Programmed Environment Management of Confined Microsocieties: Mission to Mars

Henry H. Emurian
College of Engineering and Information Technology
UMBC
&
Joseph V. Brady
The Johns Hopkins University School of Medicine

Behavioral Health Management of Space Dwelling Microsocieties: Safe Passage Beyond Earth Orbit

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College of Engineering and Information Technology
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Précis

- **Extended stays** by human groups in extraterrestrial vehicles and habitats will be common in this century.

- Ensuring participants' **behavioral health** requires microsociety management based upon sound scientific principles.

A Recent Troublesome Event

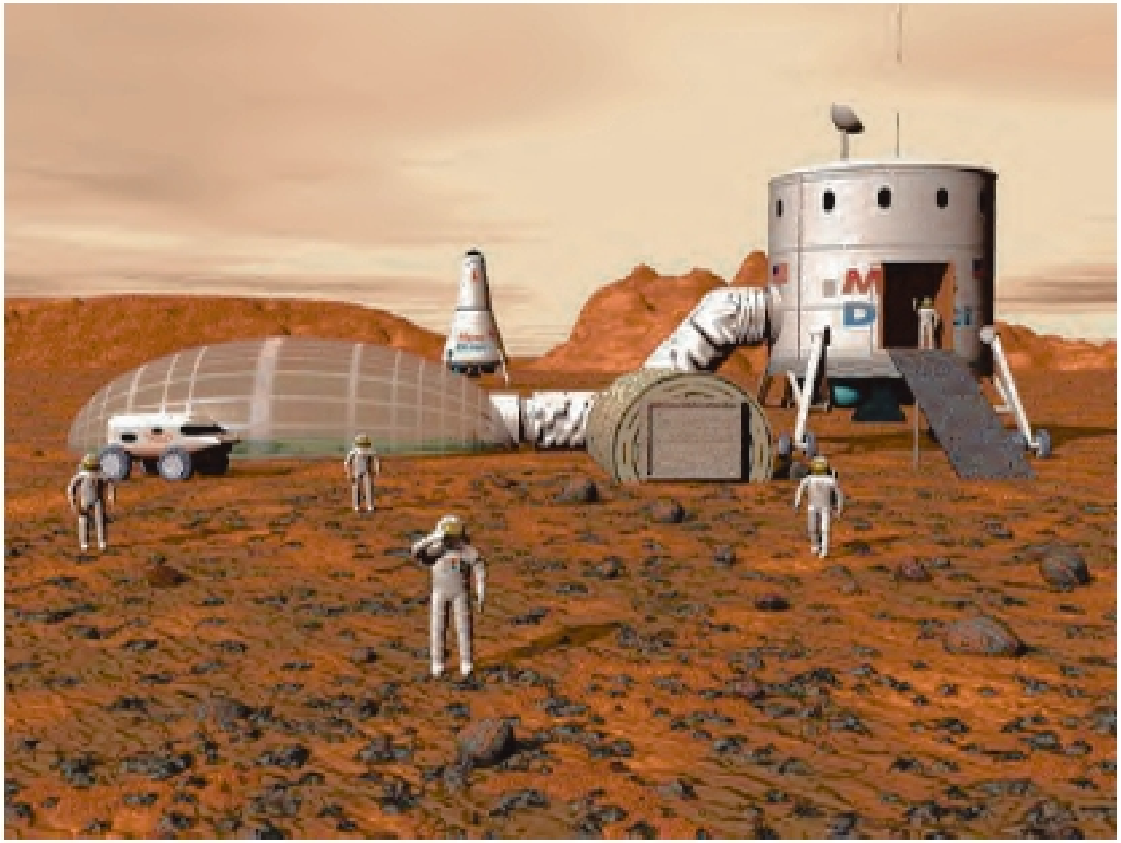
"Captain Nowak's drama played out in an airport parking lot. Imagine a comparable scene at a base on the Moon or on a spaceship to Mars."

The tragedy of Lisa Nowak. Editorial. *The New York Times*, February 8, 2007.

Humans to Mars

Supporting the Vision for Space Exploration

Winter 2005



The Mars Society
PO Box 273
Indian Hills, CO 80454
www.marssociety.org
Info@marssociety.org

Robert Zubrin
President of The Mars Society

"We could be on Mars in 10 years without a doubt."

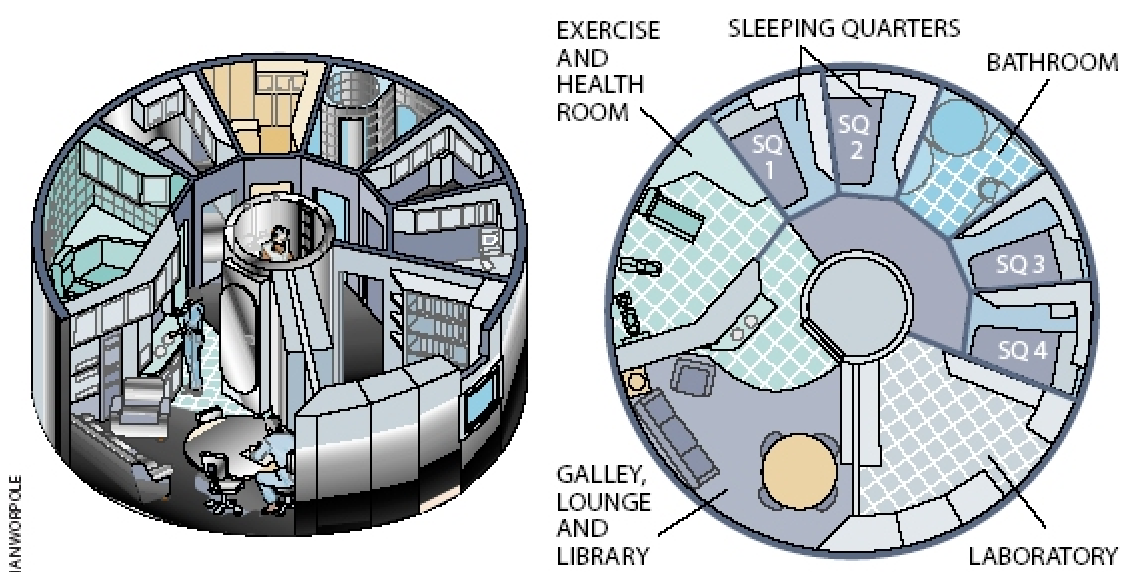
U.S. News & World Report, 12/8/2006

http://www.usnews.com/usnews/news/articles/061208/8nasa.htm

Mars Society: http://new.marsstuff.com/

THE MARS DIRECT PLAN

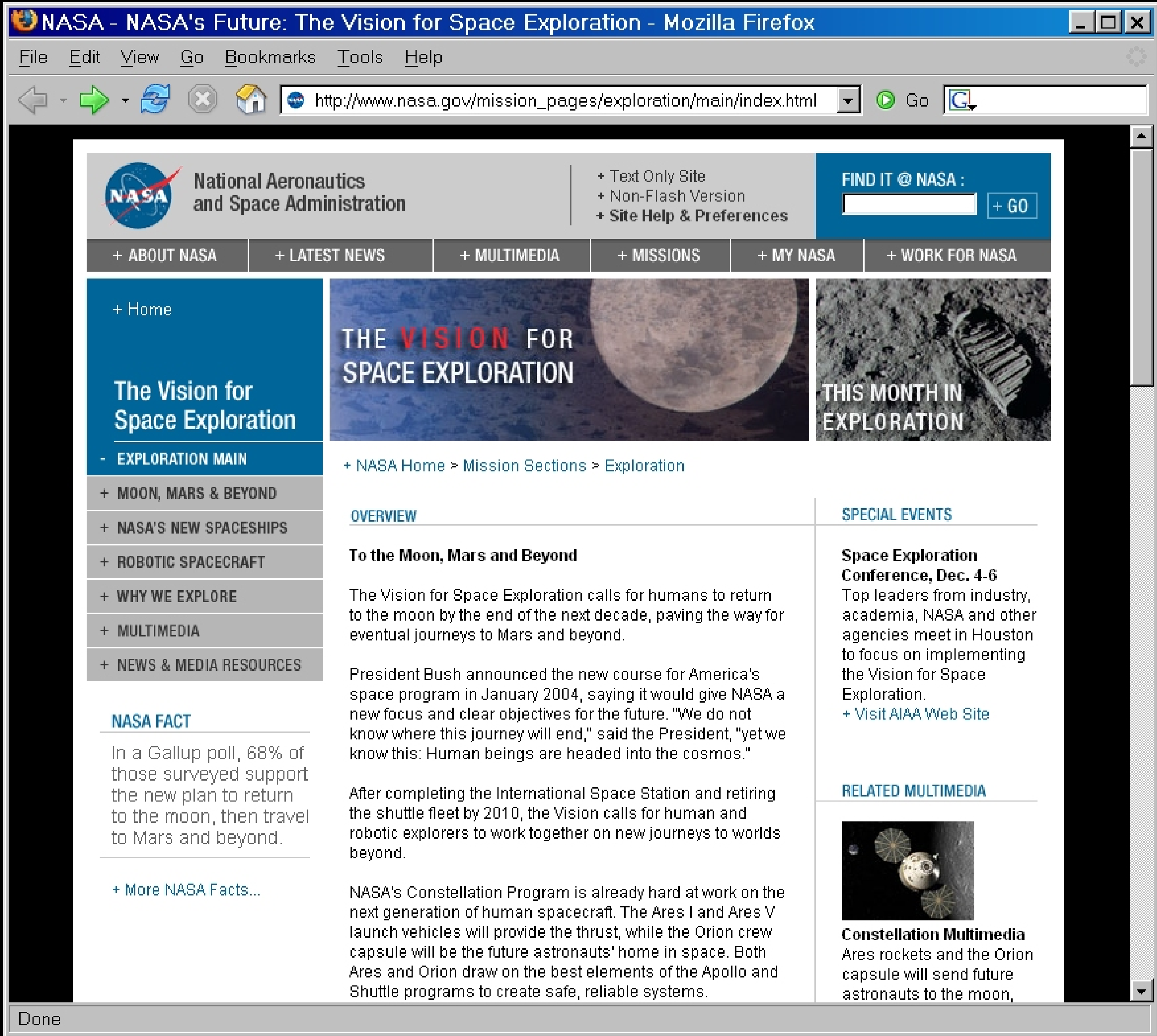
A leading advocate of manned missions to Mars, Robert Zubrin, outlines his relatively inexpensive plan to send astronauts to the Red Planet within a decade



HOME SWEET HOME in interplanetary space and on Mars might look like this. The upper deck of the habitat, shown here, would have sleeping quarters for four people as well as a laboratory, library, galley and gym. A solar-flare storm shelter would be located in the center. The lower deck (*not shown*) would serve as a garage, workshop and storage area. During the trip to Mars, a tether system could produce artificial gravity.

Zubrin, R. (2000). The Mars direct plan. *Scientific American*, *282*, 34-37.

[NASA Vision]


NASA - NASA's Future: The Vision for Space Exploration - Mozilla Firefox
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http://www.nasa.gov/mission_pages/exploration/main/index.html
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+ MISSIONS
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+ MOON, MARS & BEYOND
+ NASA'S NEW SPACESHIPS
+ ROBOTIC SPACECRAFT
+ WHY WE EXPLORE
+ MULTIMEDIA
+ NEWS & MEDIA RESOURCES
NASA FACT
In a Gallup poll, 68% of those surveyed support the new plan to return to the moon, then travel to Mars and beyond.
+ More NASA Facts...
THE VISION FOR SPACE EXPLORATION
THIS MONTH IN EXPLORATION
+ NASA Home > Mission Sections > Exploration
OVERVIEW
To the Moon, Mars and Beyond
The Vision for Space Exploration calls for humans to return to the moon by the end of the next decade, paving the way for eventual journeys to Mars and beyond.
President Bush announced the new course for America's space program in January 2004, saying it would give NASA a new focus and clear objectives for the future. "We do not know where this journey will end," said the President, "yet we know this: Human beings are headed into the cosmos."
After completing the International Space Station and retiring the shuttle fleet by 2010, the Vision calls for human and robotic explorers to work together on new journeys to worlds beyond.
NASA's Constellation Program is already hard at work on the next generation of human spacecraft. The Ares I and Ares V launch vehicles will provide the thrust, while the Orion crew capsule will be the future astronauts' home in space. Both Ares and Orion draw on the best elements of the Apollo and Shuttle programs to create safe, reliable systems.
SPECIAL EVENTS
Space Exploration Conference, Dec. 4-6
Top leaders from industry, academia, NASA and other agencies meet in Houston to focus on implementing the Vision for Space Exploration.
+ Visit AIAA Web Site
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Constellation Multimedia
Ares rockets and the Orion capsule will send future astronauts to the moon,
Done

Aim for Mars - What We Do | The Planetary Society - Mozilla Firefox

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http://www.planetary.org/programs/projects/aim_for_mars/

WHAT WE DO

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- PLANETARY RADIO
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Projects

Aim for Mars

In the summer of 2004 The Planetary Society launched Aim for Mars, a campaign to encourage and support a human mission to Mars. Aim for Mars included a letter-writing campaign, Congressional testimonies by Society officers, and groundbreaking studies demonstrating how a Mars mission can be accomplished within a realistic budget. Read here about The Planetary Society's multi-faceted campaign to send humans to the Red Planet.

SEND TO A FRIEND

The Planetary Society is going all-out to turn the Moon to Mars Vision into a reality!

Not satisfied with waiting in the wings for NASA and Congress to decide the future of space exploration, The Planetary Society has taken the initiative. In addition to our active grassroots campaign calling for human

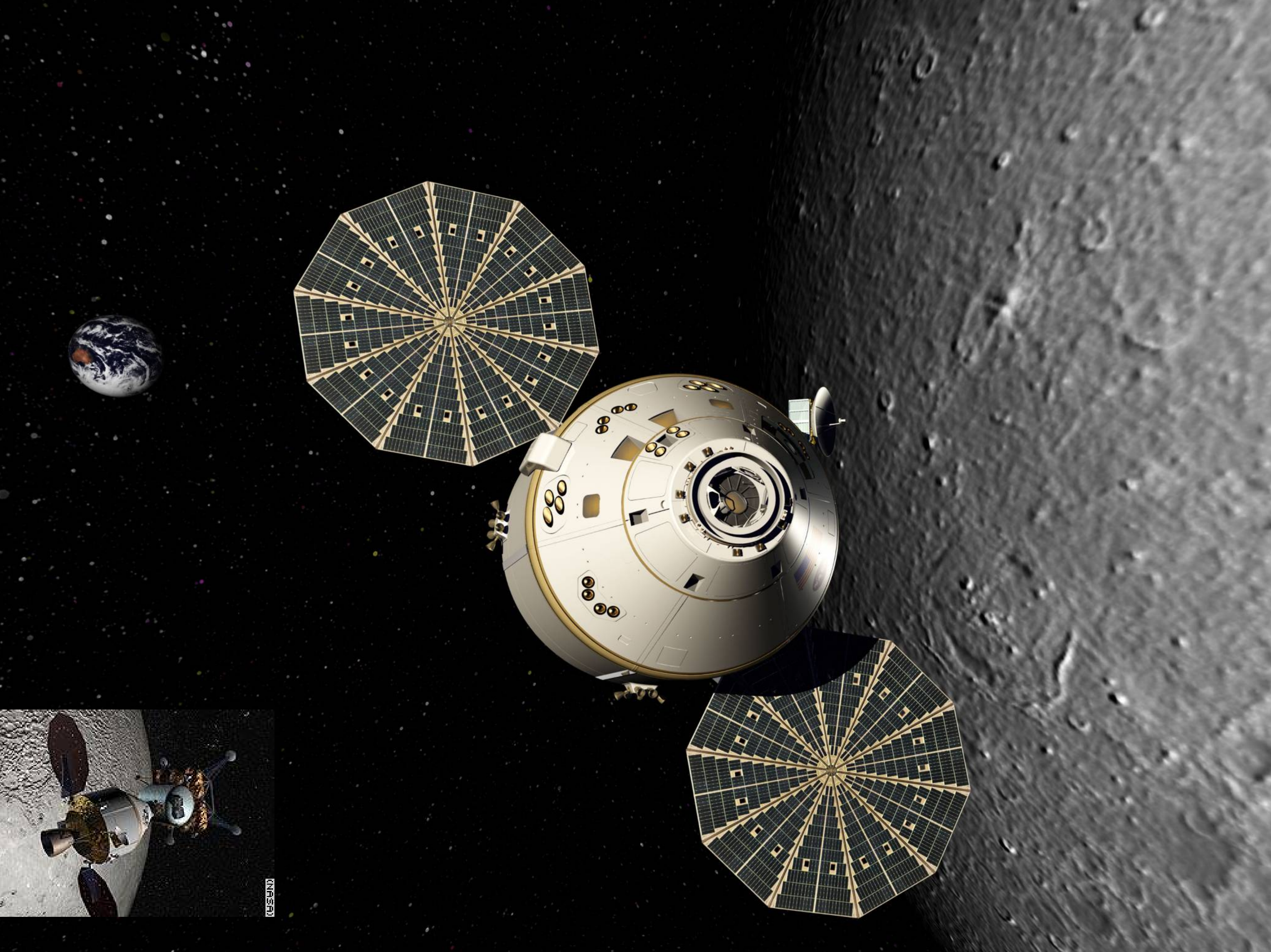
More On This Project

The Garriott-Griffin Report: "Extending Human Presence into the Solar System" [PDF]

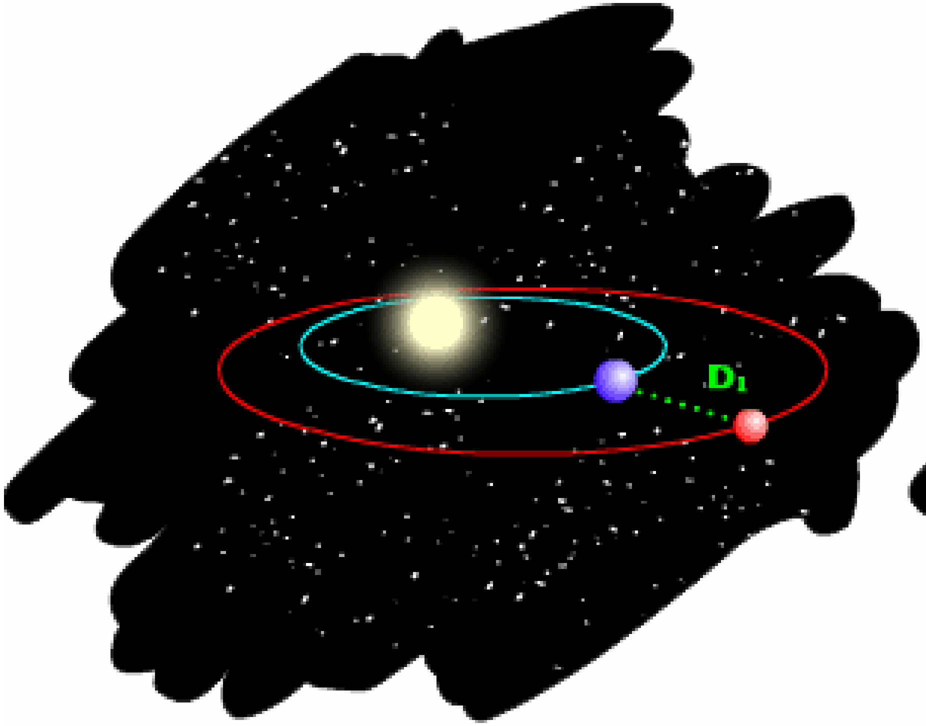
The Garriott-Griffin Report: July 2004

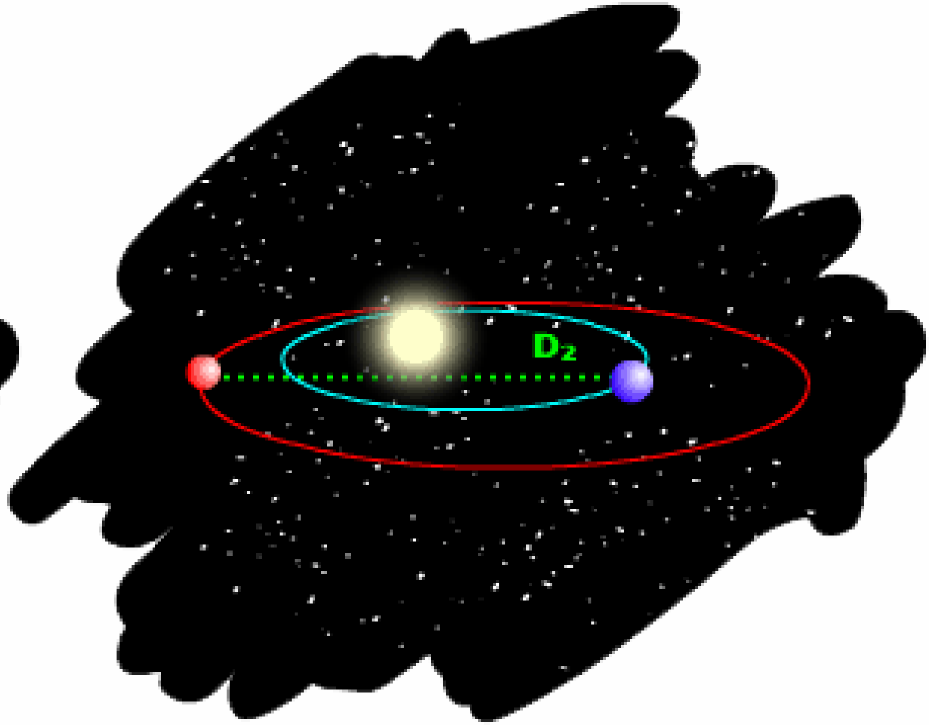
"We believe that human landings on the Moon or on Mars can begin about 2020."

http://www.planetary.org/programs/projects/aim_for_mars/study-report.pdf


(NASA)

How Far Is it?





D1 = 60,000,000 miles

D2 = 400,000,000 miles

How Long Will It Take?

- **High energy trajectory**
  - Outbound flight of 160-250 days
  - 60 days on the Martian surface
  - Return flight of 160-250 days
- **Low energy trajectory**
  - Outbound flight of 200-300 days
  - 400-500 days on the Martian surface
  - Return flight of 200-300 days

Manzey, D. (2004). Human missions to Mars: new psychological challenges and research issues. *Acta Astronautica*, *55*, 781-790.

Record Durations: Mir

- **Longest Stay:** Cosmonaut Valery Polyakov holds the record for the longest stay in orbit, **438 days**, 1994-1995. (n = 1)
- **Most Days on Mir:** Between his three separate missions to Mir, cosmonaut Sergei Avdeyev totaled **747 days** -- the longest total for any human staying in space.

http://liftoff.msfc.nasa.gov/news/2001/news-EndIsMir.asp

Why a Mars Mission Is Different

- Extremely long **distance** of travel
  - Unprecedented physical and psychological demands
- **Duration** of living under the dependence of automated life-support systems
- The **degree** of isolation, confinement, and social monotony
- **Impossibility** of short-term rescue in case of emergencies

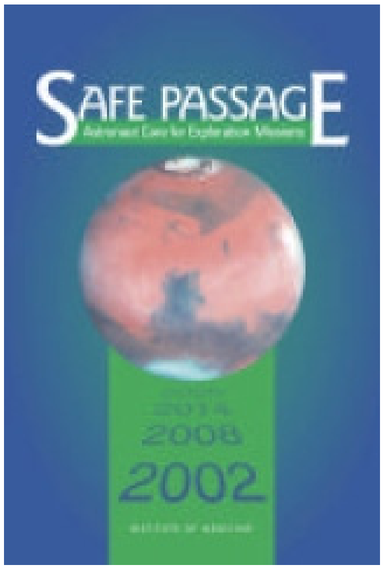
Kanas, N., & Manzey, D. (2003). *Space Psychology and Psychiatry*. Boston, MA: Kluwer Academic Publishers.

Safe Passage: Astronaut Care for Exploration-Missions (2001)

The basic findings of the committee are these:

1. **Not enough is yet known** about the risks to humans of long-duration missions, such as to Mars, or about what can effectively mitigate those risks to enable humans to travel and work safely in the environment of deep space
2. **Everything reasonable should be done** to gain the necessary information before humans are sent on missions of space exploration.

http://books.nap.edu/html/safe_passage/reportbrief.pdf


SAFE PASSAGE
2008
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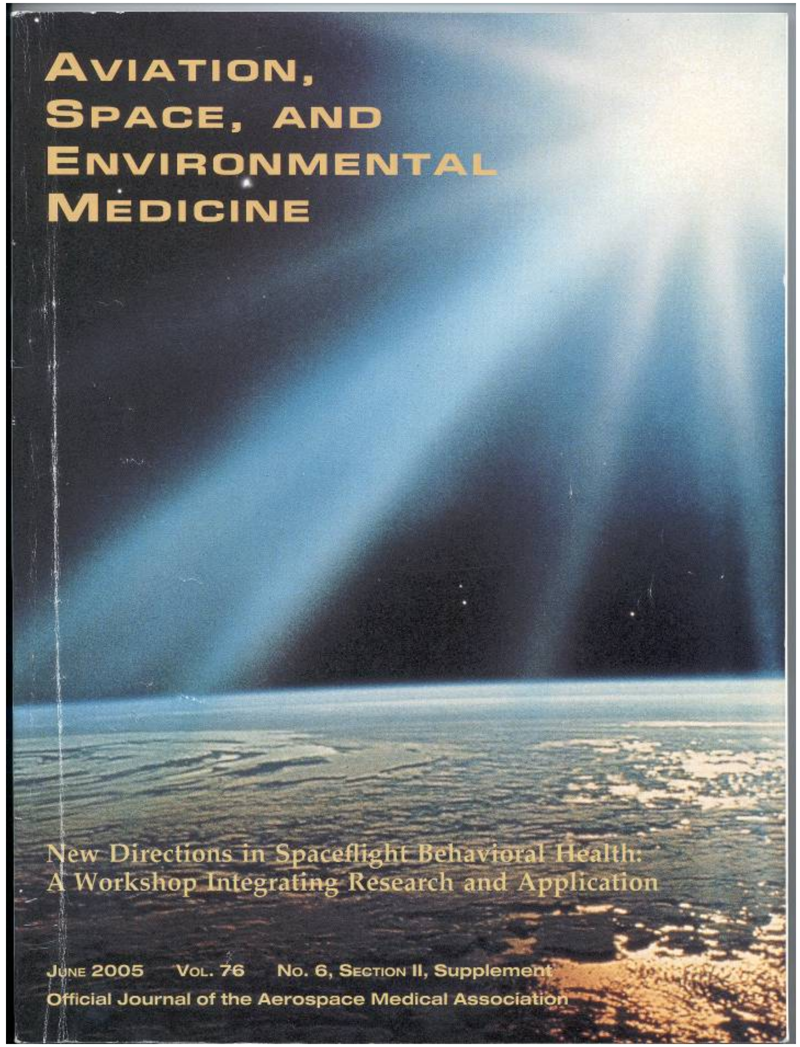
AVIATION, SPACE, AND ENVIRONMENTAL MEDICINE
New Directions in Spaceflight Behavioral Health:
A Workshop Integrating Research and Application
JUNE 2005 VOL. 76 NO. 6, SECTION II, Supplement
Official Journal of the Aerospace Medical Association

Conclusion?

Life in Space Will Not Be Easy

Countermeasures

- **Proactive**
  - Crew screening, selection, and training
  - Overcoming effects of radiation and microgravity
  - Work and habitat design, "as design is a critical strategy in ensuring behavioral health during extended-duration space missions" (Williams & Davis, 2005).
- **Reactive**
  - Medical emergencies
  - Depression and related emotional problems
  - Circadian desynchronization
  - Crew autonomy from mission control
  - Group fragmentation and interpersonal hostility
  - Loss of skilled performance

Williams, R.S., & Davis, J.R. (2005). *Aviation, Space, and Environmental Medicine*, *76*(6), Section II, B1-B2.

NASA's Bioastronautics Roadmap: http://bioastroroadmap.nasa.gov/User/risk.jsp

Countermeasure Caveat

- **Collaborations are easily compromised** among researchers, clinicians and operational support personnel, NASA program administrators, and the astronauts themselves at many levels.
- **There is no guarantee** that an evidenced-based countermeasure will be adopted or even considered for adoption.

Palinkas, L.A., Allred, C.A., & Landsverk, J.A. (2005). Models of research-operational collaboration for behavioral health in space. *Aviation, Space, and Environmental Medicine*, *76*(6), Section II, B52-B60.

Rationale for a New Approach

- "Our current psychological knowledge derived from orbital spaceflight and analogue environments is **not sufficient** to assess the specific risks of missions into outer space" (Manzey, 2004, p. 781).

Manzey, D. (2004). Human missions to Mars: new psychological challenges and research issues. *Acta Astronautica*, *55*, 781-790.

Rationale

- "The most severe stressors [after approximate 12 weeks] involve social monotony and boredom related to **hypoactivity and hypostimulation**, isolation of family and friends, and the restricted social contacts within a small crew" (Manzey, 2004, p. 784).

Manzey, D. (2004). Human missions to Mars: new psychological challenges and research issues. *Acta Astronautica*, *55*, 781-790.

Rationale

- "Data from space analogue settings and from LDM [long-duration mission] spaceflight suggest that **neither astronaut selection nor crewmember professionalism** will prevent all problems due to the psychosocial stressor that will arise in space crews" (Flynn, 2005, p. B45).

Flynn, C.F. (2005). An operational approach to long-duration mission behavioral health and performance factors. *Aviation, Space, and Environmental Medicine*, *76*(6), Section II, B42-B51.

Spaceflight Stages

1. Physiological and psychological adaptation to microgravity and onboard schedules (4-6 weeks).
2. Steady-state adaptation (6-12 weeks).
3. **Behavioral stress reactions (12+ weeks).**
   - **“Reactive countermeasures”**
4. End-of-mission euphoria

Manzey, D. (2004). Human missions to Mars: new psychological challenges and research issues. *Acta Astronautica*, *55*, 781-790.

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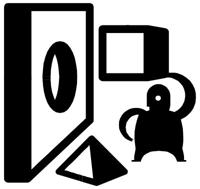
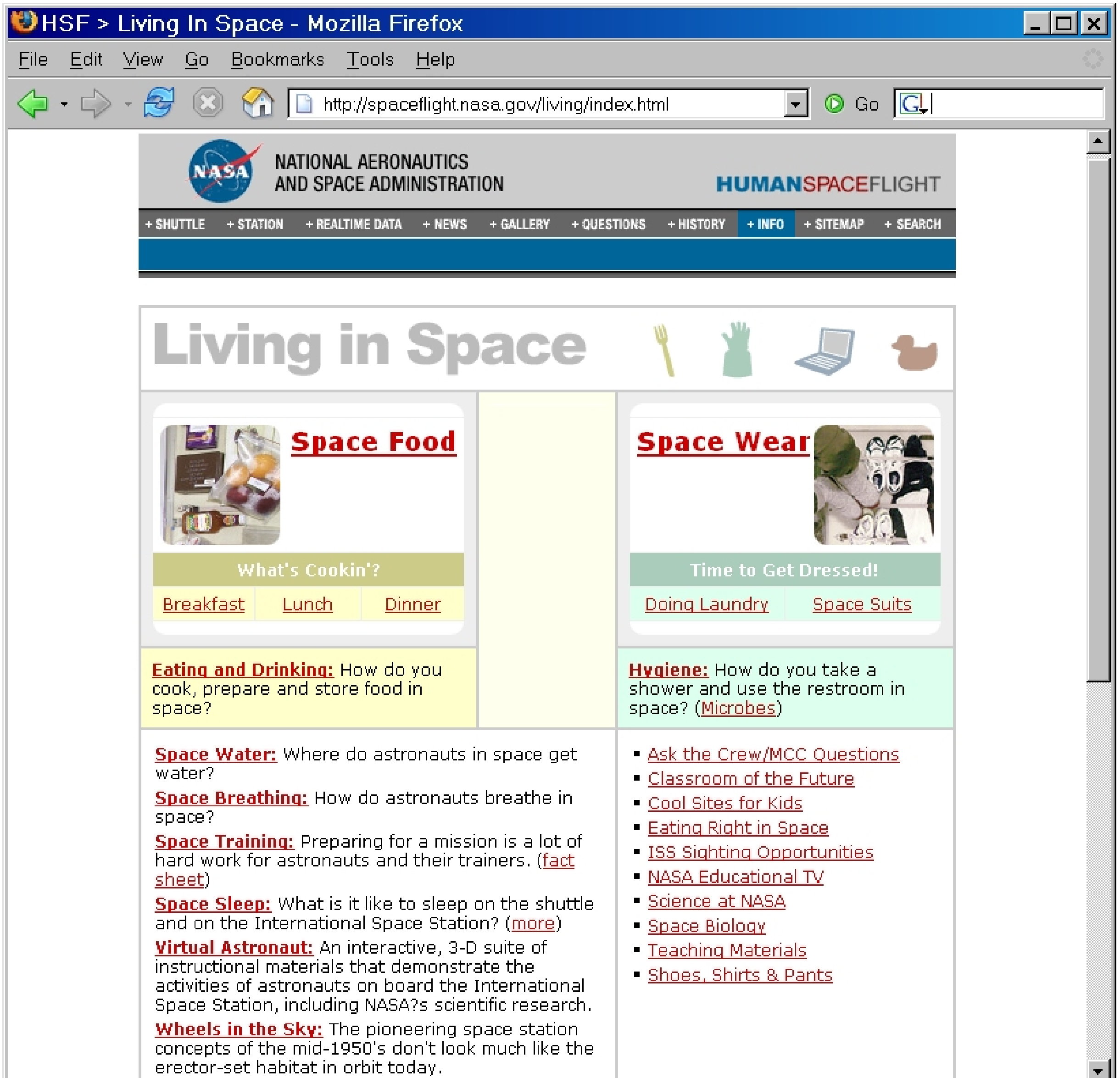
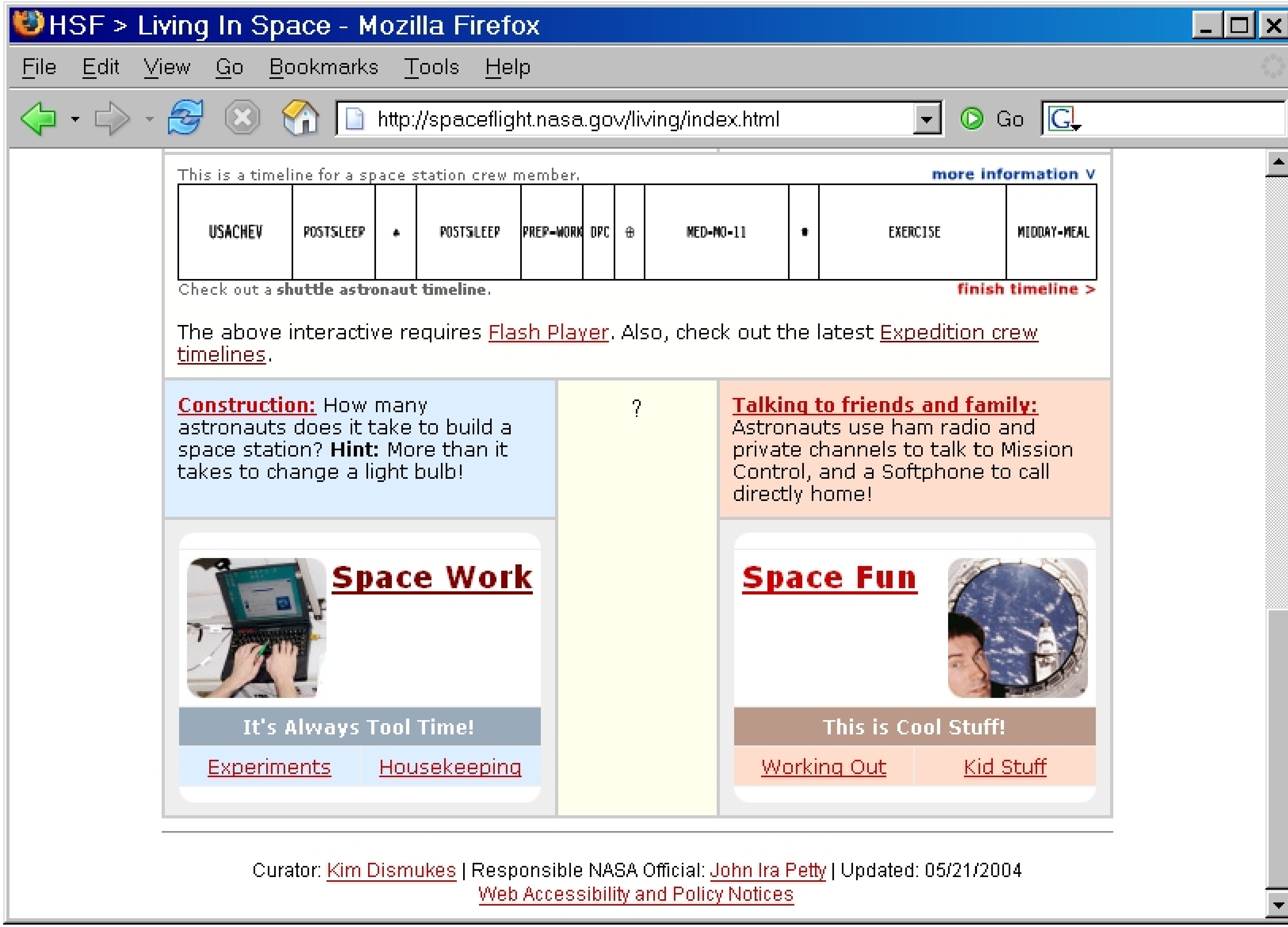
Relevance to a Mars Mission



Current Approach



Living in Space


HSF > Living In Space - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://spaceflight.nasa.gov/living/index.html
Go
This is a timeline for a space station crew member.
more information
USACHEV
POSTSLEEP
POSTSLEEP
PREP-WORK
DPC
MED-MO-11
EXERCISE
MIDDAY-MEAL
Check out a shuttle astronaut timeline.
finish timeline >
The above interactive requires Flash Player. Also, check out the latest Expedition crew timelines.
Construction: How many astronauts does it take to build a space station? Hint: More than it takes to change a light bulb!
Talking to friends and family: Astronauts use ham radio and private channels to talk to Mission Control, and a Softphone to call directly home!
Space Work
It's Always Tool Time!
Experiments
Housekeeping
Space Fun
This is Cool Stuff!
Working Out
Kid Stuff
Curator: Kim Dismukes | Responsible NASA Official: John Ira Petty | Updated: 05/21/2004
Web Accessibility and Policy Notices

“Behavioral Program”

Radiogram No. 4441u   Form 24 for 01/03/07

SETTING UP ВКЮ1,2 FAN CONTROL CONFIGURATION WITH БРУС (MANUAL FAN SPEED CONTROL UNIT)

GMT	CREW	ACTIVITY
06:00-06:10		Morning Inspection
06:10-06:40		Post-sleep
06:40-07:30		BREAKFAST
07:30-08:00	CDR, FE-2	Prep for Work
07:30-07:55	FE-1	
07:55-08:05		Switch VOZDUKH to the automatic control mode
08:05-08:20		Daily Planning Conference *(S-band)*
08:30-09:10	FE-1	Filling EDV [КОВ] for Elektron
08:40-09:10	CDR, FE-2	OGS Rack rotation to install OGS equipment
09:10-10:25		OGS H2/N2 Vent Hose Installation
09:10-09:40	FE-1	СОЖ Maintenance. *Verification of ИП-1 sensor position*
09:40-10:40		METEOROID. Dismantle MMK-2 Electronic Unit
10:25-10:40	CDR, FE-2	LAB1D1 (AV-2) rack rotation to install OGS equipment
10:40-11:10		LAB1P1 waste water hose connection

10:40-12:10	FE-1	Physical Exercise (TVIS) Day 4
11:10-11:25	CDR, FE-2	LAB1D1 (AV-2) rack reinstallation after OGS hardware installation
11:25-11:55		OGS and LAB1PD1 rack smoke detector reinstallation
12:10-13:40	CDR	Physical Exercise (CEVIS)
12:10-12:20	FE-1	Switching Vozdukh system to manual mode
12:20-14:00		Setting up ВКЮ1,2 Fan Control Configuration with the БРУС device. *Tagup with specialists (S-band)*
13:05-14:05	FE-2	Physical Exercise (RED)
13:40-14:05	CDR	Scheduled maintenance of Compound Specific Analyzer- Combustion Products (CSA-CP)
14:00-14:05	FE-1	**On MCC Go ISS O2** repress from Progress 357 СрПК (start)
14:05-15:05		LUNCH
15:05-15:20	FE-2	SLEEP - Actiwatch set up
15:05-15:10	CDR	Compound Specific Analyzer- Combustion Products (CSA-CP) spot check
15:05-15:10	FE-1	ISS O2 repress from Progress 357 СрПК (terminate)
15:10-17:30		Setting up ВКЮ 1, 2 Fan Control Configuration with БРУС device. *Tagup with specialists (S-band)*
15:20-16:00	FE-2	SLEEP - data upload and initialization of two Actiwatch devices
16:10-16:25		SLEEP - Actiwatch stow

Radiogram No. 4424u
CREW OFF-DUTY

Form 24 for 01/01/07

GMT	CREW	ACTIVITY
06:00-06:10	.	Morning inspection. **Inspection of circuit breaker [A3C] on DC1 Power Switch Panel (БВП) and fuses on БПП-30, БПП-36 in DC1**
06:10-06:40	.	Post-sleep
06:40-07:30	.	BREAKFAST
11:00-11:05	CDR	TVIS Weekly Maintenance
11:05-12:35	CDR	Physical Exercise (TVIS + CEVIS)
11:25-12:55	FE-1	Physical Exercise (TVIS), day 2
12:00-13:00	FE-2	Physical Exercise (RED)
12:55-13:00	FE-1	On MCC Go ISS O2 repress from Progress 357 СрПК (start)
13:00-14:00	.	LUNCH
14:00-14:05	FE-1	ISS O2 repress from Progress 357 СрПК (terminate)
14:05-14:35	FE-1	СОЖ maintenance
15:15-16:15	CDR	Physical Exercise (RED)
16:10-17:10	FE-1	Physical Exercise (VELO+RED) day 2
16:25-17:55	FE-2	Physical Exercise (CEVIS)
16:58-17:13	CDR	Private Family Conference *(S-band)*
17:55-18:00	FE-2	Payload status check
18:00-18:15	FE-2	Questionnaire - journal entry
18:10-18:15	CDR	Transfer TVIS/RED/CEVIS/HRM data to MEC
18:15-18:45	.	Evening work prep
18:45-19:00	.	Daily Planning Conference *(S-band)*
19:00-19:30	.	Evening work prep
19:30-20:00	.	DINNER
20:00-20:30	.	Daily Food Prep
20:30-21:30	.	Pre-sleep
21:30-06:00	.	SLEEP
Task List	FE-1	Sigma s/w application adjustment

Today, we are celebrating the New Year with you at MCC!

Background to a New Approach

BEHAVIORAL HEALTH REQUIREMENTS—BRADY

Fig. 4. Chimpanzee training device for animal pretest flights of Project Mercury. Personal collection of the author.

Brady, J.V. (2005). Behavioral health: the propaedeutic requirement. *Aviation, Space, and Environmental Medicine*, *76*(6), Section II, B13-B24.

AN EXPERIMENTAL OUTLINE FOR BUILDING AND EXPLORING MULTI-OPERANT BEHAVIOR REPERTOIRES

JACK D. FINDLEY[1, 2]

LABORATORY OF PSYCHOPHARMACOLOGY AND INSTITUTE FOR BEHAVIORAL RESEARCH

UNIVERSITY OF MARYLAND

Although theorists may be found in frequent controversy, experimenters differ in their approach to behavior, and data are sometimes ambiguous or subject to debate, the experimental organism is always right. His behavior is real, lawful, and always appropriate to the instantaneous conditions of his internal and external environments. It is basically the experimenter's job to gain control over those environmental conditions.

In the laboratory, the experimenter emits a variety of behavior and then attempts to relate changes in his behavior with changes in the behavior of the organism under study. The ideal result of such interactions is the statement of definitive relationships which ultimately give rise to what is called "understanding of behavior." Unfortunately, however, we do not have definitive statements or relationships giving us an understanding of what behavior on the part of the experimenter most effectively generates relationships acceptable to the body of behavioral science. Although they are not observed under controlled conditions, variations in behavior from one experimenter to another, or within a given experimenter, suggest that he can state definitive relationships between himself and his organism only insofar as he is able to control and manipulate the relevant environmental conditions. Yet, only occasionally is the experimenter's primary effort to gain control and to manipulate. To do so, in fact, is often punished by other experimenters and theorists. The occasion for punishment would seem particularly strong when the gains in control are substantial and when the interaction between the experimenter and his organism does not immediately result in definitive relationships, but only suggests feasible ones in terms inadequate for conventional language and conceptual analysis. In spite of the occasional punishment for efforts primarily directed at bringing more of an organism's behavior under experimental control and subject to manipulation, we know that such efforts always set the occasion for the obtaining of definitive relationships; and, moreover, that somehow this behavior is maintained.

The material to follow represents, in part, the results of several years of laboratory effort in which the pursuit of behavioral control progressively took precedence over the statement of problems and answers, and in which it was often pursued in their absence. The major result of this effort has been a demonstration that it is feasible to build, describe, and manipulate complex samples of behavior under controlled conditions, on a scale limited only by our individual laboratory behavior. It has been the argument of this section that to do so is in many ways basic to the building of a science of behavior. The following sections are concerned with: first, the nature of multi-operant behavior and general problems of its establishment and analysis; second, the conceptual and notational description of multi-operant behavior; and, finally, the reporting of the laboratory story which largely generated the notions and points of view presented below.

PART I: THE NATURE OF MULTI-OPERANT BEHAVIOR AND PROBLEMS OF ITS ESTABLISHMENT AND ANALYSIS

The continuous nature of an organism's behavior has long been recognized; yet, equally well acknowledged is the argument that behavior can not be studied experimentally in its entirety, but must be broken into units of special attention. These analytical activities are ultimately justified in that the process occasionally results in useful suggestions relevant to the control of particular behaviors, and, also, that it aids in the formulation of a more sophisticated picture of the entire behavioral process.

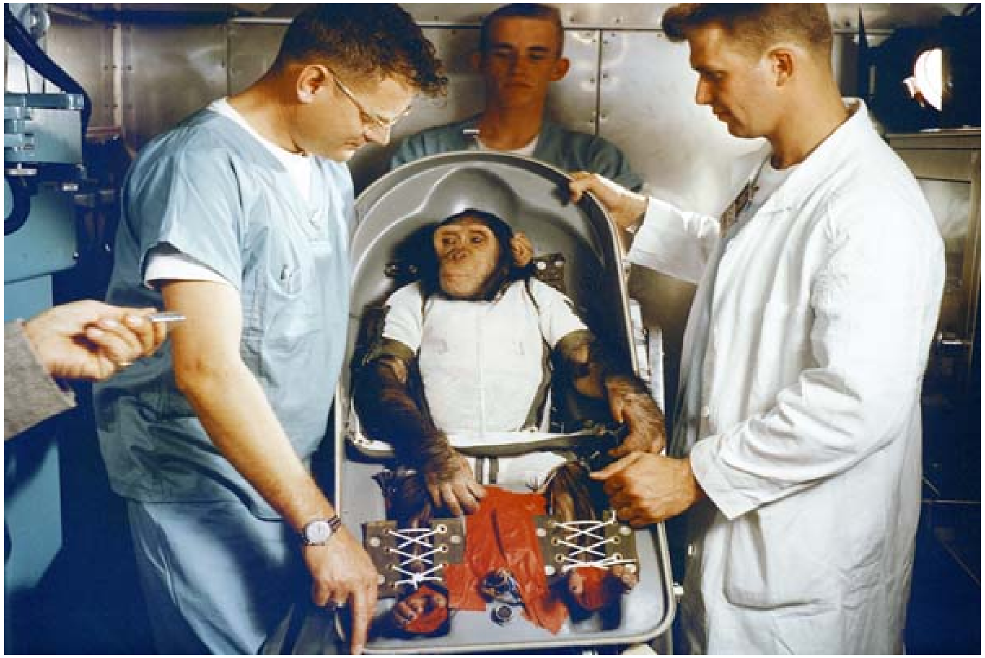
Current experimental analyses of operant behavior suggest a view of the behavior process in which specific operants under the control of numerous classes of variables are emitted one after another. Thus, one sort of behavior is followed by another in a continuous and flowing manner due to the consequences of each segment giving rise to the special conditions controlling the next. A more specific picture of the overall behavioral process is, for the most part, unavailable. This "conceptual vacuum" is perhaps most readily accounted for by our failure to establish larger samples of behavior in the laboratory under well-controlled conditions. Thus, our history of behavioral science reflects, on the one hand, rather casual observation of extensive and naturalistic samples of behavior, and, on the other, the careful experimental analysis of limited and specific operants. Fortunately,

[1]Supported in part by Grant MY-1604 from the National Institute of Mental Health to the University of Maryland.

[2]The author would like to express his appreciation for the generous encouragement of Dr. J. V. Brady.

Findley, J.D. (1962). An experimental outline for building and exploring multi-operant behavior repertoires. *Journal of the Experimental Analysis of Behavior*, *5*, 113-166.

Ham



- **Image Name:** Chimpanzee Ham in the Flight Couch for the Mercury-Redstone 2 (MR-2) flight Image
- **Description:** Chimpanzee Ham in his Flight Couch for the Mercury-Redstone 2 (MR-2) suborbital test flight.
- **On January 31, 1961**, a Mercury-Redstone launch from Cape Canaveral carried Ham over 640 kilometers down range in an arching trajectory that reached a peak of 254 kilometers above Earth.
- Mission:+ Mercury 2
- Experiment Title:+ Project Mercury Ballistic and Orbital Chimpanzee Flights (CHIMP)

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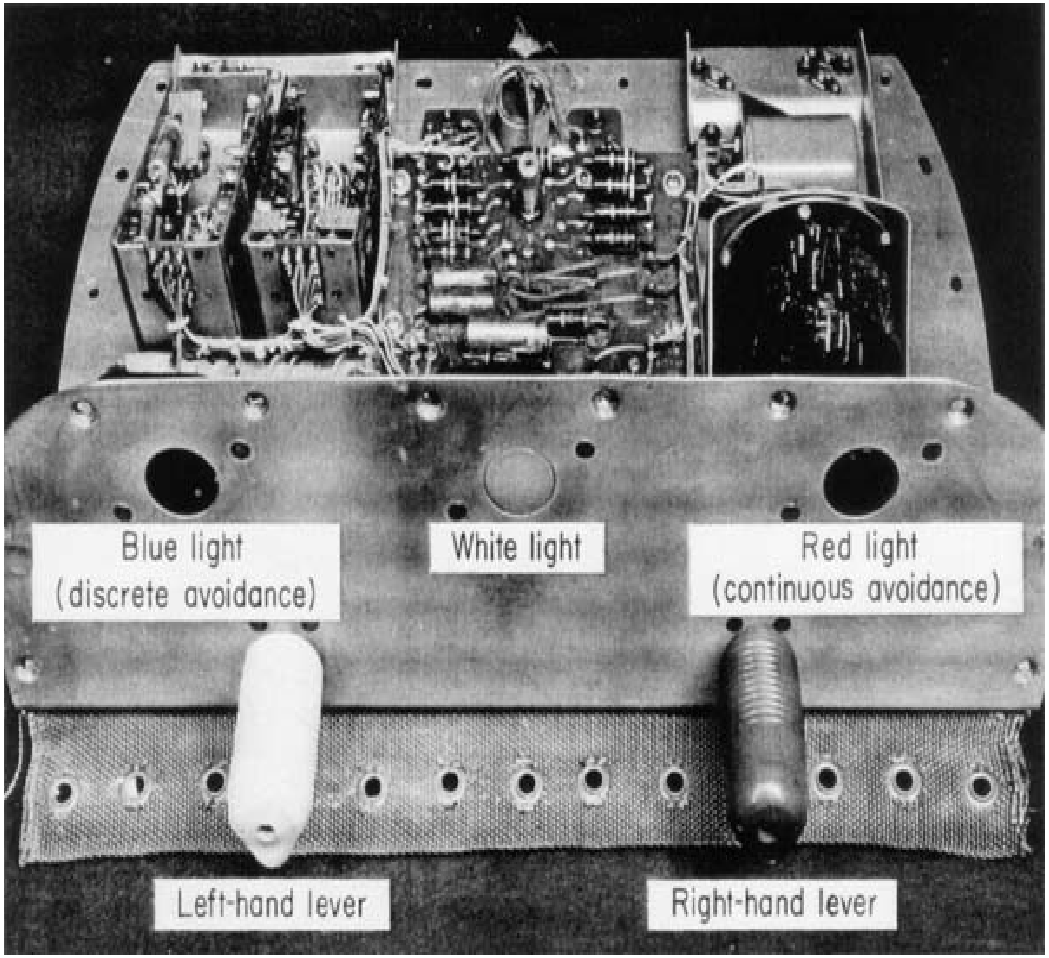
Performance Test Apparatus



- **Image Name:** Mercury-Redstone 2 (MR-2) Performance Test Apparatus
- **Image Description:** Image of the Mercury-Redstone 2 (MR-2) ballistic flight Performance Test Apparatus.
- **Mission:** Mercury 2
- **Experiment Title:** Project Mercury Ballistic and Orbital Chimpanzee Flights (CHIMP)
- **Payload:** Mercury 2 (Mercury 2)
- **Research Area:** Behavior and performance
- **Keyword:** Animals in space Hardware
- **Hardware:** Performance Test Apparatus

http://lsda.jsc.nasa.gov/scripts/photoGallery/detail_result.cfm?image_id=1817

Some Effects of Short-Duration Spaceflight: Salutogenic Consequences

- **Image Name:** Chimpanzee Ham after the successful Mercury-Redstone 2 (MR-2) suborbital flight
- **Image Description:** Close-up view of the chimpanzee Ham, the live test subject for Mercury-Redstone 2 (MR-2) test flight, being fed an apple. This photo was taken after his successful recovery from the Atlantic Ocean. Note that he is still strapped into his special Flight Couch.

http://lsda.jsc.nasa.gov/scripts/photoGallery/detail_result.cfm?image_id=1804

Behavior analysis provides the context for conceptualizing multi-operant performance repertoires. The extension, ultimately, to space dwelling microsocieties follows the method of “systematic replication” (Sidman, 1960). What is demonstrably effective in one setting is applied to another as a test of effectiveness and generality of process.

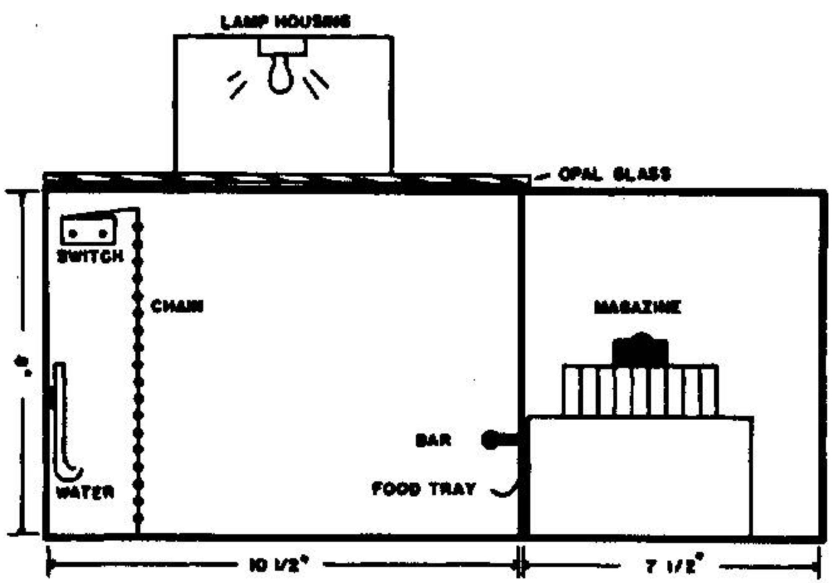
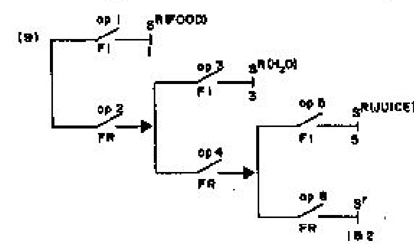


Fig. 1. Experimental chamber used with two-operant chaining procedure.

Sidman, M. (1960). *Tactics of Scientific Research*. New York: Basic Books.

for 1 (a). The failure of the organism to select the operant in each option which matches the stimulus properties of the operant producing the option leads to a timed-out condition and reinstatement of that part of the grove.

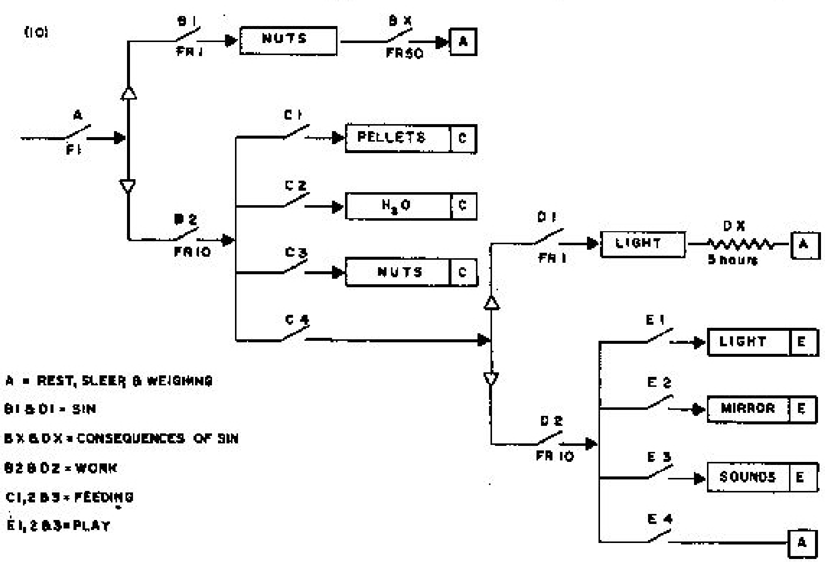
Grove (8) is composed of several trees and provides for the production of four different reinforcement conditions. The delivery of each reinforcement is followed by reinstatement of the conditions for operant 1. Numerous possibilities exist for different sequences by alteration of the reinforcement conditions. For example, if both operants 4 and 5 produced food, operant 4 could be arranged to reinstate operant 2 and operant 5 to reinstate operant 1. Such an arrangement could be used to compartmentalize the behavior associated with reinforcers of a given type and thus circumvent the necessity of going through the entire sequence for each primary reinforcement.

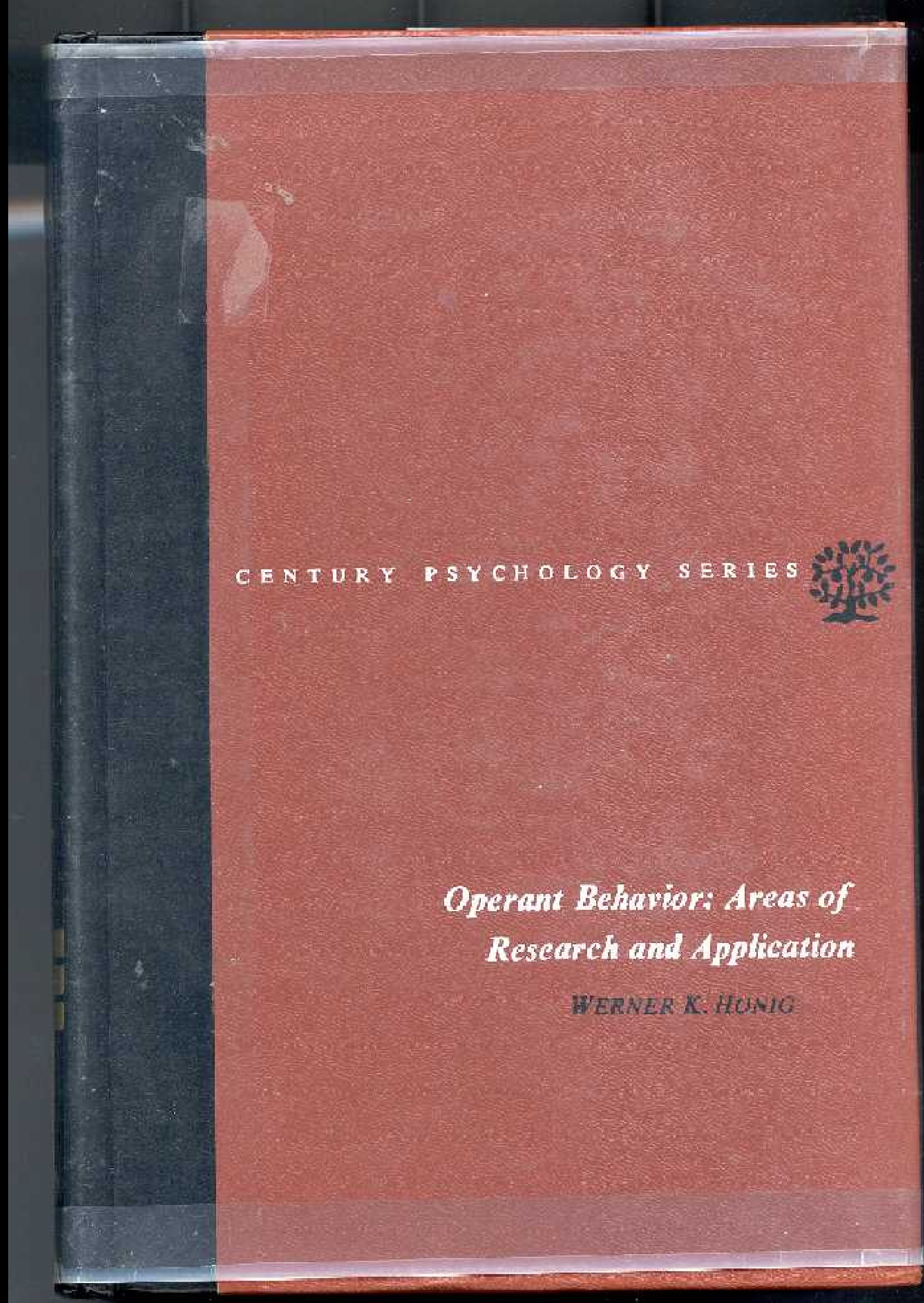


Behavior grove (9) is composed of trees in which one operant is common both to the preceding option and the subsequent tree. Thus, in this grove, operant 1 produces food and reinstates only itself. Operant 2 is concurrently in effect with operant 1, but its only function is the production of the subsequent option. Although this type of grove suggests some similarities with a multiple-schedule procedure, the translation of conditions from one reinforced operant to the next is under the organism's control via the specific operants 2, 4, and 6. It is also similar in some respects to the grove in example (5), but it allows the progression of operants to flow in only one direction.

In most of the illustrations of the present system presented above, emphasis has been placed upon the more or less detailed description of behavior samples. The example grove (10) is included to illustrate an extension of the system to still larger repertoires of behavior. In this case, the meaning of the symbolization is more general. Capital letters designate not operants, but behaviors which might be composed of many operants and described in detail separately. Special reinforcement and reinstatement conditions are described with words or with letters and enclosed in boxes.

In this example, the behavior A is considered to be restricted to a special chamber where the organism




CENTURY PSYCHOLOGY SERIES
Operant Behavior: Areas of
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WERNER K. HONIG

A LONG-TERM STUDY OF HUMAN PERFORMANCE IN A CONTINUOUSLY PROGRAMMED EXPERIMENTAL ENVIRONMENT

Jack D. Findley, Bernard M. Migler, and Joseph V. Brady

November, 1963

University of Maryland

Institute for Behavioral Research

and

Walter Reed Army Institute of Research

http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19640001916_1964001916.pdf

19

Programmed Environments for the Experimental Analysis of Human Behavior

Jack D. Findley

INTRODUCTION AND RATIONALE

Although a behavioral determinism would seem to be widely accepted in principle, its full expression is not readily found in laboratory research with humans. Indeed, experimental work with humans aimed at a basic behavioral analysis has long been constrained. Unfortunately, determinism as a system, and its resultant body of information, is severely limited without the support of good laboratory operations. Furthermore, a laboratory in which known relevant variables cannot be freely manipulated is not very likely to yield powerful information or uncover important new principles. All such constraints unduly impede the progress of a behavioral science. I would like to suggest that there is currently only a very limited experimental analysis of basic human behavior, and, furthermore, that its progress is unduly slow in view of the knowledge and technology at hand. Although the slow pace is no doubt due to several factors, I think they reduce in large measure to a new kind of entrenched secularism which overemphasizes an understanding of man in the world as we now know it. For example, in studying sleep behavior, it is usually assumed implicitly that man must function in an environment with 24-hour days. Not only is such an assumption erroneous, but it is not even drawn from information suggesting 24-hour days to be most desirable. In studying motivations, as another example, the concern is usually with the existing and familiar, rather than with an effort to devise experimental conditions which would establish new and quite different motivations for orderly dissection. Likewise, in studying marital relations, economic behaviors, and social interaction, the orientation is always toward the existing system and never toward an experimental one.

827

Findley, J.D. (1966). Programmed environments for the experimental analysis of human behavior. In W.K. Honig (Ed.). *Operant Behavior: Areas of Research and Application* (pp. 827-848). Englewood Cliffs, NJ: Prentice-Hall, Inc.

EPA 2007

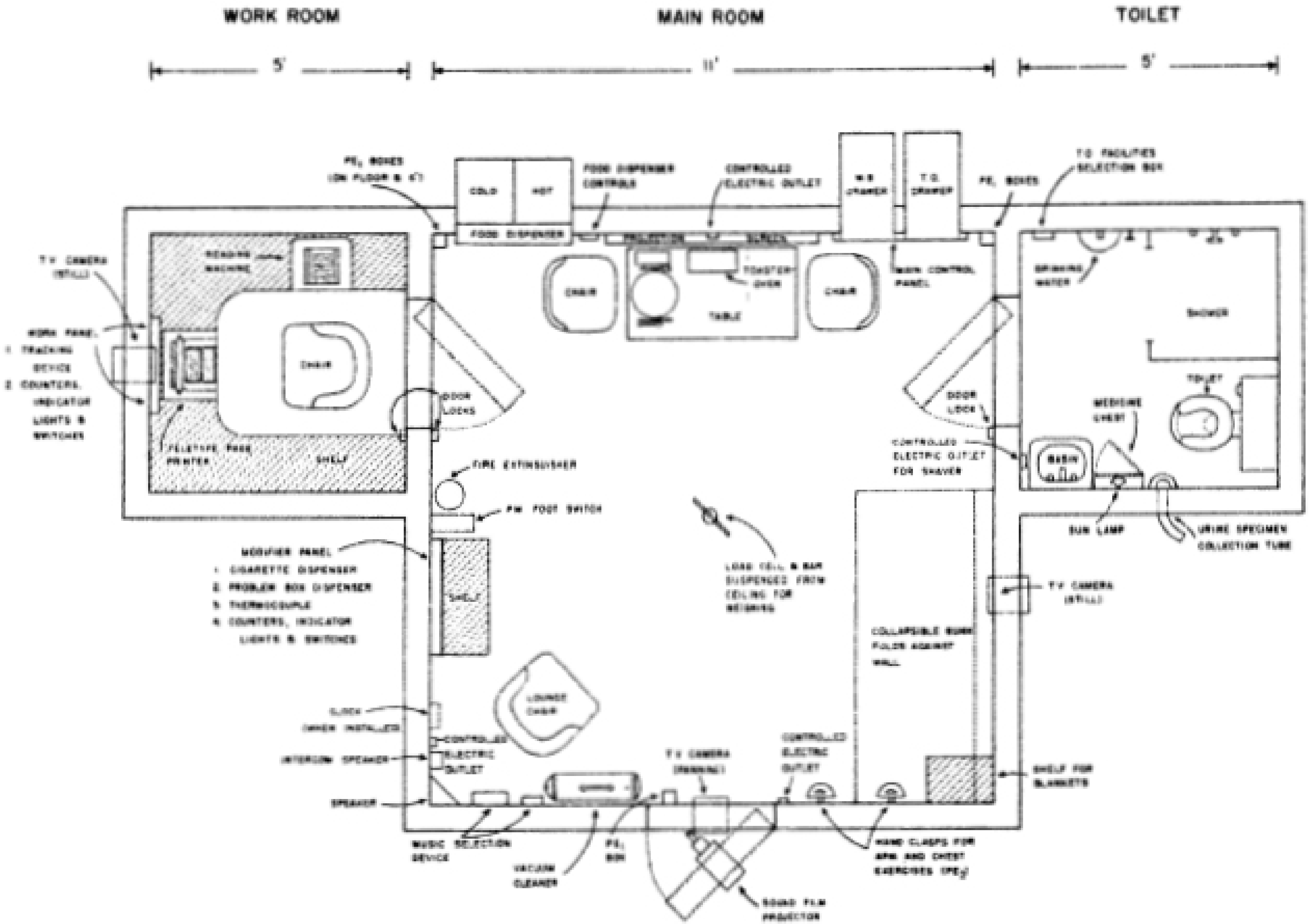
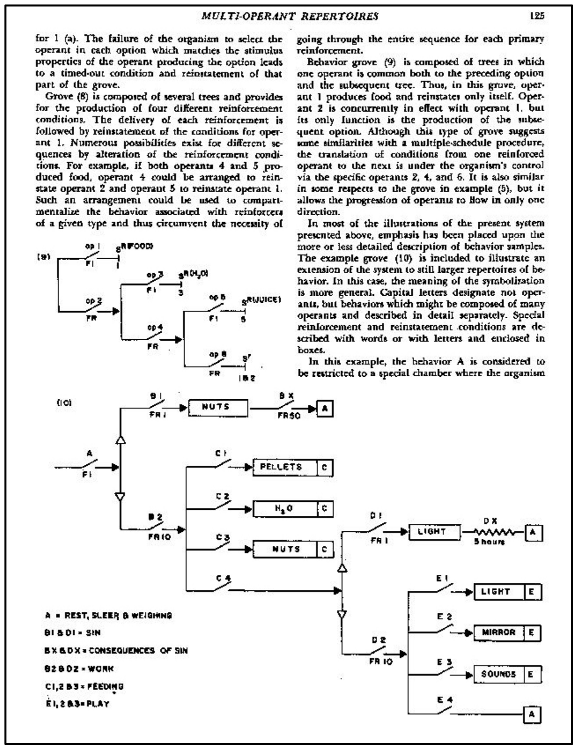


Fig 1. Diagram of experimental chamber showing furnishings and facilities in each room.

Findley, J.D., Migler, B.M., & Brady, J.V. (1963). A long-term study of human performance in a continuously programmed experimental environment. Technical Report NASA. p. 12. http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19640001916_1964001916.pdf

Behavioral program supporting a single resident of a programmed environment for 152 days. The multi-operant features are determined by activity alternatives at the transition points.



for 1 (a). The failure of the organism to select the operant in each option which matches the stimulus properties of the operant producing the option leads to a timed-out condition and reinstatement of that part of the grove.

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Systematic Replication

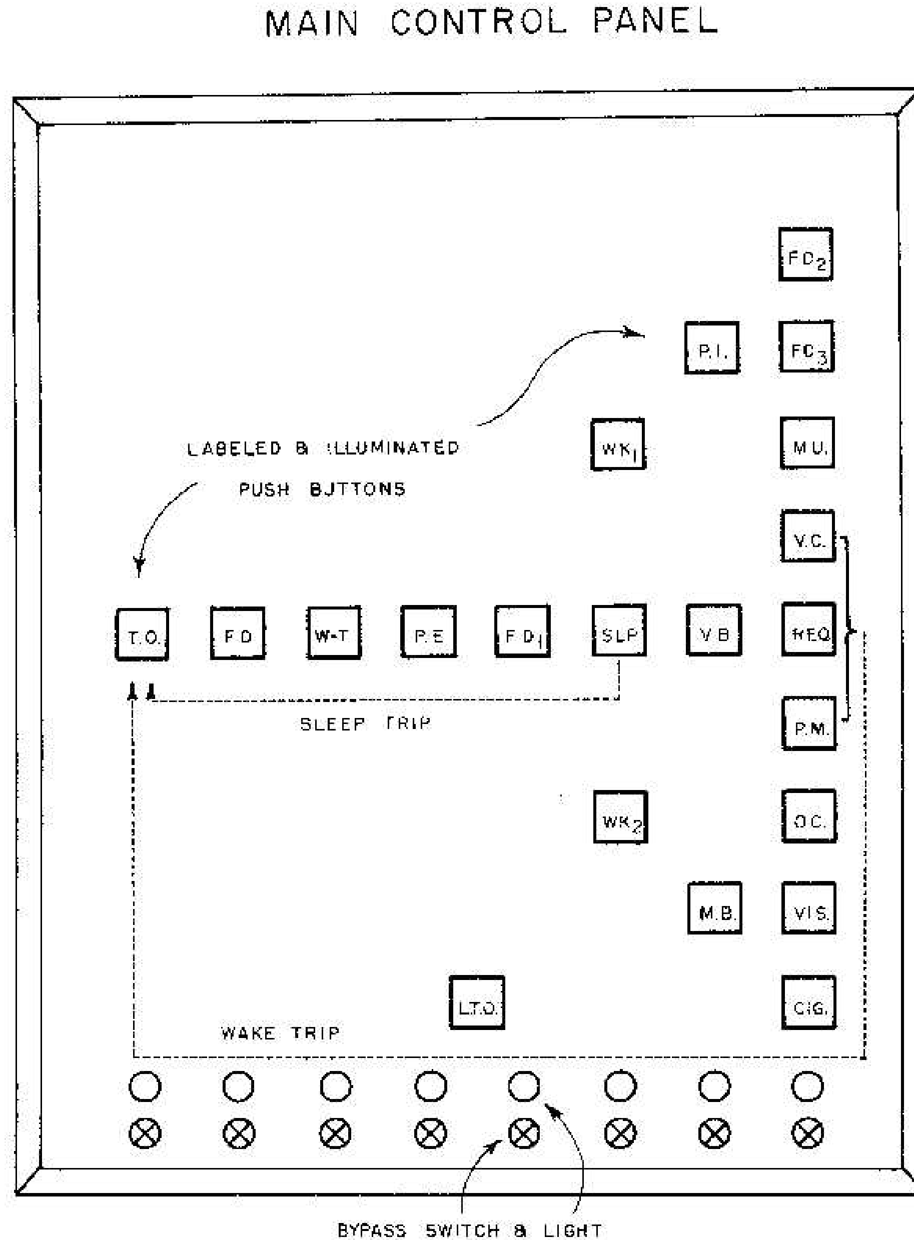
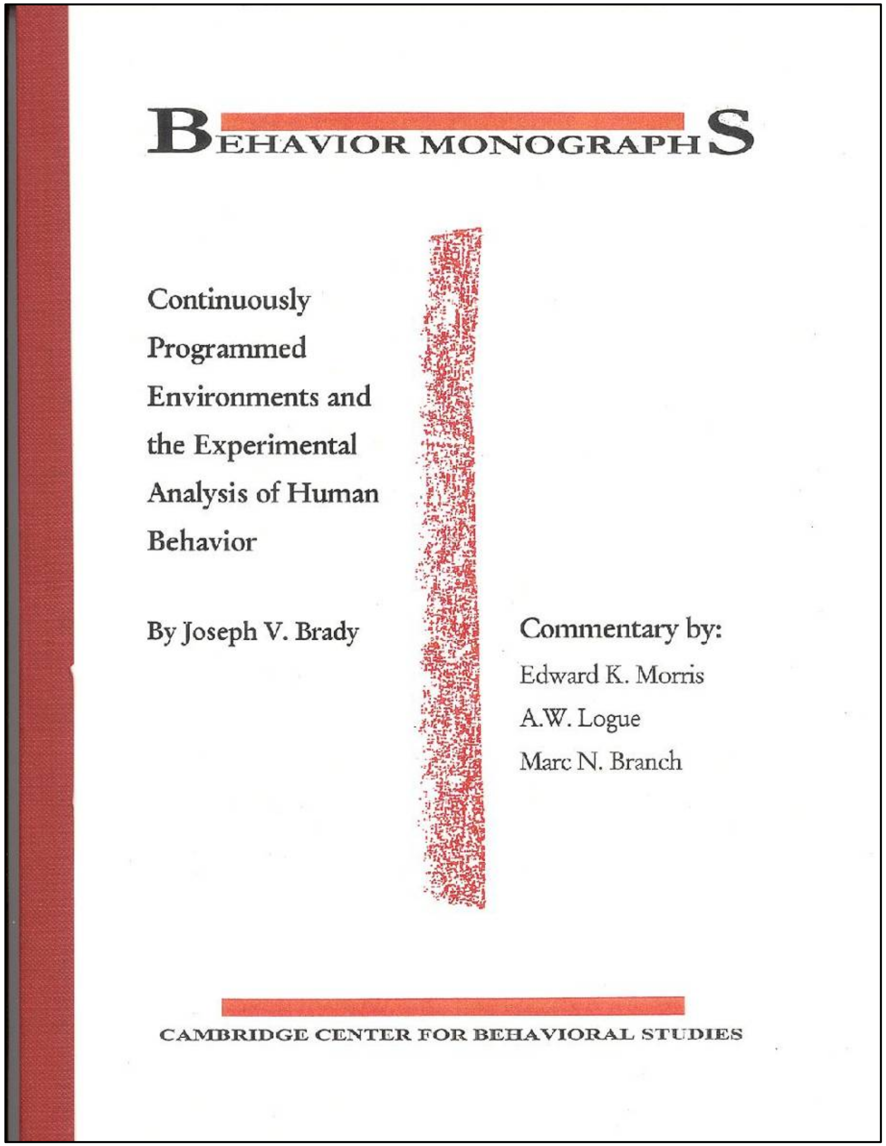


Figure 1. Main control panel containing push buttons that could be illuminated red or green. Each button is labeled with the abbreviations of the activity represented. "Wake Trips" and "Sleep Trips" are indicated by arrows.



BEHAVIOR MONOGRAPHS

Continuously Programmed Environments and the Experimental Analysis of Human Behavior

By Joseph V. Brady

Commentary by:
Edward K. Morris
A.W. Logue
Marc N. Branch

CAMBRIDGE CENTER FOR BEHAVIORAL STUDIES

Behavioral Health: The Propaedeutic Requirement

JOSEPH V. BRADY

BRADY JV. *Behavioral health: the propaedeutic requirement.* Aviat Space Environ Med 2005; 76(6, Suppl.):B13–24.

Concern about the behavioral effects of spaceflight can be traced back a half century to the earliest preparatory bioastronautics experiments in the mid-1950s. A central focus of the first primate suborbital flights, as well as the orbital chimpanzee pretest flights of Project Mercury, was the effects of such stressful ventures on the learned performances of these space behavioral health pioneers. The hiatus in spaceflight behavioral health experimental investments that followed these early initiatives began with the advent of the 'human astronaut' era of the mid-1960s, and has dominated the last several decades. Contemporary concerns in this regard have most recently been articulated by a turn-of-the century Committee of the Institute of Medicine, National Academy of Sciences, providing a visionary view of space medicine during travel beyond Earth orbit. This 2-yr study focused on those most complex behavioral health interactions involving humans in extreme, isolated, and confined microsocieties—areas that have not received the necessary level of attention. The evident behavioral health issues raised by the prospect of long-duration exploratory missions beyond Earth orbit, including performance and general living conditions, recovery and support systems, and the screening, selection, and training of candidate participants are reviewed and discussed.

Keywords: behavioral health, long-duration spaceflight missions, confined microsocieties, beyond Earth orbit, extreme isolated environments, learned performance.

THE BEHAVIORAL effects of space travel were among the primary concerns of the earliest preparatory bioastronautics spaceflight experiments during the late 1950s and early 1960s. The Russian Sputnik II experiment with the dog Laika in November 1957, for example, provided the first telemetered activity data on a living organism in the space environment, though failure of the life support system made it impossible for the animal to survive more than the first few days of the extended 5-mo orbital expedition (19). In the following year (1958), however, the first two behaviorally trained primates, Able and Baker, were launched in the nose cone of a rocket (**Fig. 1**) on an American bioastronautics spaceflight experiment. This suborbital flight was undertaken on the initiative of Dr. Wernher von Braun, Director of the Army Ballistic Missile Agency in Huntsville, AL, in collaboration with behavioral scientists at the Neuropsychiatry Laboratories of the Walter Reed Army Institute of Research in Washington, DC (11). Not only did the two rhesus monkeys endure launch in their insulated restraining couches (**Fig. 2**) and meet the pretraining performance requirements established before experiencing the 300+ mile trajectory at speeds in excess of several thousand mph, but they survived reentry as well with minimal compromise of either their behavioral or physiological integrity (**Fig. 3**).

This early focus on the behavioral effects of spaceflight was perhaps most evident in the 1961 animal pretest flights for Project Mercury with the chimpanzees Ham and Enoch*. The planning for these flights coincided with the establishment of the National Aeronautics and Space Administration (NASA) in the late 1950s and was initiated in the course of meetings with Department of Defense representatives at Langley Field, VA. Operational responsibility for these animal pretest flights was assigned to the military services since NASA had few resources available for such an undertaking at this early stage of its existence. At these early planning meetings, both the Air Force, represented by General Donald Flickenger, and the Navy, represented by Captain Ashton Graybiel, were quite receptive to participating in this obviously futuristic initiative. Their enthusiasm more than compensated for the Army's somewhat reluctant assignment of a military behavioral biologist from the Walter Reed Medical Center to attend the Langley Field gathering. It was, however, agreed that performance measurements would be an essential part of these test flights since there was then—and still is—no better indicator of an organism's physiological integrity and behavioral capabilities. With strong input from the White House, it was decided that the experimental animal of choice would be the chimpanzee (**Fig. 4**) because of its close phylogenetic relationship—not to mention its physical resemblance—to the human successors waiting to take over. Since neither the Air Force general nor the Navy captain knew much about the behavioral training and management of such experimental animals, the task of preparing the chimpanzees for the planned flights fell to the Army, though the Air Force agreed to provide the specialized chimp training facility at Holloman Air Force Base in New Mexico. The soon-to-be-famous 'space chimps,' Ham and Enoch, spent the better part of a year with scientists from the Walter Reed Army Institute of Research along with behavioral science professionals from the Air Force, learning a lever manipulation performance required to match a range of geometric symbols to sample presentations in order to obtain highly valued banana chip rewards. The animals were trained to perform this task on a work panel

From Johns Hopkins University, School of Medicine and Institutes for Behavior Resources, Baltimore, MD.

Address reprint requests to: Joseph V. Brady, Ph.D., Behavioral Biology Research Center, Johns Hopkins University School of Medicine, 5510 Nathan Shock Drive, Baltimore, MD 21224; jvb@jhmi.edu.

* (cf., Life Magazine, February 10, 1961.)

Brady, J.V. (1992). Continuously programmed environments and the experimental analysis of human behavior. Cambridge, MA: Cambridge Center for Behavioral Studies.

Brady, J.V. (2005). Behavioral health: the propaedeutic requirement. *Aviation, Space, and Environmental Medicine*, *76*(6), Section II, B13-B24.

Extending the Technology to Groups: Systematic Replication

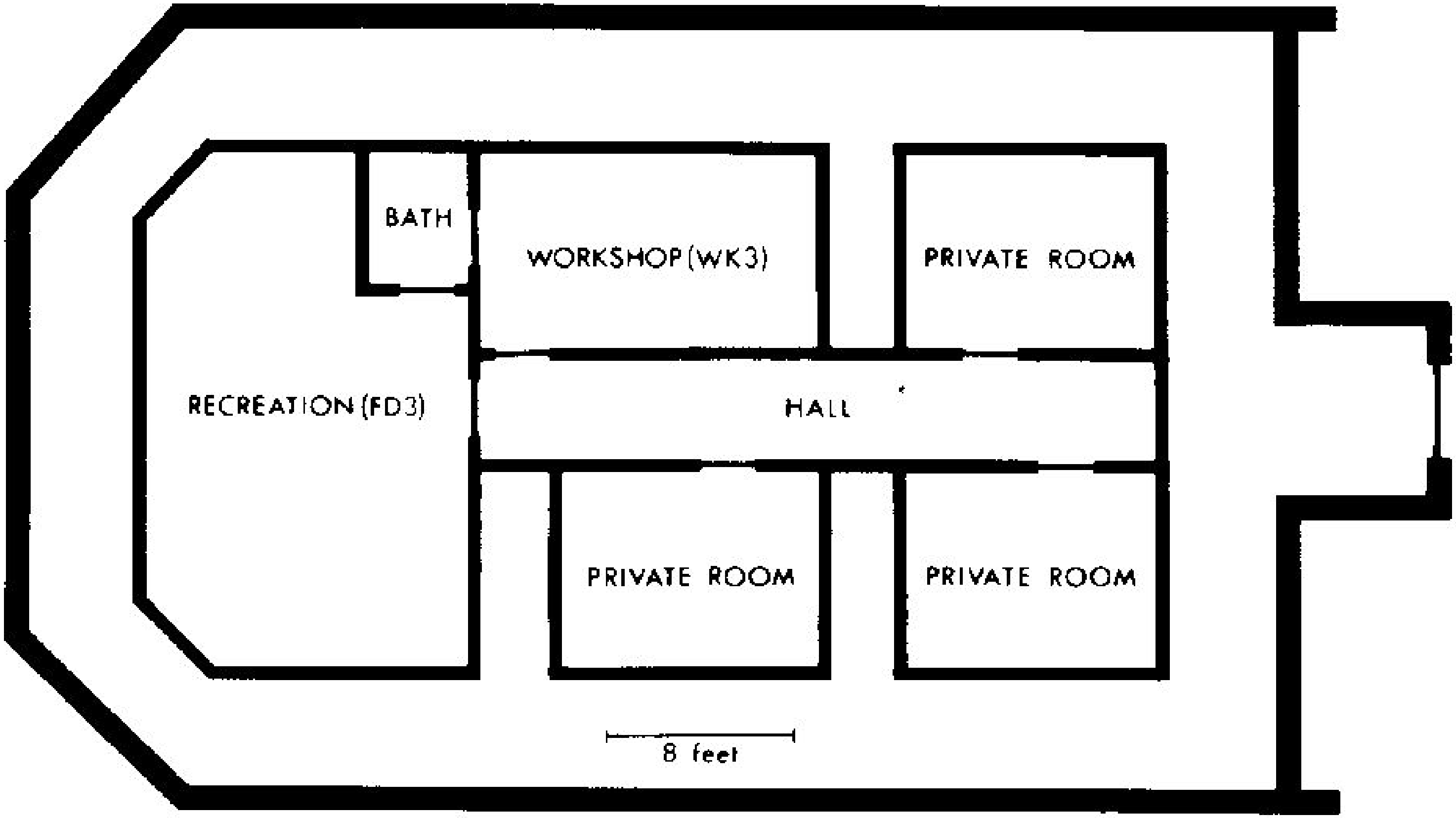


Fig. 1. A schematic diagram of the programmed environment.

MAIN CONTROL PANEL

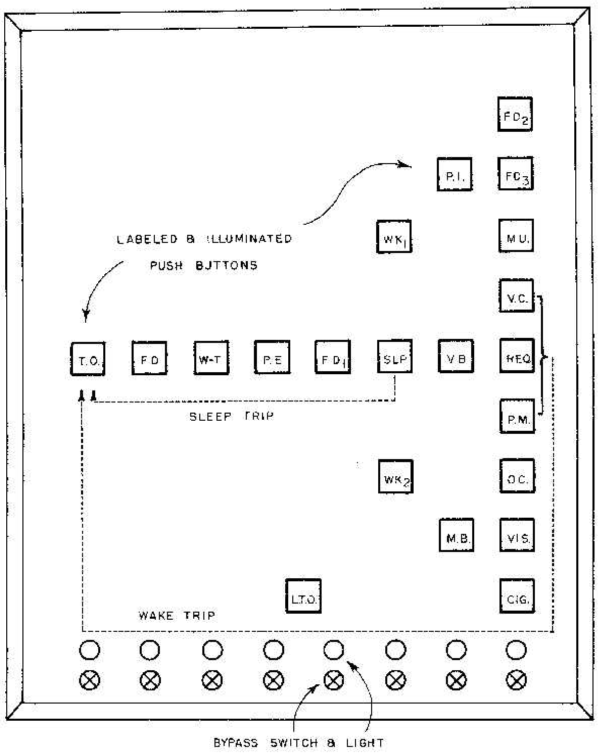
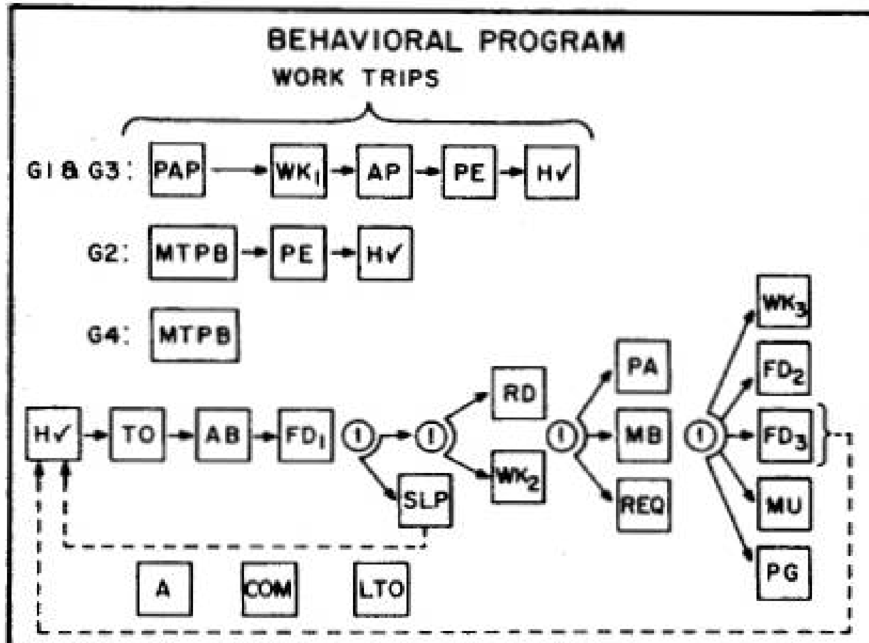


Figure 1. Main control panel containing push buttons that could be illuminated red or green. Each button is labeled with the abbreviations of the activity represented. "Wake Trips" and "Sleep Trips" are indicated by arrows.

Systematic Replication



INVENTORY OF ACTIVITIES

NOTATION	FULL NAME	BRIEF DESCRIPTION
PAP	PRIVATE ARITHMETIC PROBLEMS	150 CORRECT SOLUTIONS OF ARITHMETIC PROBLEMS
WK1	WORK ONE	5000 LEVER OPERATIONS
AP	ARITHMETIC PROBLEMS	50 CORRECT SOLUTIONS OF ARITHMETIC PROBLEMS
PE	PHYSICAL EXERCISE	500 CORRECT PRESSES ON AUTOMATED TASK
MTPB	MULTIPLE TASK PERFORMANCE BATTERY	G2: 800 CORRECT RESPONSES G4: NO RATIO
H✓	HEALTH CHECK	TEMPERATURE, PULSE, WEIGHT, STATUS REPORT
TO	TOILET OPERATIONS	USE OF PRIVATE BATHROOM AND CONTENTS OF DRAWER CONTAINING TOILETRIES
AB	AUTOGENIC BEHAVIOR	RELAXATION EXERCISES ON CASSETTE TAPE
FD1	FOOD ONE	TWO SELECTIONS FROM A LIST OF FOODS
SLP	SLEEP	USE OF BED AND PRIVACY CURTAIN
RD	READING	ACCESS TO BOOK
WK2	WORK TWO	PROBLEMS, EXPERIMENTS, ASSEMBLY PROJECTS
PA	PUZZLE ASSEMBLY	ASSEMBLE A PUZZLE
MB	MANUAL BEHAVIOR	ACCESS TO ART MATERIALS
REQ	REQUISITION	EARN DELAYED DELIVERY OF TREATS
WK3	WORK THREE	ACCESS TO WORKSHOP
FD2	FOOD TWO	PRIVATE MAJOR MEAL
FD3	FOOD THREE	MAJOR MEAL IN RECREATION ROOM, GAMES
MU	MUSIC	EARN A CASSETTE TAPE
PG	PRIVATE GAMES	ACCESS TO SOLITARY GAMES
A	AUDIT	RECEIVE WORK SCORES FOR ALL SUBJECTS
COM	COMMUNICATION	ACCESS TO INTERCOM
LTO	LIMITED TOILET OPERATIONS	ACCESS TO ESSENTIAL TOILET FACILITIES

Emurian, H.H. (1988). Programmed environment management of confined microsocieties. *Aviation, Space, and Environmental Medicine*, *59*(10), 976-980.

Programmed Environment Management of Confined Microsocieties

- Similar to Findley (1966), this approach is not offered as a replacement for current or planned experimental efforts, but rather as a **supplementary method** that could open new ways of looking at the problems and for proposing **potential solutions** (**“countermeasures”**).

Why Programmed Environments?

- Journeying in a spacecraft to Mars does **not** constitute an ecological setting into which familiar pre-flight routines of living are easily applied.
- The setting is a **unique ecology** requiring a technology applied to that inherently unfamiliar setting.

Why a Behavioral Program?

- The behavioral program manages performance requirements within the context of contingency programmed access to **scarce environmental resources** to promote crewmember endurance, performance effectiveness, and sustained "value" of available resources.
- **Motivational "force"** is intrinsic to the programmatic design.

Why a Behavioral Program?

- The behavioral program provides the opportunity for a **comprehensive status-assessment** of a confined microsociety beyond what is available from a fine-grained and multi-dimensional status-assessment of the individual crew members.

Why a Behavioral Program?

- When we think about things unforeseen taking place 18 months into a Mars expeditionary mission, interventions will very likely be required at a **spacelife systems engineering level** (*e.g.,* a ("countermeasure behavioral program").

Why a Behavioral Program?

- Its structure makes for countermeasure interventions at the **integrative systems level**, rather than at the level of an individual crew member.

Research Approach

- Ground-based "effect size" research is not applicable to developing a technology of human performance for long-duration space missions. The methodology should be similar to **"designed-based research"** in the field of education.
- **Demonstrably effective interventions** are accepted to produce an outcome of value without regard to parsing out all potential sources of influence and explanation for the phenomenon.
- Improvements in outcome achievement are reached by way of empirically driven or theory driven **systematic replication** of alterations to a demonstrably effective design.

Challenge

"The short-term nature of funded research and the **expectation of producing meaningful results in the near-term** is a result of the culture of experimental scientific research. Such an approach, however, does **not** seem to suit such settings as human spaceflight..." (Musson & Helmreich, 2005).

Musson, D.M., & Helmreich, R.L. (2005). Long-term personality data collection in support of spaceflight and analogue research. *Aviation, Space, and Environmental Medicine*, *76*(6), Section II, B119 – B125.

Challenge

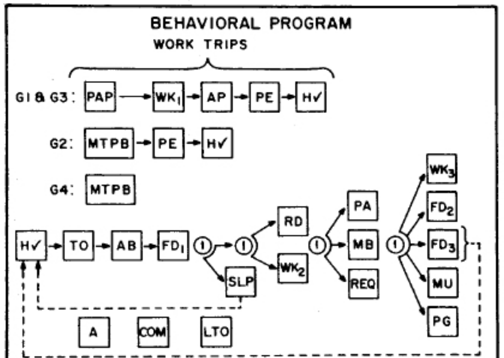
Recommendation 4.2—Conduct Periodic Assessment of Additional Risks from Lack of Resources and Use This to Make Decisions About Microgravity and **Behavioral Research Support**.

"How to support the extensive behavioral research program that would be necessary to validate processes or countermeasures such as select-in–select-out criteria (both for individual crew members and for a composite crew), issues related to cultural diversity, crew interactions, and isolation or stress-induced hazards. **These issues may well require long lead times to study adequately**."

A Risk Reduction Strategy for Human Exploration of Space: A Review of NASA's Bioastronautics Roadmap, 2006, p. 13.
http://books.nap.edu/execsumm_pdf/11467.pdf

Augmented Stages for a Mission to Mars

1. Physiological and psychological adaptation to microgravity and onboard schedules (4-6 weeks).
2. Steady-state adaptation (6-12 weeks).
3. Behavioral program “countermeasure” (12+ weeks)



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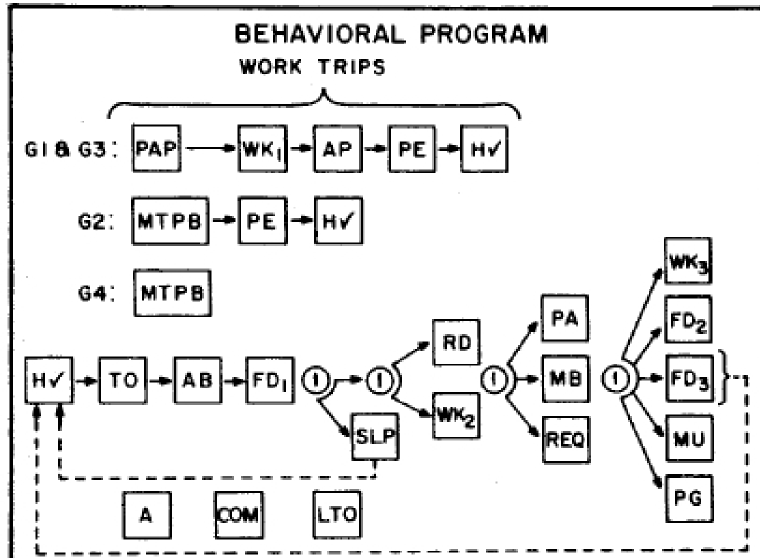
A	AUDIT	RECEIVE WORK SCORES FOR ALL SUBJECTS
COM	COMMUNICATION	ACCESS TO INTERCOM
LTO	LIMITED TOILET OPERATIONS	ACCESS TO ESSENTIAL TOILET FACILITIES

Which Approach?

Radiogram No. 4441u Form 24 for 01/03/07

SETTING UP ВКЮ1,2 FAN CONTROL CONFIGURATION WITH БРУС (MANUAL FAN SPEED CONTROL UNIT)

GMT	CREW	ACTIVITY
06:00-06:10		Morning Inspection
06:10-06:40		Post-sleep
06:40-07:30		BREAKFAST
07:30-08:00	CDR, FE-2	Prep for Work
07:30-07:55	FE-1	
07:55-08:05		Switch VOZDUKH to the automatic control mode
08:05-08:20		Daily Planning Conference *(S-band)*
08:30-09:10	FE-1	Filling EDV [KOB] for Elektron
08:40-09:10	CDR, FE-2	OGS Rack rotation to install OGS equipment
09:10-10:25		OGS H2/N2 Vent Hose Installation
09:10-09:40	FE-1	СОЖ Maintenance. *Verification of ИП-1 sensor position*
09:40-10:40		METEOROID. Dismantle MMK-2 Electronic Unit
10:25-10:40	CDR, FE-2	LAB1D1 (AV-2) rack rotation to install OGS equipment
10:40-11:10		LAB1P1 waste water hose connection



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Both approaches have value at different occasions in a mission to Mars.

Radiogram No. 4441u Form 24 for 01/03/07

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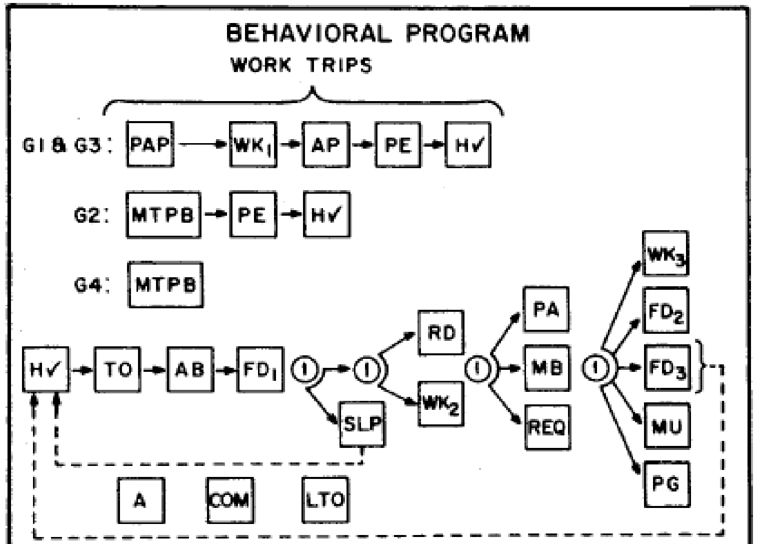

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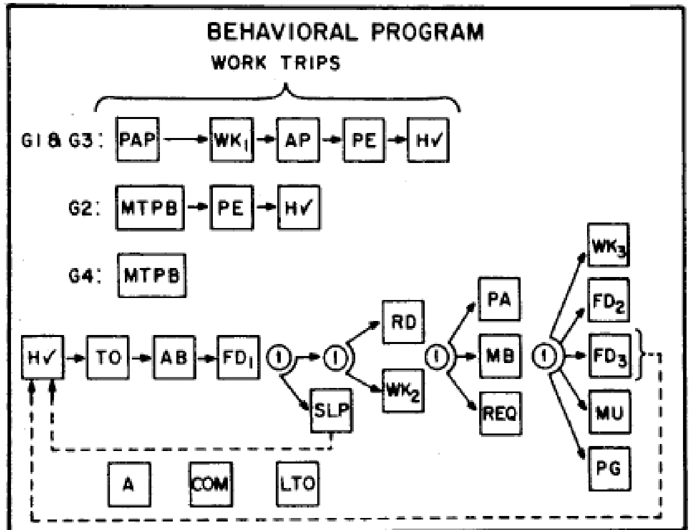
COM	COMMUNICATION	ACCESS TO INTERCOM
LTO	LIMITED TOILET OPERATIONS	ACCESS TO ESSENTIAL TOILET FACILITIES

Instructional control → Behavioral program → Instructional control

Recommendations

- **Supportive of individual and crew performance during long-duration expeditionary missions.**
- **Warrants evaluation in ground-based simulations.**



INVENTORY OF ACTIVITIES

NOTATION	FULL NAME	BRIEF DESCRIPTION
PAP	PRIVATE ARITHMETIC PROBLEMS	150 CORRECT SOLUTIONS OF ARITHMETIC PROBLEMS
WK1	WORK ONE	5000 LEVER OPERATIONS
AP	ARITHMETIC PROBLEMS	50 CORRECT SOLUTIONS OF ARITHMETIC PROBLEMS
PE	PHYSICAL EXERCISE	500 CORRECT PRESSES ON AUTOMATED TASK
MTPB	MULTIPLE TASK PERFORMANCE BATTERY	G2: 800 CORRECT RESPONSES G4: NO RATIO
H✓	HEALTH CHECK	TEMPERATURE, PULSE, WEIGHT, STATUS REPORT
TO	TOILET OPERATIONS	USE OF PRIVATE BATHROOM AND CONTENTS OF DRAWER CONTAINING TOILETRIES
AB	AUTOGENIC BEHAVIOR	RELAXATION EXERCISES ON CASSETTE TAPE
FD1	FOOD ONE	TWO SELECTIONS FROM A LIST OF FOODS
SLP	SLEEP	USE OF BED AND PRIVACY CURTAIN
RD	READING	ACCESS TO BOOK
WK2	WORK TWO	PROBLEMS, EXPERIMENTS, ASSEMBLY PROJECTS
PA	PUZZLE ASSEMBLY	ASSEMBLE A PUZZLE
MB	MANUAL BEHAVIOR	ACCESS TO ART MATERIALS
REQ	REQUISITION	EARN DELAYED DELIVERY OF TREATS
WK3	WORK THREE	ACCESS TO WORKSHOP
FD2	FOOD TWO	PRIVATE MAJOR MEAL
FD3	FOOD THREE	MAJOR MEAL IN RECREATION ROOM, GAMES
MU	MUSIC	EARN A CASSETTE TAPE
PG	PRIVATE GAMES	ACCESS TO SOLITARY GAMES
A	AUDIT	RECEIVE WORK SCORES FOR ALL SUBJECTS
COM	COMMUNICATION	ACCESS TO INTERCOM
LTO	LIMITED TOILET OPERATIONS	ACCESS TO ESSENTIAL TOILET FACILITIES

Thank You!