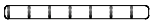
Summary		**Early Start**		**7) Countermeasure**	
G: Ground Study		**Task To Be Determined After Decision Point**		**8) Information To/From other Elements**	
F: Flight Study		**Major Milestone/Event/Accomplishment**		**9) Information to HSRB**	
L: Lunar		**1) Risk Characterization**		**10) Requirements**	
NSBRI		**2) Task↓↑Task**		**11) Study**	
DA&M: Data Analysis & Modeling		**3) Standards - New**		**Stop**	
FP: Flight Prep		**4) Standards - Update**		**Major Decision Point**	
AO: Add on to another study		**5) Tool**			
Planned/unfunded		**6) Technology**			

Task Name

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

ISS and other vehicles

a b c d e f g

▲a: 6 Crew Capability; ▲b: Shuttle Retired; ▲c: EFT1; ▲d: MPCV CDR; ▲e: EM1; ▲f: EM2; ▲g: End of US Commitment to ISS

ISS as Mars analog

Space Radiation (SR)

Risk of Acute Radiation Syndromes Due to Solar Particle Events (SPEs)

Integration/Evaluation of Research Results

Radiation Risk Projection Model V1.0

6 Baseline Radiation Risk Projection Model V1.0

Acute Radiation Risk Projection Model V2.0/PEL Recommendation #1

DA&M

6 4 ↑6: Acute Risk Model V.2; ↑4: Acute PEL Update #1 recommendation

Are updates to Acute PELs necessary?

Acute Radiation Risk Projection Model V3.0/PEL Recommendation #2

DA&M ↑3: Final Report; ↑4: Acute PEL Update #2 ↑6: Acute Radiation Risk Project Model V3.0

3 4 6

Evidence from Acute Gaps 1-3

2

Does Evidence suggest Acute PEL update is necessary?

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ISS and other vehicles

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ISS as Mars analog

Space Radiation (SR)

Risk of Acute Radiation Syndromes Due to Solar Particle Events (SPEs)

Acute - 1: Determine the dose response for acute effects induced by SPE-like radiation, including synergistic effects arising from other spaceflight factors (microgravity, stress, immune status, bone loss, etc.) that modify the biological response.

Research on Prodromal syndrome and skin injury

Define the RBE for protons of relevant energies

NSBRI: G

Determine dose rate dependence for protons over the relevant range of dose rates

NSBRI: G

Determine the dose and dose rates dependencies of acute radiation syndromes from protons

NSBRI: G

Determine impact of a large skin dose on the immune system. Will this alter the dose response of the blood system?

NSBRI: G

Is research sufficient to determine the RBE and dose rate response for acute effects from SPE's?

Yes ↓ No → continue

Increase research emphasis on skin risks and possible impact of high skin dose on immune function and synergies.

Determine microgravity and stress impacts on dose-response for prodromal risks

NSBRI: G

Research Results on Synergisms

Information exchange with SR & HHC, BHP on immune dysfunction

8

Determine skin damage and concomitant impact on immune system function from large SPE skin dose; and research on possible synergistic effects of microgravity on acute radiation effects.

G: NSCOR Research

Task Name

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025
1 2 3 4 1 2 3 4

ISS and other vehicles

a b c d e f g

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ISS as Mars analog

Space Radiation (SR)

Risk of Acute Radiation Syndromes Due to Solar Particle Events (SPEs)

Acute - 2: What quantitative procedures or theoretical models are needed to extrapolate molecular, cellular, or animal results to predict acute radiation risks in astronauts? How can human epidemiology data best support these procedures or models?

Risk Modeling and Data Analysis - Phase I

DA&M ▲a, b

Development of: ▲a: kinetic models of prodromal and blood systems; ▲b: track models of RBE's in tissues

↑3: Beta Version and V1.0 Acute Risk Model development

Risk Modeling and Data Analysis - Phase II

DA&M ↑6: DOD Model adjusted for SPE protons

▲a, ▲b

2 ↑3, ↑6

↑2: Input received from Gap 1 & 3; ↑3: Model V2.0 development

▲a: Couple GI tract with blood model; ▲b: Couple Software with Real Time Alert Data

Acute - 4: What are the probabilities of hereditary, fertility, and sterility effects from space radiation?

Research to address risks of hereditary and fertility

G

Research results on hereditary and fertility effects

Does evidence suggest Acute PEL update is necessary?

Stop ← No Yes → update PEL

Task Name

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1 2 3 4 1 2 3 4

ISS and other vehicles

a b c d e f g

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ISS as Mars analog

Space Radiation (SR)

Risk of Acute Radiation Syndromes Due to Solar Particle Events (SPEs)

Acute - 5: What are the optimal SPE alert and dosimetry technologies? (Closed. Technology maturation transferred to Advanced Exploration Systems)

Determine Dosimetry Requirements for EVA

G: Lunar dosimetry requirements

Develop EVA Alert Dosimetry

EVA Alert/Dosimetry Ground Study (Phase I)

Spacesuit & Tool-Box Apps / Technology development

Deliver Technology

NSBRI: G

6

Are EVA Technologies sufficient?

Stop ← Yes No ↓ implement Phase II

Acute - 6: What are the most effective shielding approaches to mitigate acute radiation risks, how do we know, and implement? (Closed. Transferred to Operations)

Task Name

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ISS and other vehicles

a b c d e f g

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ISS as Mars analog

Space Radiation (SR)

Risk of Acute Radiation Syndromes Due to Solar Particle Events (SPEs)

Acute - 7: What are the most effective biomedical or dietary countermeasures to mitigate acute radiation risks?

NSBRI CARR

NSBRI: G

DA&M

▲a,▲b 3 ↑3: Information of CM Requirements for Acute Effects

▲a: Determine side-effects and alteration of CM effectiveness in space

▲b: Determine the efficancy of FDA of approved CMs for radiation doses and dose rates of protons

Countermeasure Research to mitigate acute risks

Stop ← No Yes ↑ continue CM research

Are CM's for acute effects Required?

DA&M

▲: Select Appropriate CM; ↑7: CM delivery to SOMD

7

Stop ← No Yes ↑▲: Select Appropriate CM

Have suitable CM's been identified and validated?

Acute - 8: How can Probabilistic risk assessment be applied to SPE risk evaluations for EVA, and combined EVA+IVA exposures ?

Risk Modeling

DA&M ▲: EVA/IVA probabilistic risk assessments from SPE exposure

2a 2b 2c 2d

↑2a: Input data received from gaps 1 & 3; ↑2b: Acute Risk Model V.2 development

↑2c: Receive Updated Model w/ CARR research data gamma vs. protons; ↑2d: Model V.3 development