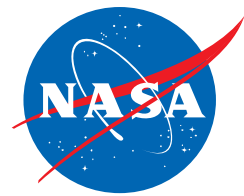


Human Research Program

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).



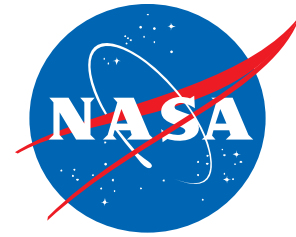
Environmental hazards:



Environmental hazards:

- Weightlessness
- Radiation
- Oxidative stress



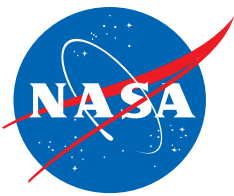


Weightlessness – what is it?



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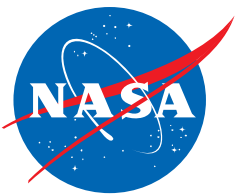




Weightlessness

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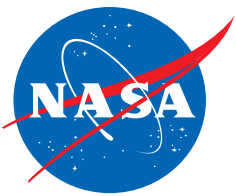




Weightlessness

Human Research Program





Weightlessness = free fall condition

Human Research Program



Radiation



SOLAR WIND

- Low hazard and continuous
- Low energy protons, electrons, and other particles travelling at about 5×10^5 m/s

SOLAR FLARE

- Very hazardous
- Intermittent and lasting for 1 to 2 days
- High energy protons traveling at the speed of light (3×10^8 m/s)



GALACTIC COSMIC RAYS

- Hazardous and continuous
- Composed primarily of gamma rays

Oxidative stress:

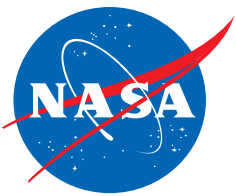
Hyperoxia

Hypooxia

Stress

Etc.

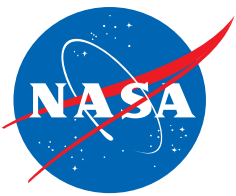




Tired people?

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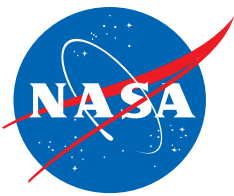




Tired people?



No, back from space



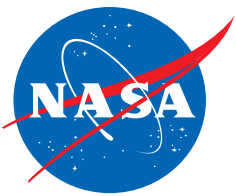
Tired people?

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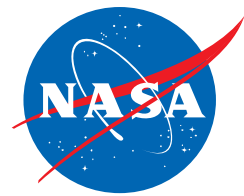
- Blood pressure reflexes
- Blood volume
- Sensori-motor function
- Bone
- Muscle
- Immune system

No, back from space



Introduction to HHC

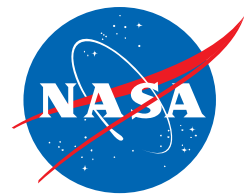
- Provides the biomedical expertise for the development and assessment of:
 - medical standards.
 - vehicle and spacesuit requirements dictated by human physiologic needs.
 - a validated and integrated suite of countermeasures that ensure the maintenance of crew health during all phases of exploration 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

Human Research Program

- 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.

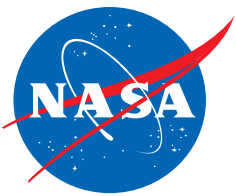


An example:

Orthostatic intolerance:

Mitigated by:

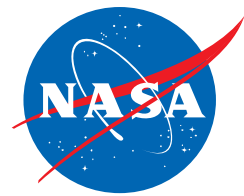
- Oral salt and fluid loading
- Antigravity garment
- Additional clinical treatment



Bed rest, flight analog for 0 G

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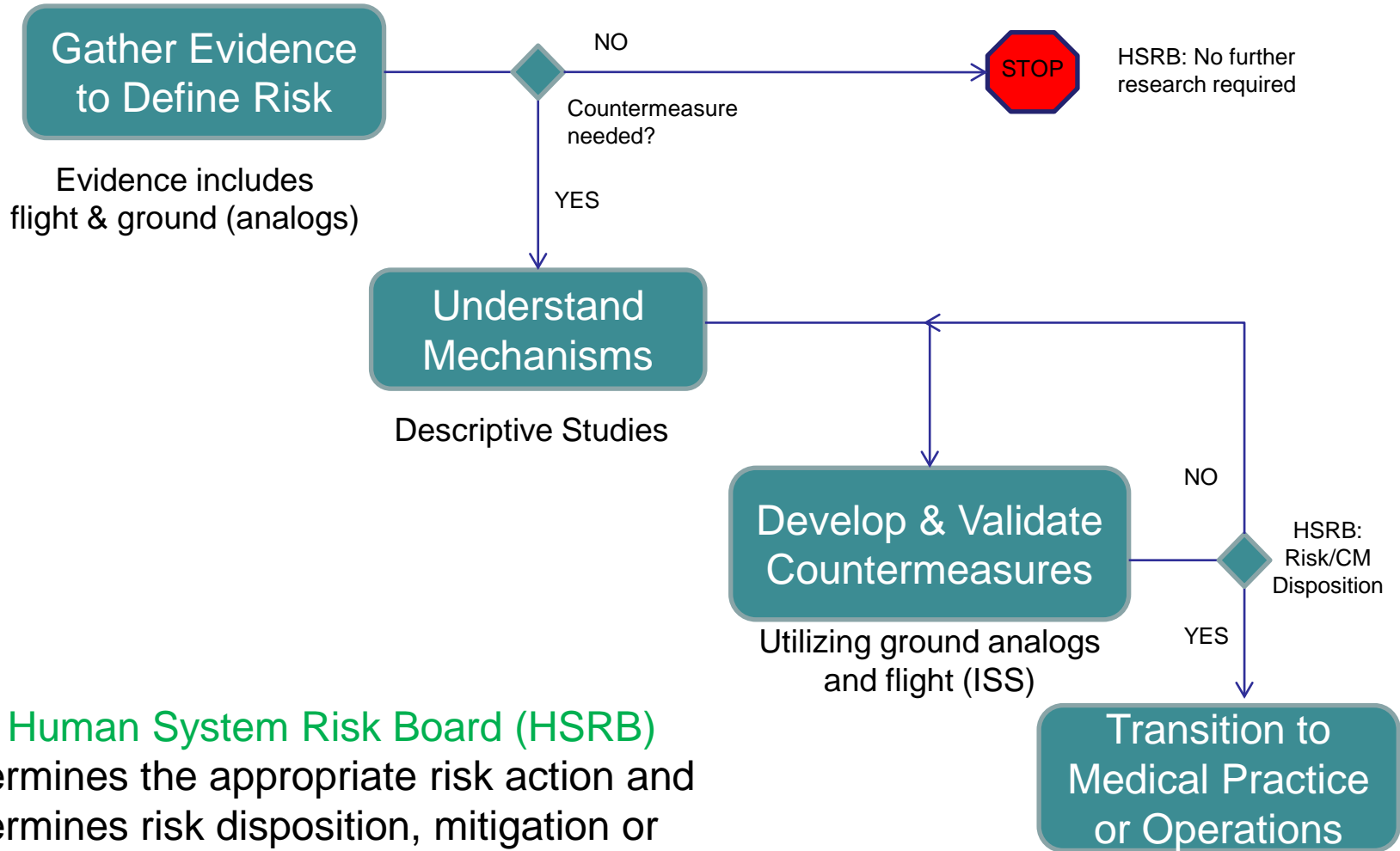
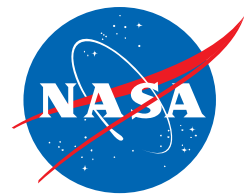




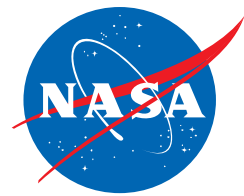
Parabolic flight – shortterm 0 G

Human Research Program





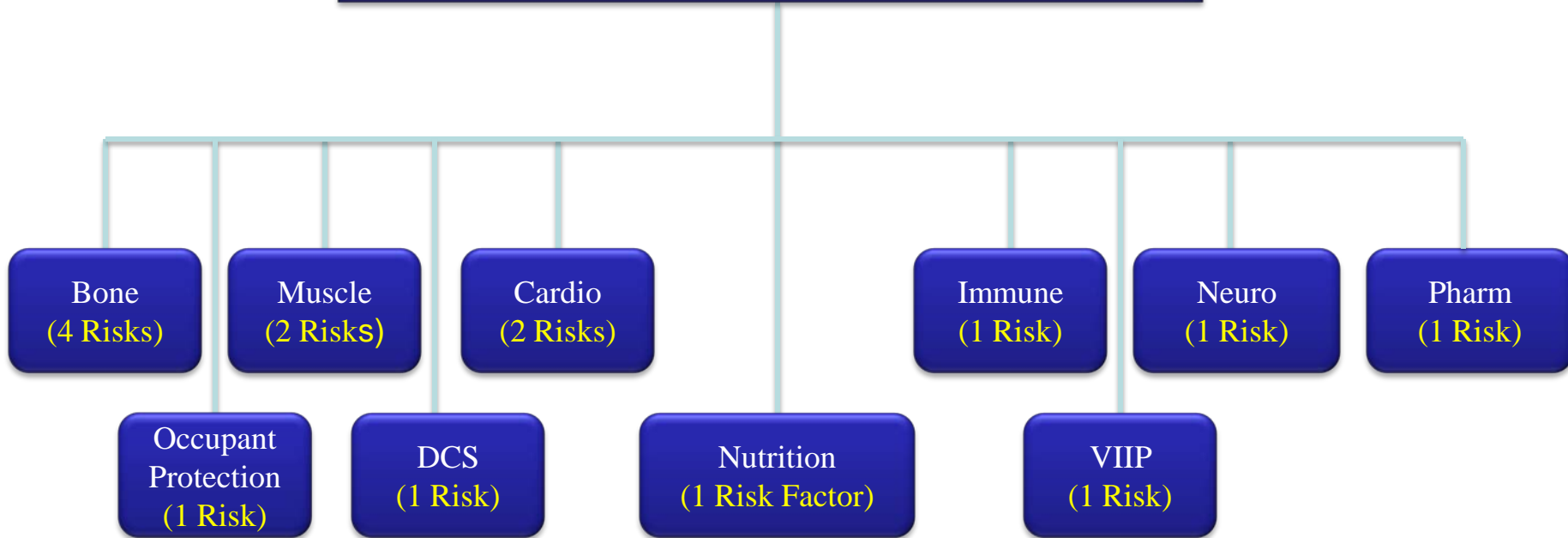
The **Human System Risk Board (HSRB)** determines the appropriate risk action and determines risk disposition, mitigation or monitoring strategy.

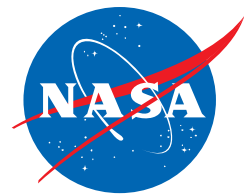


HHC Program Element Disciplines

Human Research Program

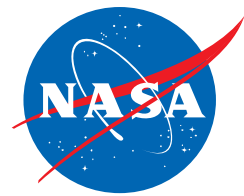
Human Health Countermeasures
Manager – *David Baumann*
Element Scientist – *Peter Norsk, M.D.*
Deputy Element Scientist – *Lauren Merkle, Ed.D.*





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)

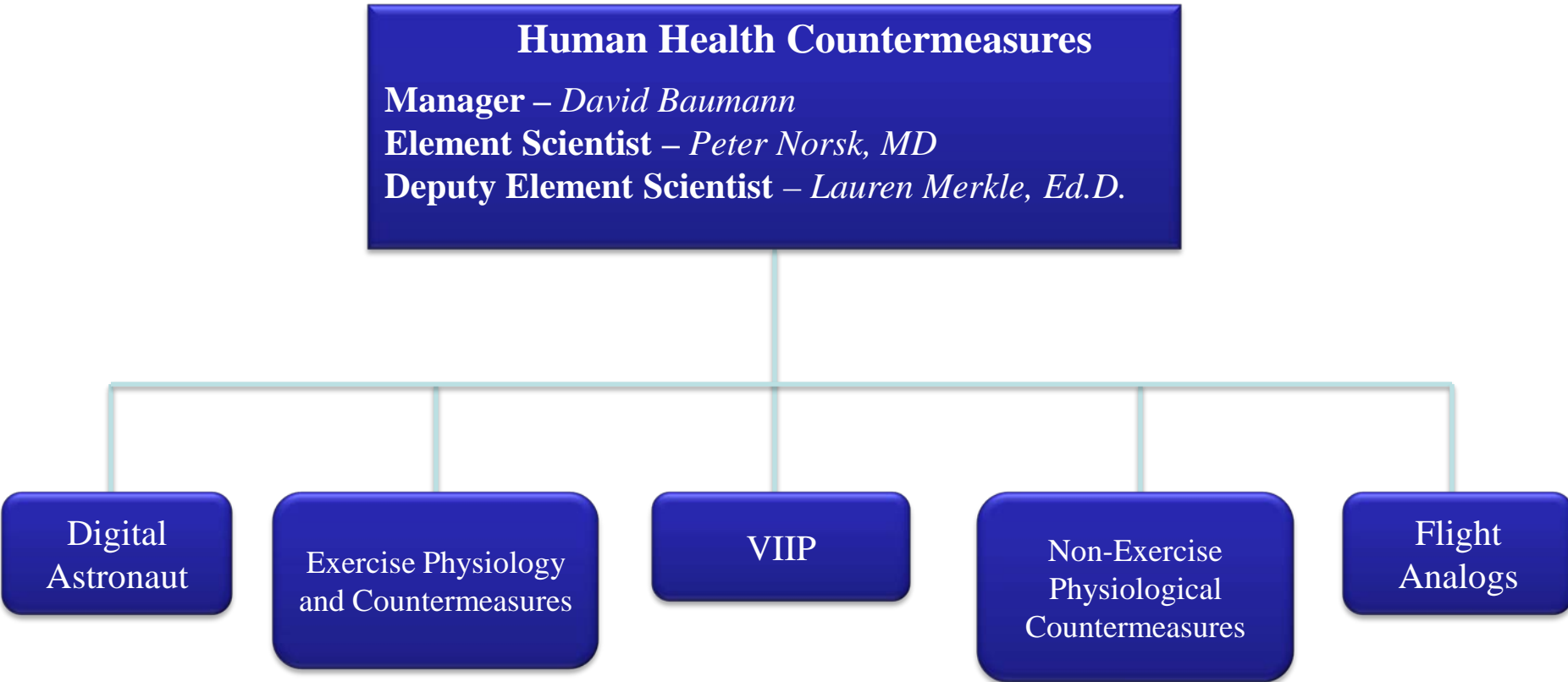
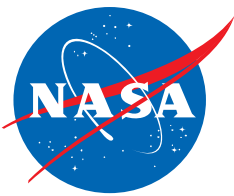


HHC Risks

- 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

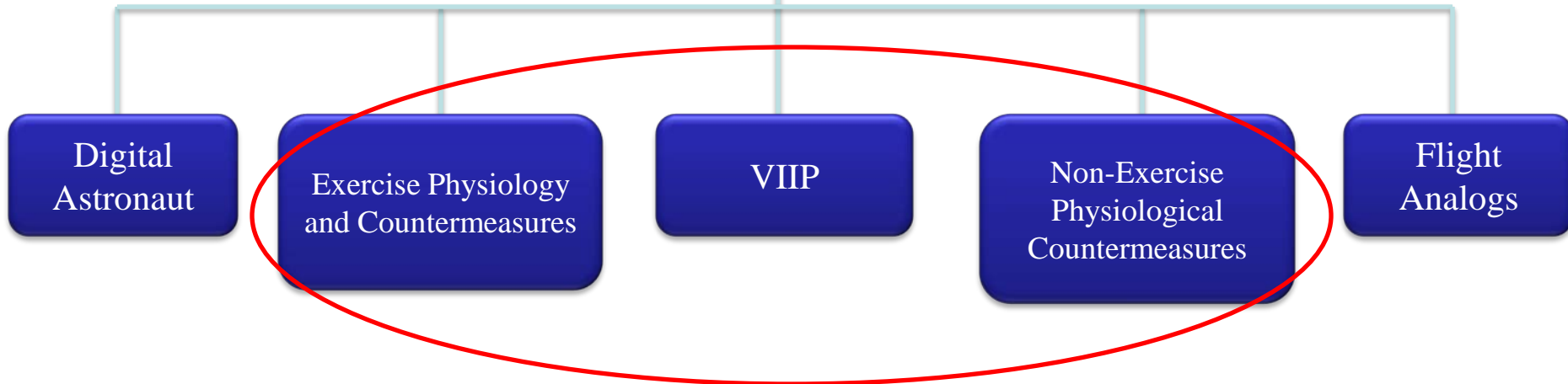
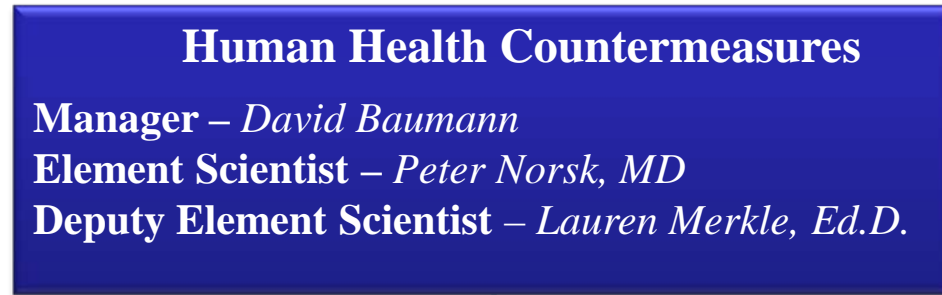
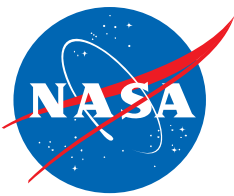


Human Health Countermeasures Element Structure





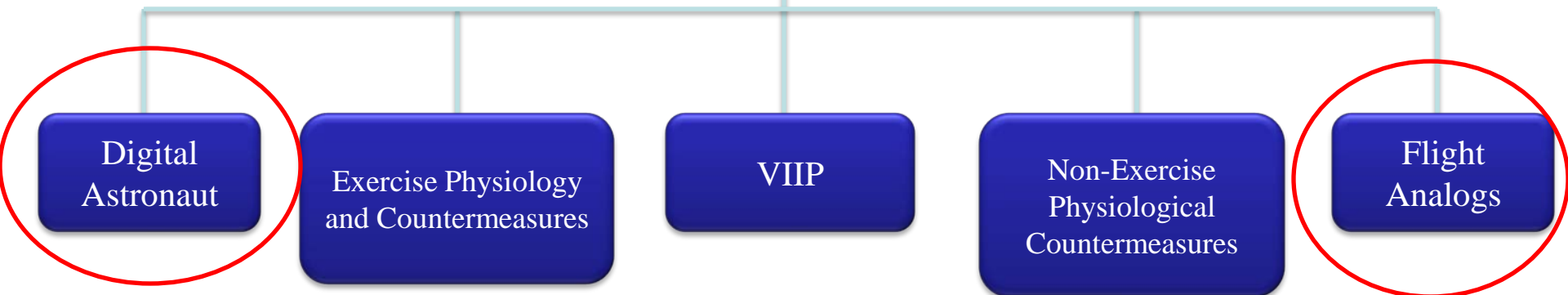
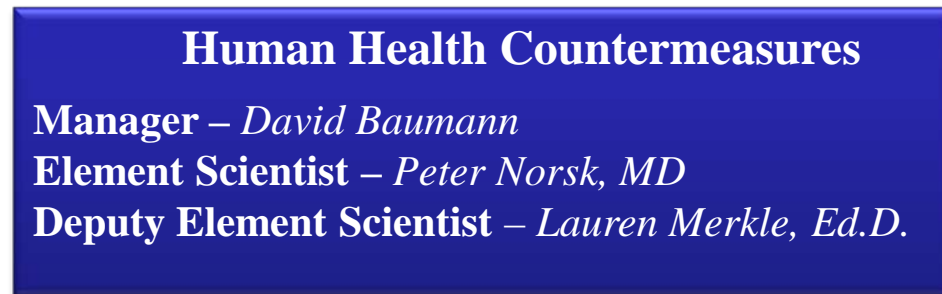
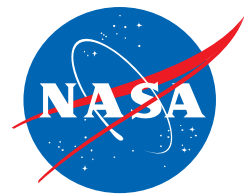
Human Health Countermeasures Element Structure



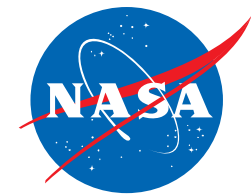
Projects directly supporting Risk Mitigation



Human Health Countermeasures Element Structure



Enabling Projects - Infrastructure

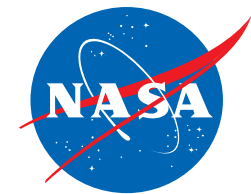


HHC Scorecard of Evidence

Human Research Program

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

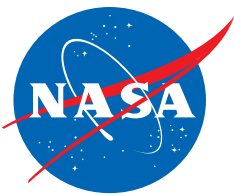
Green = no additional evidence/data needed
 Yellow = incomplete evidence/data
 Red = little or no evidence/data
 Grey = not applicable (N/A), need is unknown (UKN), or to be determined (TBD)



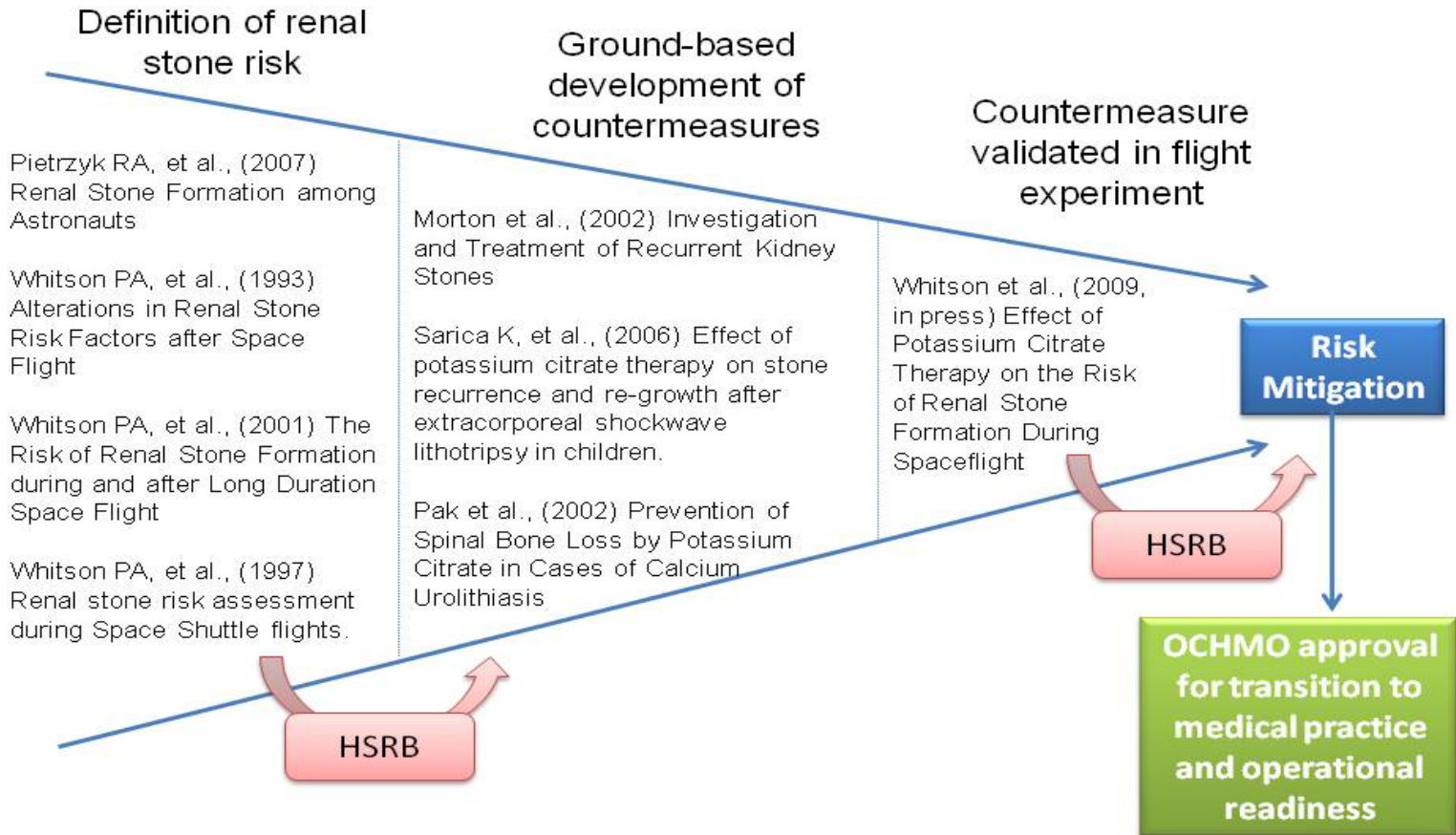
Human Research Program

Study Areas										
Discipline/Risk	Evidence/Data					Performance	Mechanistic Studies	CM Studies	Technology Development	Informing Operations
	Ground Analogues	Pre/Post-flight		In-flight						
		short dur	long dur	short dur	long dur					
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)

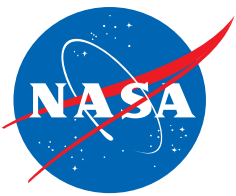


Types of Deliverables

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



National Aeronautics and Space Administration

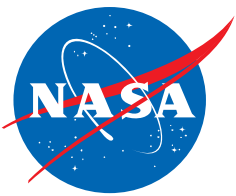


Human Research Program

Thank you



National Aeronautics and Space Administration



Human Research Program

Questions?