Introduction to Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT)

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Abstract

A key component in the development of NASA Human Research Program's (HRP) next generation risk model, the Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT) intends to deliver a means to quantify how HRP products impact astronaut medical and health risks. MEDPRAT is extensible to the majority of exploration missions. Similar to other risk models, the tool utilizes the available space and terrestrial medical data. MEDPRAT is designed to be extended with additional human health research information, medical equipment, space and terrestrial standards and practices to assess space flight medical risk in a manner consistent with other risk measures used in spacecraft and mission design. This tool provides risk-based medical system design information necessary to evaluate new technologies, procedures, research insights and mission plans.

Our Vision

- HRP Cross-cutting Computational Modeling Project (CCMP) is charged with identifying areas in which computational modeling can support HRP success.
- MEDPRAT provides a human health and medical **risk prediction** tool that is *extensible* to the majority of exploration missions:
  - Assess space flight health medical risk in a manner consistent with other risk measures used in spacecraft and mission design.
  - Provide risk-based design information necessary to evaluate new technologies, procedures, research insights and mission plans.
  - Use available space, terrestrial medical data, human health research.
  - Provide modelling tool extensible to *new* data, findings, medical capabilities, missions and outcomes.

Development Activities and Milestones

- MEDPRAT interface and contribution to the ExMC SE&I tools demonstration (Feb 2018 – Sept 2018).
- Test the extent of MEDPRAT event space capability to include HFBP critical events (Sept 2018 - Sept 2019).
- Potential to interface MEDPRAT with agent based models to improve mission performance metrics.
- Complete MEDPRAT prototype (June 2019) and begin production tool development and validation.

Our Model

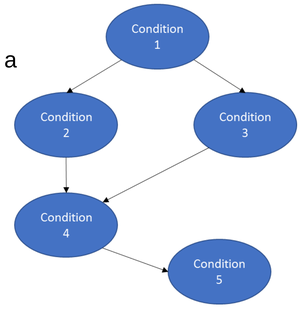
Pre-processors:
Develop conditional dependencies and control database interfaces

Dynamic Event Integrator:
Propagates potential events to predict outcomes

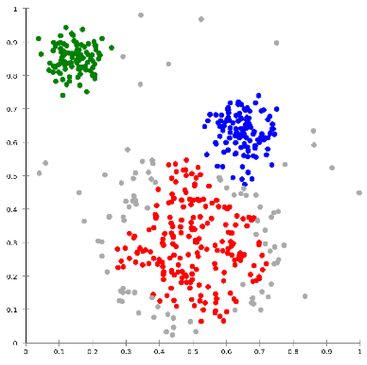
Post Processors:
COTS and in-house data reduction

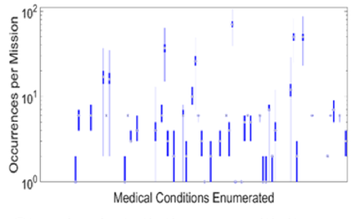
- Bayes network
- Direct correlations
- Influence and transmission models

Example of a Bayesian Network

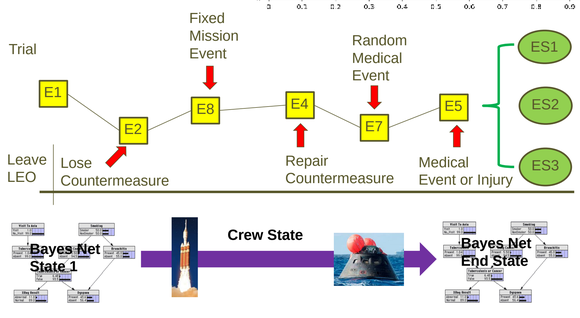


Specialty analytics





Standard statistics, sensitivity analyses



ExMC Prototype

ExMC Questions

- Given a pre-specified list of available medical equipment, what is the estimated level of risk?
- How will changing the likelihood of a condition affect the risk estimates?
- How does the risk change if there is a change in the available resources or existing resource attributes?
- How does the risk change with the addition or removal of simulated conditions?
- How does the risk change if the "time to definitive care" varies?
- How does LOCL risk change if an intermediate EVAC decision point allows consideration of LOCL?
- How does performance decrement affect the medical risk and vice versa?

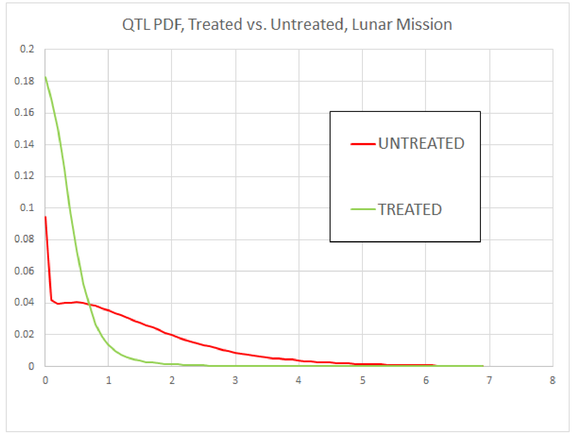
- ExMC Requirements
  - Utilize existing medical data and ExMC medical data tools
  - Allow for correlated and dependent conditions
  - Allow for extension of medical capabilities and protocols

- ExMC SE&I Interface Challenges
  - Device information, including power, mass, volume
  - Format of ExMC data sources be supplied to MEDPRAT
  - Expect a few iterations to achieve tool integration

Development History

- Summer 2017 - Student supported proof of concept MATLAB model testing of dynamic probabilistic risk assessment with event queuing, correlated and dependent conditions

- AGILE-like Sprints from Oct 2017 – Jan 2018:
  1 – Planning data flow and objects, classes
  2 – Capability mapping
  3 – Prototype coding – initial capability set
  4 – Prototype coding – additional capability set
  5 – Baseline regression, output testing, debug
  6 – Complete Beta version of Release 1.0
  7 – Release testing and documentation for release to ExMC tools team (in progress)



Current Status

- Object-oriented software design with over 4000 source lines of C++ code.
- Completed and tested regression tests.
- Finalizing code to manage incidence of Space Adaptation Syndrome; Solar Particle Event; Extravehicular Activity.
- Deferring transmission (contagion); susceptibility (Bayes net) until after first release to ExMC.