent, strong emphasis is placed upon the participation of the most highly competent individuals of the scientific community as principal investigators, whether they are from within or outside of NASA. Secondly, a general philosophy of the program is to plan experiment flight schedules not only to explore known or expected problems in depth, but also to conduct human systems monitoring across the board to the extent and level of detail consistent with good practice and practicality. As an example of the importance of this concept, had this not been done in Gemini we would still be totally unaware of the red blood cell and fluid compartment changes which were found. Thirdly, regarding the technical content of the program, the major variable is duration of flight. The most unknown environmental factor is prolonged weightlessness. This does not by any means imply that weightlessness is the only factor of interest, or even that it will necessarily turn out to be the most important. However, it is an important factor and it remains unknown because of our inability to reproduce it for much over thirty seconds in the earth environment. Fourth, with respect to the question of artificial g, the medical/behavioral experiments program seeks to establish the need for it by evaluating flight crews exposed to the unaltered zero g environment on flights of increasing durations. Shorter term flights can provide the opportunity to investigate and establish artificial g techniques most consistent with optimal crew, spacecraft, and mission function and performance. However, until the need for artificial g can be better determined, it is our feeling that this capability should be included in at least the design of future spacecraft. Lastly, the small number of flight crew members and the broad range of variability of individual responsiveness to a given set of conditions, which is so characteristic of us humans, necessitate the repetition of most experiments to establish statistical validity of flight findings.

The medical/behavioral experiment program began in 1963 with the study of the Biomedical Experiments Working Group (Fig. 3). This was an ad hoc group of NASA life scientists who devoted a series of meetings to an evaluation of the medical and behavioral aspects and requirements of an orbiting research laboratory. This was followed by two study contracts with industry, one with Republic and the other with North American, to explore this question in greater depth. In January 1964, the Space Medicine Advisory Group (SPAMAG), a group of 20 prominent consultants of the medical community, began its in-depth study of this problem. The SPAMAG report followed a series of eight two-day meetings chaired jointly by the NASA and the DOD.

In February 1965, a Technical Advisory Committee of ten NASA Center and Headquarters Life Sciences personnel was called together to assemble from these four reports a group of medical and behavioral experiments which could be considered condidates for an AAP (then AES) flight program. This was part of an exercise conducted for Dr. Seamans and resulted in the formulation of 23 medical/behavioral experiment concepts as a representative AAP medical experiments package. Shortly thereafter, this group of pseudo-experiments was reassembled into its eight component areas of body function, each with its list of required measurements and procedures (Fig. 4). This list has been reviewed and updated repeatedly with the aid of our consultant advisors, the Biomedical Subcommittee of STAC (formerly the Medical Advisory Council) and constitutes the desired measurement capability of the IMBLMS.

The first flight manifestation of the medical/behavioral experiments program took place in Gemini, preparations for which began in early 1964. The Gemini package consisted of eight experiments several of which were flown on more than one mission (Fig. 5 and 6). The experiments plan for the Apollo program was an expansion of the Gemini package, but necessary alterations of the flight program ultimately restricted these plans to the extent that only three pre- and postflight experiments are actually being implemented. The remainder are delayed until AAP.

As alluded to earlier, the medical/behavioral experiments program is functionally organized into two mutually dependent areas of activity (Fig. 7). The first consists of the planning, solicitation, and management of the experiments, themselves, during both definition and development. The activities entailed are outlined on this slide. Of these, the review for scientific merit deserves an additional word of explanation (Fig. 8). The system, which has been employed since 1966, includes an objective scientific review by the NIH Study Section system and a succeeding evaluation, also scientific but oriented toward Manned Space Flight capabilities and requirements, by a highly qualified team of medical consultants to NASA. This group was established in May 1965 as the Medical Advisory Council and is now the Biomedical Subcommittee of Dr. Mueller's Science and Technology Advisory Committee (STAC).

The present program of medical experiments is organized into the exploration and evaluation of the eight areas of body function mentioned earlier (Fig. 9). The individual experiments are components of these eight overall endeavors. There are currently fourteen experiments in development for AAP, five experiments in definition, and ~~nine~~ EIGHT in process of review for scientific merit. The slide (Fig. 10) indicates the body function areas and corresponding experiment numbers. The presently approved experiments cover six of these eight areas. A governing protocol describing the investigation of each functional area is included in existing documentation. The existing AAP medical/behavioral experiments, their organization, designators, and personnel are shown in Appendix B. Appendix C lists these same experiments using more descriptive titles to better indicate their content.

Of the five experiments in definition, only three have been funded and two of these are now overdue for renewal for lack of fiscal 1969 funds (Fig. 11). Although the remaining two experiments of the five were approved for definition over a year ago, we have not been able to initiate them thus far because of the curtailment of FY68 funds and lack of availability of FY69 experiment definition funds.

Of the ~~nine~~ EIGHT experiments currently in review, six are candidates for development, three will supplement existing experiments in the hematology area, and three are in the microbiology area, the seventh of the areas of body function (Fig. 12). Dr. Cameron's bone densitometry technique proposes both a pre- and postflight and an inflight portion. The pre- and postflight portion is a candidate for development and the inflight for definition. The ballistocardiography and pulmonary function proposals are both candidates for definition.

Turning now to the R&D support of the medical/behavioral experiments program, three task areas are defined. The first of these, the Integrated Medical and Behavioral Laboratory Measurement System (IMBLMS) program, will develop a highly flexible and sophisticated laboratory system to accommodate the medical and behavioral measurements required for all existing experiments as well as those anticipated for the future. Its two basic aims are (1) the accommodation of medical and behavioral investigations in accordance with the full objectives of the program, and, (2) provision of maximum flexibility (Fig. 13). It is basically a rack and module system which can be assembled into working consoles according to the requirements of the spacecraft and the experiments program for any particular mission. Hardware modules or submodules for a specific experiment can be developed to fit the specifications of the IMBLMS and utilized on an "as needed" basis. The flexibility afforded by the modular approach will significantly reduce lead time requirements, enhance inflight maintenance, and enable the relatively inexpensive introduction of updated techniques and equipment. The IMBLMS will consist of five functional elements: (1) physiological, (2) behavioral, (3) biochemical, (4) microbiological, and, (5) data management. Together they will accommodate required measurements in all eight areas of medical/behavioral investigation. Appendix D is the list of measurement requirements currently targeted for the flight IMBLMS. For the AAP program or Space Station, the IMBLMS will be composed of two or three consoles plus four to six pieces of peripheral equipment, such as the bicycle ergometer, rotating litter chair, body mass measurement system, and lower body negative pressure device.

The IMBLMS concept grew out of the studies discussed earlier. The need for time-lining the 23 pseudo-experiments issuing from the Dr. Seamans exercise in early 1965 resulted in our extending an existing MT contract with Lockheed to build a mock-up of a medical/behavioral laboratory in a mock-up of a LEM and time line these measurements with crew suited and unsuited (Fig. 14). This was accomplished as a four-month effort which ended in February 1966. In our first draft work statement in March 1966, we defined the present highly flexible IMBLMS concept including modularity, prefabricated rack mountings and interfaces, etc., and began preparations for Phase B of this phased project procurement. A Source Evaluation Board was established, an RFP drawn up and distributed, responses were evaluated, and in April 1967, two contractors were selected by Mr. Webb. Phase B1 work started in June 1967 followed by Phase B2 in October 1967. The present Phase B3 was begun in December 1968. The two contractors are continuing to work competitively in this thirteen-month phase, which will result in fabrication and test of a functional breadboard of IMBLMS. The first flight units can be completed by the summer of ~~CY72~~ CY73 (Fig. 15). However, schedules will be altered in accordance with manned space flight requirements. It is anticipated that competition will be terminated at the initiation of hard design, Phase C2. An IMBLMS Project Office has now been established in the Medical Research and Operations Directorate at the Manned Spacecraft Center in Houston, and the contracts are now being transferred from Headquarters to MSC.

The second task area of the R&D support of the program consists of a series of independent grants and contracts aimed at advancing states-of-the-art of measurement techniques and equipment to augment the capabilities and accuracies of the IMBLMS. This is an important task area for many reasons, a major one being that many standard techniques are not adaptable to the environmental and other circumstances of manned space flight. Most of these requirements (Fig. 16) were identified several years ago. The existing efforts to meet these requirements have been reviewed by previous discussants. Many are progressing satisfactorily but there is a need for expanded efforts, especially in the areas of biochemistry and microbiology, as will be noted in a review of technical problems.

The third R&D task area consists of chamber studies, bed rest studies, and similar types of simulations as sources of essential ground based data. Although individual principal investigators do obtain ground based or control data as part of their experiments, economic feasibility dictates that evaluations of certain environmental factors such as spacecraft atmosphere by long term chamber studies, weightlessness as simulated by bed rest, etc., are best done by NASA with the participation of all principal investigators whose flight findings would be influenced by these aspects of the environment. Although bed rest studies have been and are being carried out, the Apollo accident, but more currently, funding and man power limitations, have caused delays and cancellations in chamber studies. As recently as four months ago, a planned 60-day 5 psi 2-gas AAP atmosphere simulation which was to be run jointly by NASA and the Air Force at Wright-Patterson Air Force Base had to be cancelled for lack of sufficient personnel and funding resources on the part of both the Air Force and NASA.

Some of the more important technical problems confronting the program are shown on this slide (Fig. 17). Although progress is being made in these areas, there is need for a more concerted attack on the measurement of metabolic costs of suited activity, and our old chronic problem of accurate fluid intake and output measurement during flight. We do have one promising lead on viral identification in-flight but funding limitations threaten to delay it even further than the $1\frac{1}{2}$ years it has already been waiting. There are existing productive efforts in biochemistry techniques and in the behavioral area but these need to be expanded considerably to enable us to work out satisfactorily the overall problems which we are attempting to resolve in manned space flight, the questions of artificial g, and manned vs. automated task accomplishment.

Resources are summarized on the slide (Fig. 18). The experiment development figures are <u>requirements</u> for Apollo medical and biology experiments as well as for AAP. The definition numbers indicate dollars <u>available</u> as do those for parallel development and simulation studies. The IMBLMS figures are requirements; the FY69 dollars have been expended and it does appear at this point that FY70 requirements for IMBLMS will be made available.

The personnel figures represent present full time professionals at MSC, MR&O. In addition to these there are approximately 12 including the principle coordinating scientists who are able to devote only a part of their time to the medical/behavioral experiments. Minimum requirements for IMBLMS, alone, are 5 MSC personnel now, and will increase progressively to 10 for Phase C. To meet this least requirement are one full time and two part time personnel presently on hand. Headquarters, MM, personnel devoted to this program number one full time and two part time professionals, a personnel shortage of long standing.

Of the major issues of the program, the funding and personnel problems have already been discussed (Fig. 19). The excessively long and complex procurement procedures have been a significant impediment to the initiation of needed efforts within the short periods in which funding is actually available. Lastly, but most fundamentally, these and other issues could be dealt with more effectively were it not for the fact the medical/behavioral experiments program has never been a program. Although we have repeatedly referred to it as such, it has been a program only in terms of its purpose, objectives, planning, and technical content. It has never had a budget or organization of its own. Until March of 1966, the effort had no budget available to it at all, except for the funding of experiments in development by the flight program offices. Definition money became available through MT in the spring of 1966, but beginning one week later the funding history has been one of budgetary reductions and funding delays in the various budgetary sources from which the total effort draws its support. As a result, overall progress could not be smoothly and evenly maintained. These funding uncertainties have led to a variety of problems, most of them obvious; but one perhaps less obvious has been its influence on the participation of the scientific community. As mentioned earlier, two of our experiments which were approved for definition over a year ago are still not funded. This kind of delay causes planning discontinuities and expense to principal investigators and their parent institutions. It constrains our ability to request and to receive the enthusiastic participation of the scientific community.

As a true programmatic effort, it would be possible to establish a coordinated base level of activity consistent with the priority of its function, the evaluation of man in manned space flight. Such a base level, suited to the lean years would be appropriately embellished for more rapid progress during better years, but in either case the effort could then progress smoothly and in a coordinated manner toward planned achievements and objectives.

A

QUESTIONS MEDICAL/BEHAVIORAL AREA
SEEKING TO RESOLVE

NEUROPHYSIOLOGY

1. What are the effects of the space flight environment on sleep?

2. What is the change in susceptibility to motion sickness as a function of:

   a. Time aloft?

   b. Freedom of movement within the spacecraft?

   c. Rotation of the spacecraft?

3. What are the effects of sustained loss of gravitational cues on sensory perception (the special senses, kinethesis, and other somatic senses) and on spatial orientation?

PULMONARY FUNCTION AND ENERGY METABOLISM

1. What are the effects of sustained weightlessness on the mechanics of breathing in which, normally, the gravitational forces interact with the respiratory muscles and elastic forces of the chest and lungs?

2. What is the energy cost (metabolic gas exchange) at rest and during activity in the spacecabin with and without the suit, in normal flight and during EVA?

3. What is the degree and duration of arterial hypoxia due to ventilation/perfusion inequality in the lungs during launch and re-entry in space flight?

4. Are there any alterations in alveolar gas transfer or the control of breathing under prolonged combined effects of weightlessness and a low pressure mixed gas or pure oxygen environment?

CARDIOVASCULAR FUNCTION

1. Is cardiac output adequately maintained in prolonged space flight?

2. To what extent does space flight affect normal arterial pressure controls?

APPENDIX A

3. How are venous compliance and central venous pressure and their adjusting mechanisms influenced by prolonged space flight?

4. How is cardiac function affected by long duration space flight?

5. What are the factors of space flight which cause changes in circulating blood volume and its distribution? At what point and under what conditions is a new equilibrium established?

6. What is the time course of changes in overall circulatory function as determined by provocative testing (tilt table, LBNP)?

NUTRITION AND MUSCULOSKELETAL FUNCTION

1. What are the actual caloric requirements and the variables in caloric utilization under varying workloads and under varying configurations of space suit constraints in long duration space flight?

2. What are the space flight factors or stress conditions which might change caloric, water, electrolyte, or mineral requirements? To what extent do they change these requirements?

3. By what predictive or mathematic factors are energy costs of activity in space different from those in the one-G environment?

4. To what extent is glucose metabolism changed by space flight conditions (as noted in prolonged bed rest)?

5. Are variations in body mass during space flight within the limits to be expected with adequate food and water intake and work schedules comparable with the earth environment?

6. What is the time course and degree of skeletal and muscular changes due to weightless flight? What are the relative influences of weightlessness, relative inactivity, and the atmospheric environment?

7. What are the best preventive or restorative techniques against bone and muscle deterioration due to space flight?

8. What are the effects of long duration weightless flight on water and electrolyte balance?

ENDOCRINOLOGY

1. In view of the known changes in body water distribution and balance with changes in body position, to what extent will weightlessness per se bring about losses of fluid? To what extent is anti-diuretic hormone involved in the mechanism of this change?

2. To what extent will changes in the metabolic cost of activity in space be reflected by changes in thyroid hormone production? Can a cause and effect relationship be established?

3. To what extent are the predicted losses of mineral in long duration space flight associated with increased bone resorption mediated by elevated parathyroid hormone secretion?

4. As both a reflection and mediating factor of stress response, what is the time course of changes in adrenal cortical activity in prolonged space flight?

HEMATOLOGY AND IMMUNOLOGY

1. What are the environmental factors responsible for the loss of red cell mass noted during Gemini?

   What are the relative roles of:

   a. The 100% oxygen environment?

   b. Nitrogen in small amounts?

   c. Weightlessness?

   d. Duration of exposure?

   e. Diminished red cell production vs. increased destruction?

   f. Ambient total pressure?

   g. Vibration?

   h. Ambient temperature?

   i. Dietary factors?

2. What space flight factors are responsible for changes in plasma volume?

3. Are coagulation proteins, platelet function, and vascular friability influenced by long duration space flight? If so, what are the responsible environmental factors?

4. Can one anticipate alterations of inflammatory response as a result of long duration space flight?

5. To what extent can space flight be anticipated to produce alterations of cell division or chromosomal composition? If such changes do occurr, what environmental factors are responsible and what preventive action can be taken?

MICROBIOLOGY

1. What changes can be expected to take place in the microbial flora of flight crews during space flight?

2. What are the influences of space flight conditions on the relative dominance of pathogenic microorganisms?

3. Will there be genetic alteration in microbiological organisms as a result of the space flight environment? To what extent? Can a pattern of such changes be anticipated?

BEHAVIORAL EFFECTS

1. Will perceptual efficiency be affected by space flight conditions?

2. What changes in time and/or pattern of activity will make performance of tasks in space most efficient? Most comfortable for the astronaut?

3. What changes in the tolerance limits to stress occur over time in the extended periods of weightlessness?

4. What are optimal inflight and EVA work-rest periods based on factors of (a) fatigue, (b) energy loss, (c) discomfort, and other stress indicants?

AAP MEDICAL/BEHAVIORAL EXPERIMENTS
APPROVED AS OF DECEMBER 1968

M070 - NUTRITION AND MUSCULOSKELETAL FUNCTION (Governing Protocol)

Principal Coordinating Scientist: Paul C. Rambaut, Ph.D., MSC

Assistant Coordinating Scientists: Richard Boster, D.V.M., MSC
Miss Rita Rapp, MSC
Malcolm Smith, D.V.M., MSC

Individual Experiments or Measurements:

M071 - Mineral Balance

Principal Investigator: G. Donald Whedon, M.D., NIH

Co-Investigator : Leo Lutwak, M.D., Ph.D.
Cornell University

M072 - Bone Densitometry

Principal Investigator: Pauline B. Mack, Ph.D.
Texas Women's University

M073 - Bioassay of Body Fluids

Principal Investigator: Craig L. Fischer, M.D., MSC

Co-Investigator : Carolyn Leach, Ph.D., MSC

M074 - Specimen Mass Measurement

Principal Investigator: John Ord, Colonel, USAF, MC
Brooks AFB, Texas

Co-Investigator : William Thornton, M.D., MSC

* * * * *

APPENDIX B

M090 - CARDIOVASCULAR FUNCTION (Governing Protocol)

Principal Coordinating Scientist: Robert L. Johnson, M.D.

Individual Experiments or Measurements:

M091 - LBNP (Pre- and post-flight)

Principal Investigator: John Ord, Colonel, USAF, MC
Brooks AFB, Texas

Co-Investigator : Robert L. Johnson, M.D., MSC

M092 - Inflight LBNP

Principal Investigator: R. L. Johnson, M.D., MSC

Co-Investigator : John Ord, Colonel, USAF, MC
Brooks AFB, Texas

M093 - Vectorcardiogram

Principal Investigator: Capt. N.W. Allebach, Bureau of
Medicine & Surgery, Washington,

Co-Investigator : R. F. Smith, M.D., Naval Aerospa
Medical Institute, Pensacola, Fl

* * * * *

M110 - HEMATOLOGY AND IMMUNOLOGY (Governing Protocol)

Principal Coordinating Scientist: Craig Fischer, M.D., MSC

Individual Experiments or Measurements:

M111 - Cytogenetic Studies of Blood (Pre- and post-flight)

Principal Investigator: Michael Bender, Ph.D., ORNL, Ten

Co-Investigator : Miss P. Carolyn Gooch, ORNL, Ten

M110 - HEMATOLOGY AND IMMUNOLOGY (Continued)

M113 - Blood Volume and Red Cell Life Span

Principal Investigator: Phillip C. Johnson, M.D.
Baylor University, Texas

Consultants: Wallace N. Jensen, M.D., Ohio State University
David Turner, Ph.D., Hospital for Sick Children
Scott N. Swisher, M.D., Michigan State University
Vernon Knight, M.D., Baylor University
Wolf Vishniac, Ph.D., University of Rochester

* * * * *

M130 - NEUROPHYSIOLOGY (Governing Protocol)

Principal Coordinating Scientist: Milton R. DeLucchi, Ph.D., MSC

Individual Experiments or Measurements:

M131 - Human Vestibular Function

Principal Investigator: Ashton Graybiel, M.D., Naval Aerospace Medical Inst., Pensacola, Florida

Co-Investigator : Earl F. Miller, Ph.D., Naval Aerospace Medical Institute, Pensacola, Florida

M132 - Neurological Experiment - EEG
Principal Investigators: Adey and Kelloway

Consultant: Maitland Baldwin, M.D.

* * * *

M150 - BEHAVIORAL EFFECTS (Governing Protocol)

Principal Coordinating Scientist: Edward C. Moseley, Ph.D., MSC

Individual Experiments or Measurements:

M151 - Time and Motion Study

Principal Investigator: Joseph F. Kubis, Ph.D., Fordham U, New York

Co-Investigator : Edward J. McLaughlin, Ph.D., NASA Headquarters

Consultants: John T. Elrod, Ph.D.
Jesse Orlansky, Ph.D.

* * * * *

M170 - PULMONARY FUNCTION AND ENERGY METABOLISM (Governing Protocol)

Principal Coordinating Scientist: Edward L. Beckman, M.D.

Individual Experiments or Measurements:

M171 - Metabolic Activity

Principal Investigator: Mr. Edward Michel, MSC

Co-Investigator : J. A. Rummel, Ph.D., MSC

M172 - Body Mass Measurement

Principal Investigator: John Ord, Colonel, USAF, MC
Brooks AFB, Texas

Co-Investigator : William Thornton, M.D., MSC

Consultants: Ulrich Luft, M.D., Lovelace Foundatioh
Wayland Hull, Ph.D., MSC
George C. Armstrong, Jr., M.D., MSC

* * * * *

ADDITIONAL AREA OF INVESTIGATION:

M190 - MICROBIOLOGY (Governing Protocol)

Principal Coordinating Scientist: James McQueen, D.V.M.

Assistant Coordinating Scientist: James K. Ferguson, Ph.D.

AAP MEDICAL/BEHAVIORAL EXPERIMENTS
APPROVED AS OF JANUARY 1969

M070 - NUTRITION AND MUSCULOSKELETAL FUNCTION (Governing Protocol)

M071 - Mineral balance study to determine muscle, bone, and electrolyte changes due to space flight

M072 - Measurements of bone density to determine the skeletal effects of space flight

M073 - The analysis of blood and urine specimens to evaluate physiological changes occurring during and following space flight

M074 - The evaluation of an inflight specimen mass measurement technique by means of its utilization in inflight mineral balance and body fluid assays studies

M090 - CARDIOVASCULAR FUNCTION (Governing Protocol)

M091 - The evaluation of space flight induced alterations of circulatory responsiveness by means of the application of a fixed stimulus, lower body negative pressure (pre and post flight)

M092 - The evaluation of space flight induced alterations of circulatory responsiveness by means of the application of a fixed stimulus, lower body negative pressure (inflight)

M093 - Vectorcardiographic study of cardiac responses to space flight

M110 - HEMATOLOGY AND IMMUNOLOGY (Governing Protocol)

M111 - Cytogenetic studies of blood (pre and postflight) to determine chromosomal changes which may be induced by space flight

M113 - Blood volume and red cell life span studies to evaluate space flight induced alterations

M130 - NEUROPHYSIOLOGY (Governing Protocol)

M131 - Human vestibular function as affected by space flight conditions

M132 - The evaluation of sleep during manned space flight by means of the study of electroencephalographic patterns

M150 - BEHAVIORAL EFFECTS (Governing Protocol)

M151 - Time and motion study of task accomplishment during space flight

M170 - PULMONARY FUNCTION AND ENERGY METABOLISM (Governing Protocol)

M171 - The evaluation of metabolic cost of activity during space flight

M172 - The study of changes in body mass as influenced by space flight environmental factors utilizing a new inertial mass measurement technique

MEDICAL/BEHAVIORAL MEASUREMENT CAPABILITY
of
INTEGRATED MEDICAL AND BEHAVIORAL LABORATORY MEASUREMENT SYSTEM

INCLUDE

I. NEUROLOGICAL

Clinical Evaluation (to include reflexes and sensory and motor pathways)

Agravic Perception of Personal and Extra-Personal Space (Minimum restraint device)

Ocular Counter-Rolling

Oculogyral Illusion

Visual Task with Head Rotation

Electronystagmogram

Angular Acceleration Threshold

} To be done with litter-chair

EEG

II. CARDIOVASCULAR

Clinical Evaluation

ECG (Frank Lead System)

Phonocardiogram

Cardiac Output - (By impedance if technique verified; by indicator-dilution if necessary)

Arterial Blood Pressure

Venous Pressure - Peripheral

Blood Volume and Fluid Compartments - See Hematology and Metabolism

Regional Blood Flow - Limb (or Digit) (Distribution of Blood Volume)

Venous Compliance

Arteriolar Reactivity

} (Limb Plethysmography)

INCLUDE

Arterial Pulse Contour

In-Flight Exercise

LBNP

Elastic Leotards

PROVIDE FOR INSTALLATION IF REQUIRED:

Ballistocardiogram

Carotid Body Stimulation

Thoracic Blood Flow

Venous Pressure - Central
(By Catheter if Necessary)

III. RESPIRATORY

Clinical Evaluation

Respiratory Rate

Lung Volumes Including Residual Volume
(For total lung capacity, and mixing efficiency)

Pressure, Flow, and Volume (Simultaneously)
(→ Airway Resistance)

Compliance - Lung or Total
(Lung if can)

INCLUDE

Distribution of Blood Flow and Gas in Lungs

Includes: Capillary Blood O_2, CO_2, and pH

Breath by Breath O_2 Consumption and CO_2 Production

O_2 Consumption - With Measured Exercise

Alveolar to Arterial Gradient Breathing Air and 100% Oxygen

Diffusion Capacity (if suitable technique) (Look into $O_2{}^{18}$ method - Dr. Richard W. Hyde, U. of Pennsylvania, Dept. of Physiology)

IV. METABOLISM AND NUTRITION

Clinical Evaluation

Energy Metabolism (Continuous O_2 and CO_2 Analysis with Breath by Breath Sensitivity) with Various Levels of Activity

Oral Temperature

Skin Temperature

Caloric Intake

Body Mass In-Flight (Thornton Technique - OFE)

[Lean Body Mass Pre- and Post-Flight] - (Not a Part of IMBLMS)

Muscle Size and Strength

Balance Studies
- Fluid, including Sweat
- Nitrogen (See Area IX)
- Mineral (See Area IX)
- Electrolyte (See Area IX)

4

INCLUDE

Provide for : Accurate Urine Volume Measurement

Accurate Wet Weight of Feces

Return of Total Dry Stool

Accurate Fluid Intake Measurement

Return of all Food Packages Marked by Date Time and Individual

Sweat Measurement and Sample Return

Total Body Water (Breatholator or Deuterium)

+ Clinical Laboratory Evaluations - See List Under Area IX

PROVIDE FOR INSTALLATION IF REQUIRED:

EMG

Bone Densitometry - Isotope Technique

Gastric Pressure and pH (Endoradiosonde)

Plasma Volume On-Board

Mineral Metabolism by Isotopic Techniques

V. ENDOCRINOLOGY

Clinical Evaluation

+ Clinical Laboratory Evaluations - See List

INCLUDE

VI. HEMATOLOGY

Clinical Evaluation

Rumple Leede

Blood Volume and Fluid Compartment
  Plasma Volume - RIHSA
  RBC Mass - DFP^{32} or Cr^{51}
  Total Body Water

RBC Survival - DFP^{32}

Clinical Laboratory Evaluations - See List

VII. MICROBIOLOGY AND IMMUNOLOGY

Clinical Evaluation

Body Microflora (Bacterial, Viral, and Fungal)

Environmental Culturing (Bacterial, Viral, and Fungal)

Clinical Laboratory Evaluations - See List

VIII. BEHAVIORAL EFFECTS

Clinical Evaluation

Sensory Test Battery (See Also Neurology)

Perceptual Evaluation (If validity of Tests Established)

Higher Thought Processes

Memory - Short and Long Term

Vigilance (By measurement of operational tasks)

INCLUDE

Learned Activity (Tracking and Reaction Time)

Recording of Crew Intercommunication with Automatic Erase in 15 Minutes if not Sampled

Time and Motion Study

IX. CLINICAL LABORATORY EVALUATIONS	Reference Area
Creatine and Creatinine - Urinary	IV
Urinary and Fecal: N, Ca, P, Na, K, Cl, and Mg	IV
Mucoproteins - Urinary (Pi)**	IV
Pyrophosphates - Urinary (Pi)**	IV
Hydroxyprolines - Urinary (probably Pi)**	IV
Total Amino Acids - Urinary (Pi)**	IV
Urinary: Osmolality, Color, Sp Gr, pH, Glucose, Protein, Bile, Blood, and Microscopic (ie., Routine Urinalysis - Inflight)	IV
Plasma Volume (probably P&P)*	IV & VI
Electrolytes - Serum	IV
Total Protein - Plasma	IV
Protein Electrophoresis - Plasma	IV
Glucose - Blood (Inflight)	IV
Ca and PO_4 - Serum (probably Pi)	IV
Bilirubin - Serum	

*P&P - pre & post-flight

**Pi - Post-flight evaluation of inflight samples

INCLUDE	Reference Area
Cholesterol - Serum (probably Pi)	IV
BUN (probably Pi)	IV
Uric Acid - Blood (Pi)	IV
Alkaline Phosphatase - Serum (probably Pi)	IV
pH, pO_2, and pCO_2 - Blood	III & IV
Bicarbonate - Blood	III & IV
CPK (Creatine Phosphokinase - Serum (Pi)	IV
LDH and LDH Isoenzymes - Serum (On-board if have electrophoresis)	IV
SGOT - Serum	IV
SGPT - Serum	IV
Aldosterone - Urine (Pi)	IV & V
ADH - Urinary and Serum (Pi)	V
ACTH - Blood (Pi)	V
Serum Free Thyroxin (T_4 - Serum) (If in-flight, will require thin layer chromatography)	V
TBPA (Probably Pi)	V
17-hydroxycorticosteroids - Urine and blood (Pi)	V
17-ketosteroids - Urine (Pi)	V
VMA - Urine (Probably Pi)	V
Metanephrines - Urine (Pi)	II & V
Catechols - Urine (Pi)	II & V
Histamine - Blood and Urine (Pi)	II & V

INCLUDE	Reference Area
5 Hydroxy indolacetic acid - Urinary (Probably Pi)	V
Blood Cell Morphology (RBC, WBC, and Diff - Smear will suffice for platelets)	VI
Reticulocyte Count	VI
Hematocrit	VI
Hemoglobin	VI
RBC Fragility (Osmotic)	VI
RBC Mass and Survival	VI
Bleeding Time	VI
Clotting Time	VI
Prothrombin Consumption	VI
Clot Retraction	VI
Lymphocyte Karotyping (probably Pi)	VI
WBC Mobilization (Rebuck Technique)	VI
Immunoglobulins and Fibrinogen Transferins Hemoglobin Methemoglobin	VI & VII onboard if have electrophoresis
RBC Enzyme Studies (Pi) (ref. Governing Protocol M110)	VI
Complement Titration	VII
Antibody Titration	VII

PROVIDE FOR INCLUSION IF REQUIRED:

Sulfate - Urinary	IV
TSH (Pi)	V
Growth Hormone (Pi)	V
Thyroid Bound Globulin (T_3) (Pi)	V

Figures

INCLUDE	REFERENCE AREA
PROVIDE FOR INCLUSION IF REQUIRED (Cont'd):	
Parathyroid Hormone (Radio-immune Technique - Serum) (P1)	V
Parathyroid Hormone - Urinary (Nelson Technique -(P1)	V
Calcitonin - Serum (P1)	V
Insulin Assay (P1)	V
Glucagon Assay (P1)	V
Serotonin (5 HIAA) - Blood (P1)	V
Platelet Adhesiveness	VI
Fibrinolytic Activity	VI
Blood Rheology	VI
Blood Lipids	VI

MEDICAL EXPERIMENTS PROGRAM

OBJECTIVES

A. TO EXTEND MAN'S CAPABILITIES IN MANNED SPACE FLIGHT BY DETERMINING:

1. THE EFFECTS OF SPACE FLIGHT ON MAN, AND THE TIME COURSE OF THESE EFFECTS.

2. THE SPECIFIC ETIOLOGIES AND MECHANISMS BY WHICH THESE EFFECTS ARE MEDIATED.

3. MEANS OF PREDICTING THE ONSET AND SEVERITY OF UNDESIRABLE EFFECTS.

4. THE MOST EFFECTIVE MEANS OF PREVENTION OR CORRECTION OF UNDESIRABLE EFFECTS.

B. TO OBTAIN SCIENTIFIC INFORMATION OF VALUE TO CONVENTIONAL MEDICAL RESEARCH AND PRACTICE.

FIGURE 1

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
MAJOR CONCEPTS

1. ABLEST PRINCIPAL INVESTIGATORS OF SCIENTIFIC COMMUNITY

2. EXPERIMENTS DIRECTED TOWARD:
   (a) INVESTIGATION OF KNOWN PROBLEMS
   (b) IN DEPTH SYSTEMS MONITORING FOR EARLY IDENTIFICATION OF POTENTIAL PROBLEMS

3. RE TECHNICAL CONTENT:
   (a) MOST IMPORTANT VARIABLE IS DURATION OF FLIGHT
   (b) MOST UNKNOWN ENVIRONMENTAL FACTOR IS PROLONGED WEIGHTLESSNESS

4. RE ARTIFICIAL G:
   (a) FIRST EVALUATE MAN IN LONG DURATION WEIGHTLESSNESS
   (b) UTILIZE SHORTER FLIGHTS TO DETERMINE OPTIMAL ARTIFICIAL G TECHNIQUES
   (c) INCLUDE ARTIFICIAL G OPTION IN <u>DESIGN</u> OF SPACE STATION

5. EXPERIMENT REPETITION REQUIRED TO ESTABLISH STATISTICALLY VALID DATA.

NASA SPONSORED
SOURCES OF AAP EXPERIMENTS
(MEDICAL BEHAVIORAL)

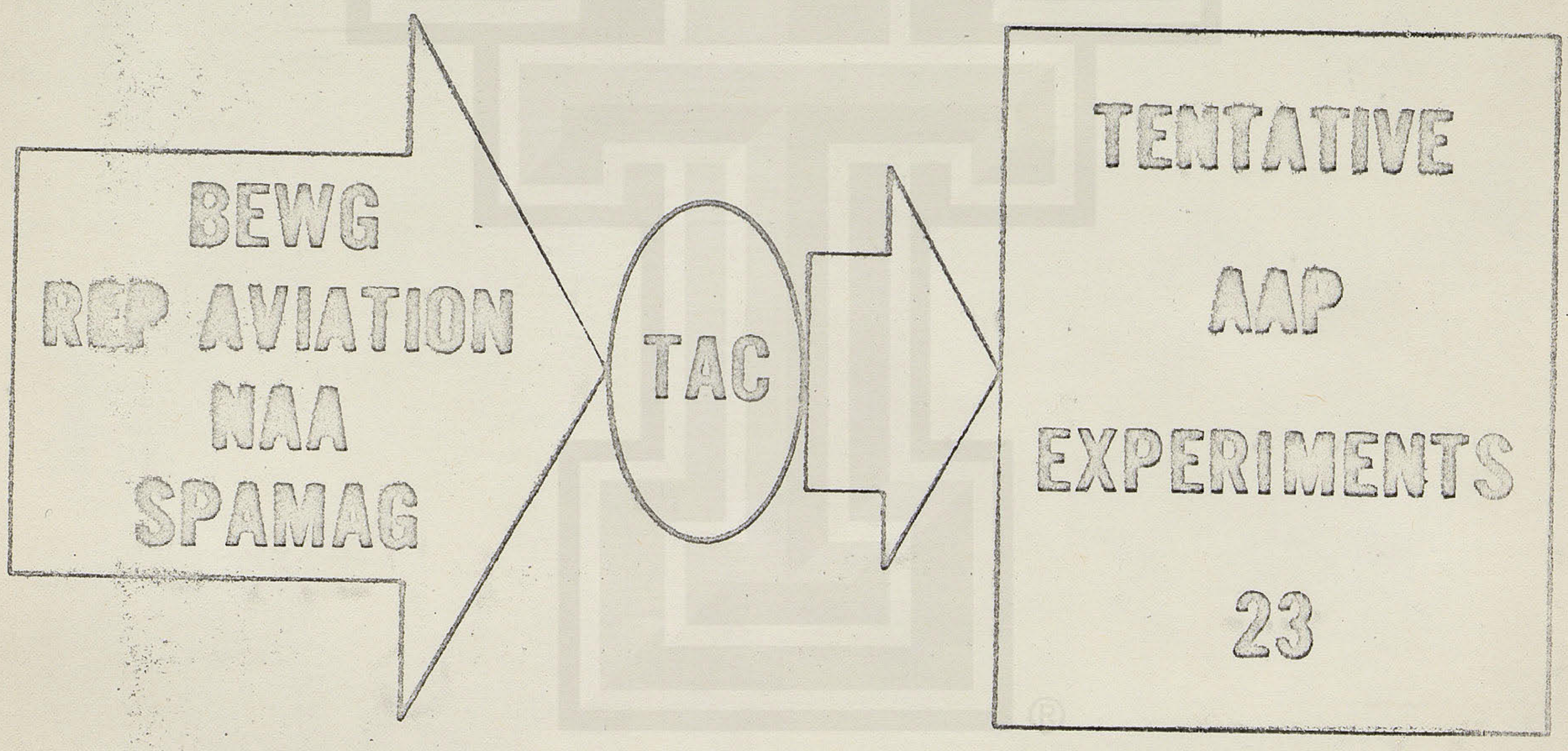

FIGURE 3

NASA MM66-6111

AREAS OF BODY FUNCTION TO BE INVESTIGATED

AAP MEDICAL-BEHAVIORAL EXPERIMENTS

1. NEUROLOGICAL
2. CARDIOVASCULAR
3. RESPIRATORY
4. METABOLIC & NUTRITIONAL
5. ENDOCRINE
6. HEMATOLOGICAL
7. MICROBIOLOGICAL & IMMUNOLOGICAL
8. BEHAVIORAL

FIGURE 4

FIGURE 5

EIGHT AREAS OF MEDICAL EVALUATION

EXPERIMENTS	NEURO.	RESP.	CARDIO-VASC.	METAB. & NUTRITION	ENDOCR.	HEMATOL.	MICROBIOL.	BEHAV.
GEM.	M008 M009	M003	M001 M003 M004 M005 MED. OPS.	M005 M006 M007	M005	MED. OPS.		MED. OPS.
AP.		M020	M012 M017 M023 M048	M012 M019		M011	MED. OPS.	

GEMINI MEDICAL EXPERIMENTS

M-1 CARDIOVASCULAR CONDITIONING

M-3 INFLIGHT EXERCISER

M-4 INFLIGHT PHONOCARDIOGRAM

M-5 BIOASSAYS BODY FLUIDS

M-6 BONE DEMINERALIZATION

M-7 CALCIUM BALANCE STUDY

M-8 INFLIGHT SLEEP ANALYSIS

M-9 HUMAN OTOLITH FUNCTION

FIGURE 6

MEDICAL EXPERIMENTS PROGRAM
FUNCTIONAL ORGANIZATION

I. MEDICAL/BEHAVIORAL EXPERIMENTS

A. DETERMINATION OF REQUIREMENTS AND MAINTAINING RELATIONSHIPS, SUPPORT, AND PARTICIPATION OF THE SCIENTIFIC COMMUNITY.

B. REVIEW OF EXPERIMENT PROPOSALS FOR SCIENTIFIC MERIT.

C. SUPPORT OF EXPERIMENTS IN DEFINITION.

D. SELECTION, CONVERSION, AND SUPPORT OF EXPERIMENTS FOR DEVELOPMENT PHASE.

E. SUPPORT AND GUIDANCE DURING OPERATIONAL DATA GATHERING, AND POST MISSION DATA REDUCTION AND REPORTING PHASES.

F. APPLICATION OF DATA TO THE MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM, MANNED SPACE FLIGHT, AND THE CIVILIAN COMMUNITY AS INDICATED.

II. R&D SUPPORT OF MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM

A. IMBLMS (INTEGRATED MEDICAL AND BEHAVIORAL LABORATORY MEASUREMENT SYSTEM).

B. PARALLEL DEVELOPMENT EFFORTS TO ADVANCE STATES OF THE ART IN MEASUREMENT TECHNIQUES AND EQUIPMENT TO ENHANCE THE CAPABILITIES OF IMBLMS AND PROPOSED EXPERIMENTS.

C. SIMULATIONS AND GROUND BASED DATA, I.E., THE SUPPORT OF GROUND BASED SIMULATION AND OTHER STUDIES IN ORDER TO OBTAIN A BODY OF PERTINENT DATA AS A NORMATIVE OR CONTROL BASE TO PERMIT THE EXTRACTION OF VALID CONCLUSIONS FROM FLIGHT DATA.

FIGURE 7

MEDICAL / BEHAVIOR EXPERIMENTS PROGRAM
SCIENTIFIC MERIT EVALUTIONS SYSTEM

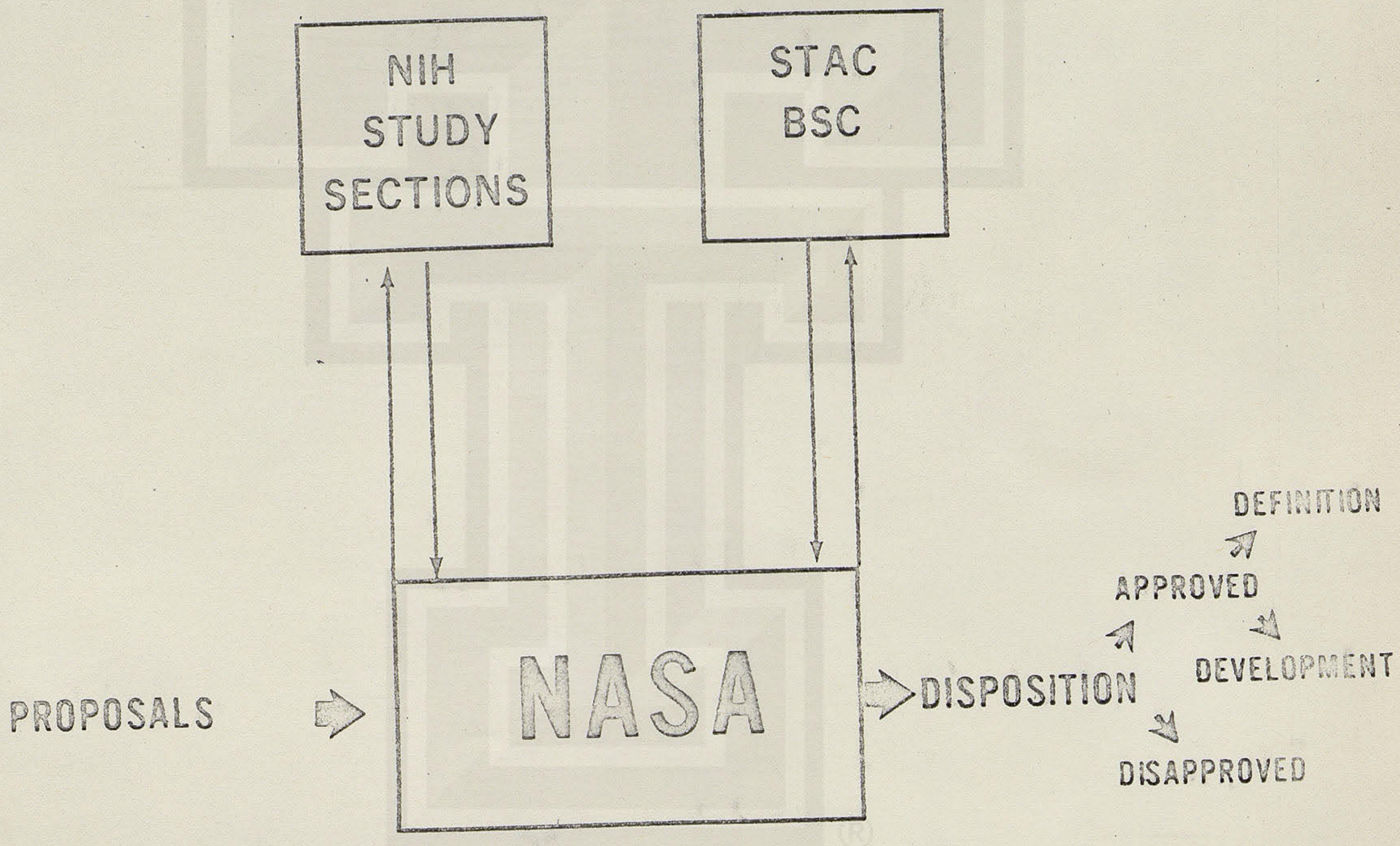

FIGURE 8

NASA HQ MM69-4377
2-14-69

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
EXISTING EXPERIMENTS
(FEBRUARY 1969)

	Nutr. & Musc. Skel. (M070)	Cardio-vascular (M090)	Hematol. & Immun. (M110)	Neuro-physiol. (M130)	Behav. Effects (M150)	Pulm. Funct. & Energy Metabolism (M170)	Micro-biology (M190)	Endocrine (M210)
Development (Approved AAP)	M071 M072 M073 M074	M091 M092 M093	M111 M113	M131 M132	M151	M171 M172		
Definition	M075 M076		M114 M115					M211
In Review	One	One	Three (Incl. review of M114 for development- ment)			One	Three	

FIGURE 9

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
EXPERIMENTS IN DEVELOPMENT
(FEBRUARY 1969)

M071 - MINERAL BALANCE
DOCTORS WHEDON & LUTWAK (NIH & CORNELL)

M072 - BONE DENSITOMETRY
DR. MACK (TEXAS WOMEN'S U)

M073 - ANALYSIS OF BODY FLUIDS
DR. FISCHER (MSC)

M074 - SPECIMEN MASS MEASUREMENT
COL ORD (BROOKS AFB)

M091 - LBNP (PRE AND POSTFLIGHT)
COL ORD (BROOKS AFB)

M092 - LBNP (INFLIGHT)
DR. R. JOHNSON (MSC)

M093 - VECTORCARDIOGRAM
CAPT. ALLEBACH (NAMI, USN)

M111 - CYTOGENETIC STUDIES
DR. BENDER (ORNL)

M113 - BLOOD VOLUME
DR. P. JOHNSON (BAYLOR)

M131 - VESTIBULAR FUNCTION
DR. GRAYBIEL (NAMI, USN)

M132 - EEG
DRS. ADEY & KELLOWAY (UCLA & BAYLOR)

M151 - TIME AND MOTION
DRS. KUBIS & McLAUGHLIN (FORDHAM & NASA HQS.)

M171 - METABOLIC ACTIVITY
MR. MICHEL (MSC)

M172 - BODY MASS MEASUREMENT
COL ORD (BROOKS AFB)

FIGURE 10

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
EXPERIMENTS IN DEFINITION
(FEBRUARY 1969)

---

*M075 - GASTRIC MOTILITY
DR. M. PETERSON (WASHINGTON U)

*M076 - CHEMICAL ANALYTICAL TECHNIQUES
DR. HUEBNER (BECKMAN INSTRUMENTS, INC.)

M114 - RED BLOOD CELL METABOLISM
DR. MENGEL (U. OF MISSOURI)

**M115 - ENDOGENOUS CO PRODUCTION
DRS. LAWRENCE & WINCHELL (U OF CALIFORNIA)

**M211 - URINARY ENDOCRINE ASSAY
DR. NELSON (LATTER DAY SAINTS)

*AWAITING FUNDING FOR INITIATION

**AWAITING FUNDING FOR CONTINUATION

FIGURE 11

FIGURE 12

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
EXPERIMENT PROPOSALS IN REVIEW
FOR SCIENTIFIC MERIT
(FEBRUARY 1969)

NUTRITION AND MUSCULOSKELETAL FUNCTION

- SKELETAL STATUS***
  DR. CAMERON (U. OF WISCONSIN)

CARDIOVASCULAR FUNCTION

- SPACE BALLISTOCARDIOGRAPHY*
  DRS. CUNNINGHAM & SMITH (U OF CALIF. & STANFORD)

HEMATOLOGY AND IMMUNOLOGY

- MAN'S IMMUNITY, IN VITRO ASPECTS**
  DRS. RITZMANN & LEVIN (U OF TEXAS)

- RED BLOOD CELL METABOLISM (M114)**
  DR. MENGEL (U OF MISSOURI)

- SPECIAL HEMATOLOGIC EFFECTS**
  DR. FISCHER (MSC)

PULMONARY FUNCTION AND ENERGY METABOLISM

- PULMONARY FUNCTION*
  DR. WEST (U OF CALIF., LaJOLLA)

MICROBIOLOGY

- BACTERIOLOGY AND MYCOLOGY**
  DR. FERGUSON (MSC)

- VIROLOGY **
  DR. McQUEEN (MSC)

- SPACECRAFT ECOLOGY**
  DRS. MCQUEEN & FERGUSON (MSC)

*CANDIDATE FOR DEFINITION
**CANDIDATE FOR DEVELOPMENT
***CANDIDATE FOR DEFINITION AND DEVELOPMENT (2 PARTS)

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
IMBLMS

AIMS

1. PROVIDE INFLIGHT MEASUREMENT CAPABILITY TO ACCOMMODATE ALL MEDICAL/BEHAVIORAL EXPERIMENTS

2. PROVIDE MAXIMUM FLEXIBILITY FOR:

   a. ADAPTABILITY TO LATE CHANGES IN MISSION EXPERIMENT PLANS

   b. EASE OF INFLIGHT MAINTENANCE

   c. EASE AND ECONOMY OF INCORPORATION OF UPDATED TECHNIQUES AND EQUIPMENT

IMBLMS FUNCTIONAL ELEMENTS

1. PHYSIOLOGICAL MEASUREMENT

2. BEHAVIORAL MEASUREMENT

3. BIOCHEMICAL

4. MICROBIOLOGICAL

5. DATA MANAGEMENT

FIG 13

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
IMBLMS PROGRAM MILESTONES

<u>PHASE A - EARLY DEFINITION</u>

AUG. 1964 - NASA'S FOUR STUDIES COMPLETED

FEB. 1965 - TECHNICAL ADVISORY COMMITTEE (DR. SEAMAN'S STUDY)

OCT. 1965 to FEB. 1966 - MOCK-UP AND TIME LINE STUDY (LMSC)

<u>PHASE B - FINAL DEFINITION</u>

MAR. 1966 to DEC. 1966 - PHASE B1 WORK STATEMENT WRITTEN AND COORDINATED; PROCUREMENT PLAN APPROVED; SEB ESTABLISHED; AND RFP RELEASED

FEB. 1967 to APR. 1967 - PROPOSALS RECEIVED AND EVALUATED; SELECTION OF TWO COMPETING CONTRACTORS (GE AND LMSC) BY MR. WEBB

JUNE 1967 to OCT. 1967 - PHASE B1 CONTRACTS

DEC. 1967 to FEB. 1968 - PHASE B2 CONTRACTS

DEC. 1968 - PHASE B3 CONTRACTS INITIATED

FEB. 1969 - TRANSFER OF CONTRACTS FROM HQS. TO IMBLMS PROJECT OFFICE, MSC, MR&O

JAN. 1970 - PHASE B3 COMPLETED

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
IMBLMS PROGRAM MILESTONES (CONT'D)

PHASE C - DESIGN

JAN. 1970 - PHASE C1 (PRELIMINARY DESIGN) INITIATED

SEP. 1970 - PHASE C1 COMPLETE; SINGLE CONTRACTOR SELECTED

SEP. 1970 - PHASE C2 (FINAL DESIGN) INITIATED

PHASE D - DEVELOPMENT (FABRICATION)

AUG. 1971 - PHASE C2 COMPLETE; OVERLAPPING INITIATION OF PHASE D

AUG. 1972 - FLIGHT IMBLMS FABRICATED AND QUALIFIED

FIG 15

FIGURE 15

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
PARALLEL DEVELOPMENT

REQUIREMENTS (SELECTED)

METABOLIC ANALYZER, RAPID RESPONSE, ADAPTABLE TO SUITED ACTIVITY

MICROBIAL CULTURE AND IDENTIFICATION TECHNIQUES FOR INFLIGHT USE

TECHNIQUES FOR INFLIGHT BIOCHEMICAL ANALYSIS

SAMPLE PRESERVATION TECHNIQUES FOR INFLIGHT USE

IMPROVED LIMB PLETHYSMOGRAPHY TECHNIQUES

NON-INVASIVE CARDIAC OUTPUT DETERMINATION TECHNIQUES

NON-INVASIVE VENOUS PRESSURE TECHNIQUES

BEHAVIORAL MEASUREMENT TECHNIQUE REFINEMENT

BLOOD CELL COUNTING TECHNIQUES FOR INFLIGHT USE

TECHNIQUES FOR INFLIGHT MEASUREMENT OF PULMONARY DIFFUSION CAPACITY

IMPROVED URINE VOLUME MEASUREMENT DEVICE

96

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
PROBLEMS

MEASUREMENT OF METABOLISM DURING EVA

ACCURATE FLUID INTAKE AND OUTPUT MEASUREMENT IN FLIGHT

CULTURE AND IDENTIFICATION OF VIRUSES IN FLIGHT

BIOCHEMICAL ANALYTICAL TECHNIQUES SUITABLE FOR SPACE FLIGHT

PREDICTIVE INDICES AND SENSITIVE EVALUATIVE TECHNIQUES TO DETERMINE GROUP INTEGRITY AND THE PROBLEMS OF LONG TERM GROUP ISOLATION

BROAD PROBLEMS:

a. DETERMINE THE NEED FOR ARTIFICIAL G

b. DETERMINE TASKS BEST ACCOMPLISHED BY MAN AND THOSE BEST DONE BY AUTOMATION

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM
RESOURCES

FUNDS (IN 1000'S)

		FY69	FY70
I.	EXPERIMENTS		
	DEVELOPMENT	7613	11414
	DEFINITION	400	0 AVAIL.
II.	R&D SUPPORT		
	IMBIMS	2350	3800
	PARALLEL DEVELOPMENT	0 AVAIL.	?
	SIMULATIONS & G/B DATA	0 AVAIL.	?

PERSONNEL (PRESENT TOTALS - MSC)

CIVIL SERVICE 13

CONTRACTOR 0 (IMBIMS TEST CONTRACT PERSONNEL TO BE ADDED)

FIGURE 18

MEDICAL/BEHAVIORAL EXPERIMENTS PROGRAM ISSUES

1. FUNDING DEFICIENT AND INSECURE

2. PERSONNEL INSUFFICIENT, ESPECIALLY AT MSC

3. PROCUREMENT CYCLE EXCESSIVELY LONG

4. PROGRAMMATIC ISSUE

MEDICAL/BEHAVIORAL MEASUREMENT CAPABILITY
of

INTEGRATED MEDICAL AND BEHAVIORAL LABORATORY
MEASUREMENT SYSTEM

INCLUDE

I. NEUROLOGICAL

Clinical Evaluation (to include reflexes and sensory and motor pathways)

Agravic Perception of Personal and Extra-Personal Space (Minimum restraint device)

Ocular Counter-Rolling

Oculogyral Illusion

Visual Task with Head Rotation

Electronystagmogram

Angular Acceleration Threshold

(Ocular Counter-Rolling through Angular Acceleration Threshold: To be done with litter-chair)

EEG

II. CARDIOVASCULAR

Clinical Evaluation

ECG (Frank Lead System)

Phonocardiogram

Cardiac Output - (By impedance if technique verified; by indicator-dilution if necessary)

Arterial Blood Pressure

Venous Pressure - Peripheral

Blood Volume and Fluid Compartments - See Hematology and Metabolism

Regional Blood Flow - Limb (or Digit) (Distribution of Blood Volume)

Venous Compliance

Arteriolar Reactivity

(Regional Blood Flow through Arteriolar Reactivity: Limb Plethysmography)

INCLUDE

Arterial Pulse Contour

In-Flight Exercise

LBNP

Elastic Leotards

PROVIDE FOR INSTALLATION IF REQUIRED:

Ballistocardiogram

Carotid Body Stimulation

Thoracic Blood Flow

Venous Pressure - Central
(By Catheter if Necessary)

III. RESPIRATORY

Clinical Evaluation

Respiratory Rate

Lung Volumes Including Residual Volume
(For total lung capacity, and mixing efficiency)

Pressure, Flow, and Volume (Simultaneously)
(→ Airway Resistance)

Compliance - Lung or Total
(Lung if can)

INCLUDE

Distribution of Blood Flow and Gas in Lungs

Includes: Capillary Blood O_2, CO_2, and pH

Breath by Breath O_2 Consumption and CO_2 Production

O_2 Consumption - With Measured Exercise

Alveolar to Arterial Gradient Breathing Air and 100% Oxygen

Diffusion Capacity (if suitable technique) (Look into O_2 ^{18} method - Dr. Richard W. Hyde, U. of Pennsylvania, Dept. of Physiology)

IV. METABOLISM AND NUTRITION

Clinical Evaluation

Energy Metabolism (Continuous O_2 and CO_2 Analysis with Breath by Breath Sensitivity) with Various Levels of Activity

Oral Temperature

Skin Temperature

Caloric Intake

Body Mass In-Flight (Thornton Technique - GFE)

[Lean Body Mass Pre- and Post-Flight] - (Not a Part of IMBLMS)

Muscle Size and Strength

Balance Studies

- Fluid, including Sweat
- Nitrogen (See Area IX)
- Mineral (See Area IX)
- Electrolyte (See Area IX)

INCLUDE

Provide for : Accurate Urine Volume Measurement

Accurate Wet Weight of Feces

Return of Total Dry Stool

Accurate Fluid Intake Measurement

Return of all Food Packages Marked by Date Time and Individual

Sweat Measurement and Sample Return

Total Body Water (Breatholator or Deuterium)

+ Clinical Laboratory Evaluations - See List Under Area IX

PROVIDE FOR INSTALLATION IF REQUIRED:

EMG

Bone Densitometry - Isotope Technique

Gastric Pressure and pH (Endoradiosonde)

Plasma Volume On-Board

Mineral Metabolism by Isotopic Techniques

V. ENDOCRINOLOGY

Clinical Evaluation

+ Clinical Laboratory Evaluations - See List

INCLUDE

VI. HEMATOLOGY

Clinical Evaluation

Rumple Leede

Blood Volume and Fluid Compartment
- Plasma Volume - RHISA
- RBC Mass - DFP^{32} or Cr^{51}
- Total Body Water

RBC Survival - DFP^{32}

Clinical Laboratory Evaluations - See List

VII. MICROBIOLOGY AND IMMUNOLOGY

Clinical Evaluation

Body Microflora (Bacterial, Viral, and Fungal)

Environmental Culturing (Bacterial, Viral, and Fungal)

Clinical Laboratory Evaluations - See List

VIII. BEHAVIORAL EFFECTS

Clinical Evaluation

Sensory Test Battery (See Also Neurology)

Perceptual Evaluation (If validity of Tests Established)

Higher Thought Processes

Memory - Short and Long Term

Vigilance (By measurement of operational tasks)

INCLUDE

Learned Activity (Tracking and Reaction Time)

Recording of Crew Intercommunication with Automatic Erase in 15 Minutes if not Sampled

Time and Motion Study

IX. CLINICAL LABORATORY EVALUATIONS	Reference Area
Creatine and Creatinine - Urinary	IV
Urinary and Fecal: N, Ca, P, Na, K, Cl, and Mg	IV
Mucoproteins - Urinary (Pi)**	IV
Pyrophosphates - Urinary (Pi)**	IV
Hydroxyprolines - Urinary (probably Pi)**	IV
Total Amino Acids - Urinary (Pi)**	IV
Urinary: Osmolality, Color, Sp Gr, pH, Glucose, Protein, Bile, Blood, and Microscopic (ie., Routine Urinalysis - Inflight)	IV
Plasma Volume (probably P&P)*	IV & VI
Electrolytes - Serum	IV
Total Protein - Plasma	IV
Protein Electrophoresis - Plasma	IV
Glucose - Blood (Inflight)	IV
Ca and PO_4 - Serum (probably Pi)	IV
Bilirubin - Serum	

*p&p - pre & post-flight
**Pi - Post-flight evaluation of inflight samples

INCLUDE	Reference Area
Cholesterol - Serum (probably P1)	IV
BUN (probably P1)	IV
Uric Acid - Blood (P1)	IV
Alkaline Phosphatase - Serum (probably P1)	IV
pH, pO_2, and pCO_2 - Blood	III & IV
Bicarbonate - Blood	III & IV
CPK (Creatine Phosphokinase - Serum (P1)	IV
LDH and LDH Isoenzymes - Serum (On-board if have electrophoresis)	IV
SGOT - Serum	IV
SGPT - Serum	IV
Aldosterone - Urine (P1)	IV & V
ADH - Urinary and Serum (P1)	V
ACTH - Blood (P1)	V
Serum Free Thyroxin (T_4 - Serum) (If in-flight, will require thin layer chromatography)	V
TBPA (Probably P1)	V
17-hydroxycorticosteroids - Urine and blood (P1)	V
17-ketosteroids - Urine (P1)	V
VMA - Urine (Probably P1)	V
Metanephrines - Urine (P1)	II & V
Catechols - Urine (P1)	II & V
Histamine - Blood and Urine (P1)	II & V

INCLUDE	Reference Area
5 Hydroxy Indolacetic acid - Urinary (Probably Pi)	V
Blood Cell Morphology (RBC, WBC, and Diff - Smear will suffice for platelets)	VI
Reticulocyte Count	VI
Hematocrit	VI
Hemoglobin	VI
RBC Fragility (Osmotic)	VI
RBC Mass and Survival	VI
Bleeding Time	VI
Clotting Time	VI
Prothrombin Consumption	VI
Clot Retraction	VI
Lymphocyte Karotyping (probably Pi)	VI
WBC Mobilization (Rebuck Technique)	VI
Immunoglobulins and Fibrinogen Transferins Hemoglobin Methemoglobin } onboard if have electrophoresis	VI & VII
RBC Enzyme Studies (Pi) (ref. Governing Protocol M110)	VI
Complement Titration	VII
Antibody Titration	VII

PROVIDE FOR INCLUSION IF REQUIRED:

Sulfate - Urinary	IV
TSH (Pi)	V
Growth Hormone (Pi)	V
Thyroid Bound Globulin (T_3) (Pi)	V

INCLUDE	REFERENCE AREA

PROVIDE FOR INCLUSION IF REQUIRED (Cont'd):

Parathyroid Hormone (Radio-immune Technique - Serum) (P1)	V
Parathyroid Hormone - Urinary (Nelson Technique -(P1)	V
Calcitonin - Serum (P1)	V
Insulin Assay (P1)	V
Glucagon Assay (P1)	V
Serotonin (5 HIAA) - Blood (P1)	V
Platelet Adhesiveness	VI
Fibrinolytic Activity	VI
Blood Rheology	VI
Blood Lipids	VI

LIQUID BREATHING

Edward J. Burger, Jr., M.D.
Department of Physiology
Harvard School of Public Health
Boston, Massachusetts

I. Origins of interest in the study of liquid breathing

   A. Studies to determine the mechanisms of drowning

   B. Interest in lavage of the lung as a therapeutic tool

II. Practical applications of liquid breathing for life support

   A. Avoidance of decompression sickness in the face of very rapid decompressions from high pressure environments

      1. The inert component would be fluid rather than gaseous. Thus, there would be no noticeable change in volume with change in pressure nor would there be a change in state with change in ambient pressure

   B. Avoidance of inert gas narcosis

   C. Prevention of large perfusion and ventilation gradients and distortion (or rupture) of lung tissue with acceleration forces of great magnitude.

      1. "Package" the lung in a medium which has physical properties similar to those of tissue and blood.

III. Summary of work performed

   A. Fluids considered and used

      1. Examples

         a. Water
         b. Saline
         c. Buffered solutions
         d. Silicone oil
         e. Fluorinated hydrocarbons

      2. Physical properties of importance

         a. Density
         b. Viscosity
         c. Solubility in other solvents (such as water)
         d. Solubility of dissolved gases (O_2, CO_2)
         e. Diffusion coefficient for gases
         f. Surface tension
         g. Vapor pressure
         h. Toxicity

B. Examples of experiments performed

1. Description

2. Results

a. Survival

b. Effect of temperature

c. Transition back to a gaseous medium

3. Attempts at rapid decompression

4. Attempts at protection from G-forces

IV. Problems and limitations

A. Surface tension

1. Limitation of maximum flow

2. Transition back to an air-liquid interface

B. Requirement for increased ventilation

1. Based on diffusion limitation

a. Oxygen - satisfied by increasing O_2 gradient and by using a fluid medium in which oxygen is very soluble.

b. Carbon dioxide remains a problem in spite of high solubility of CO_2.

C. Limitation of ventilation

1. Maximum expiratory flow

a. Limited by:

1. Physical properties of fluid

2. Static recoil pressures - reduced with obliteration of gas-liquid interface.

b. When expressed as percentage of body weight, man appears to be at a greater disadvantage than mice, dogs, and rats.

MAN'S ROLE ON THE OCEAN FLOOR

Capt. George Bond MC, USN
Deep Submergence Systems Project
Chevy Chase, Maryland 20015

Man's exploration and exploitation of the continental shelves and greater ocean depths presents one of the most exciting areas of present applied research. Although the capability of the free diving exploits to 200 meter depth has been within reach for some years, such dives had to be measured in minutes, and called for a prohibitive ratio of useful time on the ocean floor to the immutable time requirement for decompression of human body tissues, to avoid injury or outright fatality.

Commencing in 1957, naval investigators commenced to explore the concept of saturation diving as a means of ameliorating the unhappy dive-decompression time ratio. This rationale called for provision of a suitable bottom-emplaced habitat for the ocean-floor worker. The undersea house would be supplied with an especially prepared gas mixture - a captive atmosphere - in which the aquanaut would live at ocean ambient pressure, and be free to exit for work at great ocean depths, with no requirement of decompression until the completion of his ocean floor stay, which might last more than sixty days.

The experimental procedures leading to these final human capabilities, exemplified in Genesis E, and SEALABS I, II and III, will be described. In addition, the factual accomplishments and engineering problems related to these exercises will be discussed.

AVIATION MEDICINE
MEDICAL STANDARDS AND CERTIFICATION

Dr. Peter V. Siegel
Federal Air Surgeon
Federal Aviation Administration
Department of Transportation
Washington, D. C.

The FAA Act of 1958 makes it clear that the mission of the agency is to promote safety of flight by prescribing minimum standards governing the design, materials, workmanship, construction, and performance of aircraft in the interest of safety and to issue airmen certificates to those individuals who demonstrate their qualifications to exercise the privilege of the certificate sought or held. The Act does not address itself to specific minimum standards or qualifications. It does direct and serve as the administrative authority to develop and establish standards.

The specific detailed standards for all areas of civil aviation are promulgated by the agency in the form of the Federal Aviation Regulations (FARs). Our discussion will be limited to Part 67 of these regulations-- Medical Standards and Certification.

The following areas will be discussed:

1. Philosophy of regulation
2. Development of aeromedical standards
3. The rule-making procedure
4. The aeromedical certification system
    a. Scope of the system
    b. The airman population
    c. Aviation medical examiners
    d. Records processing
    e. Records review
    f. Decision making
    g. Appeals

CIVIL AVIATION ACCIDENT INVESTIGATION AND MEDICAL RESEARCH

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Federal Aviation Administration
Washington, D.C. 20590

Civil aviation in the United States is conducted in two broad categories of operations. The first and most extensive of these categories in terms of numbers of airmen and aircraft is that of general aviation. The second category is that of air carrier operations and within this category the vast majority of the traveling public flies.

The Federal Aviation Administration is responsible for promoting safety in both of these categories. Since the type of aircraft and the nature of the flight environment varies considerably with respect to these two categories, the bases for accidents differ between the categories. From the general aviation category data will be presented which describes such matters as alcohol, drugs, pilot age, and other significant considerations. For the air carrier aspects, supersonic transport decompression profiles, airline passenger smoke protection devices, and other safety topics will be discussed.

Abstract of presentation for National Aeronautics and Space Administration Aerospace and Undersea Summer Seminar, Massachusetts Institute of Technology, Cambridge, Massachusetts, 21 August 1969.

OPERATIONAL ASPECTS OF AVIATION MEDICINE

Captain Frank H. Austin, Jr., MC, USN
Head, Life Sciences Department
Naval Safety Center
Naval Air Station
Norfolk, Virginia 23511

1.0 Introduction - Over view of Naval aviation medicine, operational and safety programs

2.0 Problem Areas - Summary of present practices and state-of-the-art

1.1 Operational aeromedical problems in Naval aviation

1.2 Aeromedical factors in safety programs

1.3 Aeromedical aspects of aircraft accident investigation

3.0 Operational Applications of Current Research and Development

3.1 Clinical Aerospace Medicine

3.2 Physiological Aspects

3.3 Personnel Performance Monitoring

3.4 Human Factors Engineering

3.5 Life Support Systems

4.0 Summary - What course should future Naval aviation medicine programs follow

5.0 Questions and Discussion

Visual Aids - 3' x 3' (35 mm) slides
16 mm sound movie

MEDICAL ASPECTS OF COMMERCIAL AVIATION

G. J. Kidera, M. D.
Medical Director
United Air Lines, Inc.
Chicago, Illinois

A. Physiologic Variables Encountered in a Commercial Jet Operation.

1. Altitude and cabin pressurization.
2. Ozone at jet altitudes.
3. Radioactivity.
4. Cabin humidity, temperature, air exchange, noise.
5. Diurnal rhythm.

B. Passenger Considerations.

Present-day passengers are primarily a medically unselected group. Occasionally air carriers are aware of specific pre-existing illnesses or injuries when special handling is required, i.e., request for a wheel chair, ambulance bringing passenger to airport, request for continuous oxygen, etc.

1. Medical and surgical considerations in selecting airline passengers, i.e., myocardial infarction, cardiac pace-maker, pneumothorax, recent pneumoencephalography.

2. Common in-flight medical emergencies.

3. In-flight medical care.

4. Passenger deaths in flight.

C. Aircrew Considerations.

1. Selection.

2. Medical maintenance. Value of: glucose challenge, tonometry, measurement of flight deck vision, stress ECG's.

3. Relative yield of periodic and return-to-work physical examinations.

4. Common aircrew complaints.

5. Review of causes for medical grounding of flight personnel.

C. Aircrew Considerations. (Continued)

6. Medical aspects (human factors) involved in flight training.

7. Medical approach to progressive and non-progressive diseases in airline pilots.

8. Fatigue.

D. Environmental Medicine.

1. Hearing conservation program.

2. Physical examinations of ground staff.

3. Accident prevention.

4. Aircraft accident investigation.

5. In-plant inspections.

6. Transportation of dry ice, etiologic agents, radioactive material, laboratory animals.

7. Disinsection of aircraft--proposed DDVP system.

E. Report on Investigative Studies.

1. Five-year experience with blood lipid lowering agent (clofibrate).

2. Turbulence: jet upset, G forces, control of aircraft, etc.

3. Use of Propranolol as a tool in evaluating reactivity of examinee.

4. Effect of programmed exercise on abnormal ECG's.

5. Use of reservoir cigarette lighters at altitude.

6. A new approach to the herniated disc--chymopapain injections.

SPACE STATION PROGRAM

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Advanced Manned Missions Program
National Aeronautics and Space Administration
Washington, D.C. 20546

Introduction and Background

1) Accomplishments of Manned Space Flights - Vostok - Soyuz - Mercury - Gemini - Apollo in determining man's inherent capability to work and live in space.

2) The landing of men on the Moon and their safe return to Earth is one of the outstanding accomplishments of man in the 20th century. It makes available to the nation the skills, industrial capability, Apollo/Saturn systems and ground support network for use on a new, imaginative space program.

Program Rationale

An Earth orbital program appears a logical and desirable next step because it

- -- Is a necessary developmental step to future missions
- -- Offers the potential of tangible economic returns to
  - -- Earth resources survey
  - -- in space processing of materials
- -- Offers an opportunity for scientific research in
  - -- Astronomy
  - -- Biology
  - -- Physics
- -- May have application, either direct or indirect to national security
  - -- Prestige
  - -- Technical Preeminence

-- Military development

-- Provides the nation with technological goal for the next decade

Description of Space Station Program Elements

1) Apollo Application Program

-- Workshop - description and function

-- ATM - description and function

-- Total Program objectives

2) Space Station Module

-- Desired Characteristics

-- Crew Size

-- Duration

-- Subsystems

-- Growth Capability

-- Experiment Module

3) Space Shuttle

Desired Characteristics

-- Low operating cost

-- Land Landing

-- Low Acceleration

-- Use as point to point transportation

Impact of Space Station on Medicine

Long duration effect

-- Is artificial gravity necessary or desirable

-- Chronic low level radiation exposure

-- Habitability effects

-- Privacy

-- Food

-- Personal hygiene

-- Interpersonal relationships

-- Boredom

-- Confinement

Summary

1) The next decade will see greater space achievements than the past decade.

2) Men will play an increased role in operations. In turn, he must be provided with the accommodations which allow him to live and work in safety and with the dignity of a man on Earth.

THE BIOSATELLITE PROGRAM

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Director, Bioscience Programs
Office of Space Science and Applications
National Aeronautics and Space Administration
Washinton, D.C.

I. Objectives of the Biosatellite Program

II. The biosatellite missions and their purposes

1. The radiation and general biology mission

2. The primate mission

III. The Biosatellite Spacecraft

IV. Experiments on Biosatellite I and II

1. Effects of weightlessness on plants (wheat seedlings and pepper plants)

2. Effects of weightlessness on animal cells (amoeba [Pelomyxa] and frog eggs)

3. Genetic effects of weightlessness

4. Combined effects of weightlessness and radiation (Neurospora spores)

(Beetles [Tribolium])

(Wasps [Habrobracon])

(Tradescantia)

(Lysogenic bacteria)

(Vinegar gnats [Drosophila])

V. Experiments on Biosatellite III

1. Effects of prolonged weightlessness on the central nervous system

2. Effects of prolonged weightlessness on the cardio-vascular system

3. Effects of prolonged weightlessness on metabolism

4. Effects of prolonged weightlessness on bone density

VI. Summary

EXOBIOLOGY AND PLANETARY EXPLORATION

Richard S. Young
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Washington, D.C. 20546

An integral and perhaps inevitable event in the origin and evolution of the universe, was the Origin of Life. An understanding of the controlling factors in the Origin of Life and a determination of the uniqueness of life on the Earth are the primary objectives of the Exobiology Program of the NASA. Described here are the research areas considered basic to the program.

1- Chemical Evolution - a study of the chemical events on the primitive Earth or on any primitive planet with a similar history, which preceded and led to the Origin of Life. There are two approaches to chemical evolution: a) Abiogenesis - the syntheses of biologically significant organic molecules by the application of energy (electrical discharge, ultra violet radiation, heat, etc.) to the simple components (methane, ammonium, water) of the primitive atmosphere, and b) Organic Geochemistry - the analysis of ancient rocks and sediments of the Earth, Moon and other planets, for fossils (both chemical and biological), providing a record of the events taking place at the time of the origin of life. Extraterrestrial analyses can be done *in situ* or on returned samples.

2- Biological Adaptation - a study of the response of terrestrial organisms (primarily microorganisms) to extremes of environment (temperature, radiation, pressure, atmospheric composition, water availability, etc.) likely to be characteristic of extraterrestrial environments. Two basic problems are being explored - survival and growth. Are terrestrial organisms accidently landed on an extra-terrestrial surface likely to survive and be detected inadvertently by our life detection experiments, and are terrestrial organisms likely to grow and destroy an indigenous biota? What are the limits of environmental extremes which carbon based life can tolerate, - so that we may estimate the liklihood of life on any given planet? Are there other chemistries which could produce a "living" system capable of tolerating quite different environments than we ordinarily consider?

3- Life Detection - the development of techniques which will allow us to determine the presence or absence of past, present or future life elsewhere in the universe. The emphasis is on automated systems performing relevant environmental measurements and chemical analyses early in the program, evolving to more complex payloads making more integrated and sophisticated measurements and ultimately to unmanned and even manned laboratories. The most likely techniques are those which seek the more basic attributes of terrestrial life - organic chemical, metabolic and growth analyses, as well as imaging systems for visual detection and morphology. Ultimately, data on all of these basic attributes will be required, hopefully on a single sample.

McGraw-Hill
Lectures
Symposium
Student Lab

HX – PURPOSE – ENHANCE 1D APPROACH TO [illegible]
3rd TIME COURSE GIVEN – MIP HOST – EXPANDED
LY → PROGRESS SUMMARY – RNG.

I General
NEUROLOGY
SPEC. SENSES & ~~VESTIB.~~ – FUNCTION
CHRONOBIOL (CIRCADIAN RHYTH.)
GEN PSYCHOL. & MAN MACH. – INTEGRATION
RESPIRATORY PHYSIOL.
CARD-VASC. & ECG
ACID-BASE & ~~Fluid & Electrolyte~~ Regulation
Calcium & Mineral Metabolism
BIOCHEM. – GEN.
HEMATOLOGY

~~II HAZARD PATH~~

II ENVIRONMENTAL PROBLEMS
MICROBIAL
TOXICOLOGY
IONIZING RADIATION
MAGNETIC FIELDS
VISIBLE LIGHT
PLANETARY CHARACTERISTICS & HAZARDS
INERTIAL FORCES

III LIFE SUPPORT SYSTEMS
ATMOSPHERE SELECTION
ENVIRONMENTAL CONTROL ~~[illegible]~~ SYSTEMS
METABOLIC FACTORS
MSF LIFE SUPPORT SYSTEMS
MANUAL CONTROL
DATA DISPLAY
BIOINSTRUMENTATION INCL. ADVANCED CONCEPTS
DATA MANAGEMENT INCL. ADVANCED CONCEPTS
~~ADVANCED CON~~
LIVING CONDITIONS & STANDARDS, &
FOR HABITABILITY

IV MEDICAL/BEHAVIORAL INVESTIGATION IN MSF

M/B EXPERIMENTS PROGRAM

SIMULATIONS FOR EARTH BASED DATA

V UNDERSEA MEDICINE

MEDICAL ASPECTS & PROBLEMS

FUNDAMENTAL PHYSIOLOGY

LIQUID BREATHING DEMONSTRATION

SEALAB

DESIGN OF DEEP SUBMERGENCE VEHICLES

OPERATIONAL ASPECTS OF UNDERSEA EXPLORATION

VI AVIATION MEDICINE

MEDICAL STDS & CERTIFICATION

AVIATION ACCIDENT INVESTIGATION & MED. RESEARCH

MILITARY AVIATION MEDICINE

COMMERCIAL AVIATION MEDICINE

VII ~~SPACE FLI~~ MEDICAL SUPPORT OF MANNED SPACE FLIGHT ~~SPACE FLIGHT MEDICAL~~

MSF MEDICAL OPERATIONS

PERSPECTIVE OF FLIGHT CREW

VIII SUBJECTS OF SPECIAL INTEREST

SPACE STATION PROGRAM

BIOSCIENCE IN SPACE, BIOSATELLITE 2

EXOBIOLOGY

SCHED. CHANGES

1. JEROME KASSNER REPL. SCHWARTZ
2. MRS. GALIANA REPL. BEISCHER
3. (3+4) ~~[illegible]~~ DOLAN REPL. MEIRE
5. 6 BRIGGS PHILLIPS, B-D G. repl. PICKERING
6. STAN WHITE WITHDRAWN
7. ASTRONAUT WILL BE DR. JOE KERWIN
8. – FLICK
9. – LOEWE

Dr. FERRIS for LEVY

MOLLER

LONG & SHORT DAYS

BOOKS – MOVIE

EXAMS