Human Machine Teaming (HMT) Elements of AI-enabled Course of Action Wargaming

Presentation for 2020 AI4SE/SE4AI Workshop

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Goal

- Describe a systems engineering process that enables AI to act as a partner to decision makers in future military programs
  - Results of an AI system can be surprising and/or confusing; careful design of how people understand and direct it is important
- Present a use case illustrating this process within the AI COA Recommender (AICR) project, currently under way in the Army's CCDC C5ISR Center
- Address key questions within use case:

  Why do planning staffs need AI?

  What functionality should AICR have to best assist with COA Wargaming?

Illustration from AI Magazine, John Carff, Institute for Human and Machine Cognition (IHMC)

"The more Intelligent the technological system, the greater the need for collaborative skills. Technology does not work in isolation from people; Technology thrives when successfully woven into human practice." *Johnson & Vera, No AI is an Island, AI Magazine*

CCDC = Combat capabilities development command
C5ISR = Command, control, communications, computers, cyber, intelligence, surveillance, and reconnaissance

AI COA Recommender (AICR) Program

- Addressing Course of Action (COA) Analysis Decision Support: currently time-constrained, manual, largely subjective, and complex
- Speed and complexity of battle are expected to increase
- Ongoing program creating pathways and prototypes for AI support of the COA Analysis process
  - Sponsored by Combat Capabilities Development Command's C5ISR Center

From *How to Master Wargaming*, Center for Army Lessons Learned

"*When maneuver battalion staffs plan operations, they manually analyze terrain and weather to predict enemy courses of action, considering how an enemy commander could most effectively fight. Staffs plan their own friendly course of action against this analysis. The process works much the same as it did 30 years ago.*"
- COL Edward Ballanco, January 16, 2019 (https://warroom.armywarcollege.edu/articles/enemy-analysis-tool-now)

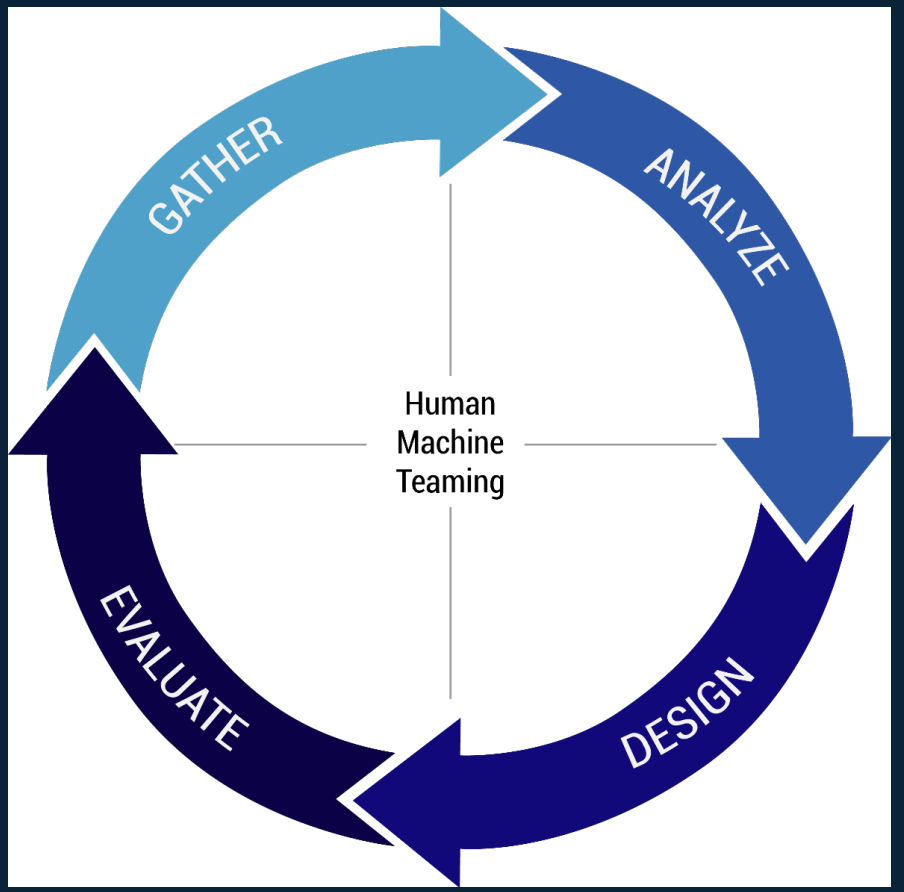
General Approach

Research Basis: HMT Framework

Design Content

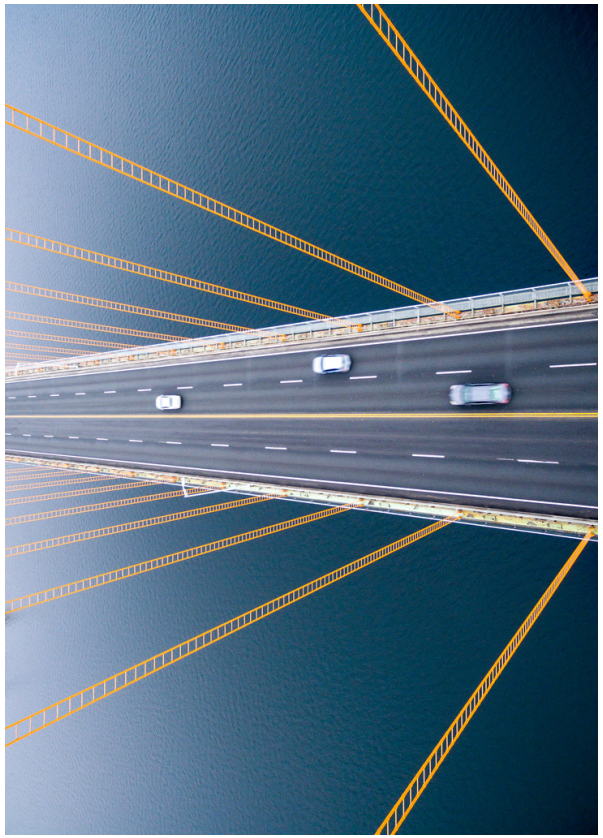
Transparency	Augmenting Cognition	Coordination	Design Process: Design Specifics
Observability Transparency into what an automation partner is doing relative to task progress	***Directing Attention*** Orient attention to critical problem features and cues	***Directability*** Humans can direct and redirect an automation partner's resources, activities, and priorities	***Information Presentation*** Format information to support understandability & simplicity
Predictability Future intentions and activities are observable & understandable	***Exploring the Solution Space*** Leverage multiple views, knowledge, and solutions to jointly understand the solution space	***Calibrated Trust*** Understand when and how much to trust automation partner	***Design Process*** Guidance on the systems engineering processes for HMT
	Adaptability Recognize and adapt fluidly to unexpected situations	***Common Ground*** Pertinent beliefs, assumptions, intentions are shared	

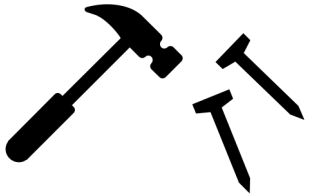
Systems Engineering Process



Bridging the Gap Between HMT Researchers and SEs

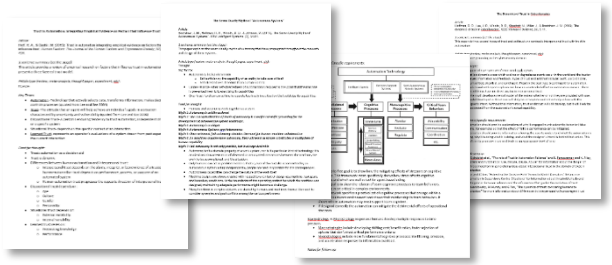
Researchers:
Don’t understand how to apply HMT research within systems engineering





Systems Engineers:
Don’t have ready access or time to read research

HMT Systems Engineering Guidance



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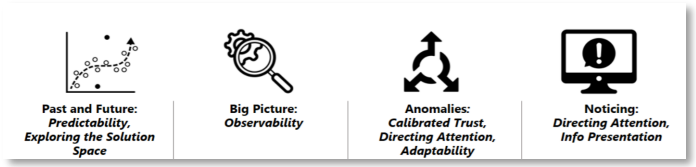

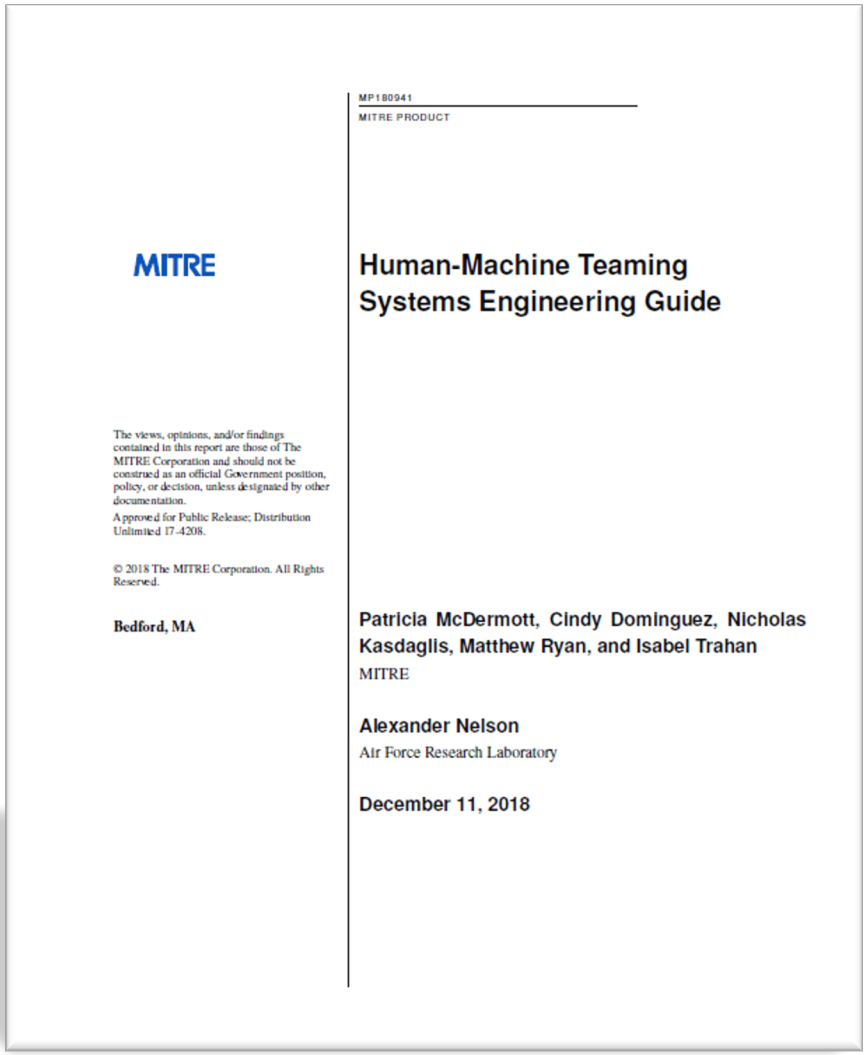

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Human-Machine Teaming Systems Engineering Guide

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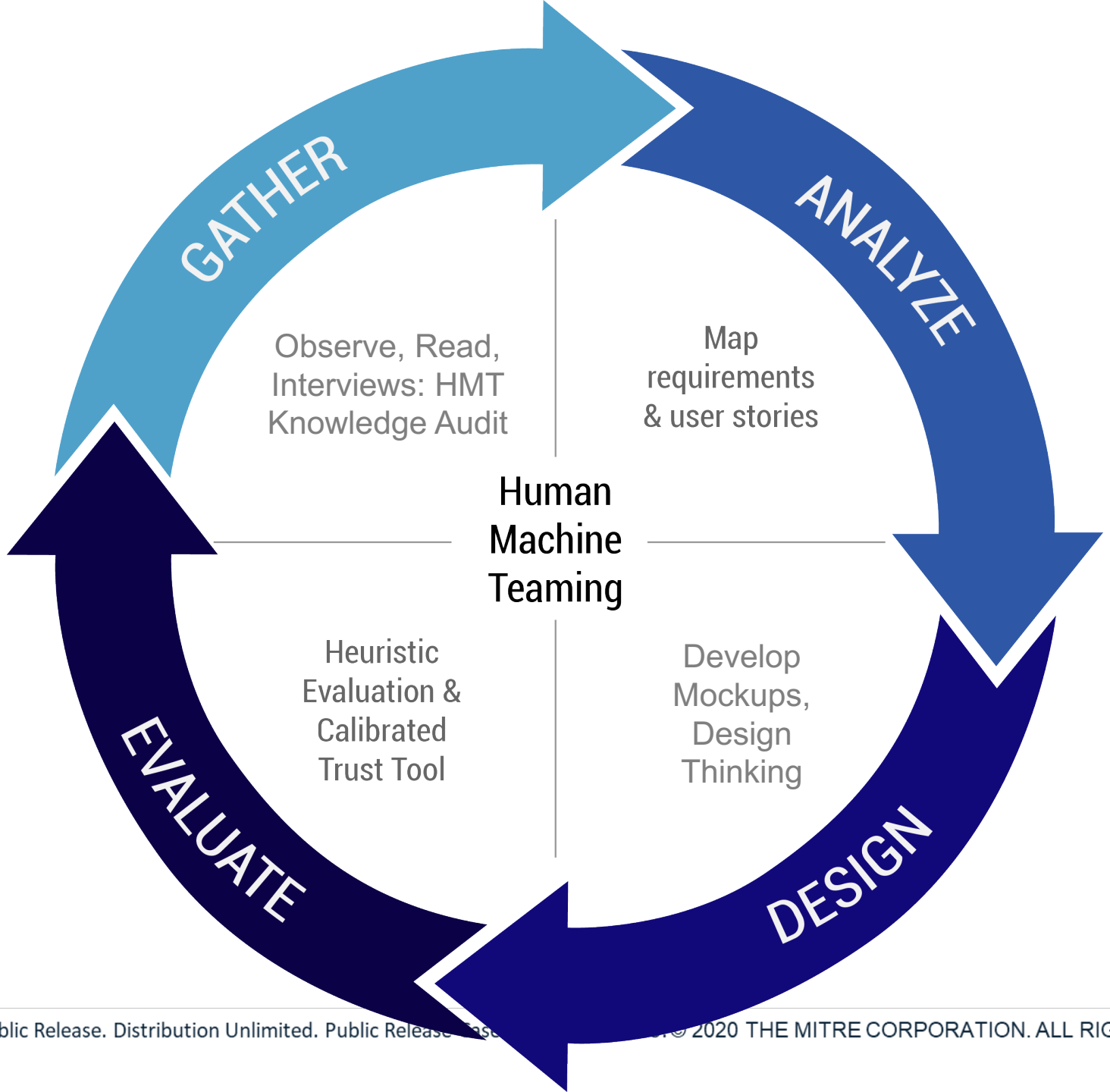
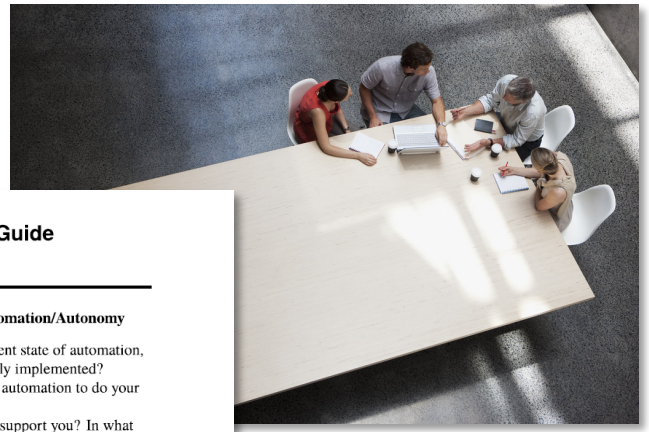
December 11, 2018

Goal: Engineers can apply HMT SE processes systematically for mission effectiveness outcomes
[Google: MITRE HMT]

Use Case: Wargaming Courses of Action



Gather Stage: AICR Project



Planned and Conducted On-line Interviews

- Developed Interview Plan and Questions; Modified HMT Knowledge Audit
- Extensive input from our team's experts
- Interviewed 6 COA wargaming experts
  - Instructors at Army leadership schools
  - Conducted with 2 SMEs at a time, 3 sessions, 2 hours each
  - 1 interviewer, 2 note-takers per interview
  - Aggregated and cleaned notes for analysis

Human-Machine Teaming Interview Guide

Introductory Material

Paint picture of envisioned autonomy

The envisioned system has autonomous features to... [tailor description]

Demographics and Top Challenges

1. Formal duty title, Rank? Years/months experience in role?
2. Other relevant experience (training, previous positions, etc.)?
3. What are the top 3-5 tasks you're responsible for?
4. Which ones are the most difficult, cognitively?

Current State of Automation/Autonomy

1. What is the current state of automation, how is it presently implemented?
2. How do you use automation to do your job?
3. How does it not support you? In what ways it is unreliable or challenging?

Optional: Critical Decision Method Probe

1. Can you think of particularly challenging time when... [tailor situation]

HMT Knowledge Audit

Past and Future: Predictability, Exploring the Solution Space

1. For missions you'd accomplish with this system, how predictable or variable are they?
2. As you do this work, what is really critical to understand about what might happen next? Are you predicting the next few
3. Can you think of a time whe information to understand satellite movements to predi
4. If you could have a tripwir What would you want to tel airfare from Denver to NY

Big Picture: Observability

1. What's the overall battle rh needed for planning change
2. What do you want the autor
3. Can you describe a time wh How the system calculated
4. What are the key vital signs
5. How might automation help

Anomalies: Calibrated trust, Di

1. What are the biggest system
2. Are there nuances that peop

1. Can you describe a future vision of COA wargaming with the best, most supportive, effective, and simple system imaginable?
2. Which part of [the wargaming] process is the most difficult for you, and why?
3. What information is most important to have before beginning course of action analysis?
   - What are ways this might be improved with intelligent assistance?
4. Can you describe a time when wargaming didn't go well? A time when it did go well?

Analyze Stage: AICR Project

1. Reviewed Interview Data
2. Identified common themes; create codes from themes
3. Assign codes to interview quotes
4. Review quotes within each theme; combine concepts into user stories
5. Themes and related quotations provided to Systems Engineering team for epic, strategic theme input

Example Theme: Visualize friendly and enemy COAs over time

Code: See friendly, enemy COAs over time

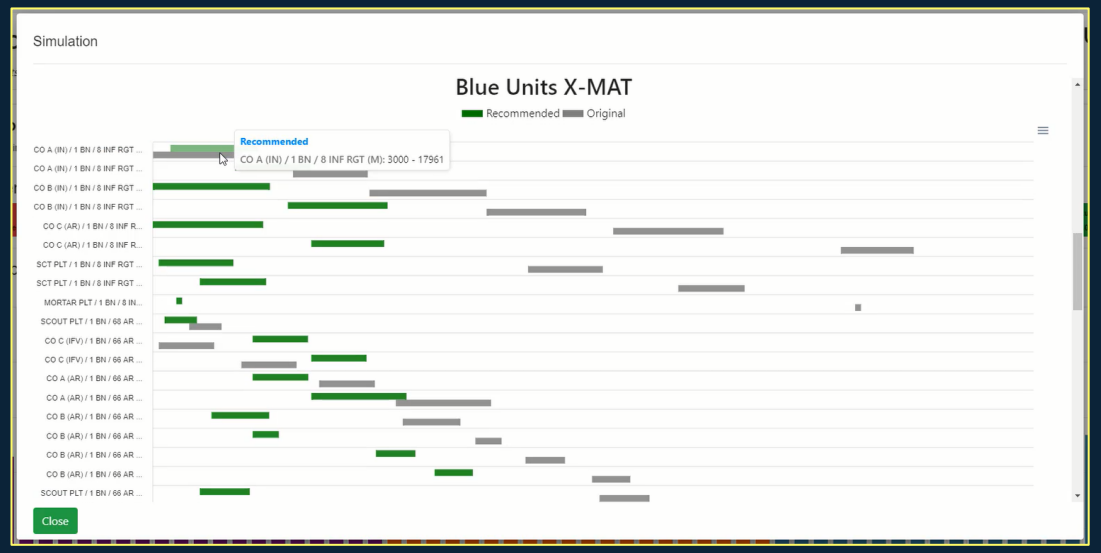
Quote: "I need help visualizing the situation. It is a challenge to visualize multiple enemy COAs. What can the enemy do; what are their choices?"

User Story: As a Division Plans officer, I want to see the different ways the enemy can react during COA wargaming, so that I can see what counteractions should be taken.

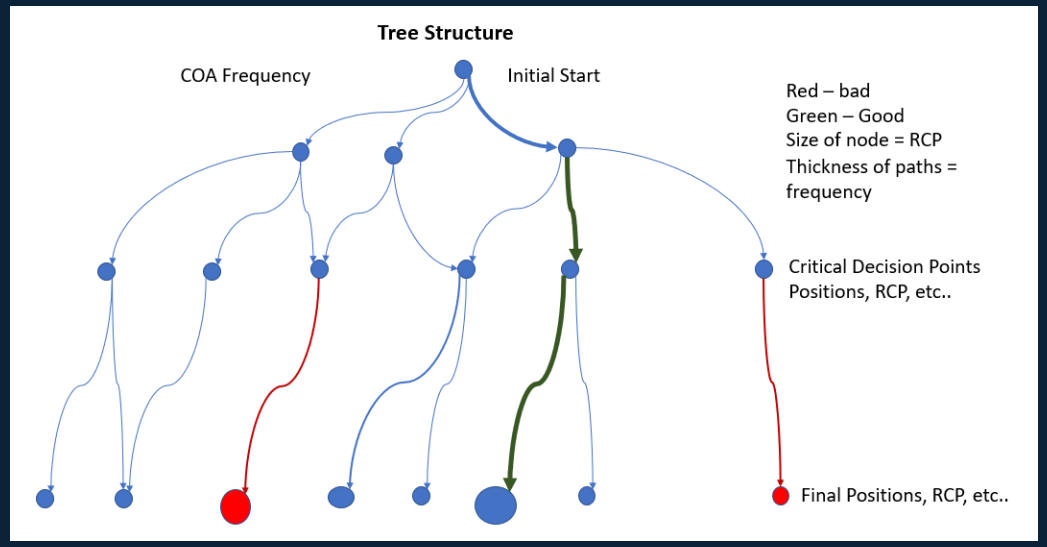
Design

Create coherent flows of work; Mock up user stories

Project will begin this effort based on data collected in near future



Current prototype's comparison of baseline COA timing with algorithm's suggested COA timing



Potential future representation of COA frequency at critical decision points

Future Evaluation

Review User Stories

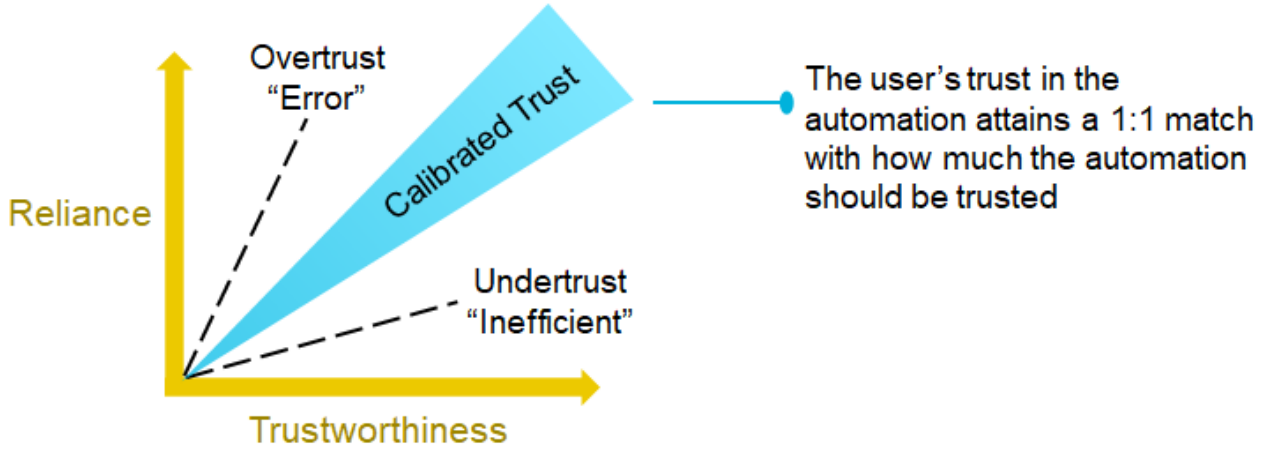
- **Internal SMEs review/refine user stories and designs**
- **Prioritize path forward**
- **Document questions, input needed from SMEs**

HMT Evaluation of working system

- **Calibrated Trust Evaluation Toolkit**
- **HMT Heuristic Evaluation**

Evaluation of Calibrated Trust

Calibrated Trust: User's *trust in the automation* matches *how much the automation should be trusted*.



Example User Story: As a Division Plans Officer, I want the system to tell me how likely an adversary COA is so I can determine how much time of my time I should spend planning for it.

Calibrated Trust Dimensions: Assessment Methods

Belief

Self-report

Primarily questionnaires

"I have confidence in the advice given by the [system]."

Understanding

Structured Interview

In which situations is system performance degraded?

In which situations does system performance excel?

Intent

Self-report

Specifically for early mock-ups

"When I am using the system, I intend to monitor the system at a rate of __."

Reliance

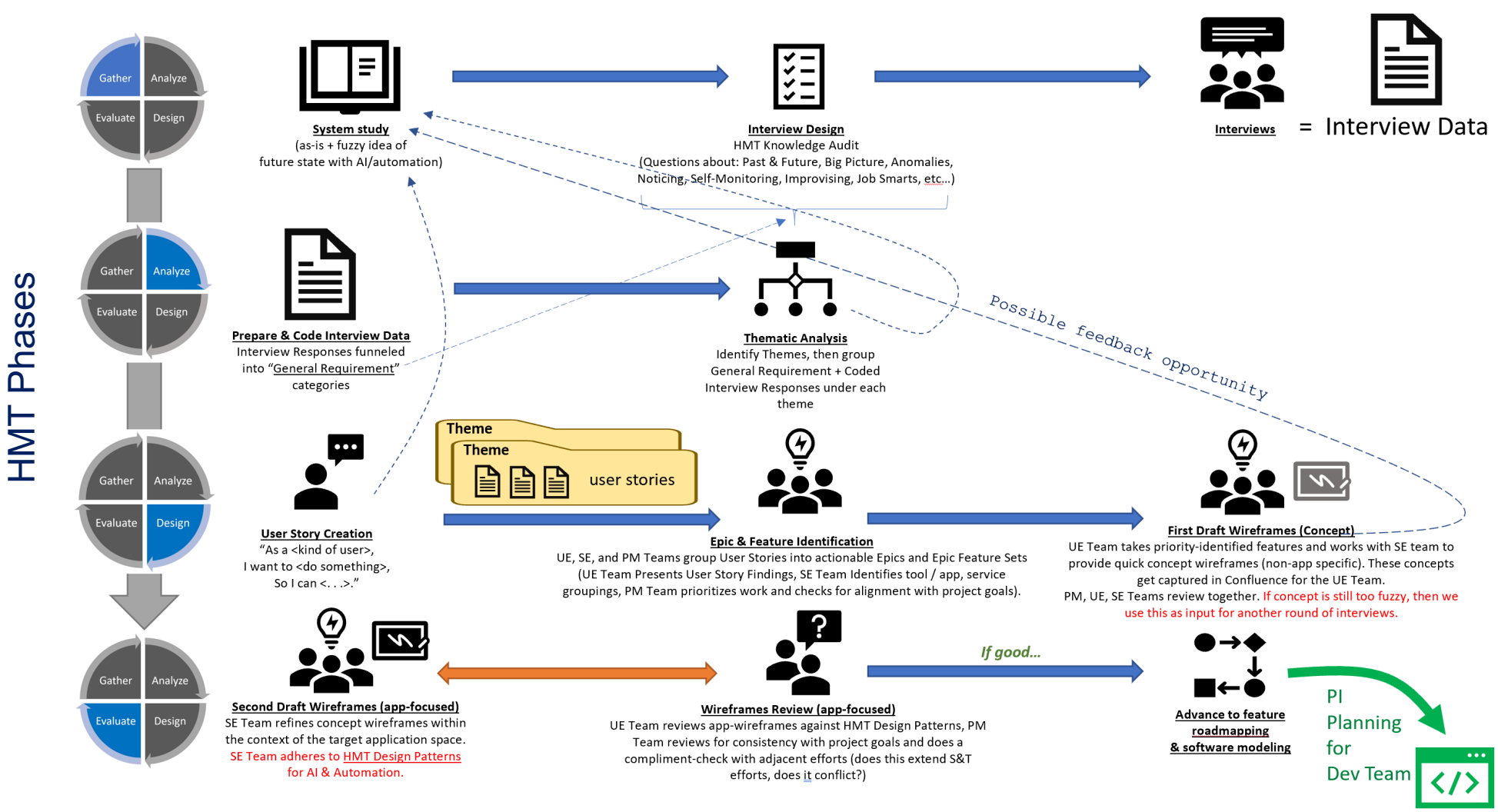
Behavioral

Requires functional prototypes

Frequency of Acceptance/Use

Accuracy of Acceptance/Use

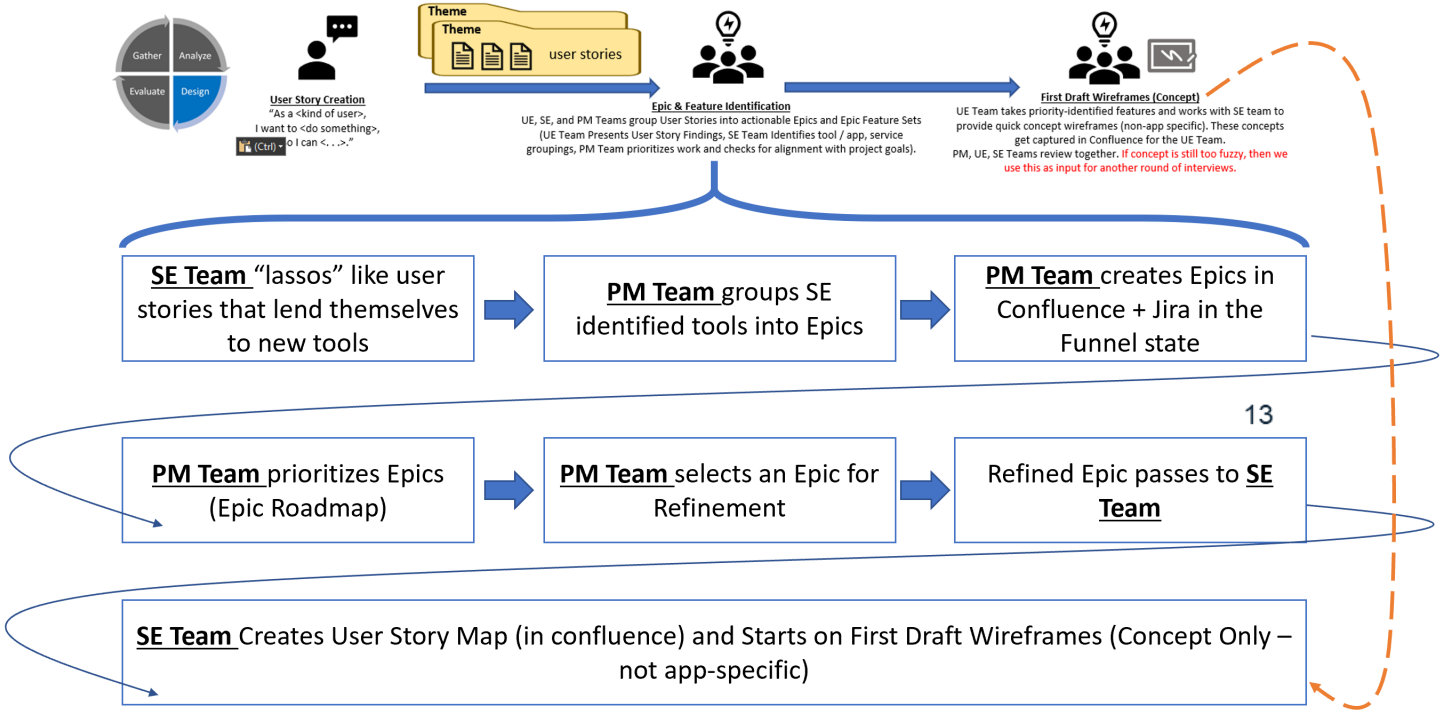
Agile Process: Scaled Agile Framework + HMT



HMT Design Phase meets SAFe as part of Epic Identification from Interview Themes

SE Team works with User Engagement Team to refine Features within Epics against HMT Design Principles, before engaging Dev Team for Program Increment Planning.

Epic & Feature Refinement with HMT



SE with AI / Automation in mind using HMT Design Principles

- Design for Appropriate Trust and Reliance
- Design for Appropriate Automation
- Design to Support the Operator Awareness, Work, and Goals
- Design Philosophy and Rationale

Execution of Program Increments using Scrum.

Conclusions

- Developing and refining Scaled Agile Framework cycles that embed mature human machine teaming processes
- AICR effort is on the path towards:
  - Functionality and design that is traceable to analyzed expert data
    - Entire team effort is connected with soldiers' needs
  - AICR technology that highlights what matters to soldiers

'Why do we need AI?' …because the problem space is complex and challenging
'What functionality should we strive for?' …helping staffs visualize friendly and enemy actions, reactions, counteractions over time

Q&A

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