Developing a Human Performance Model Based Systems Engineering System Architecture (MBSE-SA) for Defense Applications

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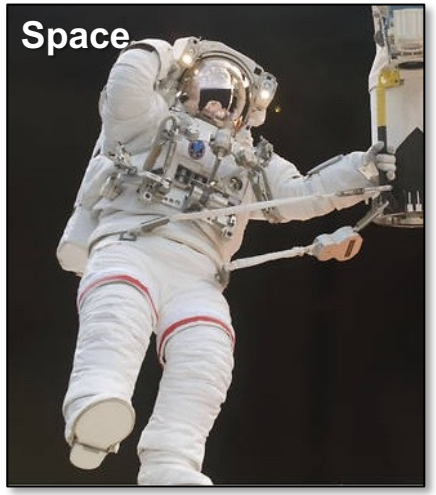
IS2022 Session 5.1.1

28 June 2022

This material is based upon work supported by the Department of the Army under Air Force Contract No. FA8702-15-D-0001. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of the Army.

Monitoring Operators in Stressing Conditions



High consequence for poor performance, both physically and cognitively

Enabling Mission Success Through Human Performance

Requires warfighter data

Physiological Data
- Physical
- Cognitive
- Social-Emotional
- Health

Task Outcome Data
- Doctrinal success criteria
- Subjective success assessment
- Objective success assessment

Individualized and team analytics

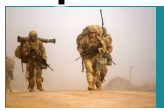
Human performance relationships

Human Performance Model

Task Performance Model

Requires Relationship Models

Providing actionable information for performance decisions

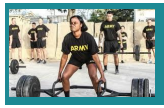

Task selection


Team selection


Performance prediction


Skill assessment


Readiness assessment


Training requirements


Tactical mission decision making


Performance enhancement

Increasing mission success through improved human performance requires validated models that relate measurable human characteristics, task outcomes, and recommended actions

Strategy for Improving Human Performance

S&T / Acquisition / Training / Operation Leads *provide source requirements* for recommended military strategy

High-Level Concepts and Strategies

- **Military High-Level Concepts and Strategies**
- **Military Initial Capabilities Documents**
- **Military Capability Development Documents**

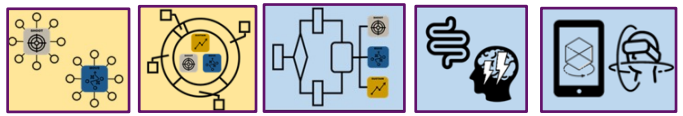
Mission Planners provide *use cases*

- METT-TC
- Goal
- Tasks
- Tactics
- Techniques and Procedures
- Actors

Human Performance MBSE-SA Model

RDT&E Developers

Research Efforts, wearable system descriptions and implementation



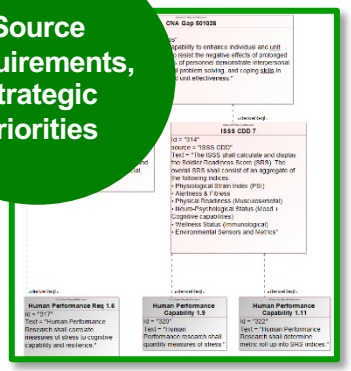
Research results, ***human and task performance relationships***

Human Performance MBSE-SA model, together with the INCOSE 2021 Wearables model, can find human performance research gaps and suggest wearable systems to use for research into that gap area

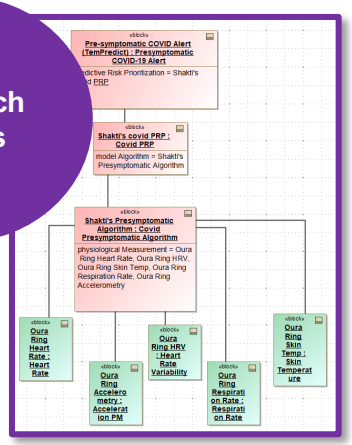
RDT&E: Research, Development, Test & Evaluation
METT-TC: Mission, Enemy, Terrain and Weather, Troops and Support Available – Time Available and Civil Considerations

Human Performance MBSE-System Architecture Framework

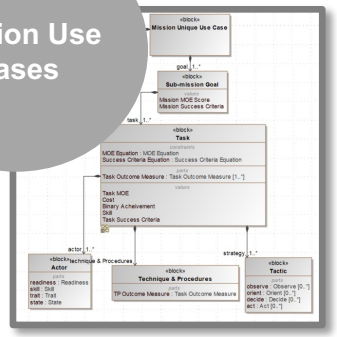
Source Requirements, Strategic Priorities



Research Efforts

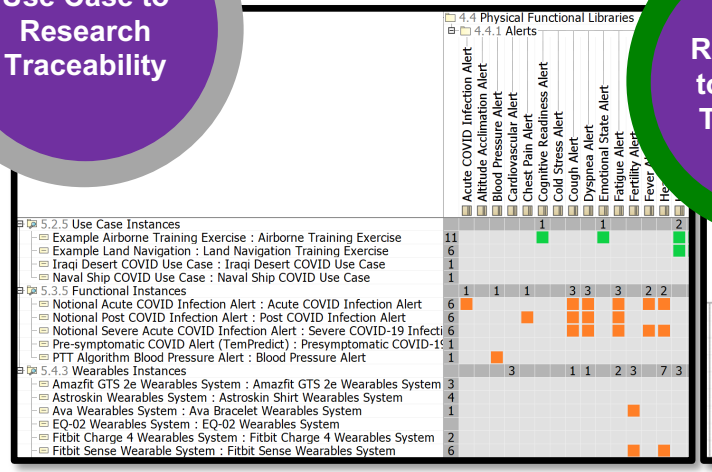


Mission Use Cases

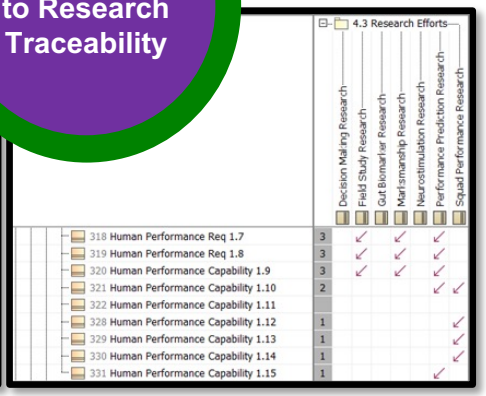


Encoded Model Relationships

Use Case to Research Traceability



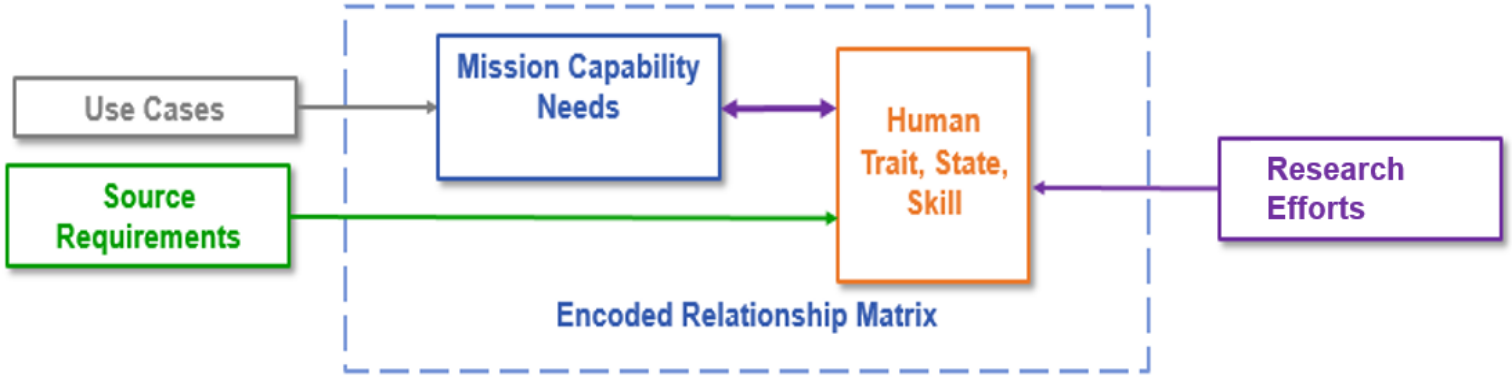
Requirement to Research Traceability



Standard encoded relationships give automated results for users to make informed decisions about present and future research applications

Encoded Relationships of the Human Performance MBSE-SA

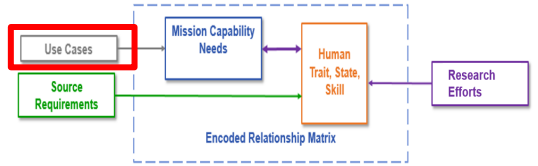
- Relationships provide traceability among research efforts, source requirements, and use cases
  - Identify research and capability gaps
  - Minimize research redundancy by detecting areas for collaboration
  - Understand human performance needs of the DoD & how to quantify human TSS
- Relationship Options
  - DIRECT: Trace research directly to requirements or use cases
  - INDIRECT: Trace source requirements and use case capability needs via human performance structures and functions (TSS) to the research focused on the TSS



Indirect encoded relationships allow for development of solution agnostic human performance requirements where multiple research efforts can address needs

DoD: Department of Defense
TSS: Traits, States, and Skills

Use Case Relationship Example



- **Focus on capturing highly leveraged "scenarios" (aka capability requirements); use cases will be built from libraries as needed.**

Use Cases

Airborne Operations

Airfield Seizure

"require…"

"require…"

Mission Capability Need

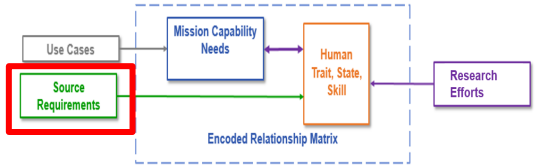
Heavy Load

Human Trait/State/Skills

- Power & Endurance
- Heat stress
- Musculoskeletal Fatigue
- Cognitive fatigue
- Stress Responsiveness

Encoded Relationship Matrix

Use Case Relationship Example



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Use Cases

Airborne Operations

Airfield Seizure

Source Req

«Custom Req Attributes»
Human Performance Capability 1.9
Id = "320"
Text = "Human Performance research shall quantify measures of stress."

"require…"

Mission Capability Need

Heavy Load

"require…"

Human Trait/State/Skills

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Encoded Relationship Matrix

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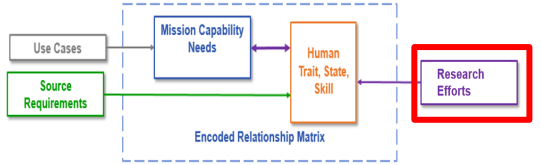

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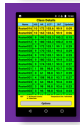
Encoded Relationship Matrix

Research Efforts

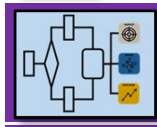
Field study endurance research

Marksmanship research



Performance prediction research

MSI research

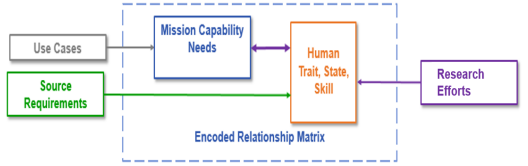


Cognitive fatigue research

Performance readiness metric research

Performance prediction research

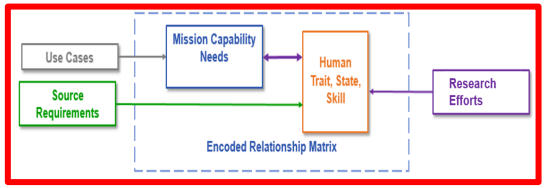
Overview of Human Performance MBSE-SA Methodology

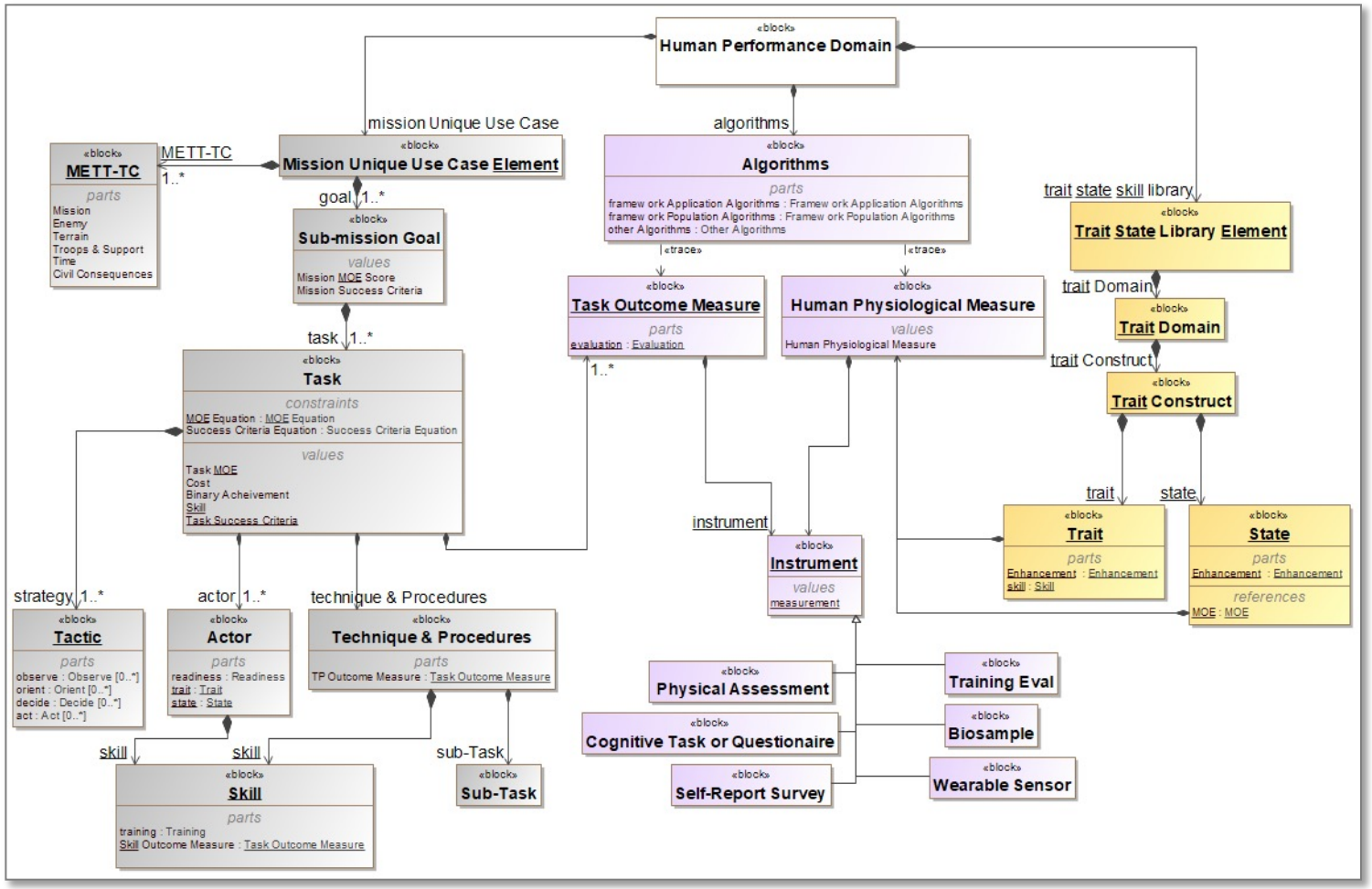


1. Create a conceptual architecture to identify and relate use case, human system, and solution architecture elements
2. Create model libraries containing specific use cases, TSS, and research efforts from military mission planner and RDT&E developer inputs
3. Capture military strategic source requirements
4. Create relationship models between the following:
   - Source requirements and research efforts via the needed human TSS
   - Use case elements and research efforts via the needed human TSS to accomplish the mission
5. Generate analysis products that compare required TSS to ongoing research focusing on those areas

TSS: Traits, States, and Skills
RDT&E: Research, Development, Test and Evaluation

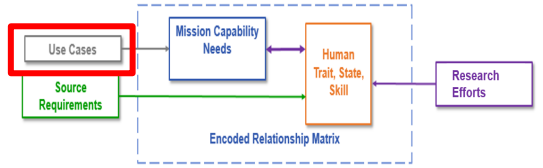
1. Conceptual Systems Architecture Framework



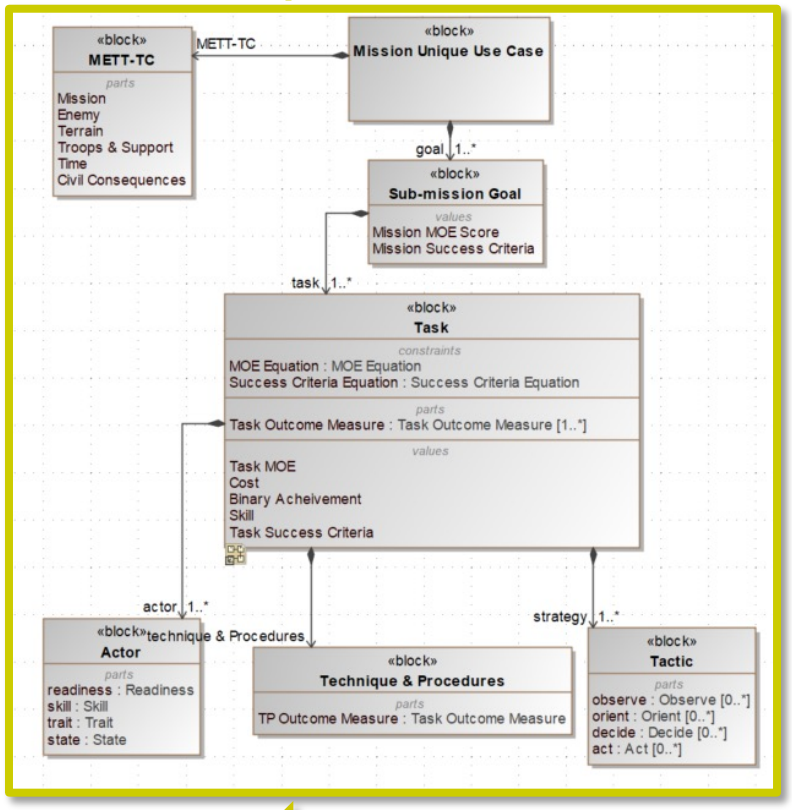


Enables straightforward integration of new capabilities and supports automatic propagation of characteristics and requirements among branches

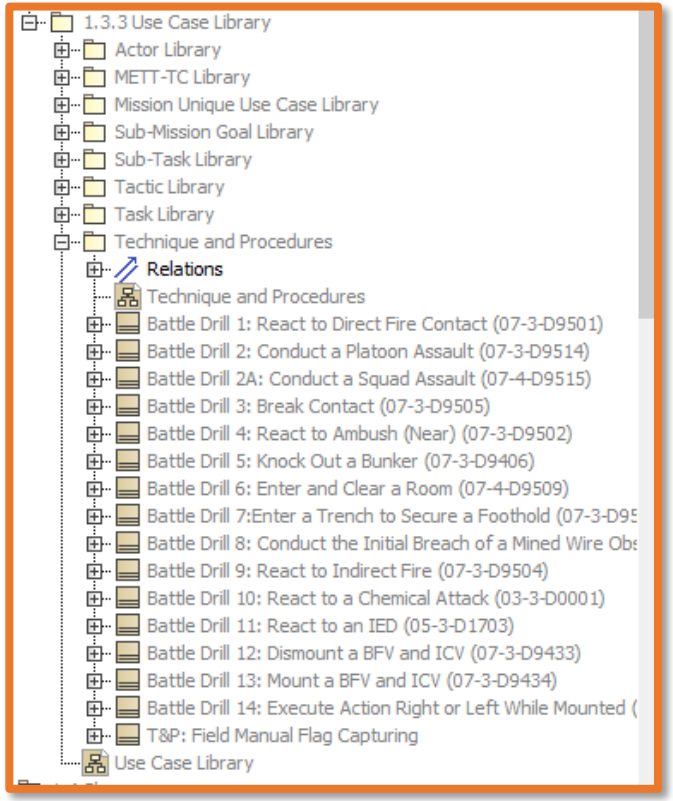
Use Case Architecture Definition



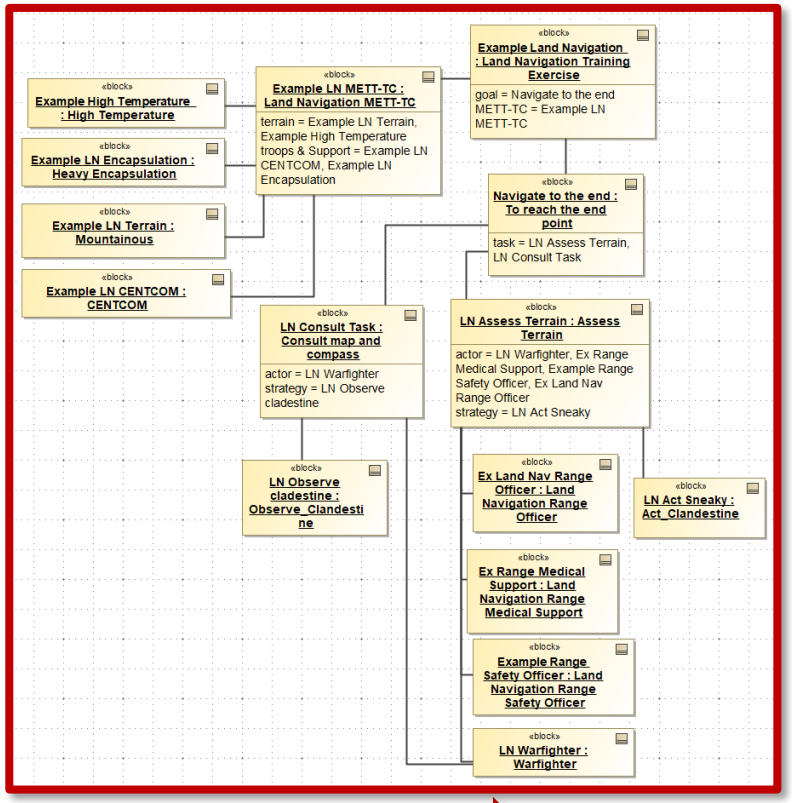
Conceptual Architecture



Use Case Library



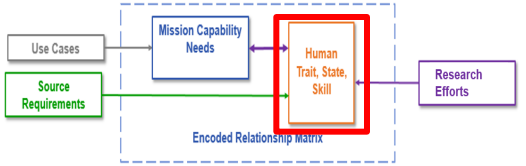
Use Case Instance



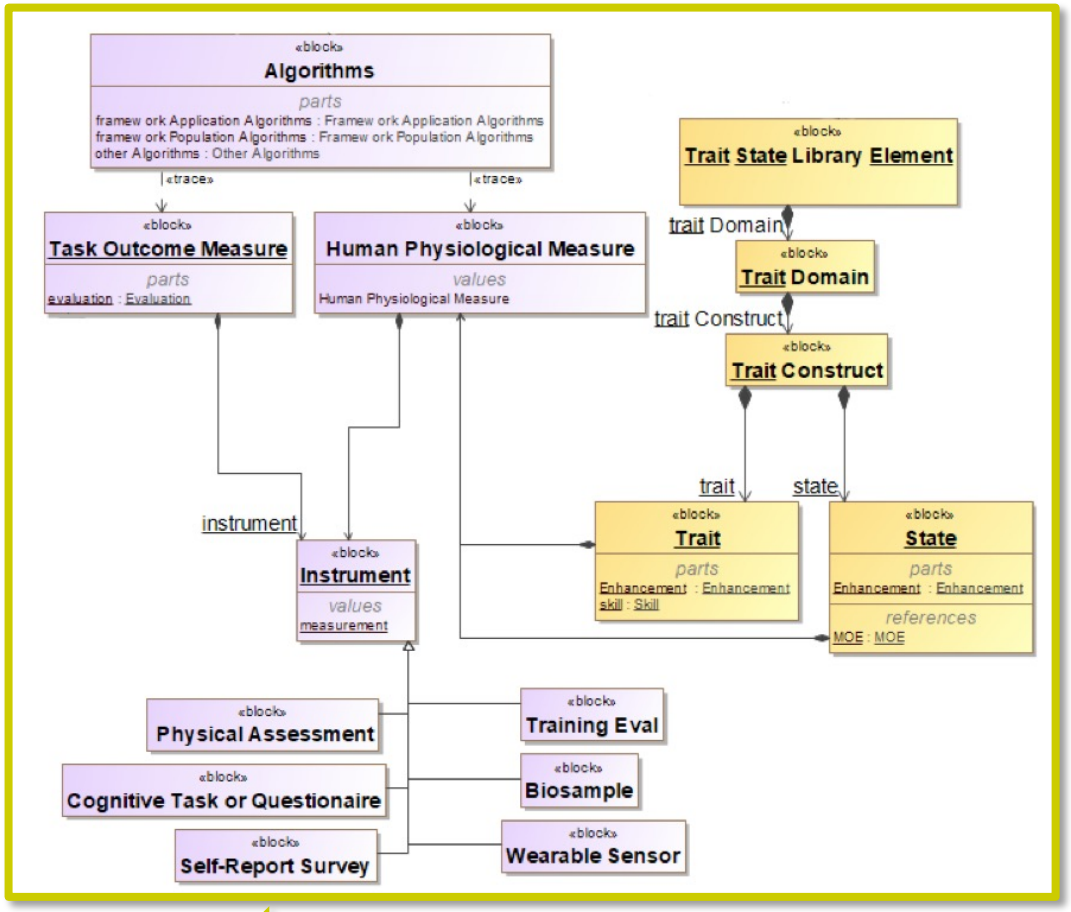
Generalized → **Specific**

Model libraries serve as a database built upon the conceptual framework abstractions, allowing for a reusable common foundation to assess the compatibility and capabilities of real-world systems

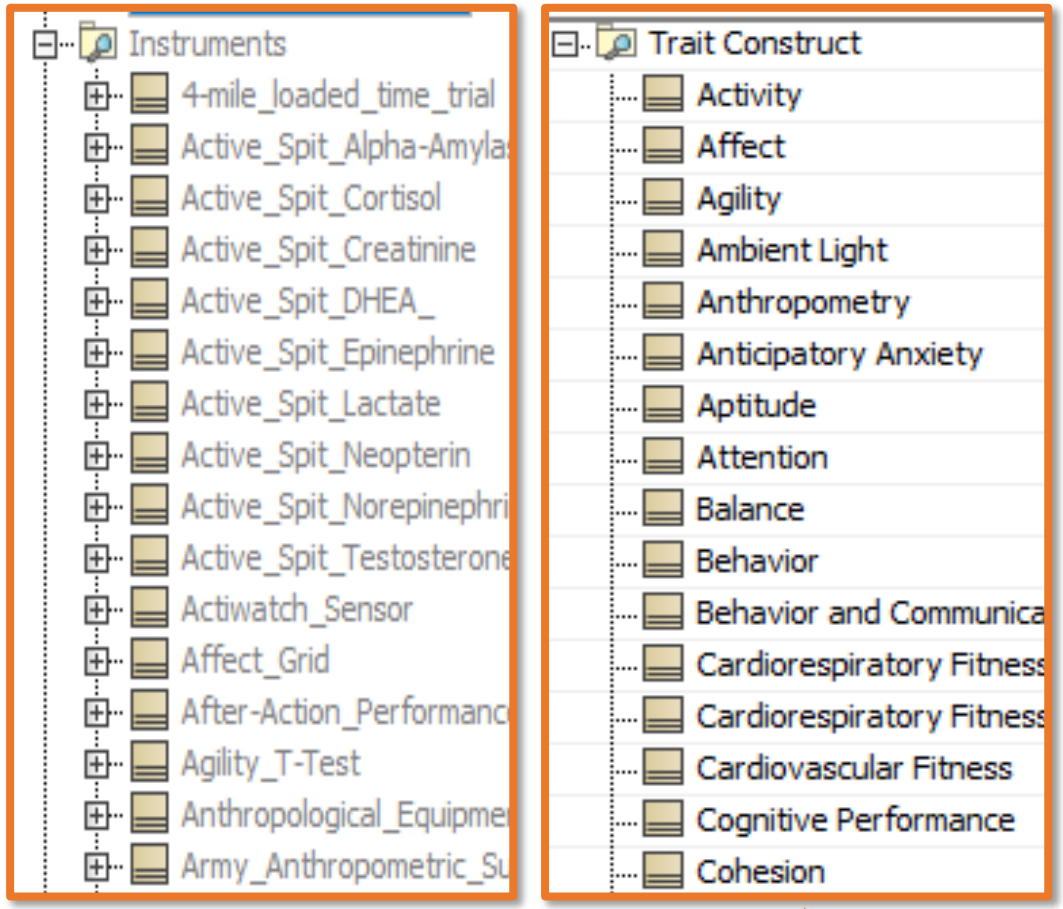
2b. Model Libraries: Human Traits, States, and Skills



Conceptual Architecture

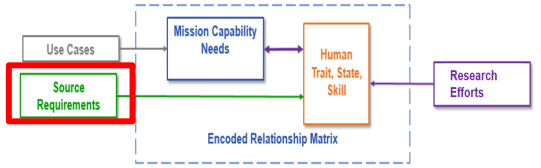


Human (TSS) and Solution Library (examples)

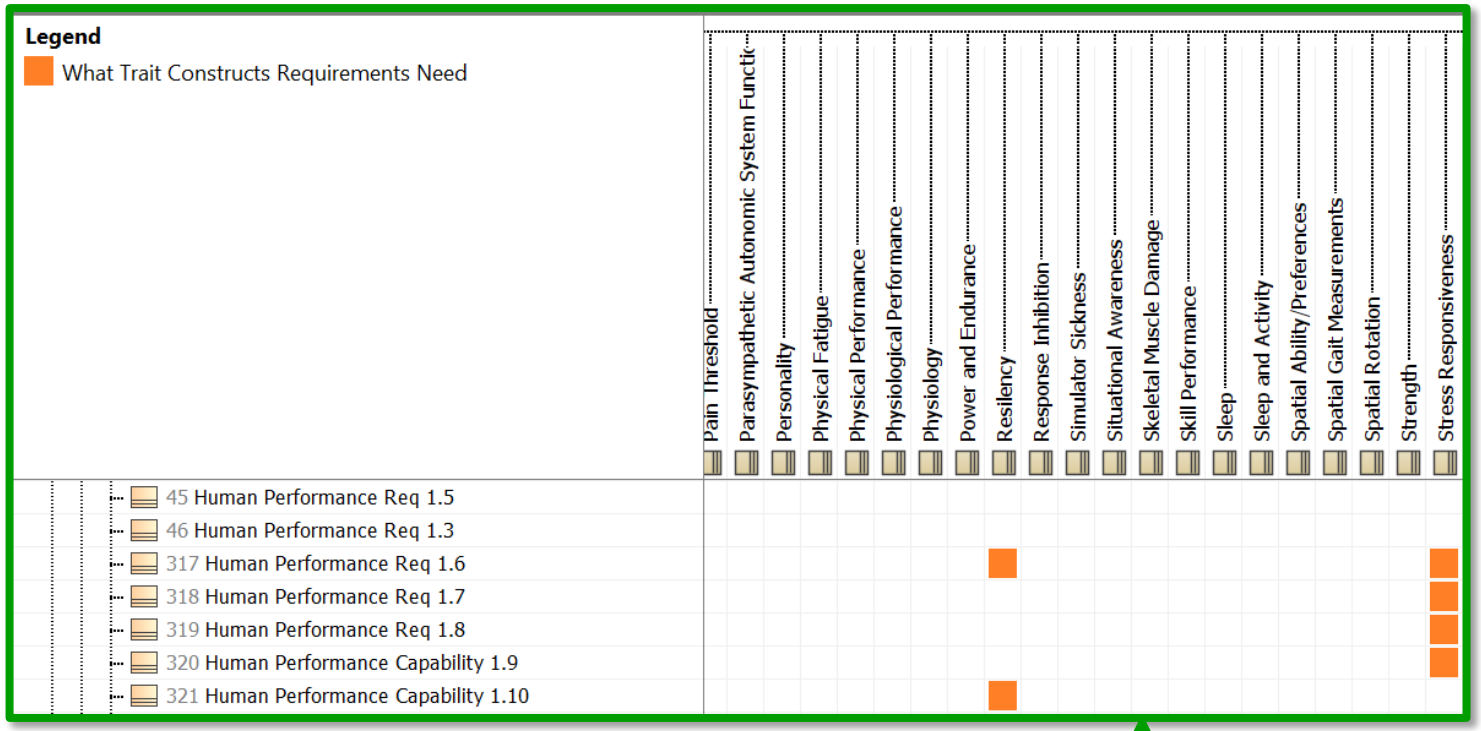


Generalized ← → **Specific**

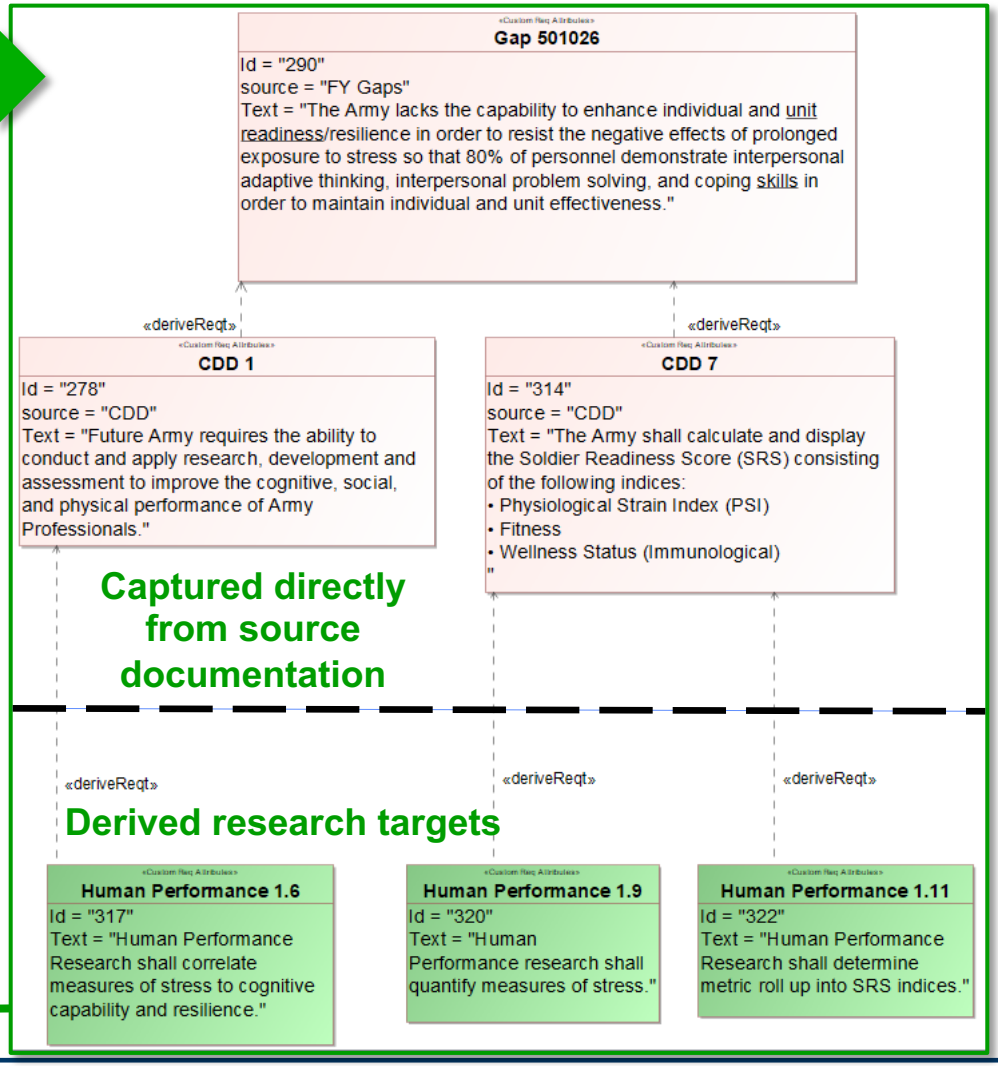
3. Source Requirement Architecture



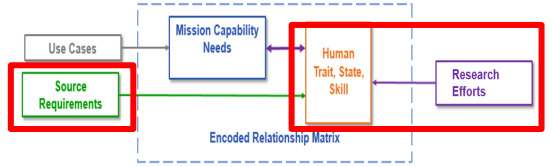
S&T / Acquisition / Training / Operation Leads provide source requirements
- **Military High-Level Concepts and Strategies**
- **Military Initial Capabilities Documents**
- **Military Capability Development Documents**

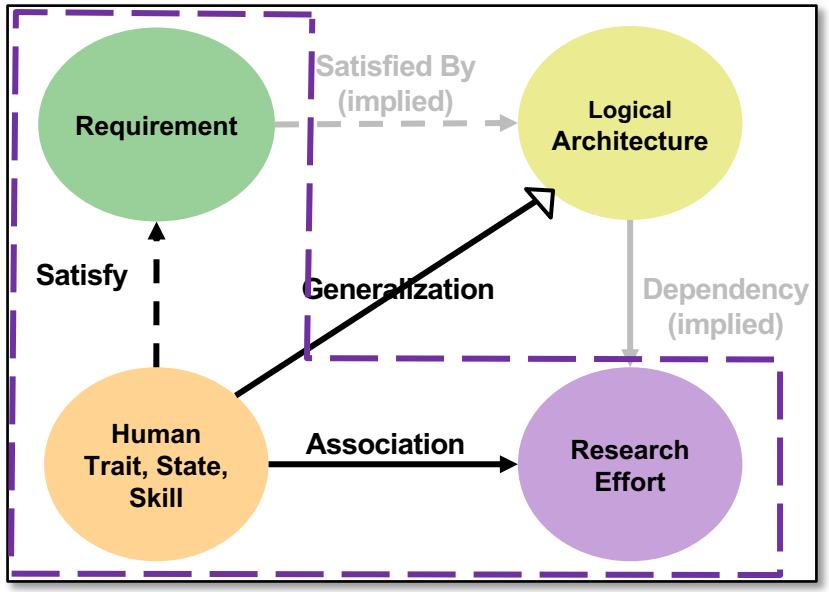


Human Trait, State, Skill Library

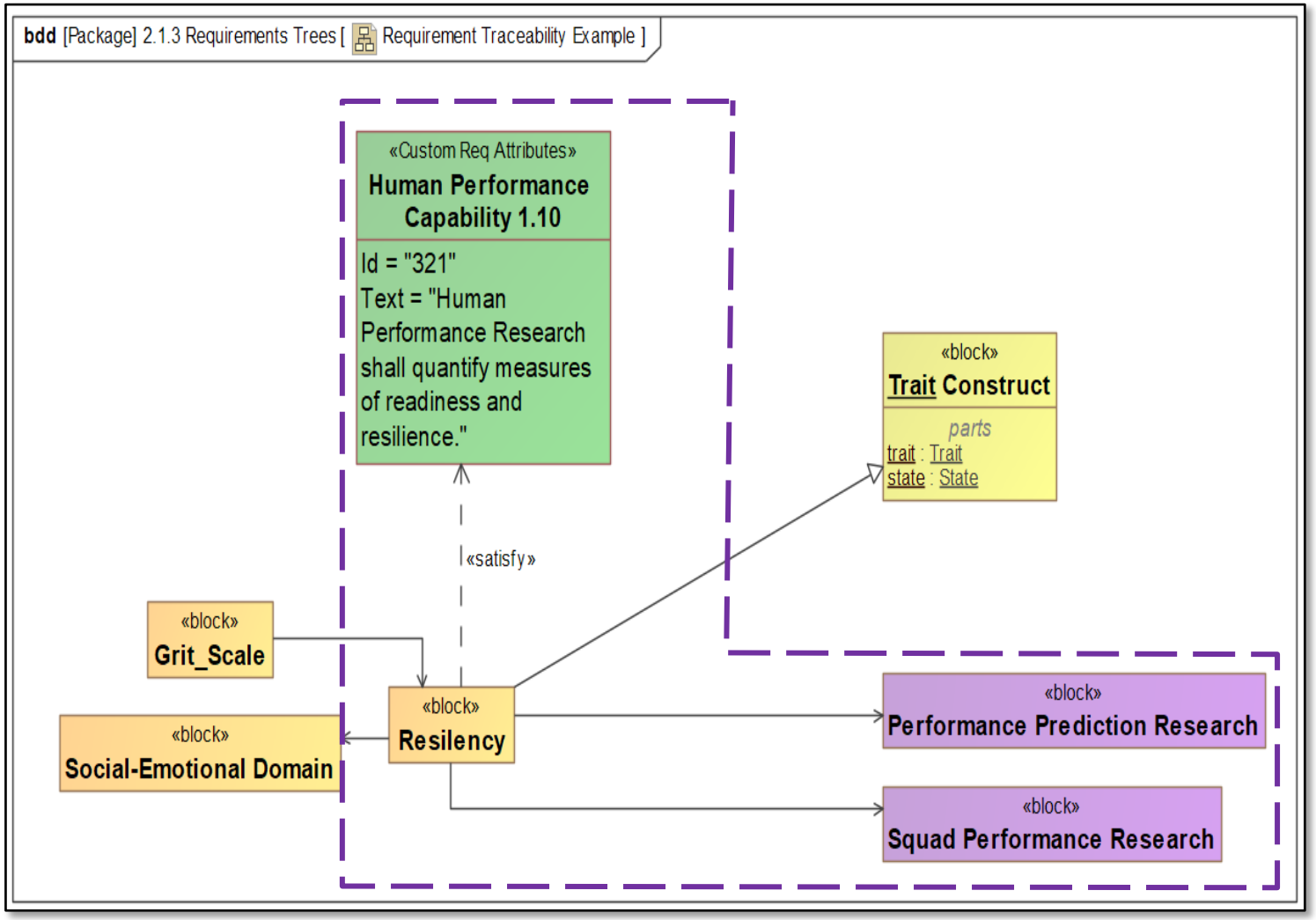


4a. Source Requirement to Research Effort Relationship Model and Analysis

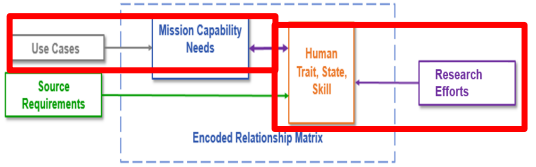


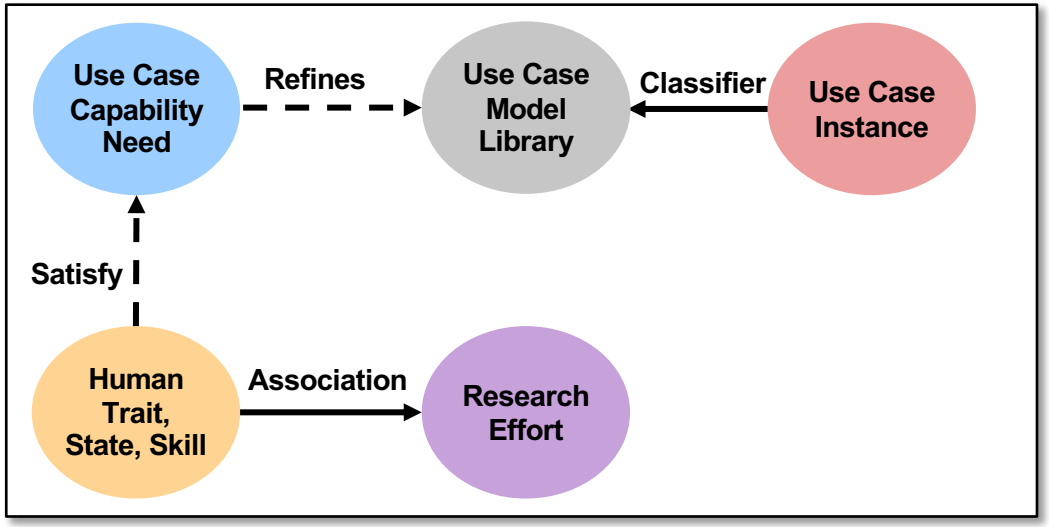


- Ingested requirements are linked to the architecture
- Research addresses architecture needs
- Indirect traceability through the architecture enables gap identification in research or requirement set

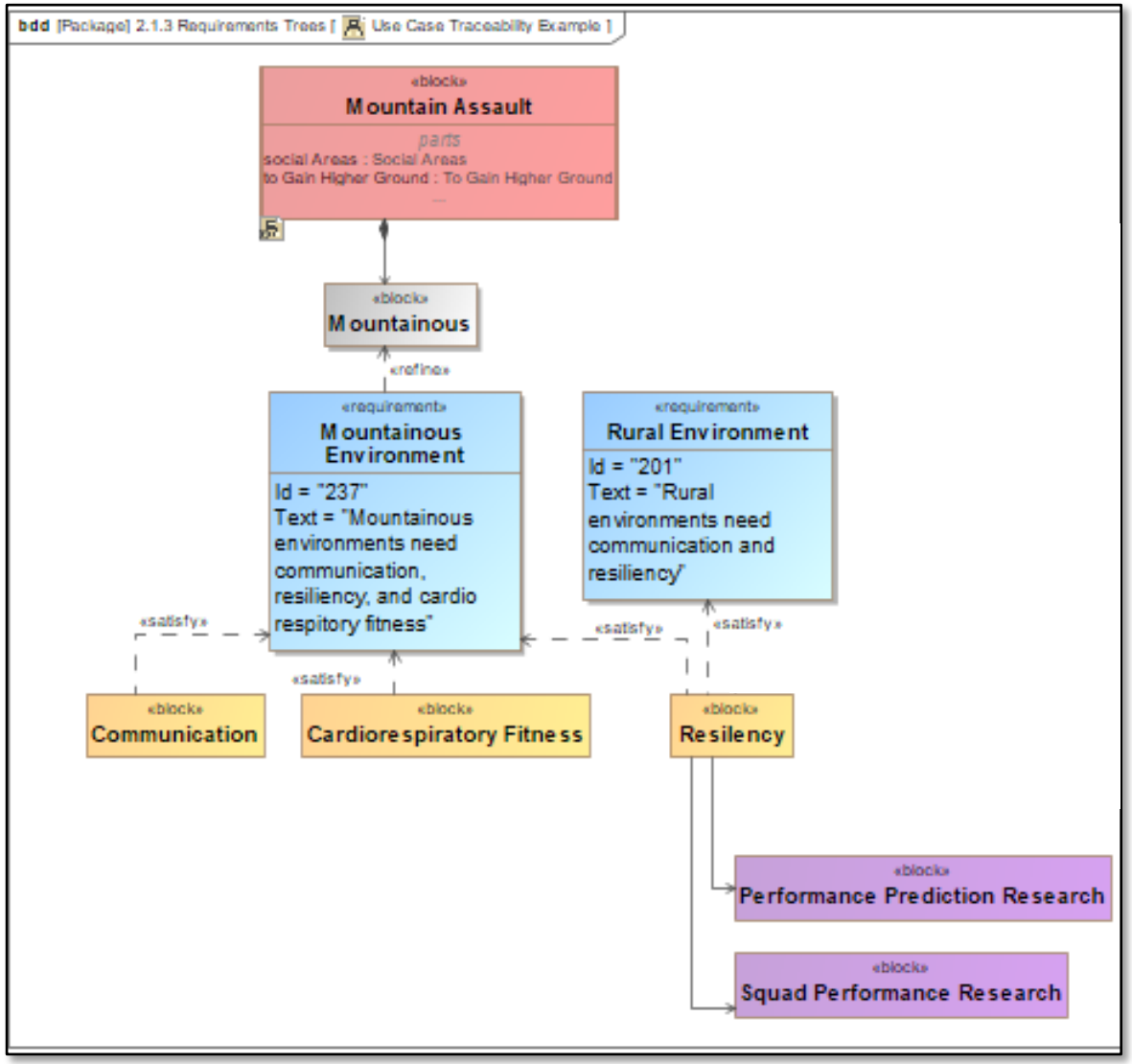


4b. Use Case to Research Relationship Model and Analysis

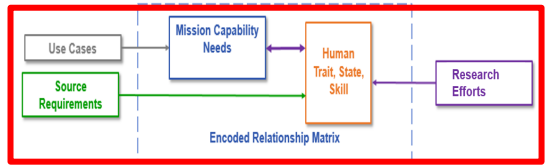




- Unique use case instances are built from library elements
- For every library element, we write capability needs requirements that are satisfied by the physical solution architecture
- Indirect modeling relationships allow for generating multiple unique use case instances that exploit the same library elements and associated requirements.

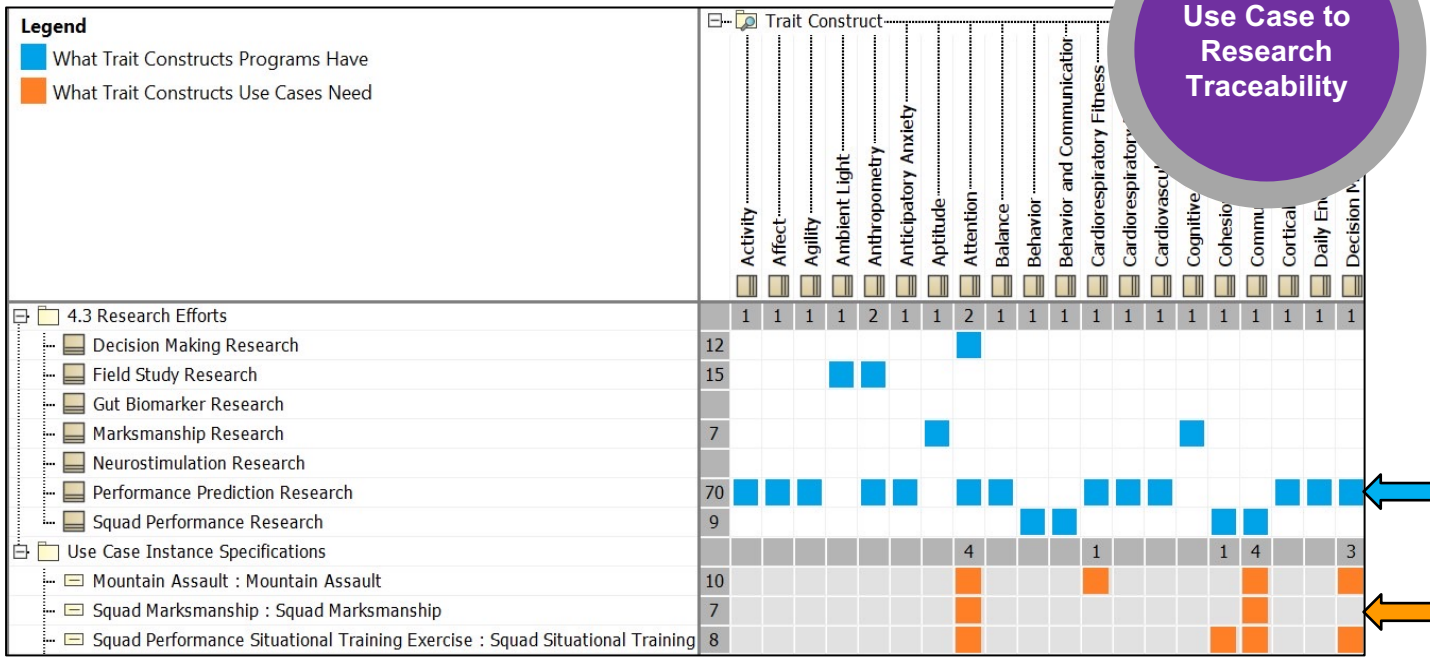


5. Model Outputs: Assess Research Portfolio and Perform Gap Analysis

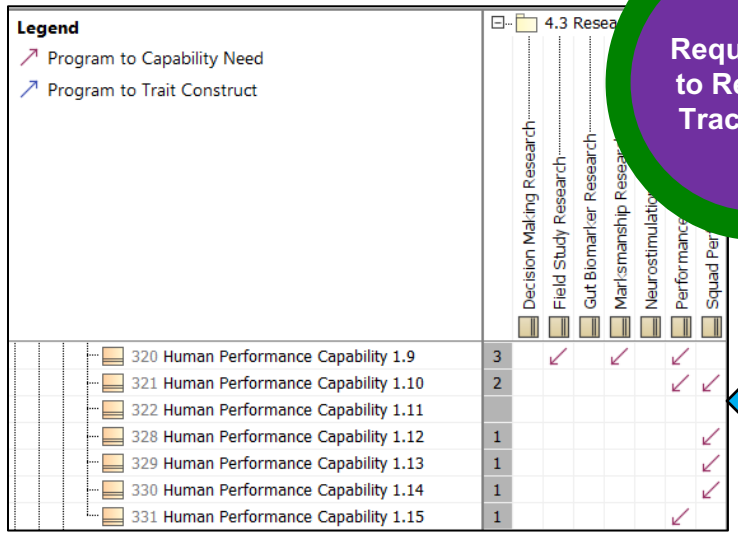


- **Research descriptions and results populate the libraries and use cases capability needs relationships**
- **Provides traceability of research to mission needs and requirements**
- **Gaps can be prioritized based on mission needs**

Use Case to Research Traceability



Requirement to Research Traceability



No number indicates a gap in research for a requirement

Blue identifies human TSS being researched via specific efforts

Orange identifies human TSS needed for a given mission use case

Model analysis can identify research gaps in areas of mission need

TSS: Traits, States, and Skills

Applying and Operationalizing the Framework

S&T

- Performance definitions
- S&T decision making and system analysis
- Research portfolio alignment and prioritization

MBSE Human Performance Model delivered to sponsoring organization

Advanced Development

- S&T alignment with operational needs
- Wearable system transition coordination across programs
- Requirements traceability and interoperability

On-going development of expanded model with sponsor

Training

- Warfighter training readiness assessment
- Mission-specific skill acquisition
- Proficiency tracking
- Special Operations candidate accession & selection

Operations

- Warfighter mission readiness assessment
- Mission-specific selection of warfighter team
- Mission alignment to operational strategy readiness levels
- Operational technology needs

Human Performance MBSE-SA Framework is the foundation on which stakeholder applications can be built

S&T: Science & Technology

Future Work Opportunities

- Seek stakeholder buy-in to the MBSE approach across human health and performance communities of interest
- Expand MBSE models for transition to broader usage
  - Improve tool usability for easier ingest of stakeholder information
  - Host model to expand access across stakeholder and technology development communities
  - Define access management, configuration management, scope, IP protection, and data security
- Populate models via stakeholder input to capture requirements, use cases, concepts of employment, and solution architectures
- Develop and extend framework applications to meet the needs of the advanced development, training, and operational communities

Summary

- **The Human Performance MBSA-SA Framework is the reusable foundation on which stakeholder applications can be built to streamline programs and reduce costs**
- **Human Performance MBSE-SA successfully addresses the military's human performance framework and knowledge repository needs by:**
  - **Automatic traceability from end user explicit and derived needs to research objectives and results**
  - **Identification of highest priority capability needs for research focus**
  - **Identification of whether critical gaps are being overlooked or only partially addressed**
  - **Tracking and traceability across research efforts**
- **Across the DoD, the MBSE-SA can be applied to improve training, procurements, and command decisions**
- **This model, together with the INCOSE 2021 Wearables model, can find human performance research gaps and suggest wearable systems to use for research into that gap area**
- **Acknowledgements: This work was funded under the Army DEVCOM Soldier Center MASTR-E program**