Human Research Program
Human Health Countermeasures Element Overview

Peter Norsk, MD

HHC Element Scientist

Who am I?

M.D., University of Copenhagen 1982

Dr. med. (Ph.D) same place 1989

Manager of DAMEC Research A/S 1989 – 2002

Consultant, Dept. of Aerospace Medicine 2002-03

Associate Professor, University of Copenhagen 2003 -06

Professor, same place, Gravitational & Space Physiology 2006 -11

HHC Element Scientist, USRA/NASA, JSC 2011 –

Research:

Using gravity and anti-gravity models to understand BP regulation

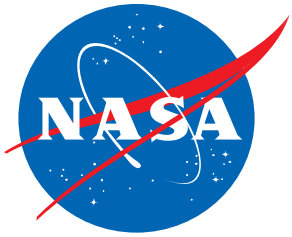
13 inflight studies (shuttle, Mir, ISS).

Environmental hazards:

Environmental hazards:

- Weightlessness
- Radiation
- Oxidative stress

Weightlessness – what is it?



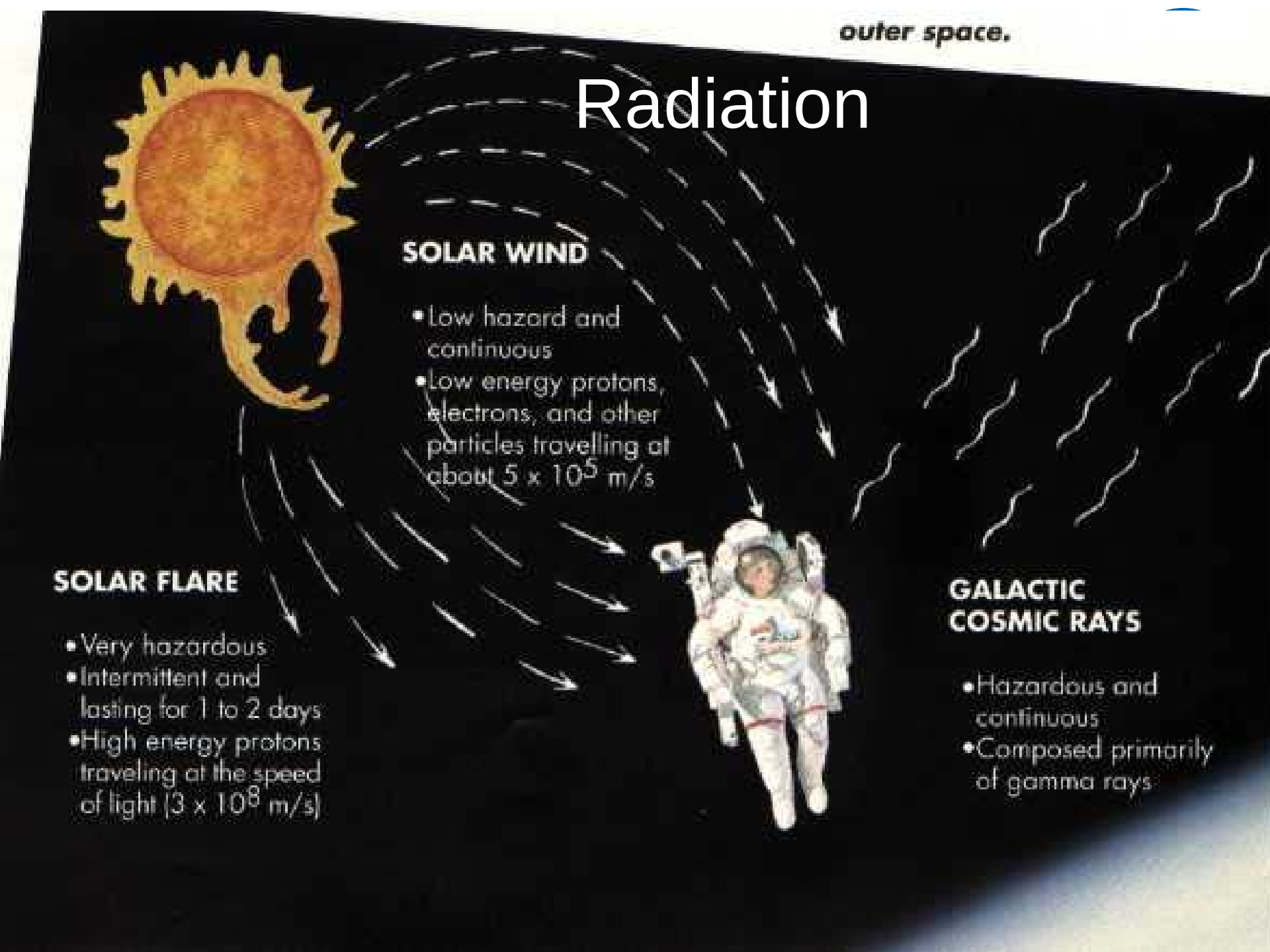
Weightlessness

Weightlessness

Weightlessness = free fall condition

outer space.

Radiation



Oxidative stress:

- Hyperoxia
- Hypooxia
- Stress
- Etc.

Tired people?

Tired people?

No, back from space

Tired people?

- Blood pressure reflexes
- Blood volume
- Sensori-motor function
- Bone
- Muscle
- Immune system

No, back from space

Introduction to HHC

- Provides the biomedical expertise for the development and assessment of:
  - medical standards.
  - vehicle and spacesuit requirements dictated by human physiologic needs.
  - a validated and integrated suite of countermeasures that ensure the maintenance of crew health during all phases of exploration missions.
- Targets human physiologic and performance capabilities at risk from spaceflight missions at each stage of mission performance.
  - Pre flight countermeasures involve physical fitness and exercise, and physiologic adaptation training.
  - In-flight countermeasures cover physiologic and nutritional health, physical fitness, and mission performance.
  - Post flight countermeasures target rehabilitation strategies and long term crew health.

Human Health Countermeasures

- Within HRP, the Human Health Countermeasures (HHC) Element focuses on:
  - Defining, understanding and mitigating the untoward physiological changes associated with human spaceflight.
  - Providing optimized countermeasures that use a minimum of flight resources
  - Defining standards for human health and performance
  - Defining requirements for mission operations and hardware design.

An example:

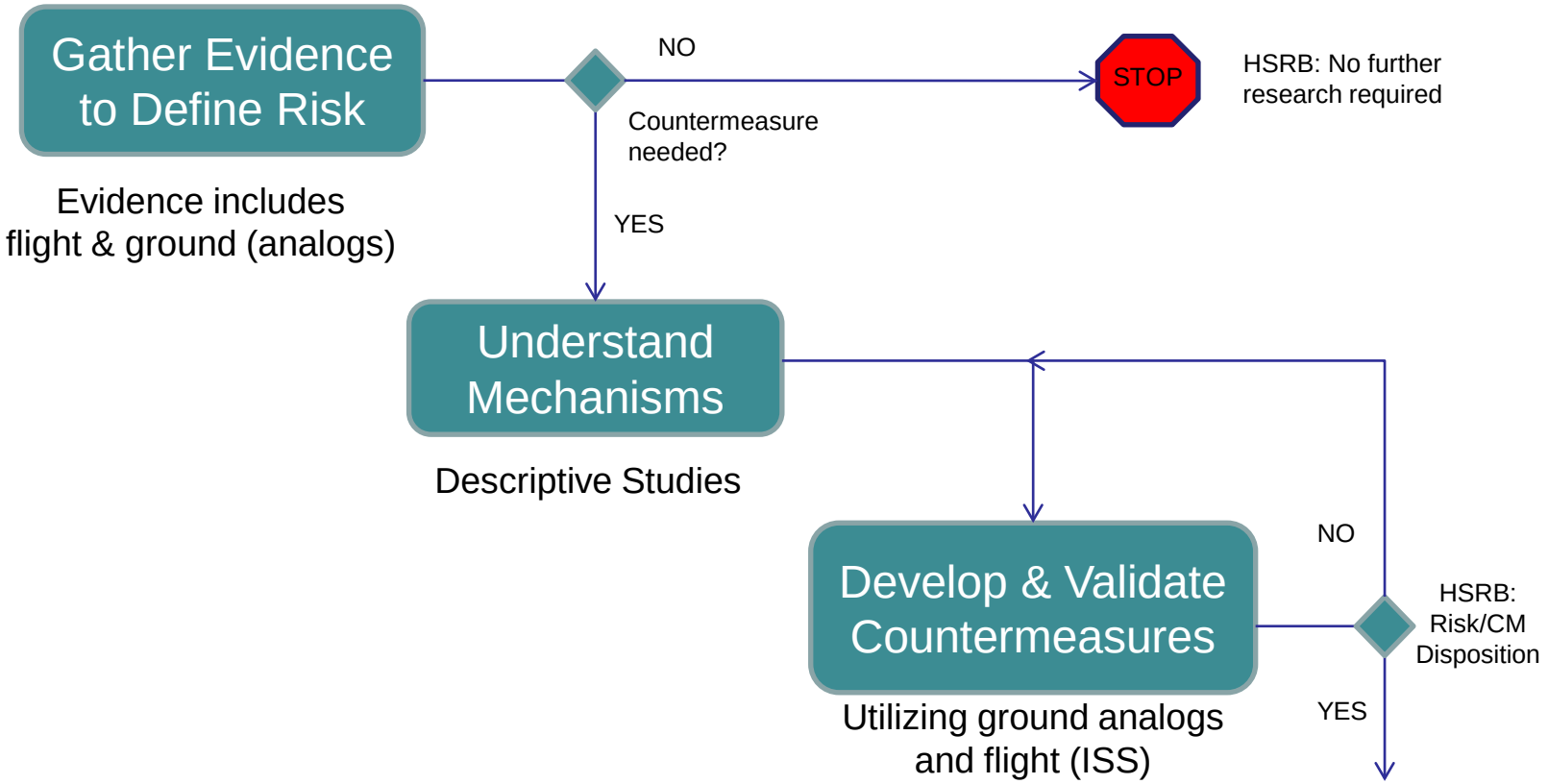
Orthostatic intolerance:

Mitigated by:

- Oral salt and fluid loading
- Antigravity garment
- Additional clinical treatment

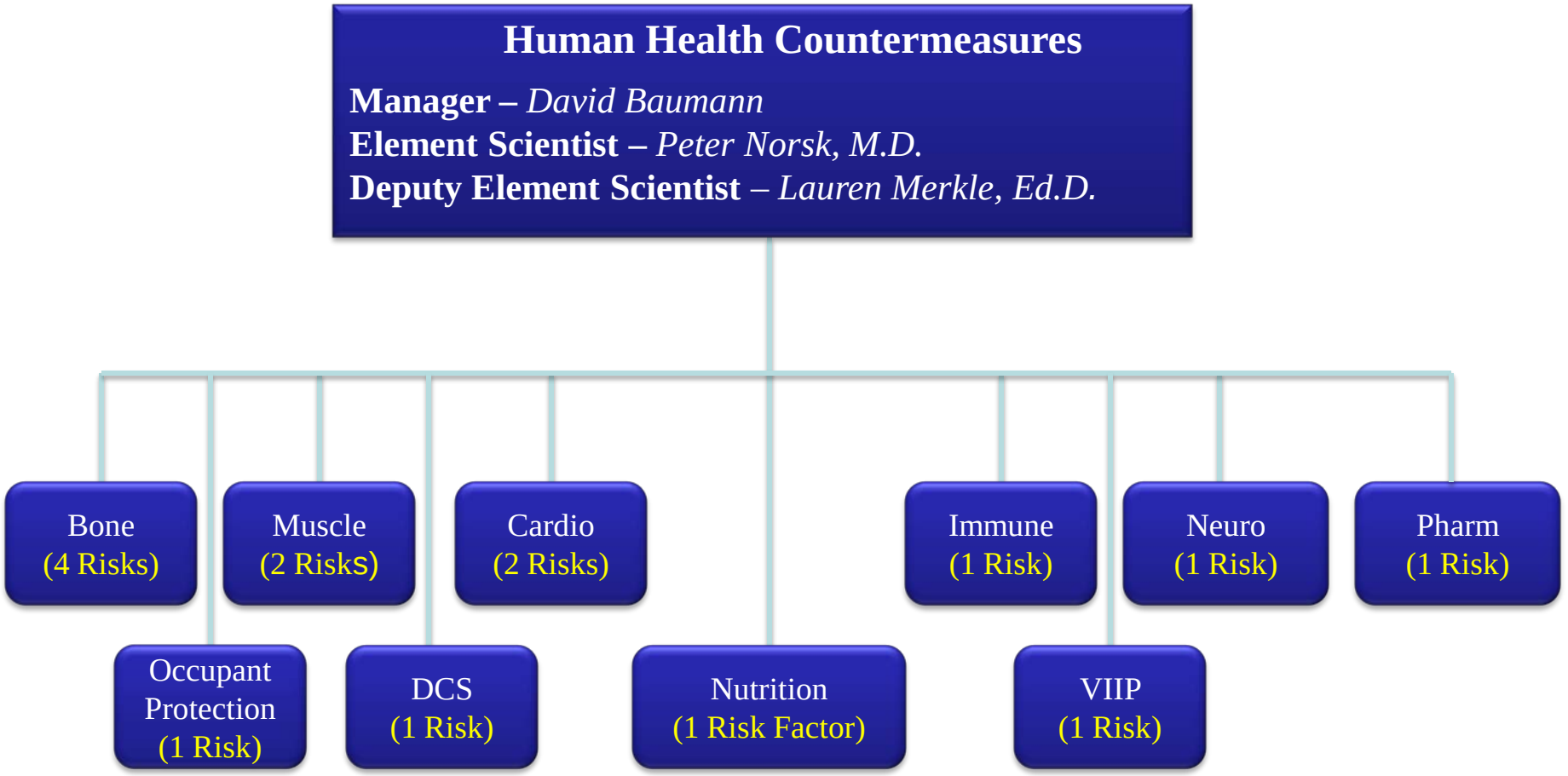
Bed rest, flight analog for 0 G

Parabolic flight – shortterm 0 G



The Human System Risk Board (HSRB) determines the appropriate risk action and determines risk disposition, mitigation or monitoring strategy.

HHC Program Element Disciplines



HHC Disciplines

- 10 disciplines in HHC examining 15 Risks
  - Bone (4 risks)
  - Muscle (2 risks)
  - Cardiovascular (2 risks)
  - Immune (1 risk)
  - Pharmacology (1 risk)
  - Sensorimotor (1 risk)
  - Occupant Protection (1 risk)
  - Decompression Sickness (1 risk)
  - Nutrition (1 risk factor)
  - Visual Impairment and Intracranial Pressure (1 risk)

HHC Risks

- Risk Factor of Inadequate Nutrition
- Risk of Bone Fracture
- Risk of Cardiac Rhythm Problems
- Risk of Adverse Health Event Due to Altered Immune Response
- Risk of Intervertebral Disc Damage
- Risk of Renal Stone Formation
- ***Risk of Therapeutic Failure Due to Ineffectiveness of Medication***
- Risk of Impaired Control of Spacecraft, Associated Systems, and Immediate Vehicle Egress Due to Vestibular/Sensorimotor Alterations Associated with Spaceflight
- Risk of Impaired Performance Due to Reduced Muscle Mass, Strength, and Endurance
- Risk of Orthostatic Intolerance During Re-Exposure to Gravity
- Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity
- Risk of Early Onset Osteoporosis
- Risk of Injury Due to Dynamic Loads
- Risk of Decompression Sickness
- Risk of Microgravity-Induced Visual Alterations/ICP

Human Health Countermeasures Element Structure

Human Health Countermeasures

Manager – *David Baumann*
Element Scientist – *Peter Norsk, MD*
Deputy Element Scientist – *Lauren Merkle, Ed.D.*

- Digital Astronaut
- Exercise Physiology and Countermeasures
- VIIP
- Non-Exercise Physiological Countermeasures
- Flight Analogs

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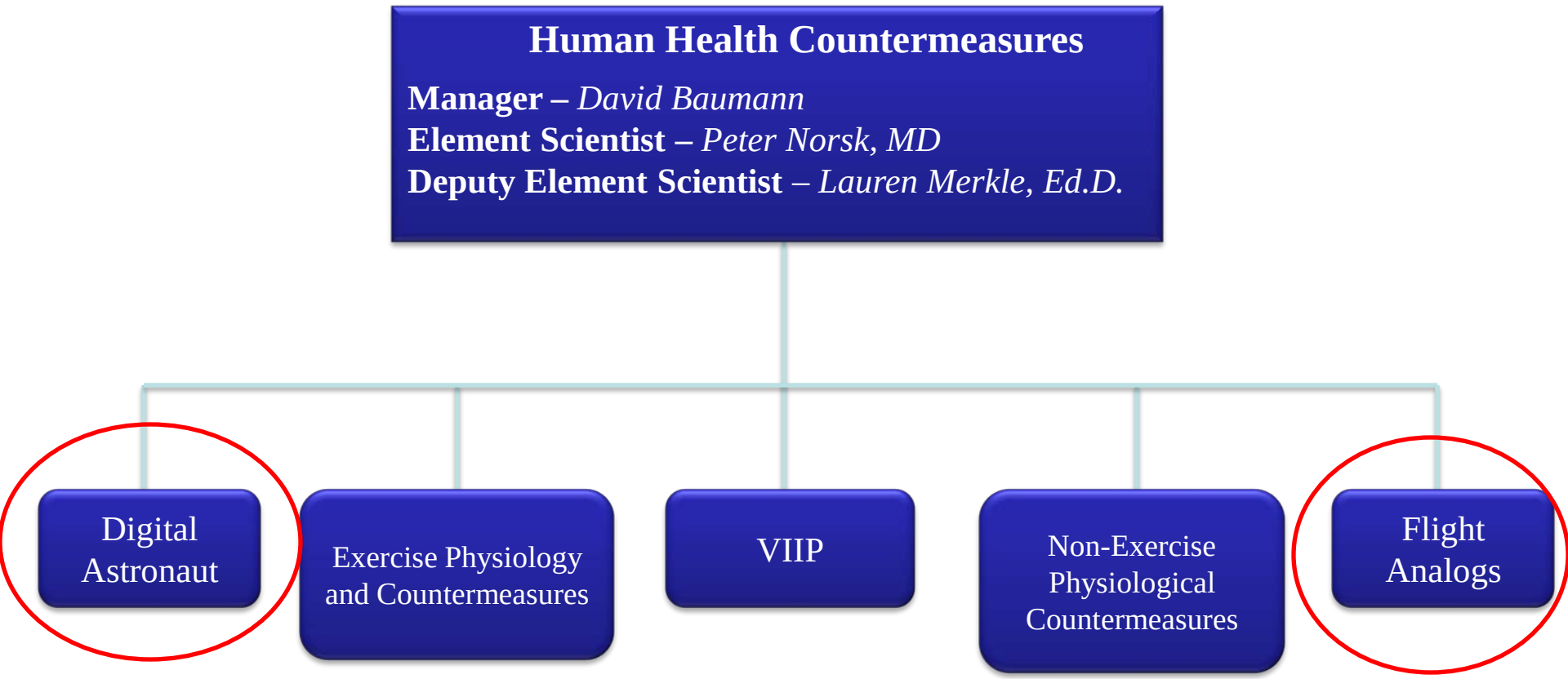
Projects directly supporting Risk Mitigation

Human Health Countermeasures Element Structure



Enabling Projects - Infrastructure

HHC Scorecard of Evidence

HHC Descriptive Evidence used for IRP Development

Discipline	Risk	Evidence/Data: Ground Analogues	Pre/Post-flight: short dur	Pre/Post-flight: long dur	In-flight: short dur	In-flight: long dur	Performance	Knowledge of Mechanism	Countermeasure (CM) required?	Maturity of CM	Technology Development
Bone	Risk of Accelerated Osteoporosis								YES		
	Risk of Bone Fracture								YES		
	Risk of Renal Stone Formation								YES		
	Risk of Intervertebral Disc Damage		N/A		N/A				YES		
Cardiovascular	Risk of Cardiac Rhythm Problems								UKN	N/A	TBD
	Risk of Orthostatic Intolerance during Re-Exposure to Gravity				N/A	N/A			YES		
EVA	Risk of Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems		N/A	N/A					YES		
Exercise/Muscle	Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance								YES		
	Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity								YES		
Immunology	Risk of Crew Adverse Health Event Due To Altered Immune Response								UKN	N/A	
Nutrition	Risk Factor of Inadequate Nutrition								YES		
Sensorimotor	Risk of Impaired Ability to Maintain Control of Vehicles and Other Complex Systems								YES		

Green = no additional evidence/data needed
Yellow = incomplete evidence/data
Red = little or no evidence/data
Grey = not applicable (N/A), need is unknown (UKN), or to be determined (TBD)

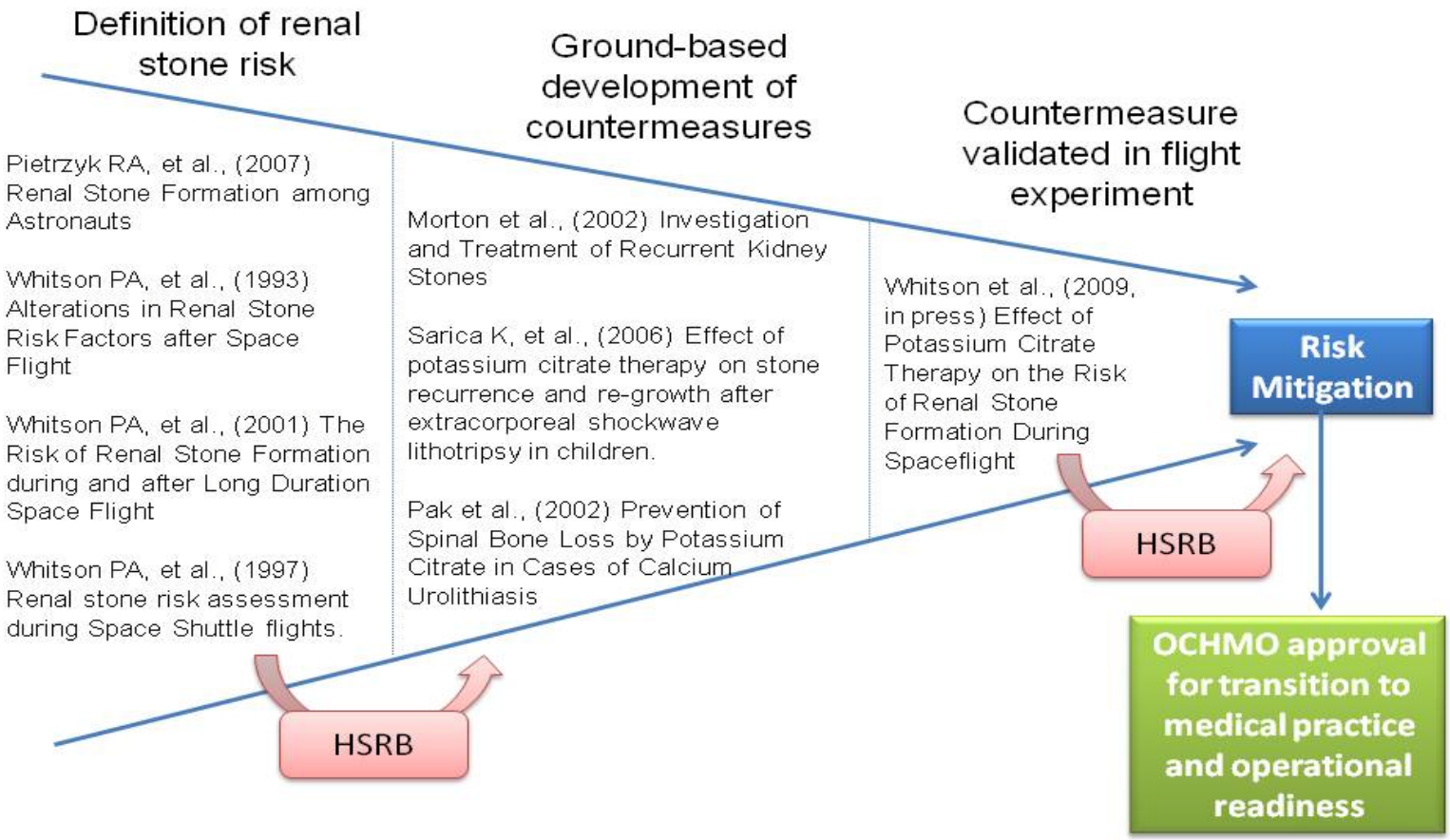
Study Areas

Discipline /Risk	Evidence/Data: Ground Analogues	Pre/Post-flight: short dur	Pre/Post-flight: long dur	In-flight: short dur	In-flight: long dur	Performance	Mechanistic Studies	CM Studies	Technology Development	Informing Operations
Bone										
Risk of Accelerated Osteoporosis	✔ c		✔ c		✔ p	✔ p	✔ c	✔ c	✔ p	✔ c
Risk of Bone Fracture	✔ c		✔ c		✔ c	✔ p	✔ c	✔ c	✔ c	✔ c
Risk of Renal Stone Formation										
Risk of Intervertebral Disc Damage	✔ p	✔ c	✔ p		✔ p		✔ p	✔ p	✔ p	✔ c
Cardiovascular										
Risk of Cardiac Rhythm Problems			✔ c		✔ c	✔ c	✔ c			
Risk of Orthostatic Intolerance during Re-Exposure to Gravity	✔ c		✔ c				✔ c	✔ c	✔ c	✔ c
EVA										
Risk of Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems	✔ c			✔ p	✔ p	✔ c	✔ c	✔ p	✔ c	✔ c
Exercise/Muscle										
Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance	✔ c		✔ c		✔ c	✔ p		✔ c	✔ c	✔ c
Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity	✔ c		✔ c		✔ c	✔ p	✔ c	✔ c	✔ c	✔ c
Immunology										
Risk of Crew Adverse Health Event Due To Altered Immune Response	✔ c	✔ c	✔ c	✔ c	✔ c	✔ c			✔ c	✔ c
Nutrition										
Risk Factor of Inadequate Nutrition	✔ c		✔ c		✔ c	✔ c		✔ c	✔ c	✔ c
Sensorimotor										
Risk of Impaired Ability to Maintain Control of Vehicles and Other Complex Systems	✔ p	✔ c	✔ c		✔ p	✔ c		✔ c	✔ c	✔ c

d work

p =IRP planned work

Ideal HHC Countermeasure Validation
(Renal Stone Risk: Potassium Citrate Example)



Types of Deliverables

- Information for Standards
- Recommended Standard Update
- Informing Mission Operations
- Countermeasures
- Information to Other Elements
- Requirements to Other Programs
- Updates to Human System Risk Forum

Thank you

Questions?