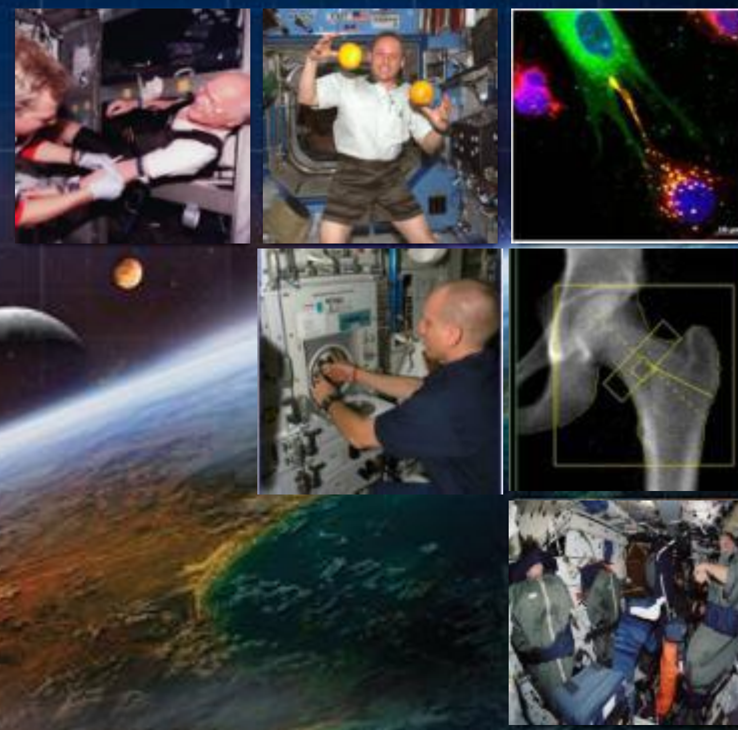
National Aeronautics and Space Administration

Human Research Program (HRP)
Countermeasure Development for Long Duration Crew Health

November 9, 2012

ASEB Fall 2012 Meeting



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NASA/JSC

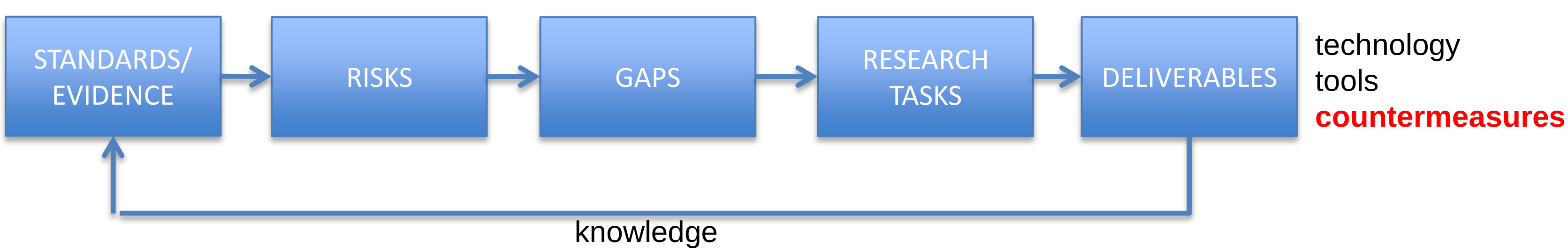
OVERVIEW

- NASA Human Research Program
- NASA Spaceflight Human System Standard
- Human Health and Performance Risks for Spaceflight
- Countermeasure Development
- Countermeasure Validation

HUMAN RESEARCH PROGRAM FOUNDATION

- Evidence/Risk-based Management Approach
  - *Program Architecture: Evidence → Risks → Gaps → Tasks → Deliverables*
  - Framed by the risks to Human Health and Performance
  - Validity of risks is based on evidence from science, clinical, and operational research
  - Externally Reviewed by Institute of Medicine (IOM)
- Gaps in Knowledge, Technology, and Countermeasures Flow from Risks
  - Each Element has specific tasks budgeted within the program to address these gaps
  - Integrated Research Plan (IRP) baselined in December 2007 and updated annually contains the gaps and tasks required to address each risk
  - Externally Reviewed by Standing Review Panels
- Documented and communicated to external communities via

  Human Research Roadmap (http://humanresearchroadmap.nasa.gov)



NASA SPACEFLIGHT HUMAN SYSTEM STANDARD

- NASA STD-3001
- This standard is published by NASA to:
  - Provide a healthy and safe environment for crewmembers
  - Provide health and medical programs for crewmembers during all phases of space flight.
  - Optimize crew health and performance, and to
  - Prevent negative long-term health consequences due to space flight.

Standards are <u>evidence based</u> and modeled on those used by the United States Occupational Safety and Health Administration involving performance standards to set exposure-type limits and/or fitness for duty criteria.

- ➢ Fitness for Duty (FFD)
  - Minimum measurable capability or capacity for a given physiological or behavioral parameter that allows successful performance of all required duties. Functional capacity measured. (e.g. cardiovascular VO2 Max)
- ➢ Space Permissible Exposure Limits (PEL)
  - Quantifiable limit of exposure to a space flight factor over a given length of time (e.g. life time radiation exposure). Physical/chemical agent measured.
- ➢ Permissible Outcome Limits (POL)
  - POLs delineate an acceptable maximum decrement or change in a physiological or behavioral parameter, as the result of exposure to the space environment. Biological/clinical parameter measured. (e.g. limiting microgravity exposure to limit bone loss)

HUMAN HEALTH AND PERFORMANCE RISKS

NASA Health and Medical Technical Authority identified 32 Risks to meeting Standards that require research

Risks Reviewed by the National Academies' Institute of Medicine

Space Human Factors

Risk Associated with Poor Task Design

Risk of Adverse Health Affects from Lunar Dust Exposure

Risk Factor of Inadequate/Inefficient Food System

Risk of Crew Adverse Health Due to Alterations in Host-microorganism Interactions

Risk of Inadequate Human-Computer Interface

Risk of Performance Errors Due to Training Deficiencies

Risk of Inadequate Design of Human and Robot Integration

Risk of an Incompatible Vehicle/Habitat Design

Behavior, Health and Performance

Risk of Behavioral and Psychiatric Conditions

Risk of Performance Errors Due to Sleep Loss, Circadian Desynchronization, Fatigue and Work Overload

Risk of Performance Errors Due to Poor Team Cohesion and Performance, Inadequate Selection/Team Composition, Inadequate Training, and Poor Psychosocial Adaptation

Space Radiation Risks

Risk of Radiation Carcinogenesis

Risk of Acute Radiation Syndromes Due to Solar Particle Events

Risk of Acute or Late Central Nervous System Effects from Radiation Exposure

Risk of Degenerative Tissue or other Health Effects from Radiation Exposure

Human Health Countermeasures

Risk of Accelerated Osteoporosis

Risk of Orthostatic Intolerance During Re-Exposure to Gravity

Risk Factor of Inadequate Nutrition

Risk of Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems

Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance

Risk of Bone Fracture

Risk of Intervertebral Disc Damage

Risk of Renal Stone Formation

Risk of Cardiac Rhythm Problems

Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity

Risk of Crew Adverse Health Event Due to Altered Immune Response

Risk of Impaired Ability to Maintain Control of Vehicles and Other Complex Systems

Risk of Therapeutic Failure Due to Ineffectiveness of Medicine

Risk of long-term visual changes due to microgravity exposure

Risk of Decompression Sickness

Risk of Injury from Dynamic Loads

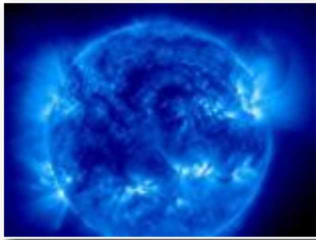
Medical Capability

Risk of Inability to Adequately Treat an ill or Injured Crew Member

COUNTERMEASURE DEVELOPMENT

Areas Requiring Countermeasures	Countermeasures in Development
Behavioral Health	Sleep Protocols and Medications, Lighting Protocols, Training Strategies and Protocols for Team Cohesion, Interactive Tools for Behavioral Health
Bone, Muscle	Exercise, Nutrition, Pharmaceuticals
Aerobic Capacity	Exercise
Orthostatic Intolerance	Fluid Loading, Compression Garments
EVA Suit Injury	Glove and Suit design
Vision Changes/ICP	Fluid Redistribution Protocols
Kidney Stones	Hydration, Potassium Citrate
Sensory Motor Deficits	Exercise, Training Protocols
Radiation Exposure	Nutrition, Pharmaceuticals, Shielding

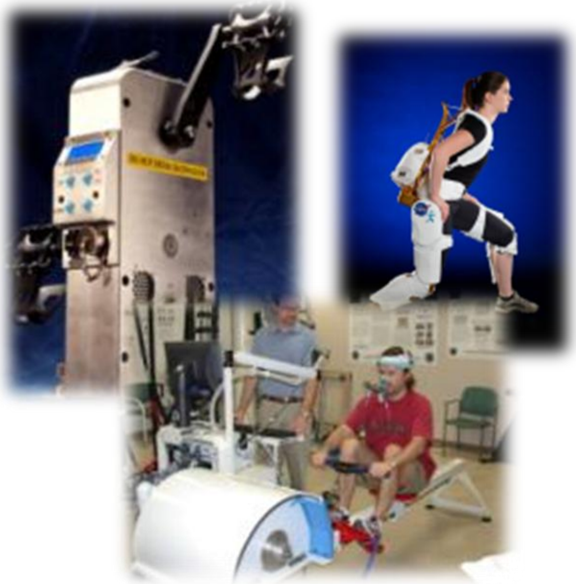




Potential Areas requiring Countermeasures

- Cardiac disease
- Immune System

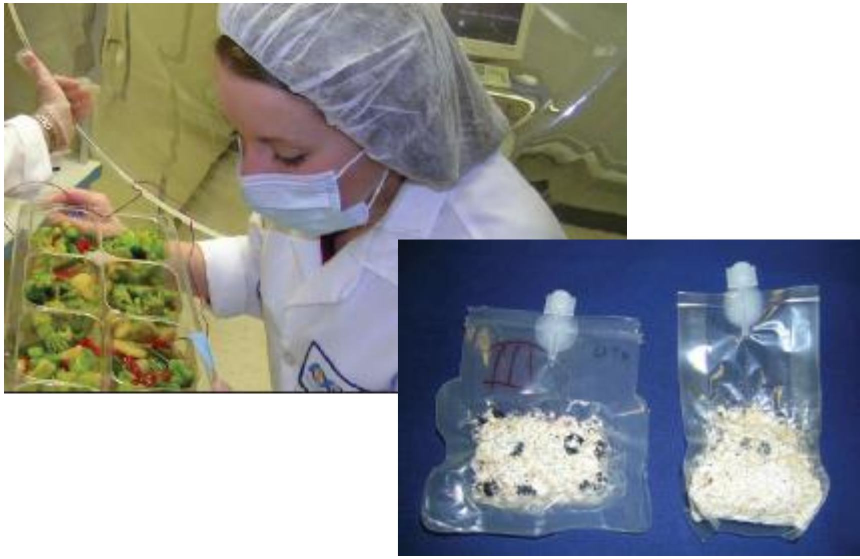
COUNTERMEASURE DEVELOPMENT EXAMPLES



Advanced Exercise Concepts

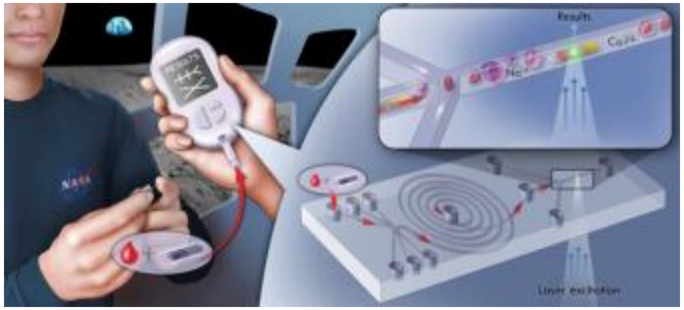
Fluid Redistribution Countermeasures

Solid State Lights and Protocols for the ISS



Advanced Food Systems

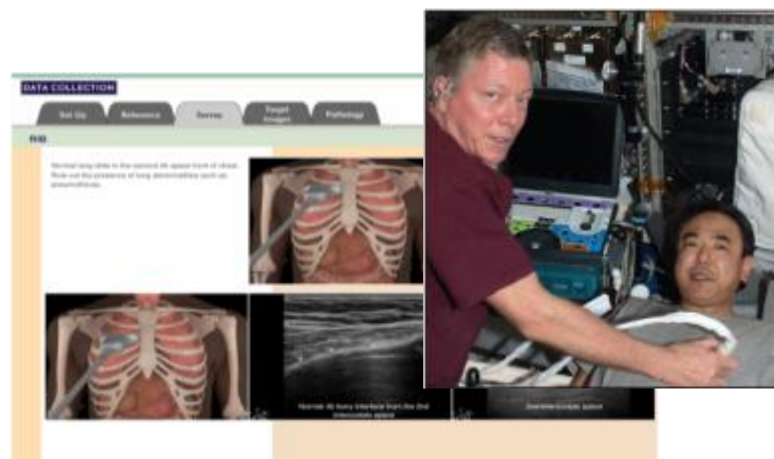
COUNTERMEASURE MONITORING TECHNOLOGIES



Point-of-Care Lab Analysis for ISS

Non-Invasive Intracranial Pressure Measurements

Behavior and Neurological Function Assessment Tools



Remote Guidance Ultrasound Techniques

COUNTERMEASURE VALIDATION

- After laboratory development, Countermeasures are further validated in operational or flight-like Analogs

NEEMO Underwater Habitat

Head-Down Tilt Bedrest

NASA Space Radiation Laboratory

Haughton Impact Crater

Antarctic Habitats

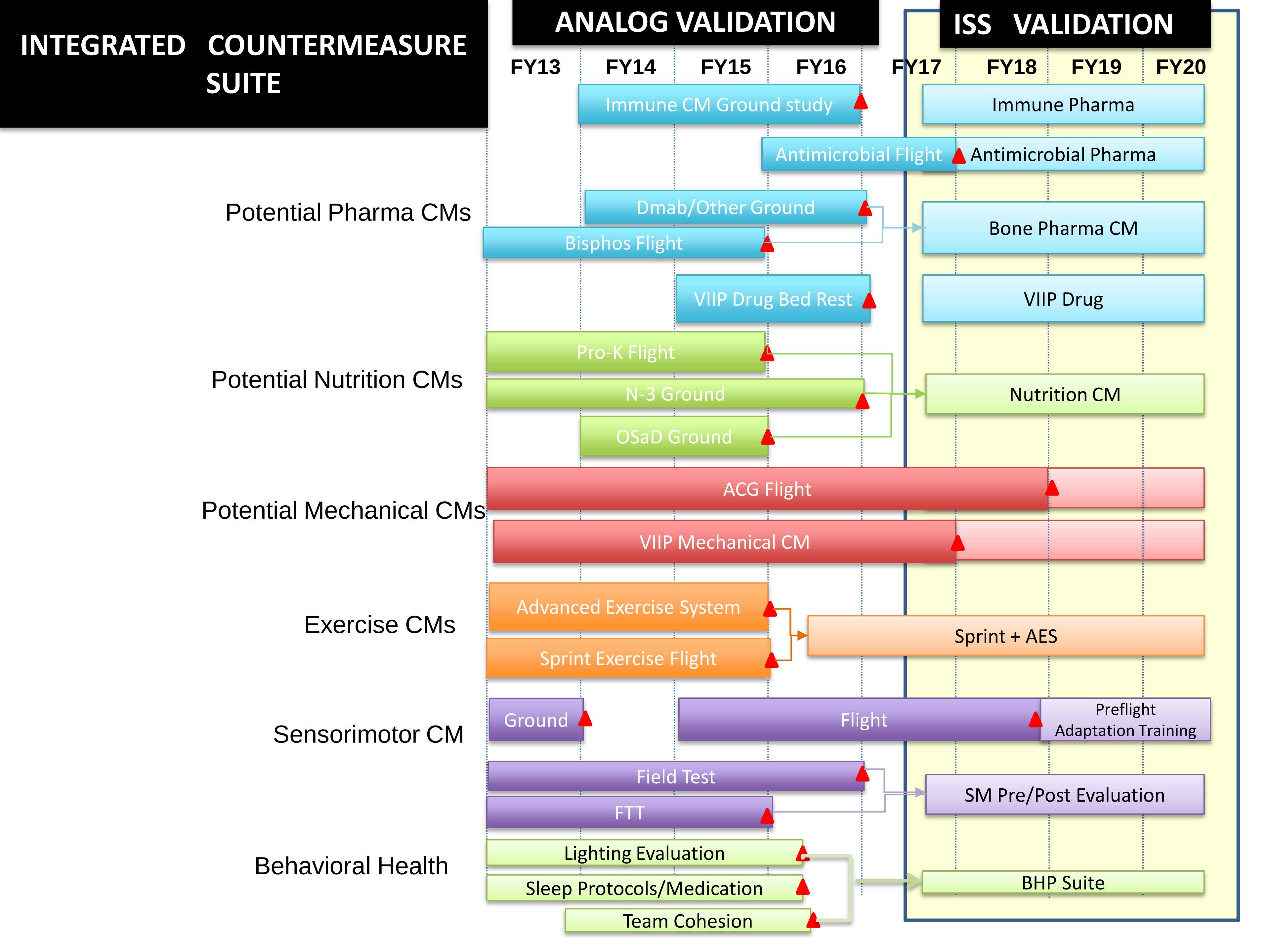
COUNTERMEASURE VALIDATION EXAMPLE

Early ISS resistive exercise was only capable of providing **300** lbs
of resistance and was found to be insufficient for maintaining muscle and bone.

Current ISS resistive exercise is capable of providing **600** lbs of resistance and initial data look promising

“These data document that resistance exercise, coupled with adequate energy intake . . . can maintain bone in most regions during 4- to 6-month missions in microgravity. This is the first evidence that improving nutrition and resistance exercise during spaceflight can attenuate the expected BMD deficits previously observed after prolonged missions.”

S. Smith et al, JBMR, September 2012


INTEGRATED COUNTERMEASURE SUITE
ANALOG VALIDATION
ISS VALIDATION
FY13
FY14
FY15
FY16
FY17
FY18
FY19
FY20
Potential Pharma CMs
Immune CM Ground study
Immune Pharma
Antimicrobial Flight
Antimicrobial Pharma
Dmab/Other Ground
Bisphos Flight
Bone Pharma CM
VIIP Drug Bed Rest
VIIP Drug
Potential Nutrition CMs
Pro-K Flight
N-3 Ground
OSaD Ground
Nutrition CM
Potential Mechanical CMs
ACG Flight
VIIP Mechanical CM
Exercise CMs
Advanced Exercise System
Sprint Exercise Flight
Sprint + AES
Sensorimotor CM
Ground
Flight
Preflight Adaptation Training
Field Test
FTT
SM Pre/Post Evaluation
Behavioral Health
Lighting Evaluation
Sleep Protocols/Medication
Team Cohesion
BHP Suite

“Human space flight remains an endeavor with substantial risks, and these risks must be identified, managed, and mitigated appropriately to achieve the nation’s goals in space.”

(A Risk Reduction Strategy for Human Exploration of Space, National Academies, Institute of Medicine, 2006)