Human Research Program (HRP)
Exploration Medical Capability (ExMC)
Standing Review Panel (SRP)
Final Report

December 2009

I. Executive Summary & Overall Evaluation

The Standing Review Panel (SRP) recommends revising the Exploration Medical Capabilities (ExMC) Risk (The Risk of Inability to Adequately Treat an Ill or Injured Crew Member) to read: The Risk of Inability to Adequately Recognize or Treat an Ill or Injured Crew Member. The SRP felt that the ability to recognize illnesses early on is fundamentally important.

The SRP believes strongly that regularly performed in-flight crew assessments are needed in order to identify a change in health status before a medical condition becomes clinically apparent. It is this early recognition in change that constitutes the foundation of the "occupational health model" expounded in the HRP Requirements Document as a key component of the HRP risk mitigation strategy that will enable its objective of "prevention and mitigation of human health and performance risks". A regular crew status examination of physiological and clinical performance is needed. This can be accomplished through instrumented monitoring of routine embedded tasks. The SRP recommends addition of a new gap to address this action under Category 3.0 Mitigate the Risk. This new gap is closely associated with Task 4.19 which addresses the lack of adequate biomedical monitoring capabilities for performing periodic clinical status evaluations and contingency medical monitoring. A corollary to these gaps is the critical emphasis on preventive medicine, not only during pre- and post-flight phases of a mission as is the current practice, but continued into the in-flight phases of exploration class missions.

The SRP offered the following comments on the overall program plans:

1. **Inclusion of a Physician Crewmember**
   The SRP strongly recommends inclusion of a physician crewmember with relevant competency maintained over the exploration mission to achieve better care/reduced risk, reduced cost, reduced training time, increased efficiency, reduced need for telementoring and increased autonomy.

   With the significant and new challenges to crew health that the Exploration Program objectives brings to NASA's Human Spaceflight program, the risks to crew safety, health, productivity and performance are enormous. Planetary travel with its hazards, limited communications, extended duration, and isolation will make NASA's responsibility to provide comprehensive medical care during all space flight mission phases daunting. In the face of these goals, objectives and requirements, the SRP upon reviewing the Integrated Research Plan (IRP) update of the ExMC element with its associated gaps, tasks and Exploration Medical Condition List cannot envision successful execution of exploration

missions without the inclusion of an experienced physician crewmember. The criticalness of this requirement to the success of analogous remote, resource poor environments like McMurdo and the South Pole Station in Antarctica, nuclear submarines and special forces is reflected by the requisite inclusion of a medical professional (physician, physician assistant) on their core staff. Medicine is not a passive endeavor, but rather one that requires years of training and experience to acquire competency. Just as one cannot automate into untrained hands the operation and safety of a spacecraft, one cannot automate delivery of responsible medical care either. At the same time, the SRP recognizes that not all medical conditions are treatable, given the limited resources, and that some cases may go untreated.

Throughout all HRP documents, a major emphasis is given to reduction of human systems resource requirements in order to reduce the overall demand on the limited Exploration Program resources. Resource limitation is such a critical issue that the HRP Requirements Document includes it as subject of one of its overarching requirements:

"6.4 The HRP elements shall develop methods and technologies to reduce human systems resource requirements (mass, volume, power, data, time, etc)."

And is equally emphasized in the HRP IRP:
"The first and most desirable approach to mitigating a human health and performance risk is to engineer the risk out of the system. ....To facilitate risk avoidance, the HRP identifies requirements for crew selection, vehicle or mission design."

The addition of a physician crewmember to exploration missions would significantly simplify the implementation of medical care and reduce the need and consequent high cost of complete automation of clinical tasks such as those proposed for on-board training systems, guided medical procedure and clinical decision support systems, and automated treatment technologies.

Both the time necessary to expend on training and the risk of failure would be considerably decreased. The autonomy and flexibility in clinical practice required in the unpredictable environment of exploration missions can only be achieved by incorporating the training and knowledge of a physician.

In order to assure crew health, safety, and performance during exploration missions while reducing costs and resource requirements, the SRP identified and added a gap and corresponding task to address this need (Gap 2.02; repeated as Gap 7.01). The SRP considered this one issue the most important and critical to the success of the ExMC Element objectives and to exploration missions in general.

2. Leveraging and Collaboration

A most important risk mitigation strategy for the ExMC Element is to prevent serious medical problems uniquely associated with space flight (or of important concern). This can be accomplished by increased communication with and reliance on other SRPs addressing the nature of musculoskeletal and associated physiological changes/medical risks; changes in host defense responses affecting healing and susceptibility to disease; toxic inhalation

exposures; radiation effects on brain performance and health; and behavioral monitoring for dysfunction associated with isolation, boredom, and altered perception. Serious medical problems such as kidney stones can be much more effectively addressed through preventive measures including adequate hydration and longer range research efforts to develop hydration monitoring technologies.

The defined tasks effectively leverage other agencies. Specific collaborations with the Department of Defense have included development of:1) a stethoscope for use in noisy environments with the US Army Aeromedical Research Laboratory; 2) a patient monitoring device with algorithms for simple alerts for nonmedical personnel (which was demonstrated for the review team) by the US Army Medical Materiel Agency; and 3) a predictive Integrated Medical Management tool using casualty data from the Naval Health Research Center and the Institute of Surgical Research. These collaborations each represent an efficient use of resources and should be promoted as examples of effective sharing to accomplish respective agency-specific mission objectives (i.e., these are not duplicative, and the agency applications are different).

There are opportunities for even greater future coordination and collaboration for the ExMC Element, especially with the Department of Defense. NASA researchers have been participating in program reviews such as the annual Advanced Technology Applications for Combat Casualty Care meeting sponsored by the US Army's Combat Casualty Care research program. Another opportunity for program coordination is the annual Special Forces Special Operations Medical Association conference in December. Jointly sponsored workshops with the Combat Casualty Care research program, Office of Naval Research, the Telemedicine and Advanced Technology Research Center, and the National Science Foundation could be used as opportunities to further advertise NASA's medical science and engineering requirements.

The Small Business Innovation Research (SBIR) program is also being leveraged. One task area was being addressed by three SBIR projects. If carefully managed, then SBIR projects can help fill under-resourced gaps. However, the SBIR program should be used only to provide additional risk reduction. Reliance on the SBIR program is a challenge because of its design, with funding that is generally insufficient to lead to a complete commercial product, and with small enterprises that cannot take risks for truly innovative solutions. Furthermore, it requires experienced and creative contract managers to maximize the benefits from such projects.

3. **ExMC relationship to National Space Biomedical Research Institute (NSBRI) exploratory research**

The separate (but communicating) extramural unit (the NSBRI) allows for new discoveries to overcome technological barriers in the ExMC Element, without confusing the applied research efforts to solve problems in the near term. It would be more powerful if the NSBRI program was better aligned with some of the key barriers in the ExMC Element (e.g., altered brain/behavior monitoring/markers; acceleration of tissue healing; hydration status monitoring, etc.). These should be interesting challenges to academic scientists and engineers. There should be more communication between NSBRI researchers and the

program manager/applied researchers working on the ExMC Element. Technology Readiness Level (TRL) 6s listed on the charts in the IRP often seemed more like desired goals than realistic objectives.

4. **Technology Approach**
The SRP noted that many of the gaps appeared to be interpreted as automatically requiring a technology approach as opposed to a broader approach to solving the problem. This is in part linked to the risk statement which is "to treat", but to treat does not necessarily mean that a piece of medical technology must be built or acquired. In this regard the engineering imperative to "build something", and in many cases to build something complex clearly has its place in addressing the stated risk, but not necessarily as a preconceived starting point. This predilection to build is perhaps best illustrated by the original ExMC 4.13 "Lack of lithotripsy or other capability to treat a renal stone." (The SRP has suggested modifying this gap.) Although "other capability" is included, the decision to invest in a flyable lithotripter appeared to the SRP to reflect just one possibility of how to deal with renal stones. Moreover, from the medical perspective it appeared that the challenges of safe and expedient lithotripsy, and its potential side effects, were at least not articulated in the material available for our review. The SRP also noted that prevention of renal stones (e.g., adequate fluid consumption) was far more desirable than treatment, in terms of safety and effectiveness, as is almost always the case. Similarly ExMC gap 4.01, Lack of autonomous medical procedure system...and ExMC gap 4.04, Lack of smart hardware for ventilation..., appear to assume that the solutions are necessary to create such systems or hardware. In fact, the gaps as stated appear to demand that they be created, but that doesn't make it correct since the gap statement is driven by the technology approach.

5. **Closure of Gaps**
The SRP noted that at least some of the gaps were worded in such a way that closing them would be difficult to do, and/or difficult to recognize. ExMC 1.03, Inadequate information on the individual susceptibility to hypobaric environments, was an example of this problem. This gap was said to have been closed by a study that was completed. However, the closure was seen as confusing by the SRP in that "inadequate information" remained to be the outcome. Perhaps if the gap had been stated as "Lack of investigation of the ability to predict individual susceptibility...", then doing such an investigation would have produced closure. This appeared to be more than a semantic issue because the SRP concluded that it would not be desirable to have a long list of gaps that by their very statement were never closed, and which would then all have to be dealt with as exceptions.

6. **Techwatch**
Techwatch component for leveraging is encouraging but may need to be a more structured activity that documents the study. An annual report or article on the activity is essential.

7. **Definition of Category 4**
The SRP noted that the category 4 of the ExMC risk currently reads as: Monitor and Treat the Unmitigated Risk. The SRP recommends that the ExMC Element revise category 4 to: Monitor and treat each condition.

8. **Definition of Technology**
   In this document, technology is defined as a solution created by man. This could include a manufactured product or a method or an application of knowledge. In addition, the SRP recommends that the program encourage cognizance of multiple uses of technologies.

In summary, after detailed review and discussion, the SRP added six gaps with tasks (one is a repeat included in two different "Categories"), deleted one gap, and added, transferred, and deleted multiple tasks throughout the ExMC IRP Update document.

II. Critique of Gaps and Tasks

RISK OF INABILITY TO ADEQUATELY TREAT AN ILL OR INJURED CREW MEMBER

Category 1.0: Validate Standards

ExMC 1.01: Inadequate and/or immature information on medical screening technology for the identification of clinical and sub-clinical pathology

The SRP recommends revising this gap to: Inadequate and/or immature information on medical screening technology for the identification of clinical and sub-clinical pathology for mission environments.

Current Tasks:

- Science and technology watch for medical screening technology (Techwatch screening)
- The SRP noted that the Science and technology watch for medical screening technology (Techwatch screening) is an important and valid task.

Comments regarding the Current Tasks by the SRP:
The SRP recommends specifying conditions that are of concern. If there are no conditions of concern, then this gap and the corresponding tasks can be deleted.

ExMC 1.02: Inadequate information on genetic screening technology

The SRP recommends revising this gap to: Inadequate information on genetic and phenotypic screening

Current Tasks:

- Science and technology watch for genetic screening methodology to inform future implementation (Techwatch genetic) (ON HOLD)

Comments regarding the Current Tasks by the SRP:
The SRP noted that the genotype screening has limited value at this time.

Missing Tasks Identified by the SRP:

1. Science and technology watch for phenotypic screening methodology to inform future implementation.

ExMC 1.03: Inadequate information on the individual susceptibility to hypobaric environments (e.g., 7.2 psi lunar habitat)

Current Task:

- Data Mining/Identification of characteristics associated with susceptibility to hypobaric environments (DM Hypobaria)

Comments regarding the Current Task by the SRP:
The SRP noted that this task has been completed.

Category 2.0: Quantify the Risk

ExMC 2.01: Lack of knowledge about incidence rates, probabilities and consequences relative to Loss of Crew and/or Loss of Mission (LOC/LOM) for the medical conditions on the Exploration Medical Condition List

Current Tasks:

- Integrated Medical Model (IMM)
- Integrated Medical Model (GRC simulations) (IMM-GRC)

Comments regarding the Current Tasks by the SRP:
The SRP noted that these are important and valid tasks. Models should be tested using data not previously used in the model. Some significant chronic events should be modeled.

SUGGESTED NEW GAP:

Define impact of inadequate assessment of value of a physician on board

Suggested task for this new gap:

- IMM Task under Gap 2.01 will help quantify the risk with and without a physician

Category 3.0: Mitigate the Risk

ExMC 3.01: Lack of knowledge about effectiveness of NASA medical training programs including crewmember and ground support

Current Tasks:

- Medical Proficiency Training (Training, Medical)
- Data Mining of Postflight Medical crew debriefs for information on crewmember medical training.

Missing Tasks Identified by the SRP:

1. Determine metrics of individual and team proficiency due to training

ExMC 3.02: Lack of knowledge about the state of the art in telementoring/telemedicine

Current Tasks:

- Data mining for telementoring studies and practices (ExMC DM)
- Validation of on-Orbit Methodology for the Assessment of Cardiac Function and Changes in the Circulating Volume Using Ultrasound and Braslet-M Occlusion Cuffs, SDTO 17011 U/R (Braslet)*
- Ultrasound Fracture Diagnosis in Space (Dulchavsky) (Ultrasound Fracture)*
- Identify medical conditions that require telementoring/telemedicine. (Techwatch tele)

* *The SRP recommends moving these two current tasks to gap ExMC 4.02*

SUGGESTED NEW GAPS:

Inadequate early recognition of in-flight medical conditions

Suggested task for this new gap:

- Determine how to regularly monitor crew members to recognize early symptoms and signs of a condition, before this condition becomes apparent. Regularly performed assessments are needed in order to identify a change in status before a medical condition becomes clinically apparent. A regular crew status examination of psychological or physiological performance is needed. This can be accomplished through embedded instrumented monitoring of routine tasks.

Lack of knowledge for early recognition and treatment of adverse psychological, behavioral, and functional conditions

Suggested tasks for this new gap:

- Techwatch for non-invasive methods for assessment such as embedded task assessment.
- Examine additional analogs for behavior assessment.
- Research designs for best environments incorporating human factors, behavioral health, and industrial engineering principles to promote optimal psychological, behavioral, and functional outcomes.

Category 4.0 Monitor and Treat the Unmitigated Risk

ExMC 4.01: Lack of autonomous medical procedure system that includes decision assistance and integrates with medical hardware

The SRP recommends revising this gap to: Lack of advanced medical procedure system that includes decision assistance and integrates with medical hardware including closed loop systems.

Current Task:

- Advanced Integrated Clinical System - Guided Medical Procedure System (AICS Assisted)

Missing Task Identified by the SRP:

1. Closed loop systems (such as anesthesia delivery system and glycemic control system)

ExMC 4.02: Lack of non-invasive diagnostic imaging capability and techniques to diagnose identified Exploration Medical Conditions involving internal body parts

Current Tasks:

- Intuitive Ultrasound Catalog for Autonomous Medical Care (Ultrasound Catalog)
- Medical Imaging Integration (Imaging Integration)
- Combined Scanning Confocal Ultrasound Diagnostic and Treatment System for Bone Quality Assessment and Fracture Healing (Ultrasound Bone Quality)

Comments regarding the Current Tasks by the SRP:
The SRP recommends that the words "and fracture healing" be deleted from the last task titled "Ultrasound Bone Quality". The revised task should read: "Combined Scanning Confocal Ultrasound Diagnostic and Treatment System for Bone Quality Assessment (Ultrasound Bone Quality)"

The SRP recommends moving the following tasks from ExMC 3.02 (Lack of knowledge about the state of the art in telementoring/telemedicine) to gap EVA 4.02.

- Validation of on-Orbit Methodology for the Assessment of Cardiac Function and Changes in the Circulating Volume Using Ultrasound and Braslet-M Occlusion Cuffs, SDTO 17011 U/R (Braslet)
- Ultrasound Fracture Diagnosis in Space (Dulchavsky) (Ultrasound Fracture)

ExMC 4.03: Lack of a system to manage medical data collected from the patient
The SRP recommends revising the gap to: Lack of a system to manage medical data both in space and on the ground collected from the patient

Current Tasks:

- Development of methods/technologies for managing medical data, images, and information
- Development of methods/technologies to transfer medical data, images, and information to the medical expertise for diagnostics and treatment

Comments regarding the Current Tasks by the SRP:
The SRP recommends editing the first task definition to: Development of methods/technologies for managing medical data, images, and information for monitoring and research. The SRP recommends editing the second task definition to: Development of methods/technologies to transfer medical data, images, and information to the medical expertise for diagnostics and treatment

ExMC 4.04: Lack of smart hardware for ventilation with variable oxygenation capability that mitigates localized oxygen build up

Current Tasks:

- Lightweight Trauma Module (ISS funded) (LTM)
- Medical Oxygen Fire Safety (Fire Safety)
- Evaluation of O 2 concentrators at altitude (Oxygen) COMPLETED
- Development of Pressure Swing Adsorption Technology for Spaceflight Medical Oxygen Concentrators (Ritter)

ExMC 4.05: Lack of medical suction and fluid containment capability for chest tube and airway management

Current Task:

- Development of methods/technologies for medical suction

ExMC 4.06: Lack of capability to stabilize and treat bone fractures and musculoskeletal injuries

The SRP recommends revising this gap to: Lack of knowledge about bone and soft tissue healing in microgravity and capability to stabilize and treat bone fractures and musculoskeletal injuries

Current Tasks:

- Development of methods/technologies for treatment of bone fractures (Techwatch Bone)
- Combined Scanning Confocal Ultrasound Diagnostic and Treatment System for Bone Quality Assessment and Fracture Healing (Ultrasound Bone Quality)

Missing Tasks Identified by the SRP:

1. Techwatch for additional promising technologies

ExMC 4.07: Lack of capability to treat back/neck injuries

SRP recommends revising this gap to: Lack of capability to treat back/neck pain and injuries

Current Tasks:

HHC has solicited tasks to help understand mechanisms of space flight back/neck pain and injuries. The results of the selected studies will help determine treatment modalities pursued by ExMC. These tasks will begin in 2010.

ExMC 4.08: Lack of reusable cold compress and heating pad capability made of suitable spaceflight materials

Current Task:

- Development of methods/technologies for providing cold compress and heating pad capability (Techwatch Cold)

Comments regarding the Current Task by the SRP:
The SRP recommends that this task be expanded to include development of other technologies for generating cold and heat (infrared, etc.,).

ExMC 4.09: Lack of in situ intravenous (IV) fluid generation capability

Current Task:

- Intravenous Fluid GENeration for Exploration Missions. (IVGen)

Comments regarding the Current Task by the SRP:
The SRP recommends that this product be submitted for FDA approval.

ExMC 4.10: Lack of rapid vascular access capability

Current Task:

- Development of methods/technologies for rapid vascular access (Techwatch Vascular)

ExMC 4.11: Lack of technique or procedure to draw injectable medication into a syringe without bubble formation and deliver medication to crewmembers in pressurized suits.

Current Tasks:

- Spaceflight Injectable Delivery System. (Injectables)
- Injectable Medication Study for ISS Medical Kit Redesign. (MedKit)

Comments regarding the Current Tasks by the SRP:
The SRP recommends separating the one gap into two with each having one task. These are two separate components.

ExMC 4.12: Lack of dental care capabilities

Current Tasks:

- CDDF/Innovative Treatments of Dental Emergencies for Lunar and Exploration Missions (COMPLETED)
- Development of methods/technologies for dental conditions (Techwatch Dental)

ExMC 4.13: Lack of lithotripsy or other capability to treat a renal stone
The SRP recommends revising the gap to: Lack of knowledge of renal stone formation, prevention and treatment

Current Task:

- Smart therapeutic ultrasound device for mission critical care (Smart Ultrasound)

Comments regarding the Current Task by the SRP:
The SRP finds that this is a low priority and high risk treatment (requires sedation and anesthesia which are added risk).

Missing Tasks Identified by the SRP:

1. Techwatch
2. Technologies for pre-clinical diagnosis

ExMC 4.14: Lack of capability to treat radiation sickness

Current Tasks:

- Development of methods/technologies for treating radiation sickness

Comments regarding the Current Tasks by the SRP:
The SRP strongly notes that this task may affect mission design and should have higher priority. We also add that the treatment protocol is of extremely great importance. The SRP also recommends that the ExMC Element work with Space Radiation Element to enhance resilience and develop treatments.

ExMC 4.15: Lack of minimally invasive inflight laboratory capabilities with limited consumables required for diagnosing identified Exploration Medical Conditions.

Current Tasks:

- Lander/Outpost Inflight Lab Analysis-ARC (Lunar Lab Analysis)
- In-flight Blood Analysis Technology for Astronaut Health Monitoring (In-flight Blood Analysis)
- Reusable Laboratory Capability (Reusables)
- rHealth (SBIR) (PHASE I COMPLETED)

Comments regarding the Current Tasks by the SRP:
The SRP recommends that the Techwatch should be part of every task listed above.

ExMC 4.16: Lack of wound care capability to improve healing following wound closure

Current Task:

- Development of methods/technologies for wound care capability (Techwatch Wound)

Comments regarding the Current Task by the SRP:
The SRP feels that through this task, the ExMC Element should evaluate the clinical significance and frequency of this problem as well as the economic impact of currently proposed solutions.

ExMC 4.17: Lack of capability to auscultate internal sounds of the body in a spaceflight environment

Current Task:

- Development of methods/technologies to auscultate and capture body sounds in a noisy environment

Comments regarding the Current Task by the SRP:
The SRP recommends deleting this gap and task.

ExMC 4.18: Lack of adequate biomedical monitoring capability for Constellation EVA Suits

Current Tasks:

- Noninvasive Biosensor Algorithms for Continuous Metabolic Rate Determination. (Biosensor Metabolic)
- Biomedical Sensors (EVA) ARC. (Biomedical Sensors)

ExMC 4.19: Lack of biomedical monitoring capabilities for performing periodic clinical status evaluations and contingency medical monitoring

Current Tasks:

- Biomedical Sensors (IVA)
- Lightweight, Wearable Metal Rubber-Textile Sensor for In-Situ Lunar autonomous Health Monitoring (Metal Rubber) (NanoSonic)
- Wearable Health Monitoring Systems (Nyx)
- Lunar Health Monitor: A Wearable System to Monitor Astronaut Health Status (Orbital)

Comments regarding the Current Tasks by the SRP:
The SRP recommends that the ExMC Element explore other non-invasive methods for measurement of blood or interstitial fluid analytes and exhaled gases.

ExMC 4.20: Lack of adequate eye wash capability to treat chemical eye exposure in a partial gravity environment

Current Tasks:

- Development of methods/technologies for eye wash capability in a partial gravity environment

ExMC 4.21 Lack of adequate protection for medications to preserve stability and shelf-life

Current Tasks:

- Stability of Pharmacotherapeutic and Nutrition Compounds (SMO). (Stability Flight)
- Development of methods/technologies for medication stability and shelf - life

ExMC 4.22: Lack of efficient medical consumable inventory tracking system that provides data on overall usage and usage rate and integrates securely with vehicle inventory management system

Current Task:

- Consumable Tracking – GRC (Medical Consumables)

ExMC 4.23: Lack of medication usage tracking system that includes automatic time stamping and crew identification

Current Tasks:

- Consumable Tracking

SUGGESTED NEW GAPS:

Lack of knowledge of treatment of conditions in remote resource poor environments

Suggested task for this new gap:

- Literature review and interviews with practitioners who have experience working in resource poor environments (i.e., special forces, third world countries, astronaut/cosmonaut flight surgeons, south pole and submarines, wilderness medicine society)

Lack of knowledge for treating pulmonary or systemic diseases due to inhalation of gases, pathogens, particulates, lunar dust and other substances

Suggested tasks for this new gap:

- Quantify risk
- Burn treatments particularly for trachea
- Pulmonary treatments for dust inhalation

Additional Comments from the SRP:

1. Smoke inhalation and toxic exposure are listed as conditions.
2. Pre- and post-flight evaluation of pulmonary function and status should be continued.

Category 5.0: Provide Enabling Capabilities

ExMC 5.01 Lack of medical data management infrastructure for Exploration Missions

Current Tasks:

- Mission Medical Information System (MMIS)
- Life Sciences Data Archive (LSDA-JSC)
- Life Sciences Data Archive (LSDA-ARC)

Category 6.0: Comply with Agency Standards
There are currently no gaps identified.

Category 7.0: Reduce Resource Requirements
There are currently no gaps identified.

Suggested New Gap (Repeated from new gap in Category 2)

Define impact of inadequate assessment of value of a physician on board

Suggested task for this new gap:

- IMM Task under gap 2.01 will help quantify the risk with and without a physician

III. Discussion on the strengths and weaknesses of the IRP

The ExMC SRP had one general comment regarding the IRP Document: "N/A" in IRP Supplement is defined to mean "Not Available".

Strengths:

- The IRP thoughtfully detailed many risks, gaps, tasks and medical conditions in a well digested manner that was easy to follow and reflected a sound overall strategy.

Weaknesses:

- The gaps are written in such a way that closure is unlikely and the tasks are insufficient to accomplish gap closure.
- Reduction of medical terminology and issues into engineering language creates a risk of oversimplification.
- Medical conditions are understood more easily when the list is organized by system rather than alphabetical – a minor concern, but an example of a non-medical approach.
- Better coordination and inclusion across silos. Ensure that vehicle design group and other engineering elements (such as EVA designers) are members of the ExMC Element advisory group.
- Advisory group could re-evaluate priority scale of some of the behavioral conditions – such as anxiety during various contingency scenarios - and *de novo* hypertension during lunar sortie

IV. Discussion of element specific questions in addendum and/or any other issues or concerns the panel chooses to address.

1. Are there obvious, unrealistic aspects in the IRP schedule?

- Lack of automatic inclusion of physician in the crew roster makes the overall schedule/plan more difficult to achieve.
- Some of the tasks achieving TRL 6 seem unrealistic in the stated timeframe.
- Autonomously functioning system which provides useful medical/clinical decision support by FY 2010 is very improbable to achieve.

- Needs to help make effective medical/clinical decisions and integrate with hardware, not just digitized procedures.

2. **Is the portfolio of tasks sufficiently complete to acquire an adequate description of the risks?**

   - No. The current tasks do not always sufficiently address the risk.
   - From the insufficient task description available to the SRP, it is difficult to assess if tasks mitigate risk or close the gaps.

3. **Is the portfolio of tasks using or developing the appropriate technologies?**

   - Development of technologies to replace a physician such as telementoring, operating an ultrasound, auscultating, managing a ventilator, administering medications, starting an IV, demonstrating medical judgment etc., will be more effective for a physician crew member than a non-physician crew member.
   - Current plan does not specify that a physician automatically be the medical officer and therefore some of the technologies under development are less likely to be effective. Avoiding inclusion of a physician crew member creates technology demands and adds impediments to the mission such as increased training time, reduced autonomy, increased cost associated with development of technologies, decreased performance and safety and increased complexity of technologies.

4. **Is the portfolio of tasks developing a sufficient number of countermeasures?**

   - The ExMC Element relies on the development of countermeasures by other elements to mitigate the need for treatment of conditions such as fractures, acute radiation exposure, and lunar dust inhalation.

5. **Is the portfolio well balanced among risk description, countermeasure development and technology development activities?**

   - Well balanced portfolio however incomplete necessitating the insertion of additional gaps and tasks provided by the SRP.
   - Overemphasis on "technology"/hardware development without apparent careful consideration of simpler solutions within the integrated system.

V. Exploration Medical Capabilities (ExMC) SRP Charge

The SRP is chartered by the Human Research Program (HRP) Program Scientist at the NASA Johnson Space Center (JSC). The purpose of the SRP is to review and provide analysis on the status and progress of HRP Elements and Projects. Your report will be provided to the HRP Program Scientist and will also be given as a courtesy to the ExMC Element at JSC.

The SRP should (to the fullest extent practicable):

1. Evaluate the ability of the Integrated Research Plan (IRP) to satisfactorily address the risk by answering the following questions:
   A. Have the proper Gaps have been identified to address the Risk?
      i) Are all the Gaps relevant?
      ii) Are any Gaps missing?
   B. Have the proper Tasks have been identified to fill the Gaps?
      i) Are the Tasks relevant?
      ii) Are any Tasks missing?

2. Identify the strengths and weaknesses of the IRP, *and* identify remedies for the weaknesses, including answering these questions:
   A. Is the risk addressed in a comprehensive manner?
   B. Are there obvious areas of potential integration across disciplines that are not addressed?

3. Address (as fully as possible) the questions provided in the charge addendum and to comment on any additional information provided to the Panel that is not addressed in #1 or 2 above.

4. Expect to receive review materials at least five weeks prior to the site visit.

5. Participate in a SRP teleconference to discuss any issues, concerns, and expectations of the review process approximately three weeks prior to the face-to-face meeting
   A. Discuss the SRP charge and address questions about the SRP process
   B. Identify any issues the SRP would like to have answered prior to the site visit

6. Attend the SRP meeting (and possible tour) at NASA/JSC
   A. Attend Element presentations, question and answer session, and briefing
   B. Prepare a draft report including recommendations from the SRP that will be briefed to the Program Scientist by the SRP chairperson or panel. The report should address #1 and 2 above, the questions in the charge addendum, and any other information considered relevant by the SRP.

7. Prepare a final report (within one month of the site visit) that contains a detailed evaluation of the risk and provides specific recommendations that will optimize the scientific return to the HRP. The final report should provide a comprehensive review of Item #1 and 2 above, address the questions in the addendum to the charge, and any additional information the SRP

would like to provide.

8. Consider the possibility of serving on a non-advocate review panel of a directed research proposal or on a solicited research peer review panel; or otherwise advise the Program Scientist.

Addendum to charge (Element Specific Concerns):

1. Are there obvious, unrealistic aspects in the IRP schedule?
2. Is the portfolio of tasks sufficiently complete to acquire an adequate description of the risks?
3. Is the portfolio of tasks using or developing the appropriate technologies?
4. Is the portfolio of tasks developing a sufficient number of countermeasures?
5. Is the portfolio well balanced among risk description, countermeasure development and technology development activities?

VI. Exploration Medical Capabilities (ExMC) SRP Roster

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