Exploration Medical Capability System Engineering Introduction and Vision

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HRP Investigators' Workshop

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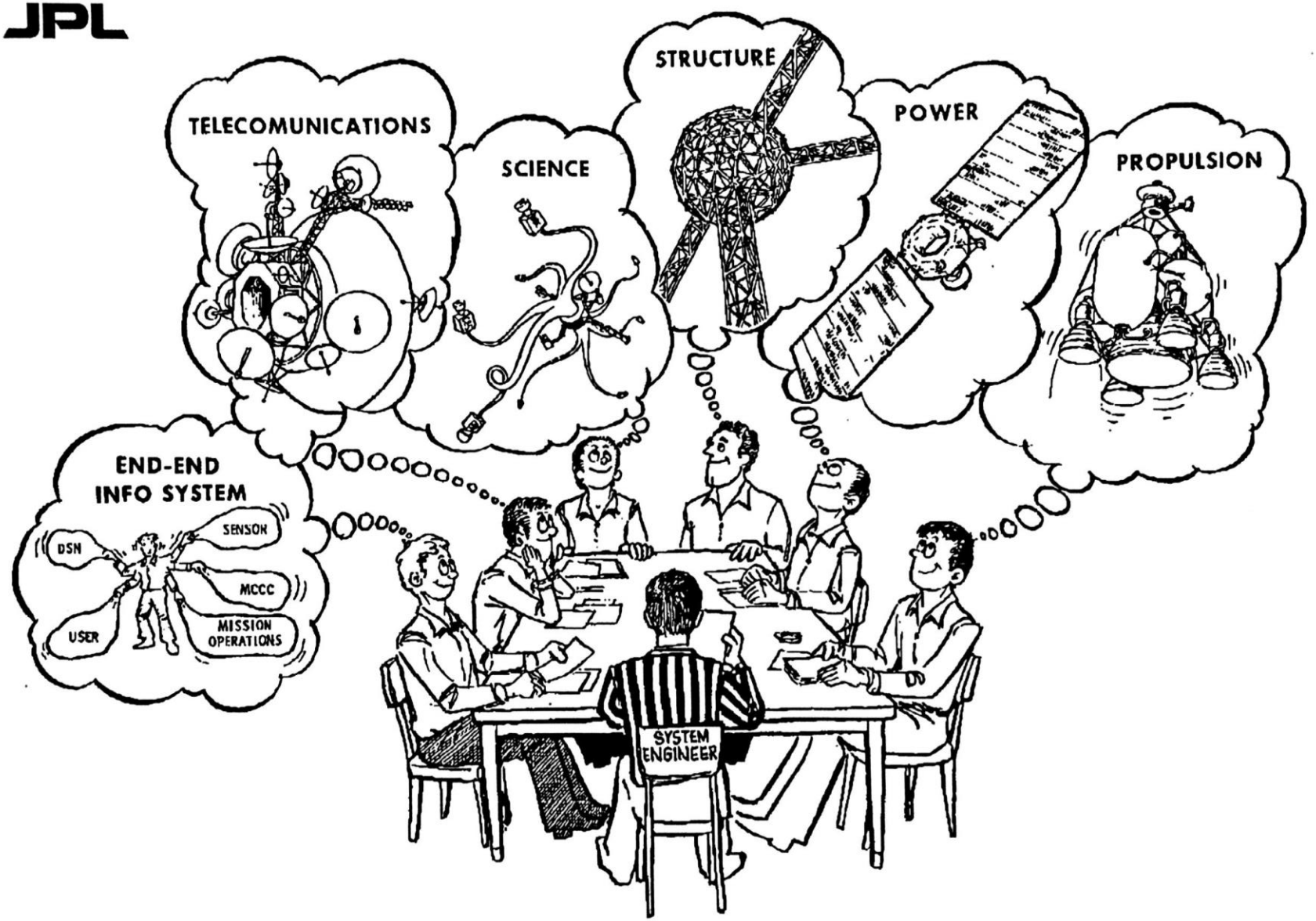
Background

- Exploration missions present significant new challenges to crew health:
  - Long duration: 1-3 years
  - Demanding environments: no medical evacuation
  - Communication challenges: delay, blackout periods, not continuous
  - Supply challenges: no expected resupply, prepositioning at best
- The human system is complex and effects of the space environment are not completely known.
- Medical technologies rapidly evolve.
- Providing health care capabilities for exploration missions necessitates definition of new medical requirements and development of technologies to ensure the safety and success of missions.
- A Medical System should maximize flexibility to enable a care provider to address conditions that were not considered in the initial design.
- Limited flight resources (e.g., mass, power, volume, data) require us to view Medical System as an integrated part of flight system development.
- --> Need systems engineering approach.

Canga, M., Shah, R., Mindock, J., Antonsen, E. A Strategic Approach to Medical Care for Exploration Missions. 67th International Astronautical Congress (IAC), Guadalajara, Mexico, Sept. 2016

Antonsen, E., Hanson, A., Shah, R., Reed, R., Canga, M. Conceptual Drivers for an Exploration Medical System. 67th International Astronautical Congress (IAC), Guadalajara, Mexico, Sept. 2016

JPL


TELECOMUNICATIONS
SCIENCE
STRUCTURE
POWER
PROPULSION
END-END
INFO SYSTEM
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USER
MISSION
OPERATIONS
SYSTEM
ENGINEER

Systems Engineering

From NASA Systems Engineering Handbook

What is Systems Engineering?

- A methodical, disciplined approach for the design, realization, technical management, operations, and retirement of a system.

What is a "System"?

- Collection of different elements that together produce results not obtainable by the elements alone.
  - Elements = people, hardware, software, facilities, policies, documents…
- Value of system primarily created by relationship among parts; that is, how they are interconnected.[1]

Systems Engineering IS:

- a way of looking at the "big picture" when making technical decisions.
- a way of achieving stakeholder functional, physical, and operational performance requirements in the intended use environment over the planned life of the systems.
- the art and science of developing an operable system capable of meeting requirements within often opposed constraints.
- a holistic, integrative discipline, wherein the contributions of e.g.,
  - structural engineers, electrical engineers, mechanism designers, power engineers, human factors engineers, and many more disciplines *(medical!)*

  are evaluated and balanced… to produce a coherent whole that is not dominated by the perspective of a single discipline.[2]

[1]Rechtin, *Systems Architecting of Organizations: Why Eagles Can't Swim*.

[2]Comments on systems engineering throughout the handbook's Chapter 2.0 are extracted from the speech "System Engineering and the Two Cultures of Engineering" by Michael D. Griffin, previous NASA Administrator.

Key SE Philosophy Points

- Team converges on same mental models
  - Of system, its context, its use, our way of working…
  - Applying aspects of Model-Based Systems Engineering using Systems Modeling Language (SysML)
- Enable technical communication with entities external to ExMC
- Tailoring is necessary
  - Not all SE processes fit all projects
- Tools are available for our use
  - We are not slaves to them

ExMC SE Mission

Define, develop, validate, and manage the technical system design needed to implement exploration medical capabilities for Mars and test the design in a progression of proving grounds.

Needs

Develop system technical foundation

- Develop ConOps
- Capture stakeholder expectations
- Define and manage requirements
- Capture and
- design
- Identify and
- disciplinary
- Plan and execute system V&V
- Inform system development decisions from scientific, technical perspective
- Identify tech dev and research needs

Approach

Apply structured, integrative science and engineering

- Use a structured and disciplined approach to develop a med system addressing medical, behavioral health, human
- performance
- Enable effective coordination and integration with exploration mission engineering, operational, and technology development efforts

Benefit

Increase relevancy to exploration system maturation

- Speak the same language as engineering and operations communities with respect to system design
- Provide regular and
- insight into the med system development
- Develop and foster shared mental models within and external to crew health and performance community

Culture

Be open, unbiased, learning, and serving

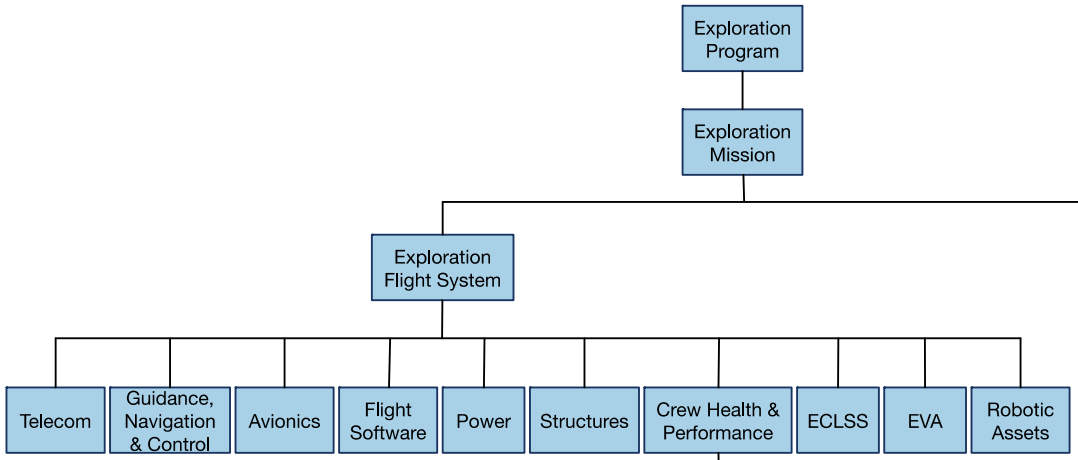
- Develop relationships across disciplines and Centers to build trust and enable teamwork
- Enhance visibility and
- nities for influence
- rrent activities of
- roups that
- e would not happen
- Foster learning of SE principles and practices
- Be both responsive to and anticipatory of stakeholder needs, keeping in mind stakeholders may be from anywhere in an org chart

Contact us if interested in this material in our Systems Engineering Management Plan!

ExMC's Purpose --> Needed Functions

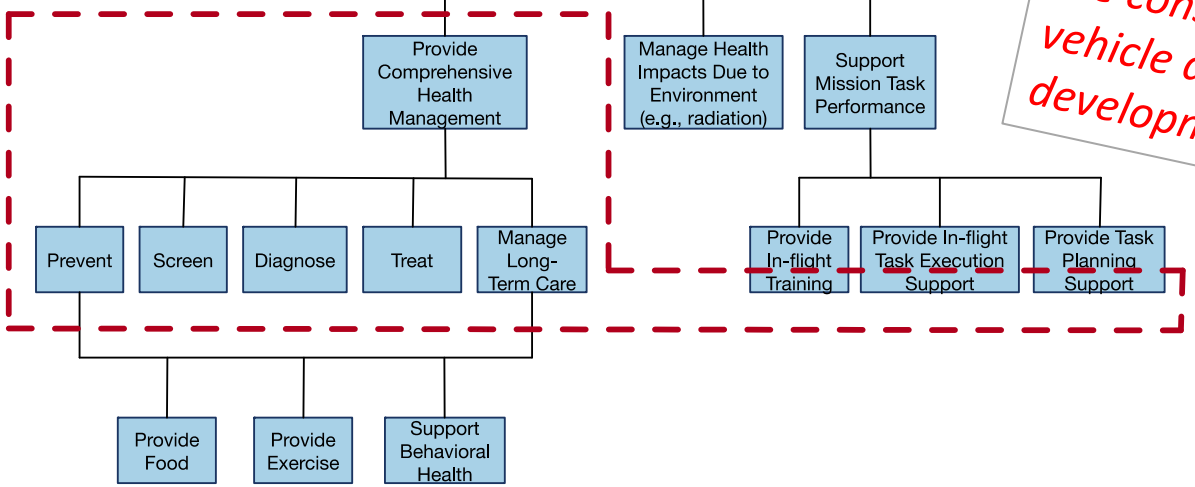
ExMC Mission: To minimize mission medical risk through medical system design and integration into the overall mission and vehicle design.

Flight Systems

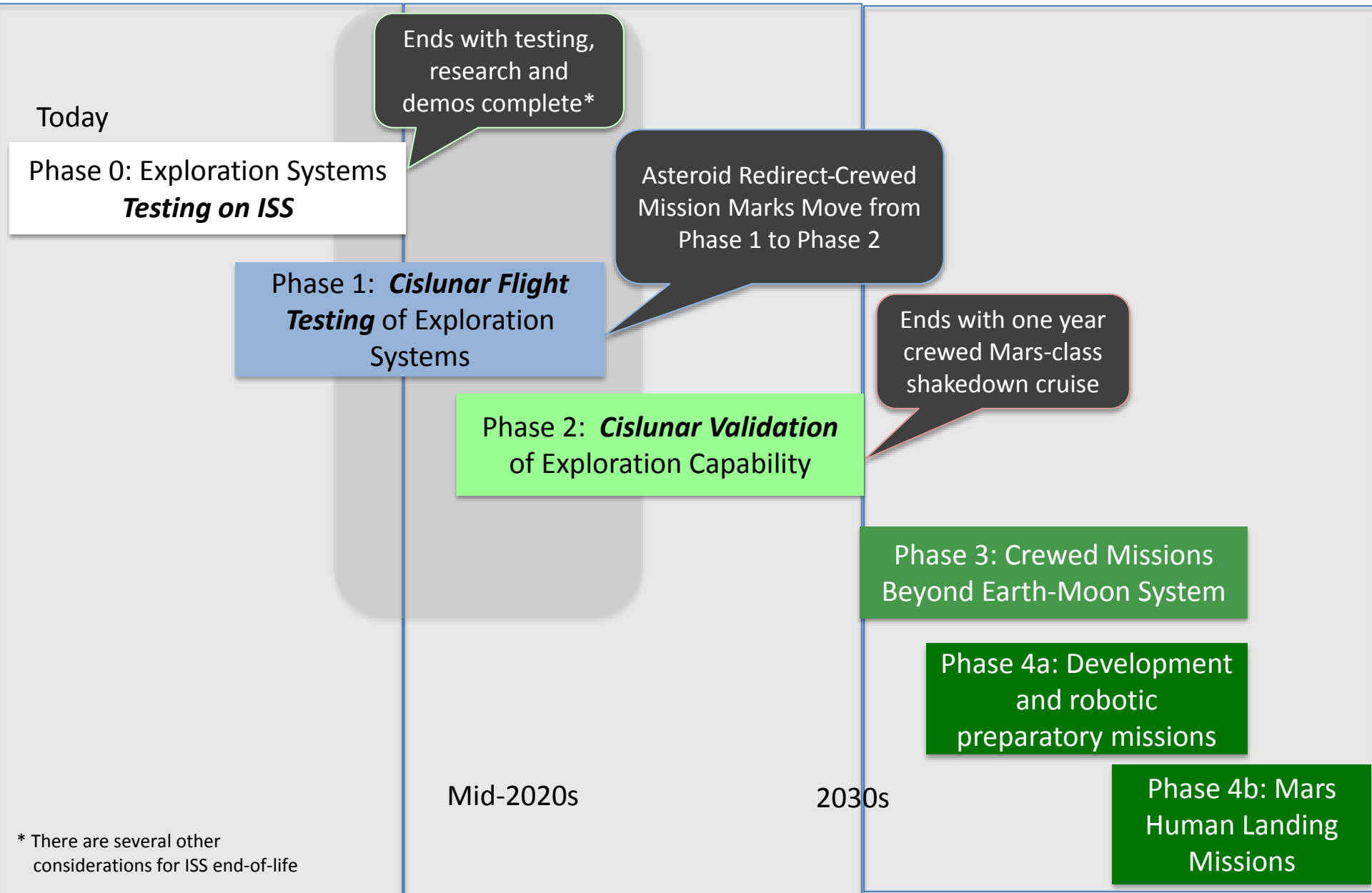


How do we ensure these capabilities are considered in the vehicle and mission development?

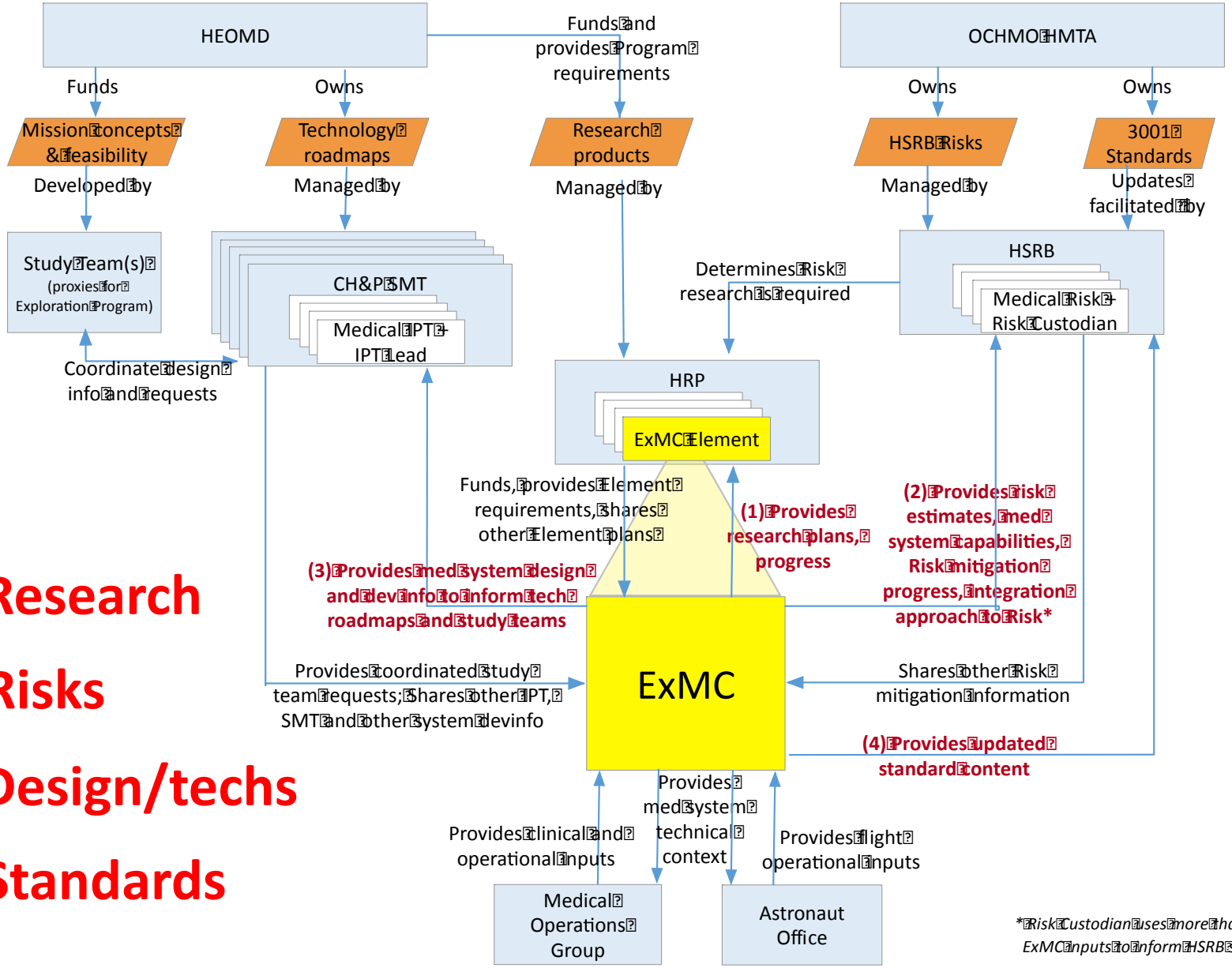
In red: Functions the medical system must support



Human Exploration Phase Context

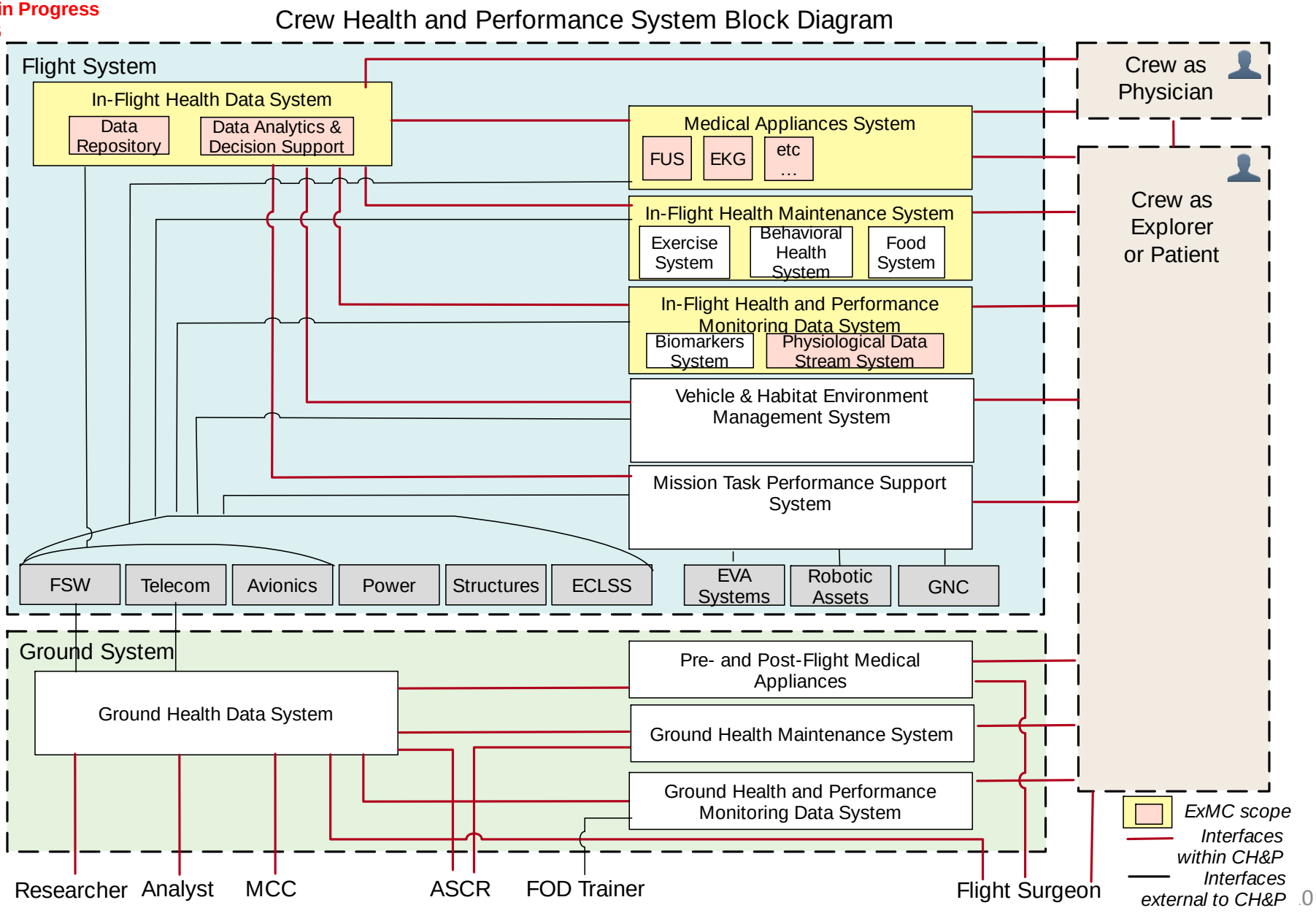


Organizational Context

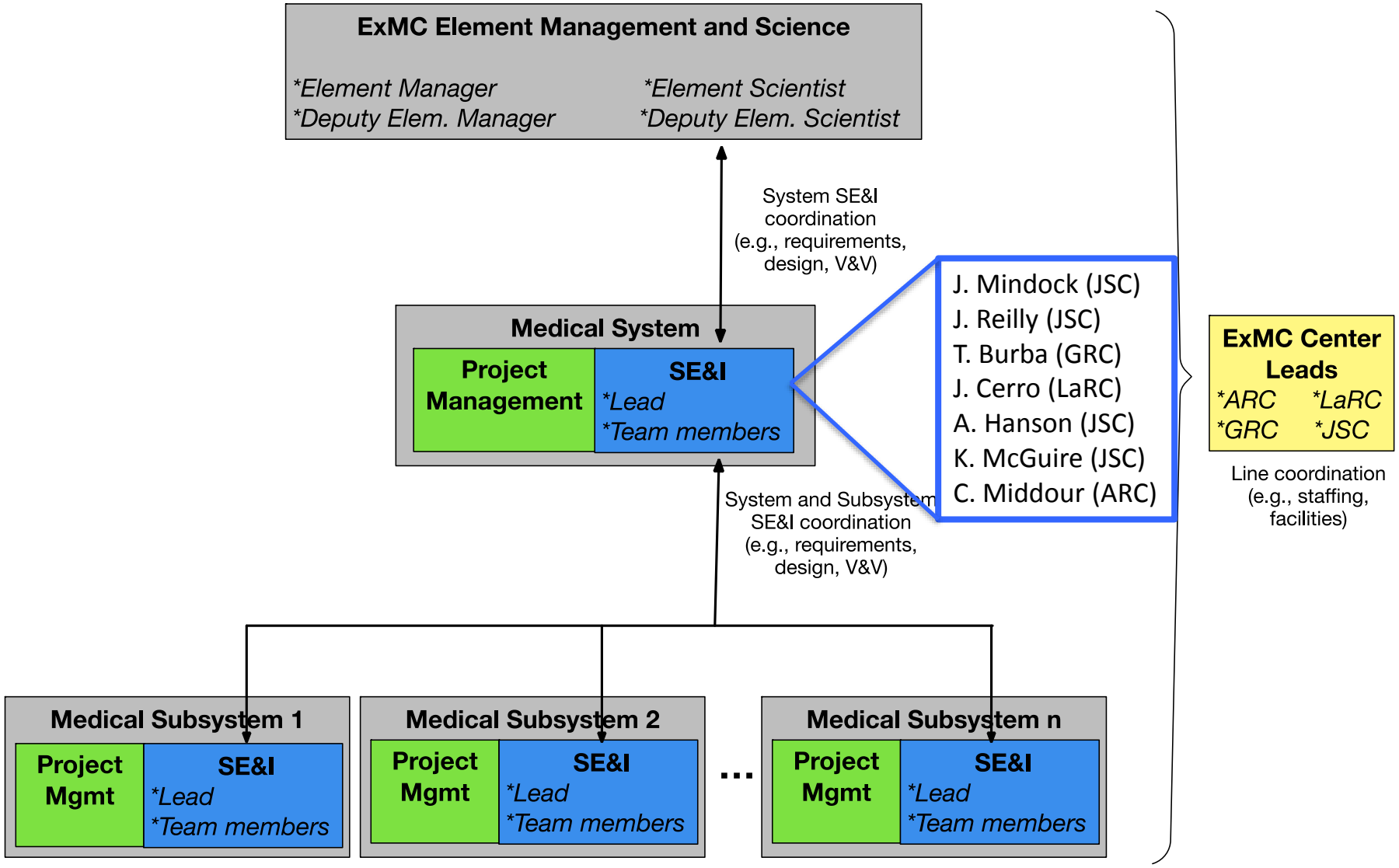


Notional System Block Diagram

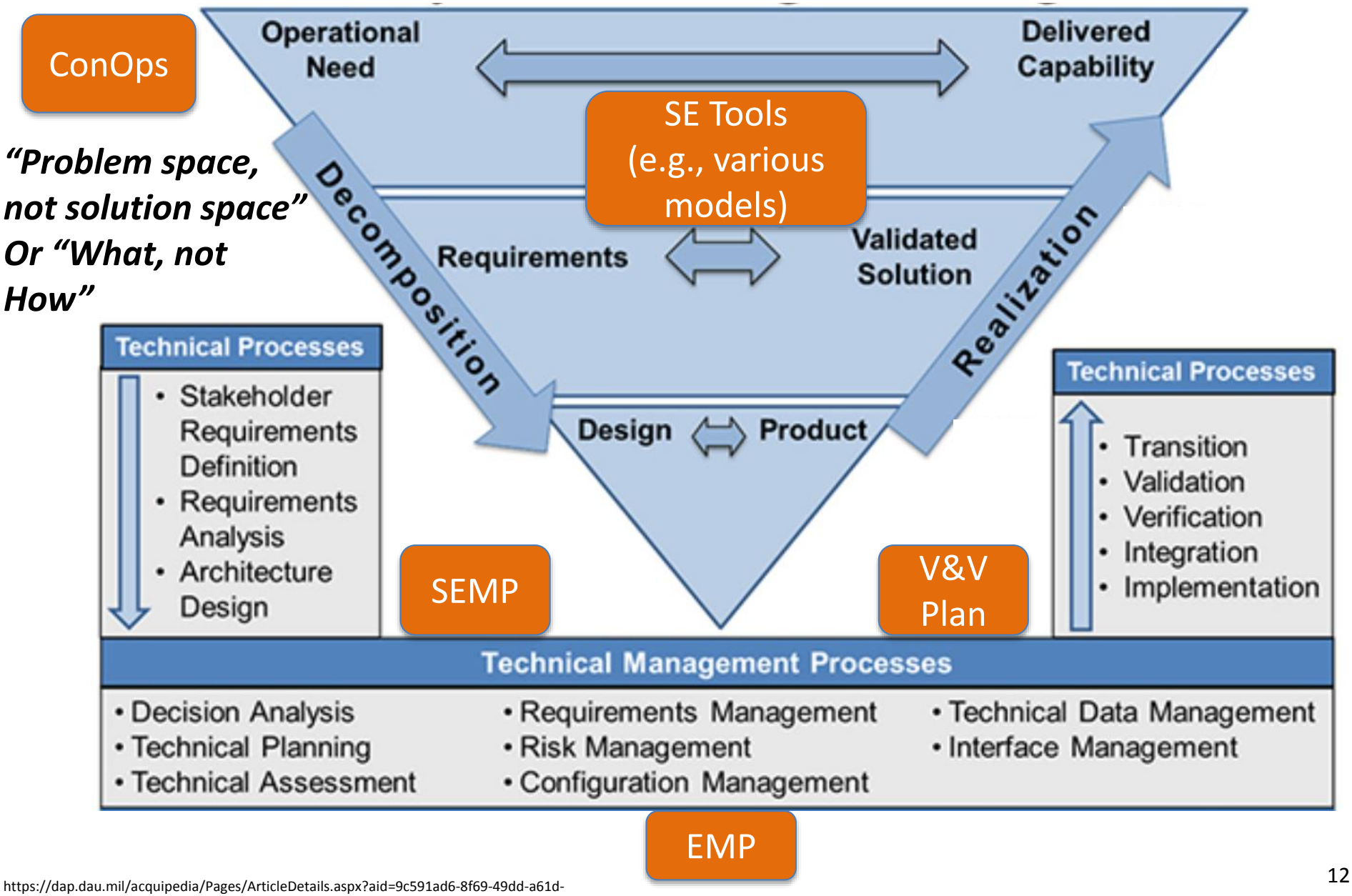
Work in Progress
9/1/16



Roles and Responsibilities Context

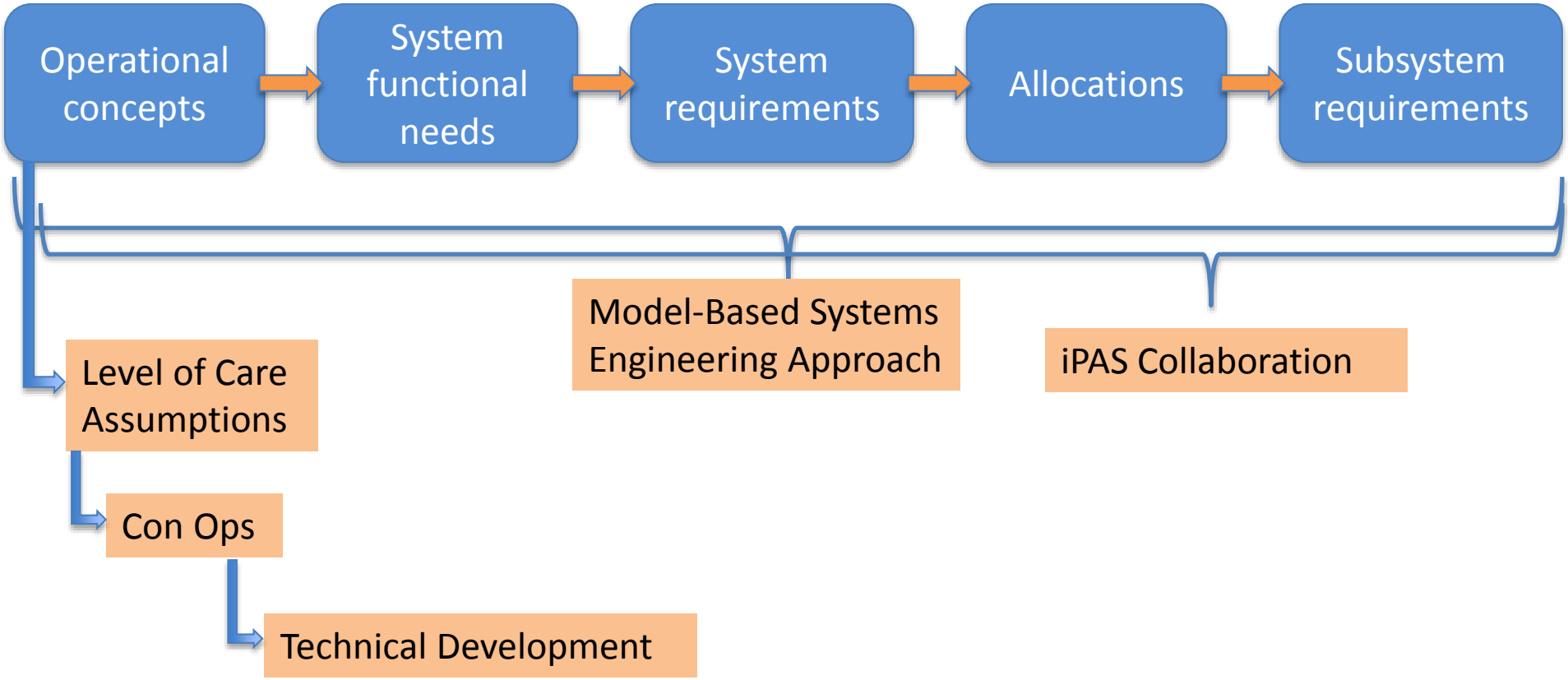


Systems Engineering Process "V" Example



https://dap.dau.mil/acquipedia/Pages/ArticleDetails.aspx?aid=9c591ad6-8f69-49dd-a61d-

Lead-in to other talks…



The needs identified by this work will drive future ExMC research

Upcoming SE steps:

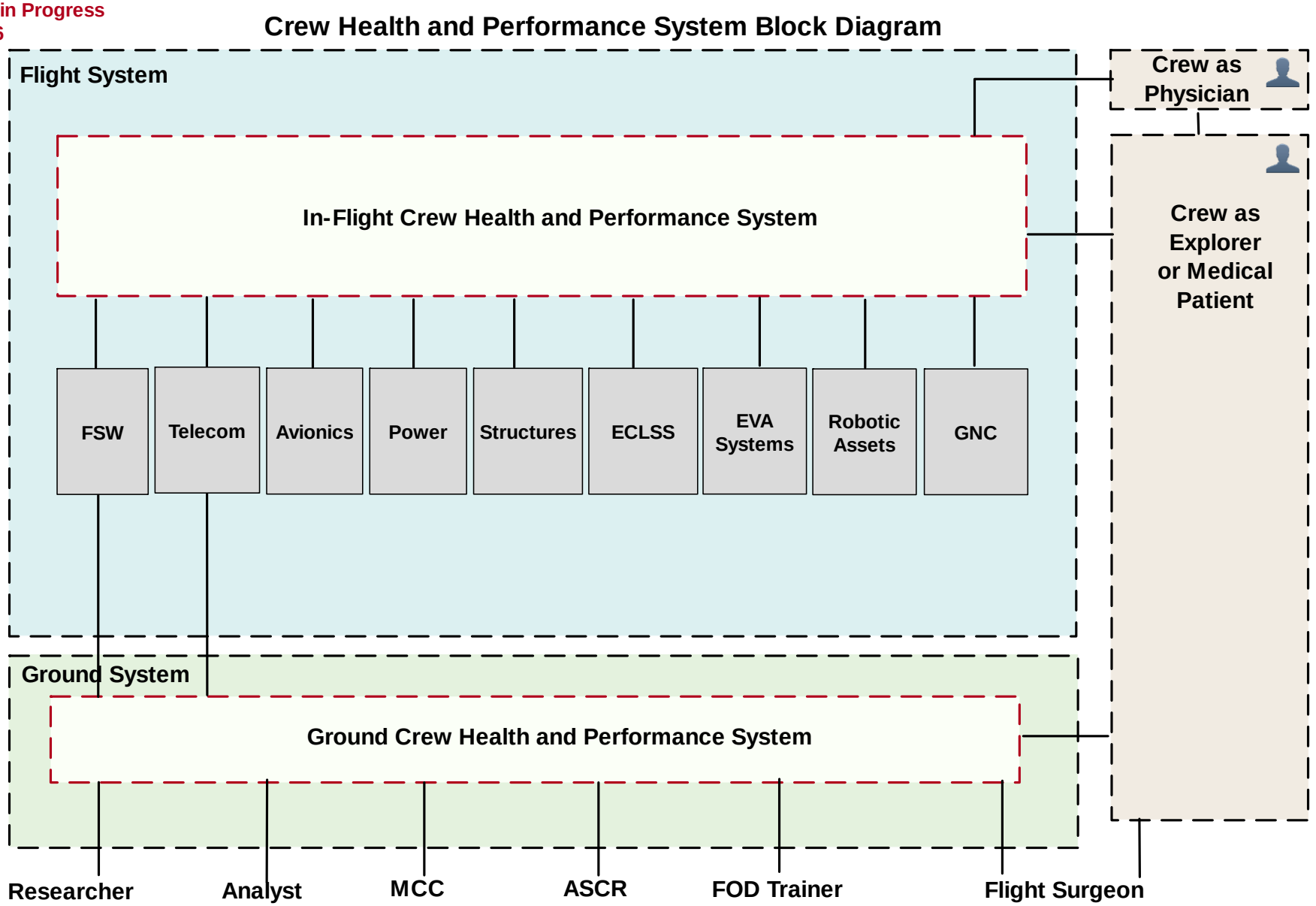
- 3/2017: Hold TIM with Driving Stakeholders
- 4/2017: OMB: Draft Concept of Operations for Medical Care for an Exploration Mission
- Goal End FY17: Draft In-Flight Medical System Requirements (Mars Transit)

Thank you

Backup

Notional System Block Diagram
CHP Level Only

Work in Progress
9/1/16



Notional System Block Diagram
Informational Interfaces

Work in Progress
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