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CROSS-CUTTING COMPUTATIONAL MODELING PROJECT: INTEGRATIVE MODELING APPROACH

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Vision and Goals

HRP has charged the Cross-cutting Computational Modeling Project (CCMP) with identifying areas in which computational modeling can support HRP success by:

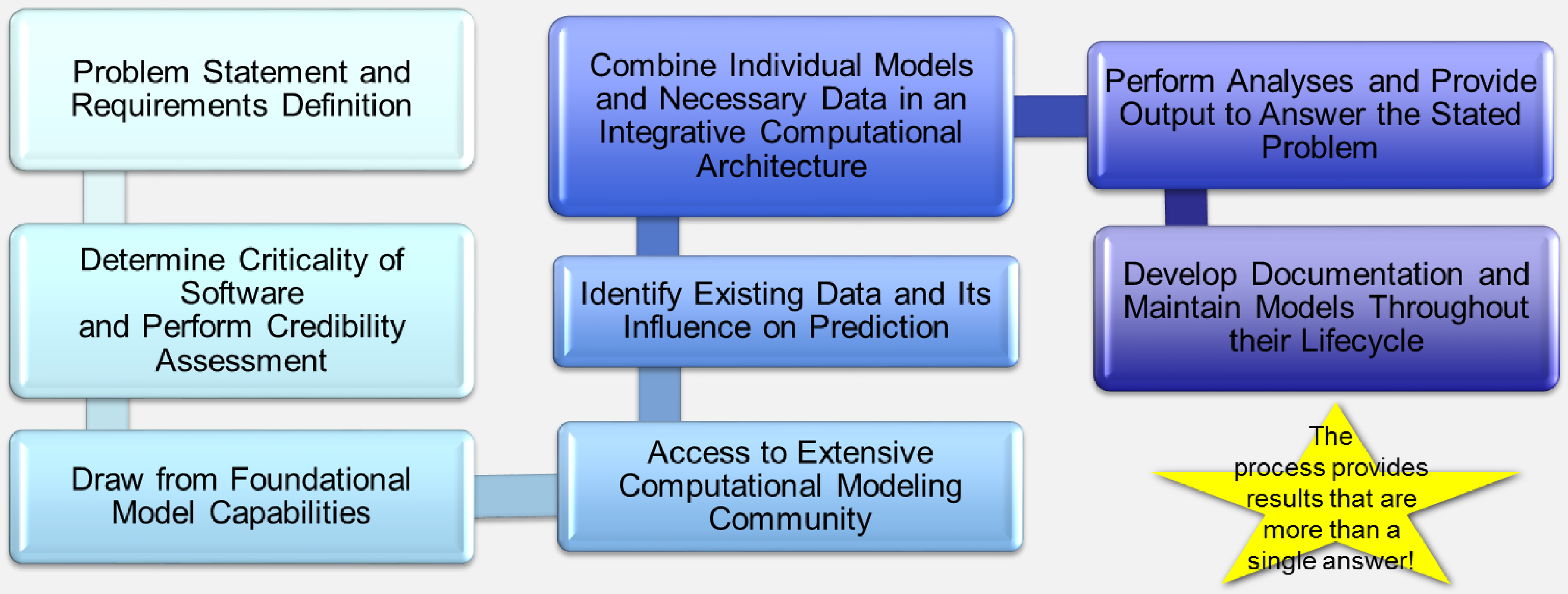
- Assessing poorly understood risks from a broader prospective to aid risk reduction.
- Identifying how computational modeling can improve or accelerate the development of products designed to reduce risk.
- Facilitating the integration of individual risk reduction efforts to enhance overall effectiveness and to reduce costs.

Specific Aims

The specific aims of the CCMP are:

- Identify areas where modeling and analysis can facilitate program integration and enhance risk reduction.
- Perform data mining, create tools and develop analyses for integrated risk quantification, assessment and reduction.
- Facilitate acceptance testing, credibility assessment, maturation and transition of software designed for use in critical applications.

Computational Modeling Approach

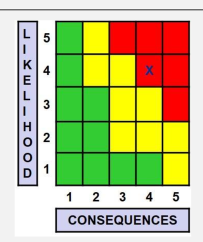


Our computational modeling approach includes the Integration of data, physiological models, and analytical tools into a computational architecture for the performance of analyses and predictions

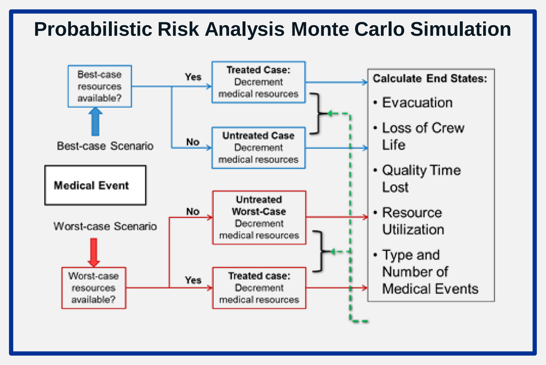
Computational Modeling Capabilities and Example Applications

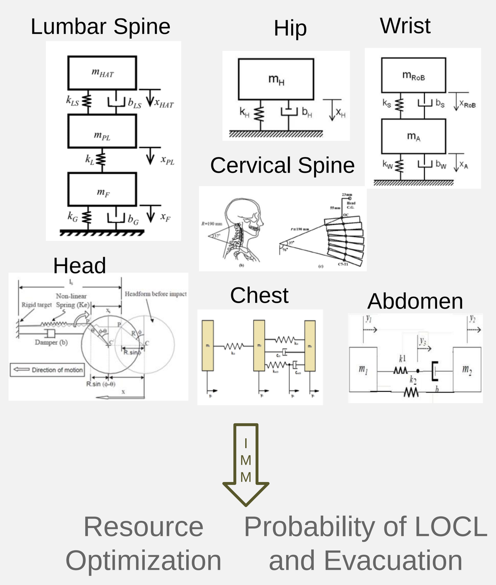
Probabilistic Risk Assessment

Integrated Medical Model (IMM)



The IMM tool quantifies spaceflight medical risk using Probabilistic Risk Assessment techniques in a manner similar to operational risk assessment models, such as used for ISS. Validation assessments were completed with ISS and STS data. A favorable subject matter expert review was completed in 2016-2017. This was a multicenter development and validation effort. IMM is currently in use by Crew Health and Safety.

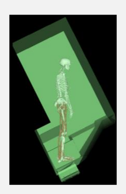


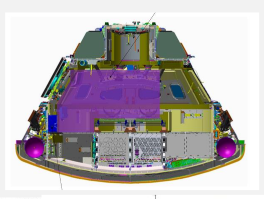


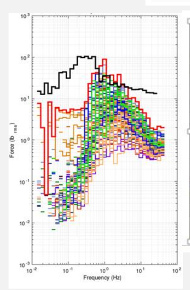
IMM Injury Probability Models

These models provided information that aided in ISS mission planning by providing likelihood values for head, neck, chest and abdominal injury and for hip, lumbar spine and wrist bone fracture. Quantification of these injuries were obtained through computational modeling. This approach was needed because these injuries have not occurred to date and therefore historical information about injury rate was not available

Biomechanical Models



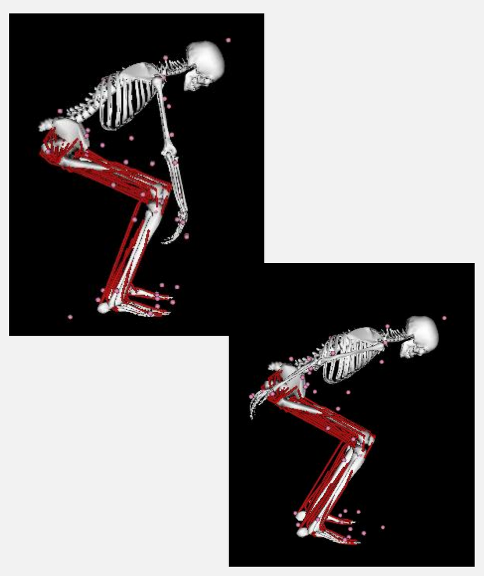




DAP Exercise Device Biomechanical Models

These models informed MPCV vehicle design by characterizing interface loads imparted to the MPCV resulting from exercise and by determining whether or not the exercise operation volume allocation would accommodate exercising crew members.

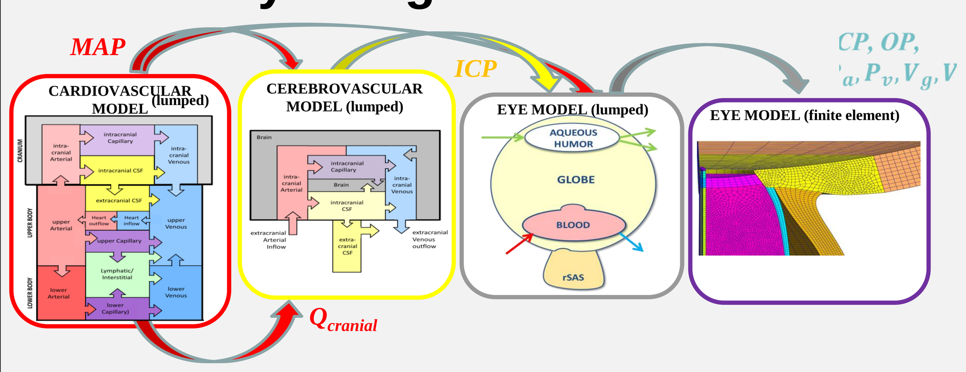
These models also informed exercise device requirements by identifying the need for an adjustable footplate and the need for a cable exit that would allow exercise in two different orientations



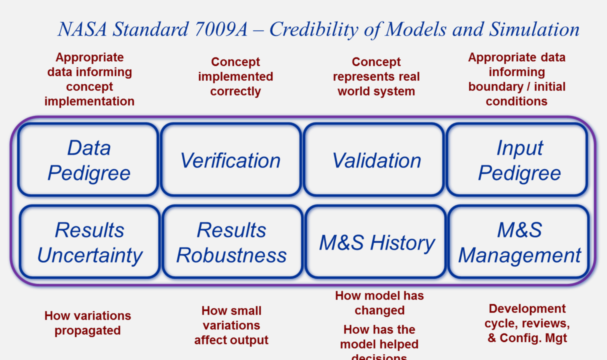
DAP Exercise Device Biomechanical Models

The results of the computational model analysis provided evidence that informed the requirement for a harness accessory to accompany the exercise device, so that crew members can perform both squat and deadlift exercises.

Physiological Models



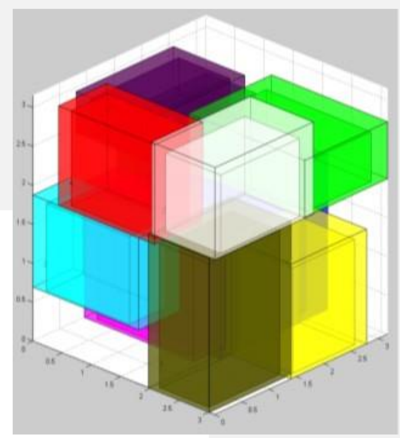
Credibility Assessments

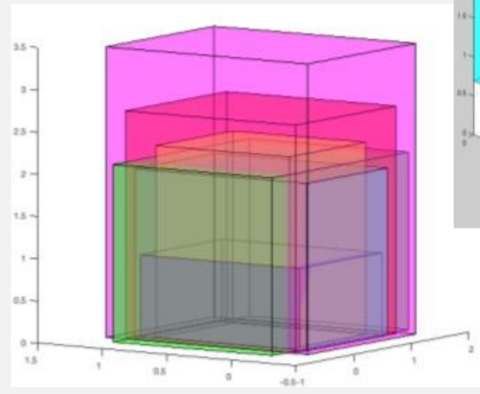


Cross-cutting Computational Modeling Project Tasks

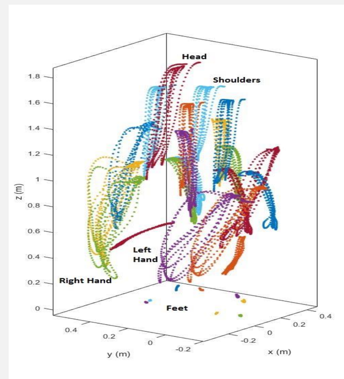
Vehicle/Habitat Design Support

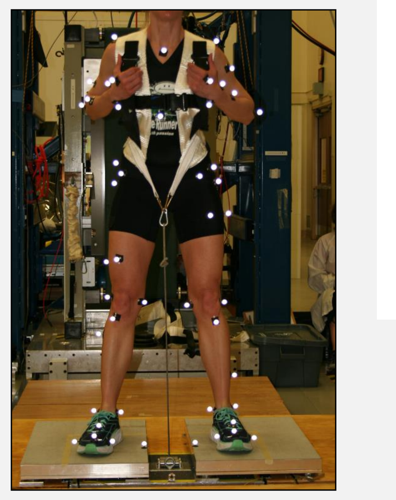
- Assist with the credibility assessment of the SOLV Tool, a Constraint-driven, optimization-based computational model developed by HRP Human Factors and Behavioral Health Group.
- The credibility assessment efforts include:
  - Improve input data pedigree
  - Identify referent information for validation
  - Facilitate identification of user credibility requirements
- Provide operational volume data for habitat design
  - Exercise operational volume
  - Medical Station Operations
  - Critical Tasks
  - Tasks with large uncertainty in their operational volume





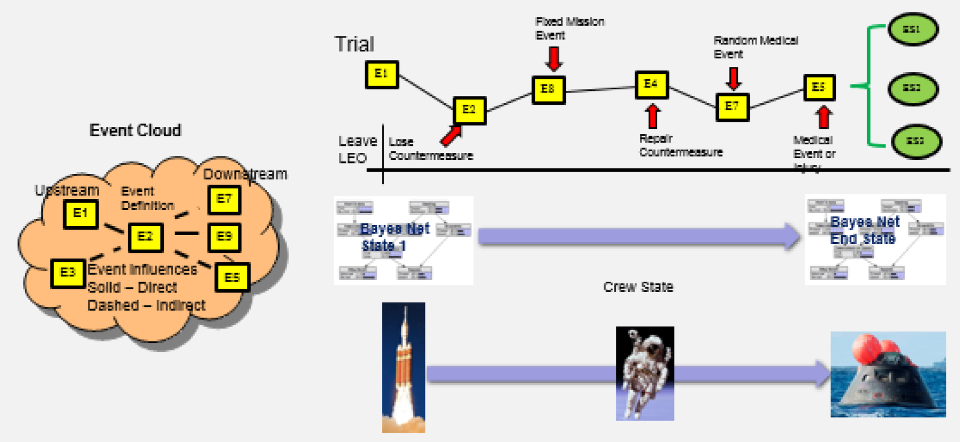
	min (m)	max (m)	total (m)
x	-0.39	0.48	0.87
y	-0.21	0.60	0.81
z	-0.04	1.88	1.92
		V=	1.35 m^3



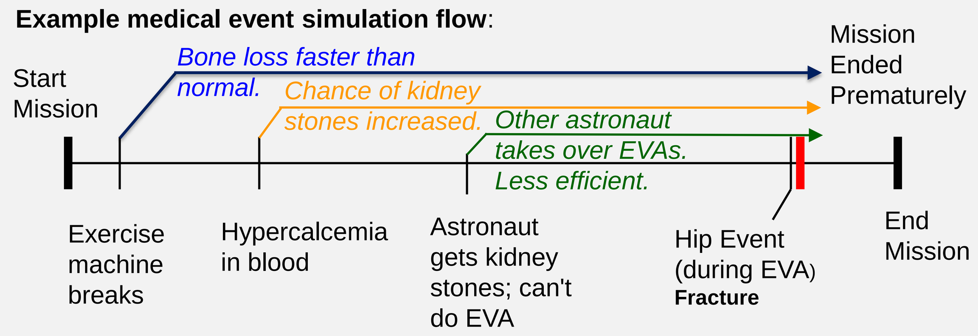


Medical System Requirements Definition

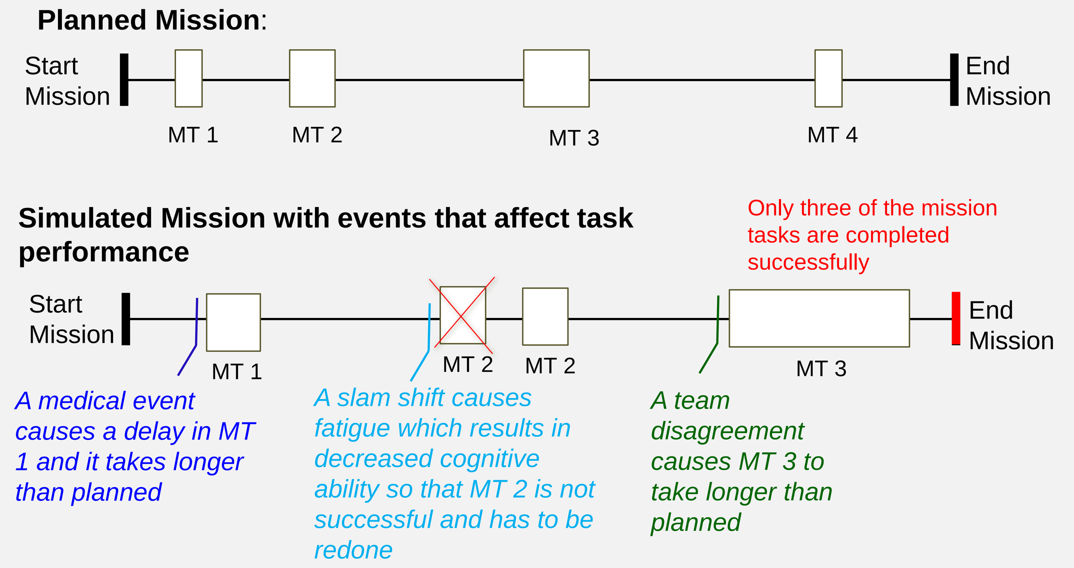
Development of the Medical Extensible Dynamic Probabilistic Risk Assessment (MEDPRAT) tool for prediction of medical event occurrences



Example medical event simulation flow:

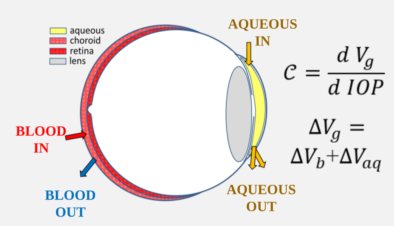


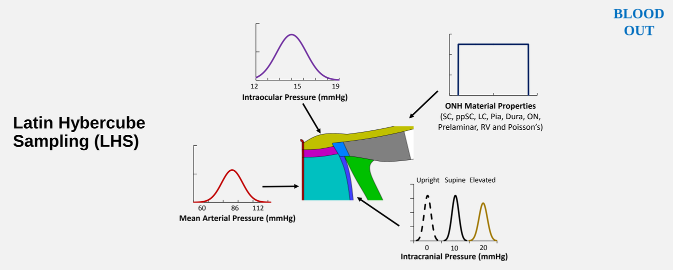
Example mission task simulation flow:

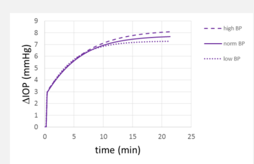


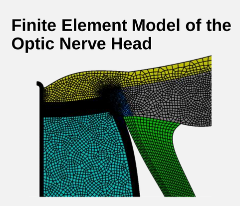
Support of the Spaceflight Associated Neuro-ocular Syndrome (SANS) Risk

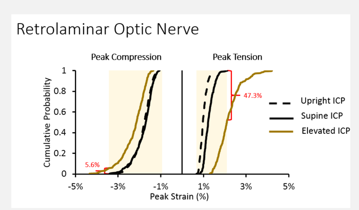
Analyzing data in a mechanistic way in an effort towards identifying causal factors.

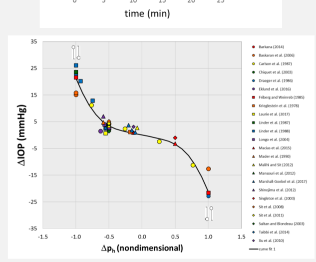






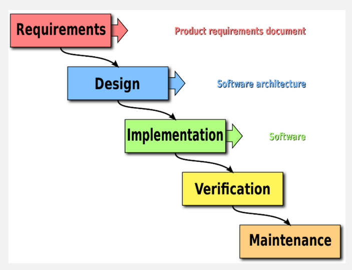






Repository, Credibility Assessment & Transition to Use

- Maintain a repository of computational models and tools which allows integrative ways to examine spaceflight data and predictive simulations of future scenarios.
- Assist with customer involved credibility assessments and identification of ways to improve credibility.



Conclusion

Computational models and their supporting analysis tools have the proven potential to integrate analyses of risk factors to enhance mission planning and preparation capabilities and to inform spacecraft design and countermeasure development. Appropriately applied, computational models may allow intelligent, unbiased physiological parameter assessment to enable hypothesis testing and model based design of experiments.