NASA HUMAN RESEARCH PROGRAM'S USE OF AI TECHNOLOGY TO MITIGATE EXPLORATION MEDICAL RISK

Human Research Program
Science Integration Office

June 2025

Truong Le[1], Jordan Blackwelder[2], Kurt L. Berens[2], Carlos De Los Santos[1], Jay Lemery[3,4]

[1] NASA Johnson Space Center, Houston, TX.
[2] KBR, Inc., Houston, TX.
[3] University of Colorado School of Medicine, Boulder CO.
[4] IPA, NASA Johnson Space Center, Houston, TX.

"Expanding the Boundaries of Space Medicine and Technology"

Disclosure Information

2025 AsMA-UHMS Annual Scientific Meeting

I will not discuss off-label use and/or investigational use in my presentation

I have no relevant financial relationships to disclose.

Agenda

- Background
- Objective
- Approach
- Challenges and Limitations
- Lessons Learned

Background

- **Earth Independent Medical Operations (EIMO) constraints**
  - Resources: cannot bring all equipment and supplies
  - Knowledge: cannot bring a variety of specialists
  - Communications: cannot always fall back to guidance from Earth-bound medical team
  - Novel conditions arise that have little precedence in terrestrial practice
- **Recent artificial intelligence (AI) advances can augment EIMO decision making**
  - Advances in modeling allow for more sophisticated knowledge capture
  - Advances in computation power make training these powerful models feasible
  - Explosion in digital data available increases the breadth, depth and fidelity of these models
- **Science Integration Office (SIO) AI approach**
  - Quickly demonstrate capabilities with rapid prototype cycles (“sprints”)
  - Leverage industry partners and tools to produce customer-driven products
  - Four projects: Clinical Finding Form (CliFF), “Doc-in-a-Box”, Mission Control Central (MCC) Flight Surgeon Emergency Procedures and UpToDate™ collaboration

NASA Trustworthy AI Principles

Accountably Managed

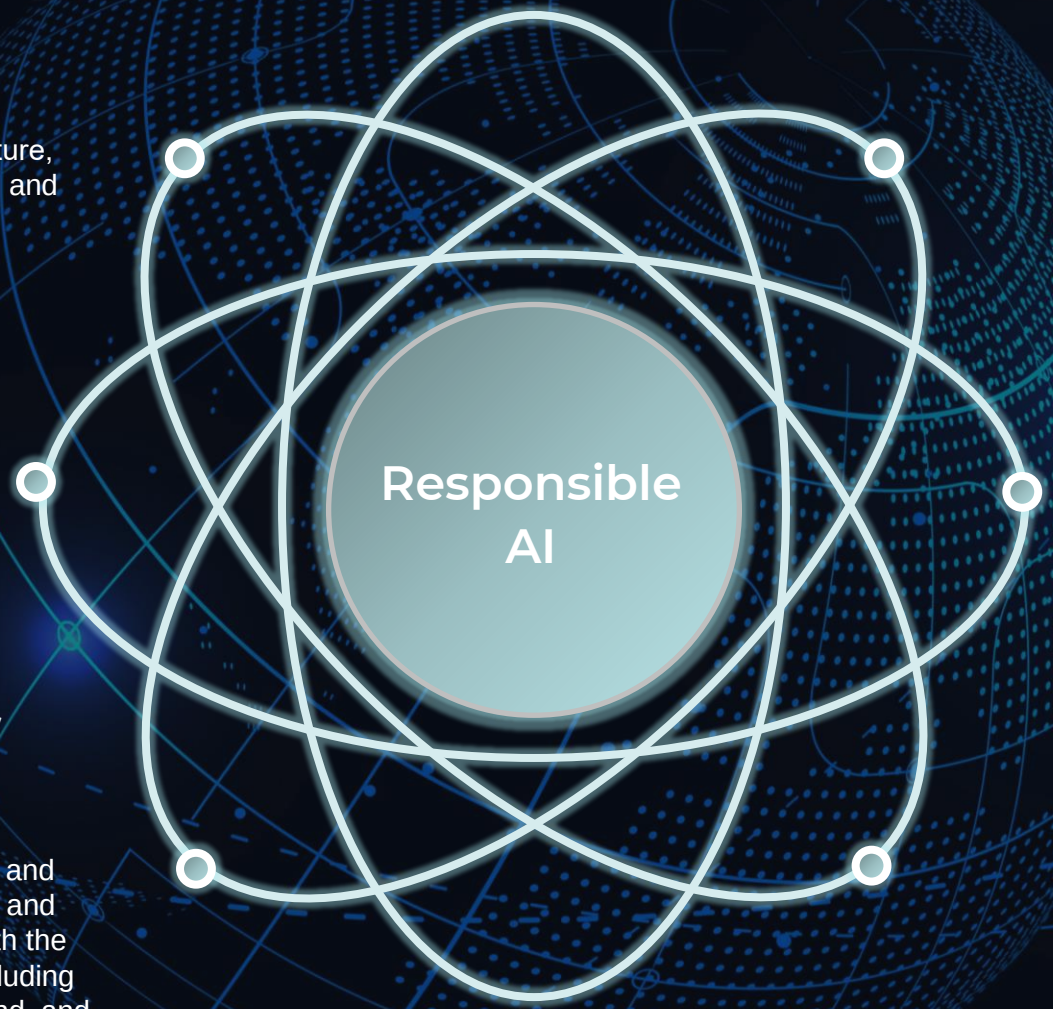
AI systems shall be trained about AI's nature, realities, and risks on current, accessible, and unbiased materials.

Beneficent

Be lawful, inclusive, equity advancing, privacy protecting, intellectual property rights respecting, having minimized biased among humankinds, and supportive of the wellbeing of the environment and persons present and future

Scientifically and Technically Robust

Meet or exceed the highest levels of rigor and completeness in its design, development, and deployment, must be made in keeping with the optimized use of the scientific method including being replicable, reproduceable, and sound, and must be accurate, precise, and reliable in its functioning



Safe and Secure

AI systems must respect privacy and do no harm. Humans must monitor and guide machine learning processes. AI system risk tradeoffs must be considered when determining benefit of use

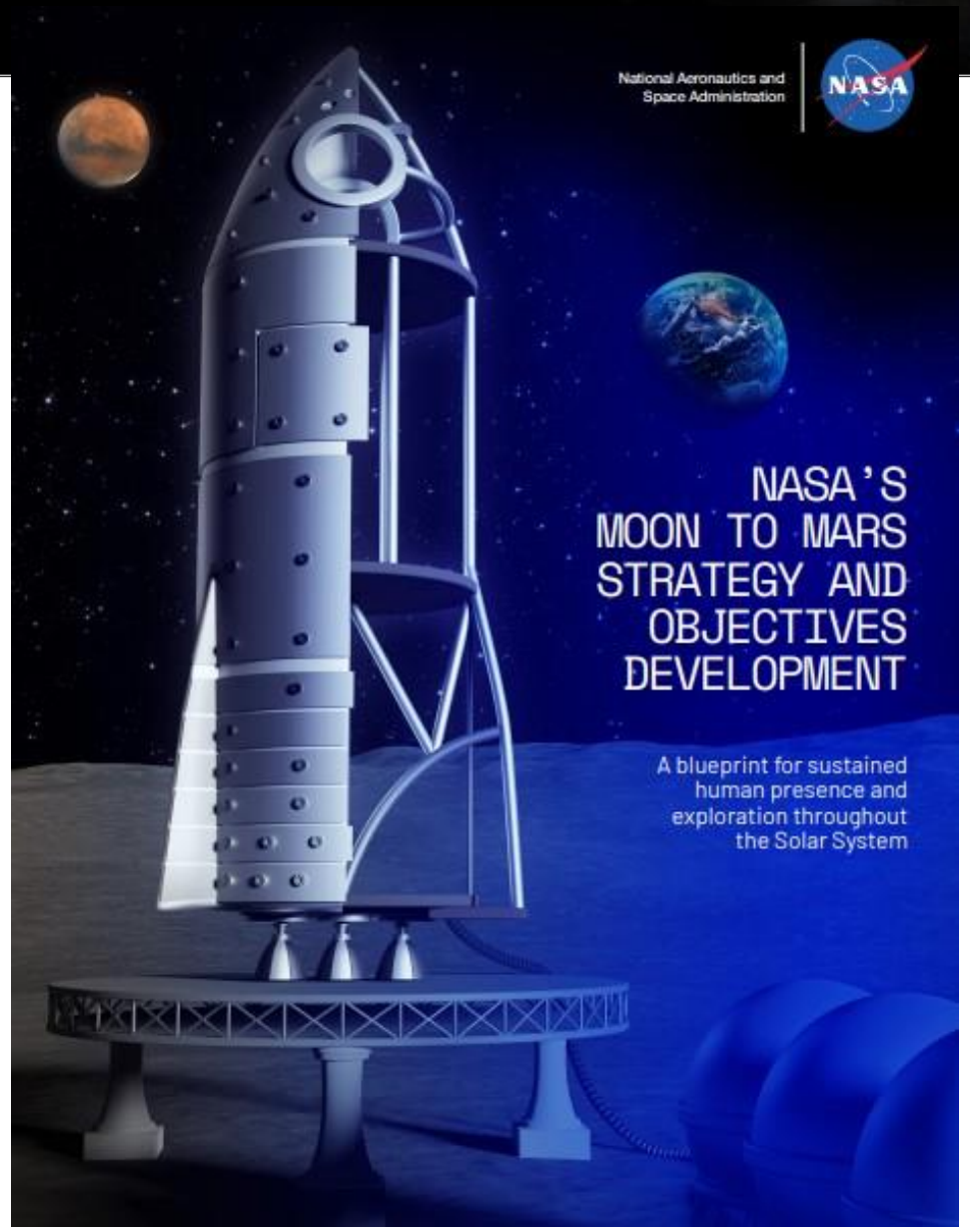
Intentional

AI systems must include considerations regarding how to treat people, including refining solutions to mitigate discrimination and bias, and preventing covert manipulation.

Transparent and Understandable

NASA AI models/systems must shall be transparent in its design, development, deployment, and functioning, especially regarding personal data use

Objectives



Recurring Tenets

RT-3:	Crew Return: Return crews safely to Earth while mitigating adverse impacts to crew health.
RT-5:	Maintainability and Reuse: When practical, design systems for maintainability, reuse, and/or recycling to support the long-term sustainability of operations and increase Earth independence.

Human and Biological Science (HBS)

HBS-2^{LM}:	Evaluate and validate progressively Earth-independent crew health and performance systems and operations with mission durations representative of Mars-class missions.
HBS-3^{LM}:	Characterize and evaluate how the interaction of exploration systems and the deep space environment affect human health, performance, and space human factors to inform future exploration-class missions.

Transportation and Habitation (TH)

TH-8^{LM}:	Develop systems that monitor and maintain crew health and performance throughout all mission phases, including during communication delays to Earth, and in an environment that does not allow emergency evacuation or terrestrial medical assistance.

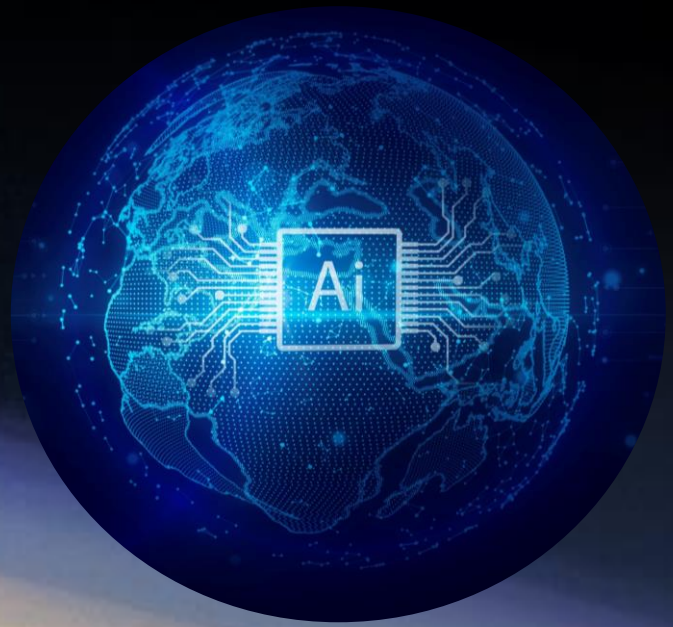
Operations (OP)

OP-1^{L}:	Conduct human research and technology demonstrations on the surface of Earth, low-Earth orbit platforms, cislunar platforms, and on the surface of the Moon, to evaluate the effects of extended mission durations on the performance of crew and systems, reduce risk, and shorten the timeframe for system testing and readiness prior to the initial human Mars exploration campaign.
OP-2^{LM}:	Optimize operations, training, and interaction between the team on Earth, crew members on orbit, and a Martian surface team, considering communication delays, autonomy level, and time required for an early return to the Earth.
OP-6^{L}:	Evaluate, understand, and mitigate the impacts on crew health and performance of a long deep space orbital mission, followed by partial gravity surface operations on the Moon.
OP-7^{LM}:	Validate readiness of systems and operations to support crew health and performance for the initial human Mars exploration campaign.

Objectives

MISSION

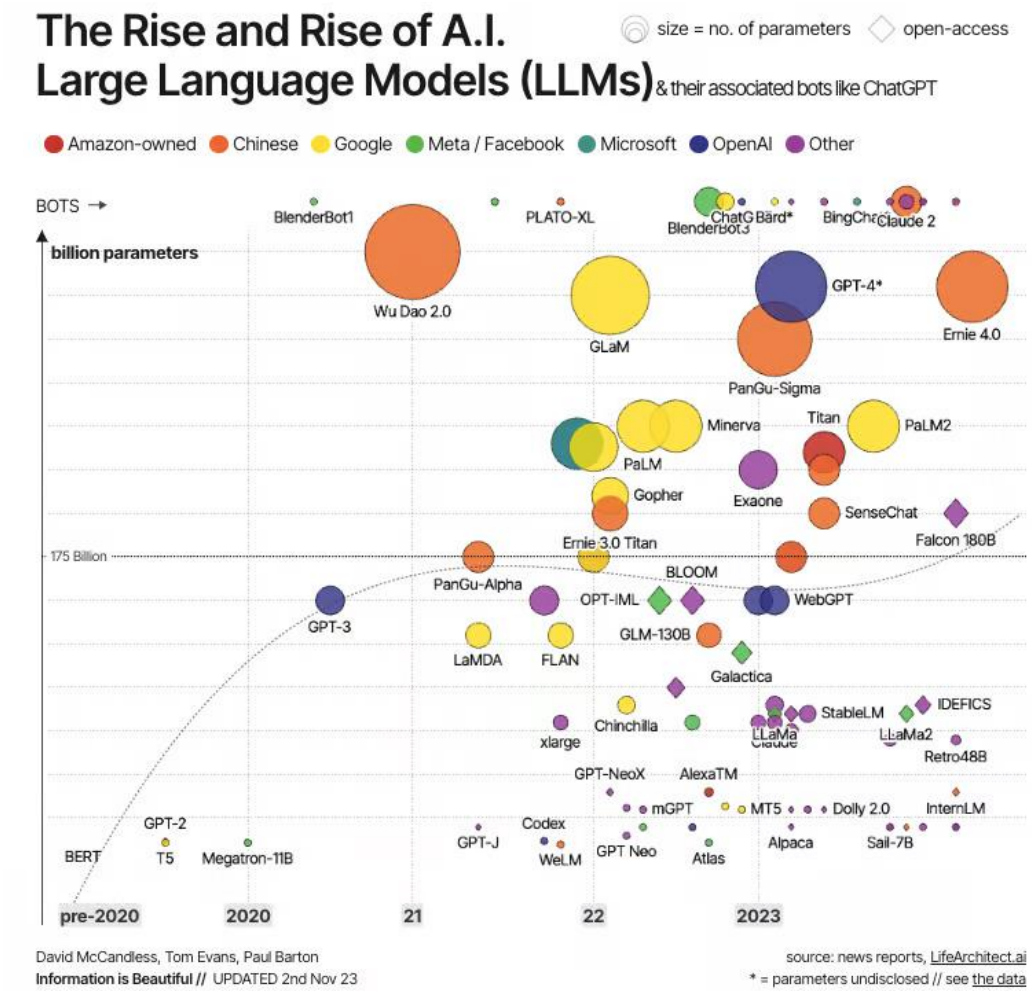
To harness the power of AI technologies to support and drive HRP innovation, efficiency, growth, and resilience. To integrate AI into medical operations through mission-aligned initiatives, while maintaining secure and high-quality data practices and following NASA Trustworthy AI principles.



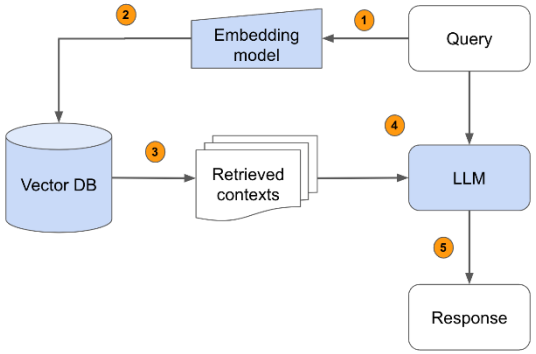
VISION

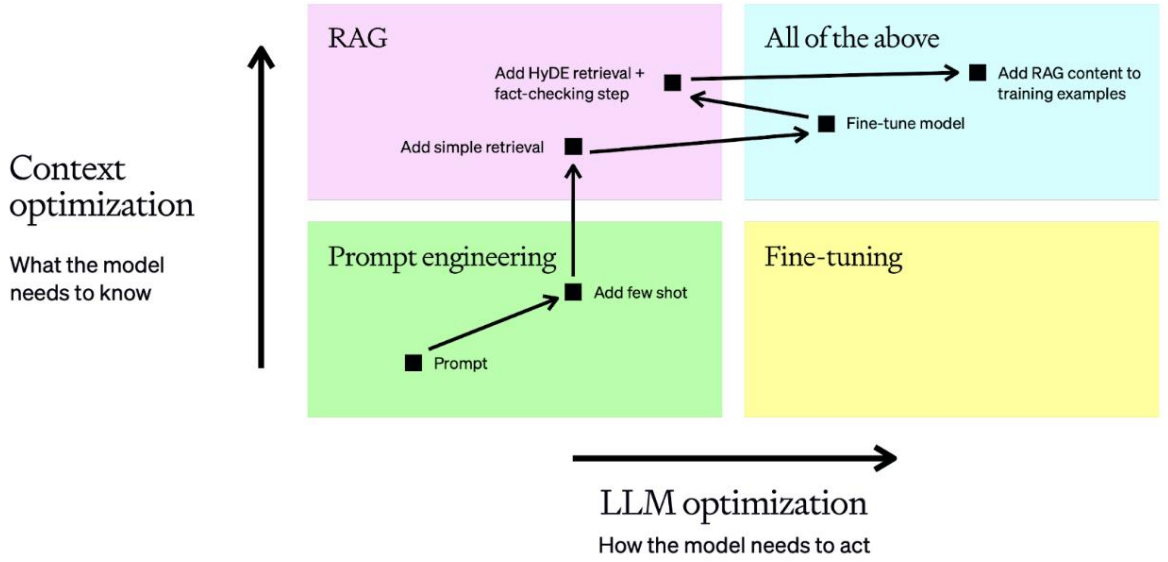
EIMO will use artificial intelligence (AI) based system that will provide support and recommendations to the crew medical officer (CMO) and ground flight surgeon during long-duration space missions

Large Language Models (LLMs)



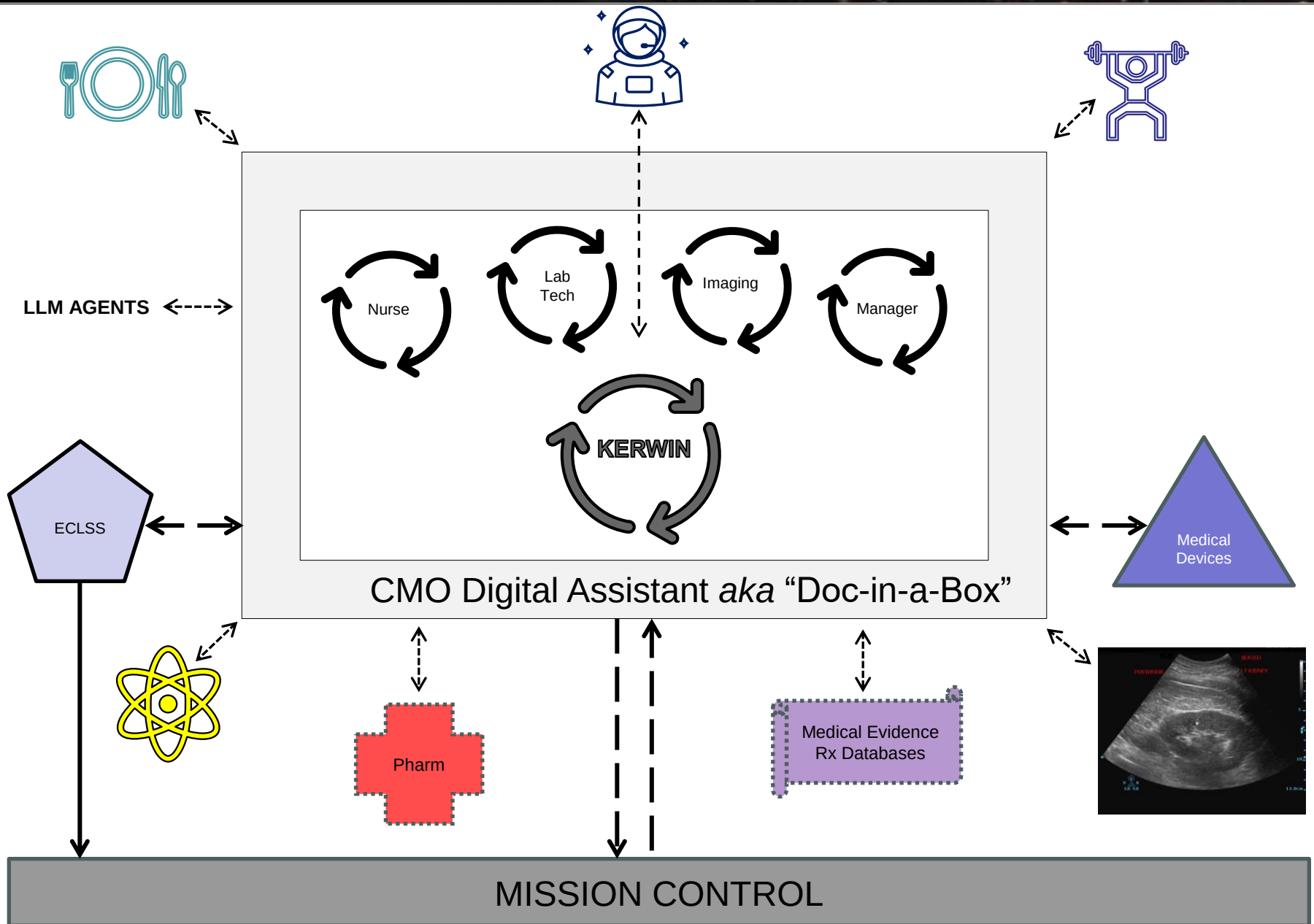
https://www.datacamp.com/blog/what-is-an-llm-a-guide-on-large-language-models



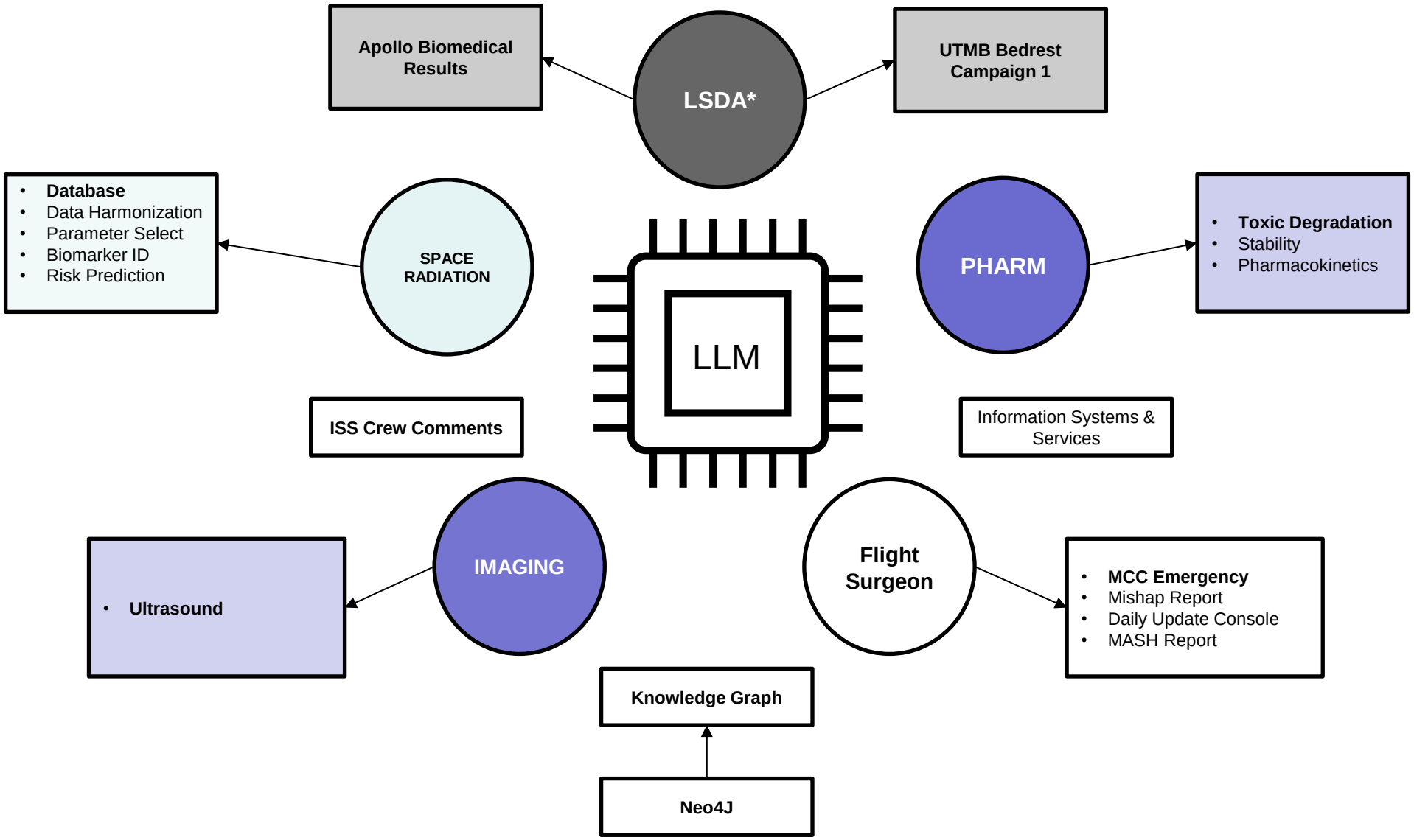


https://platform.openai.com/docs/guides/optimizing-llm-accuracy

Approach

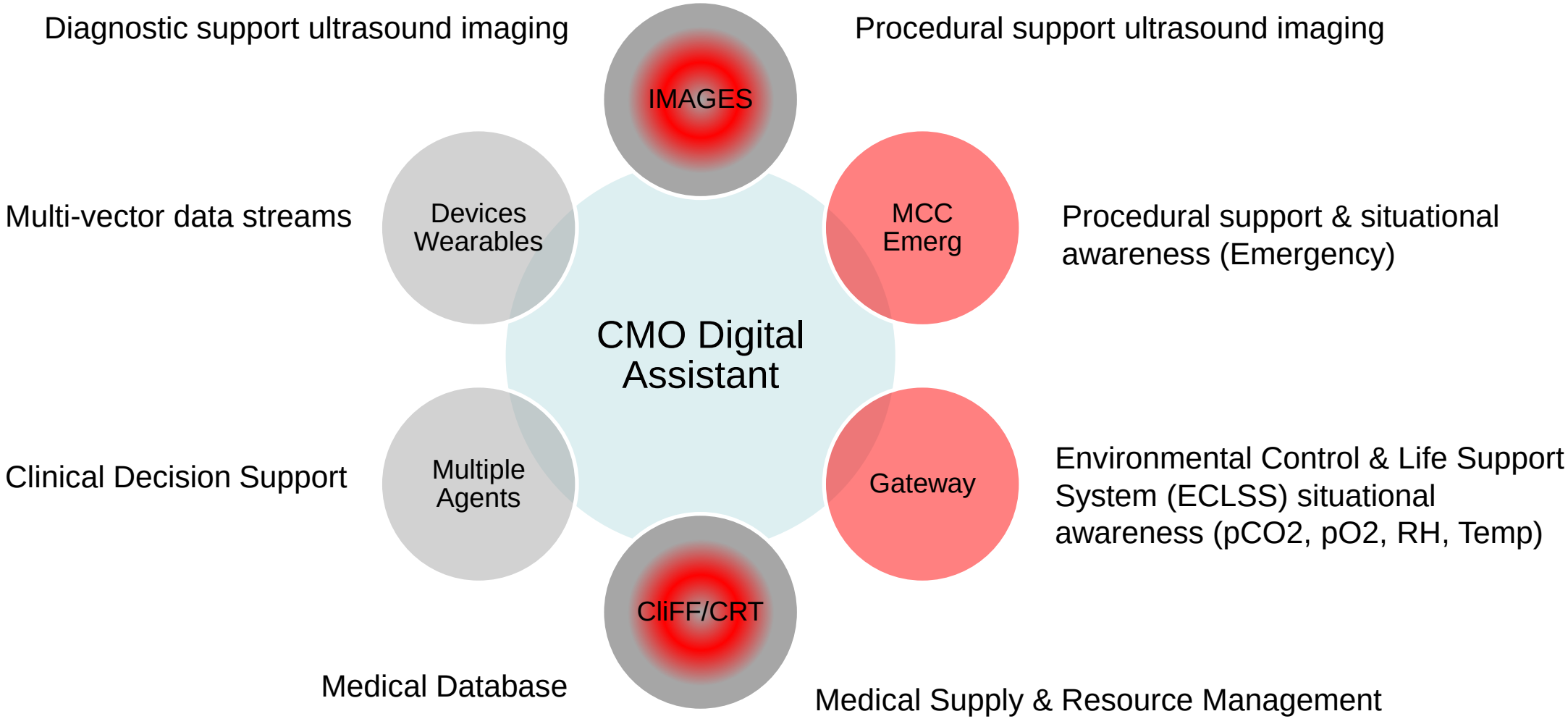

LLM AGENTS
Nurse
Lab Tech
Imaging
Manager
KERWIN
CMO Digital Assistant *aka* “Doc-in-a-Box”
ECLSS
Medical Devices
Pharm
Medical Evidence
Rx Databases
MISSION CONTROL

AI Platform Extensibility



*Life Sciences Data Archive

Interoperability of Projects in Portfolio



Challenges and Limitations

- **Computation Time and Cost**
  - Infrastructure (GPUs, Cloud Services) cost prohibitive
  - Solution: Build on open-source models, utilize industry partnerships
- **Data Governance and Privacy Protection**
  - Scarce data available relevant to aerospace medicine pathophysiology
  - Solution: Evaluating synthetic data set generation, modeling tools
- **Data Transmission to MCC**
  - Deep space network has finite capacity, increased transmission latency
  - Solution: Build tools to facilitate on-board decision making
- **AI Trustworthiness**
  - Trust gap currently exists for AI tools and technology
  - Solution: Iteratively develop with verification & validation

Lessons Learned

- **Architect from the right, build from the left**
  - Desired solution is on-premise (at the “Edge” since no Cloud environment)
  - Containerize, quantize, agentify using Federated architecture
- **Industry partnerships are key**
  - Leverage industry expertise and assemble multi-disciplinary teams
  - Utilize non-reimbursable Space Act Agreements
- **Apply tools to maximize their strengths and efficiency gains**
  - Large language models are great at summarizing vast amounts of text
  - Models like ChatGPT are less useful than smaller, fine-tuned models
  - Agentic solutions provide highly accurate and concise output
- **Communicate early and often with stakeholders**
  - “Agile-like” development, 90-day SPRINTS, highly informative & productive
  - Design and implement for interoperability and extensibility

Questions?