

## HUMAN ASPECTS OF EXTENDED DURATION FLIGHT (EDF)

### Approach to practical solution of EDF crew problems

Evolutionary or Bootstrap approach

Use existing knowledge and hardware; we have successfully flown STS ten days and Skylab for three months

Use Extended Duration Orbiter to prove hardware and procedures

Use versatile hardware to meet Space Station deadlines, develop protocols through flight experience

### Concept - Bootstrap

Use knowledge of prior flight to extend succeeding flights

Currently have flown 14 days on Orbiter and 86 days on a Space Station

Should have no human problem in extending Shuttle to 16 days and flying a 60-80 day Space Station - mission

Demonstrated performance and data from these missions will allow valid extension of times vs trying to guess what lg studies mean -

- Problem
- 1) Practical collection of data for following flights
  - 2) Exercise hardware for EDO and Space Station

- Solution
- 1) Get only data needed for operations  
NB must be willing to have controls
  - 2) Design hardware adequate to cover all (reasonable) exercise

### Plan for Development of Crew Support for EDO - 16 days and beyond

Major Problems -

1. Waste Collection
2. Trash Control
3. Crew Space
4. Study of Physiology
5. Maintenance of strength
  - Neurological Inhibition (A)
  - Muscle Function

(A) This is a current Shuttle problem

### Current Status -

Doing detailed analysis and publication of DSO's on STS-4 through STS-8 and subsequent - Primarily SMS

Trying to work exercise but no support or money

Have personally developed:

Space Station Treadmill

Space Station Prototype Upper Body exerciser

Space Station Rowing Machine

Space Station Bicycle

System for Exercise Measurement

Plans for Equipment and Tests needed for EDO, Space Station

### FUTURE

#### Proposed Activities

Complete Analysis, Documentation and Archival of Existing Data

As circumstances allow investigate and correct following problems for Extended Duration Flight

Transient post flight weakness, instability

Loss of muscle strength/mass and cardiovascular capacity

Complete development and test of exercise hardware

EDF Problems: WCS

- 1) Current WCS inadequate for existing flights; is a showstopper
  - 2) Improved Waste Collection System (IWCS<sub>1</sub>) designed, extensively ground tested, manual flight prototype ready to fly, ? is scheduled for DTO
  - 3) Fly Prototype IWCS ASAP and replace existing WCS
  - 4) Gain experience with IWCS for Space Shuttle
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- 1) Hamilton Standard, supported by NASA personnel and money has copied several unique features from the patented IWCS (Thornton, Whitmore) and are calling their compromised system IWCS-not to be confused

### EDF Problems: Trash Management

Existing practice of overpackaging and not compacting will make EDF impossible

Build and fly a practical compactor

Revise existing policy of wrapping and throw aways

### EDF Problems: Data Collection

It is essential that adequate documentation of physical performance be done

This includes strength, endurance, calcium loss, etc.

Essential data vs. research data desired by individual or groups must be determined and priorities made accordingly (managers must understand problems and apply logic not blind faith)

Data collection can and must fit within operational framework--should be transparent to crew

### EDF Problems: Post Flight Orthostasis

Loss of fluid and blood secondary to fluid shifts leave subject with inadequate cardiac output on return

This may be complicated by neurological adaptation and loss of cardio-respiratory capacity thru inactivity of legs

Provide adequate fluid to body, shift fluid to legs prior to return and provide adequate G suit on return and exit. Maintain cardiorespiratory capacity with inflight exercise

### EDF Problems: Calcium Loss

This will not be a serious problem for a decade in current United States space schedule

Take a realistic view and stop current unwarranted panic

Bone, like muscle responds to load

Bone and muscle are a unit--adequately protect muscle (primarily legs) and bone will be protected

Treadmill and other exercise will probably be adequate for flights of current concern

Implement adequate exercise in flight and document results

## EDF Problems: Loss of strength and endurance

### Two Causes of Strength Loss

#### Neurlogical Inhibition

Short term (days) adaption to force environment

Estimate 50 percent of strength of arms and legs lost on landing after seven day mission - No documentation - May be impossible for STS crew members to execute unaided emergency egress

Should be simply documented ASAP and simple exercises implemented to prevent this adaptation

#### Disuse Atrophy

Legs and lower back virtually unused and muscle mass and strength lost at near maximum rate--becomes significant in two-three weeks.

Adequate treadmill and documented protocol should be implemented on Shuttle

#### Loss of endurance

Absence of metabolic loads from legs will result in loss of cardiac and pulmonary muscle decreased strength, efficiency and endurance.

This will become significant in two-three weeks and may interfere with emergency egress.

Adequate treadmill and protocol should be implemented, demonstrated, and documented on Shuttle



## Hardware for Space Station Gym

### Concept

Baseline sufficient exercise devices to cover all reasonable requirements

Build and test hardware prototypes

Fly flight versions of above to:

Demonstrate suitability

Develop protocols

### Status (Thornton Effort)

Baseline hardware

Two treadmills

Two universal force generating and measurement systems

One rowing machine

One bicycle ergometer

### Status Hardware

Treadmill

One-g prototype completed--need flight prototype

Force generator

Electric demo unit completed

Need funds for prototype

Rowing machine

1g Flight prototype complete

Bicycle ergometer

Design complete

Need funds to add instrumentation for monitoring and documentation of use

## BACKGROUND

### Physics

Photo-Optics, Instrumentation  
3 patents

### Electronics -

Design and Engineering (including complete airborne radar systems -procured in quantity by USAF, USN)

Systems Development and Design

Complete Missile Target and Scoring Systems - 8 patents - used by US, Canada, France, Israel, etc.

Medical Electronics - Wide Range of measurement and monitoring systems - first on line EKG computer - 15 patents

### Administration -

OIC Photo-Optics Flight Test Lab

Air Proving Ground, Awarded USAF Legion of Merit for work

Chief Engineer, Electronics Div. of a Defense Contractor

Developed and headed a medical electronics company (Avionics Research, now largest ambulatory monitoring manufacturer in the world)

### 1G Medicine -

M.D. and Internships ('63 & '75) in Medicine

Associate Clinical Professor in Medicine, UTMB

Primary course in Aerospace Medicine

Flight Surgeon, BAFB 2 years

Extensive research in:

Cardiology; stress testing, ambulatory monitoring (EKG, B.P. and activity) physical conditioning, hypertension

Neurology: ambulatory EEG, sleep analysis, evoked potentials audio and visual)

Musculoskeletal: gait analysis, kinesiology, EMG

Audiology: tone thresholds, direct and GSR

## Background

### Prior Work Relevant to NASA

Developed first working Mass Measurement Devices, USAF 1965

Exercise devices, photoelectric oximetry and cardiac output instruments for Manned Orbiting Lab

Complete Patient Monitoring Systems for anesthesiology, cardiology (EKG, EMG, EEG, GSR, B.P. etc. by telemetry)

First Commercial Respiratory Gas Analyzer

Developed wide variety of exercise equipment for research and application including bicycle ergometers, treadmills, multi-function devices - 2 patents

### Major Personal Work at NASA

Mass Measurement in space\*+ (human and specimen)

Antropometric and Kinesiology studies including suits+

Documentation in flight of:

Fluid Shift and Loss\*

Mass Losses in Flight \*

Anthropometric Changes, height\*, shape\*, posture\*

Loss of strength and its prevention in flight\*

Leg compliance and blood flow changes\*

Pre, In, and post flight Ambulatory heart rate and blood pressures\*

Ambulatory in-flight EKG

Food requirements

Importance of locomotor exercise

Study of Space Motion Sickness in Flight:

Vestibular Ocular Reflex\*

Gastric Function\*

Oculomotor Function\*

Eye-hand Coordination\*

Audio & Visual Evoked Potentials\*

Complex Reaction Time\*

Hardware, Space

Electrophysiologic lab on STS 7 and 8

Treadmill

Improved Waste Collection System\* +

Fluid-gas separator\* +

Rowing Machine\*

Bicycle Ergometer\* +

Universal force generator (for upper body exercise, measurement)\* +

Kinesimetric Measurement System

Limb Volume Measuring System

\*First Time +Patent