Foundational Human-Autonomy Teaming Research and Development in Scalable Remotely Operated Advanced Air Mobility Operations: Research Model and Initial Work

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Overview

- Advanced Air Mobility (AAM)
- Human-Autonomy Teaming (HAT) Foundational Research Activity
  - Research Question
  - HAT Framework
- Research Model
- Type 4 Research and Development: Applied, Field Studies
- Type 1 Research and Development: Controlled, Lab Studies

Future Aviation Operations



Credits: NASA / Graphics

- **Advanced Air Mobility (AAM)**
  - Small UAS (sUAS/UTM) → e.g., Package Delivery
  - Urban Air Mobility (UAM) → e.g., Air Taxis
  - Regional Air Mobility (RAM) → e.g., Autonomous Cargo

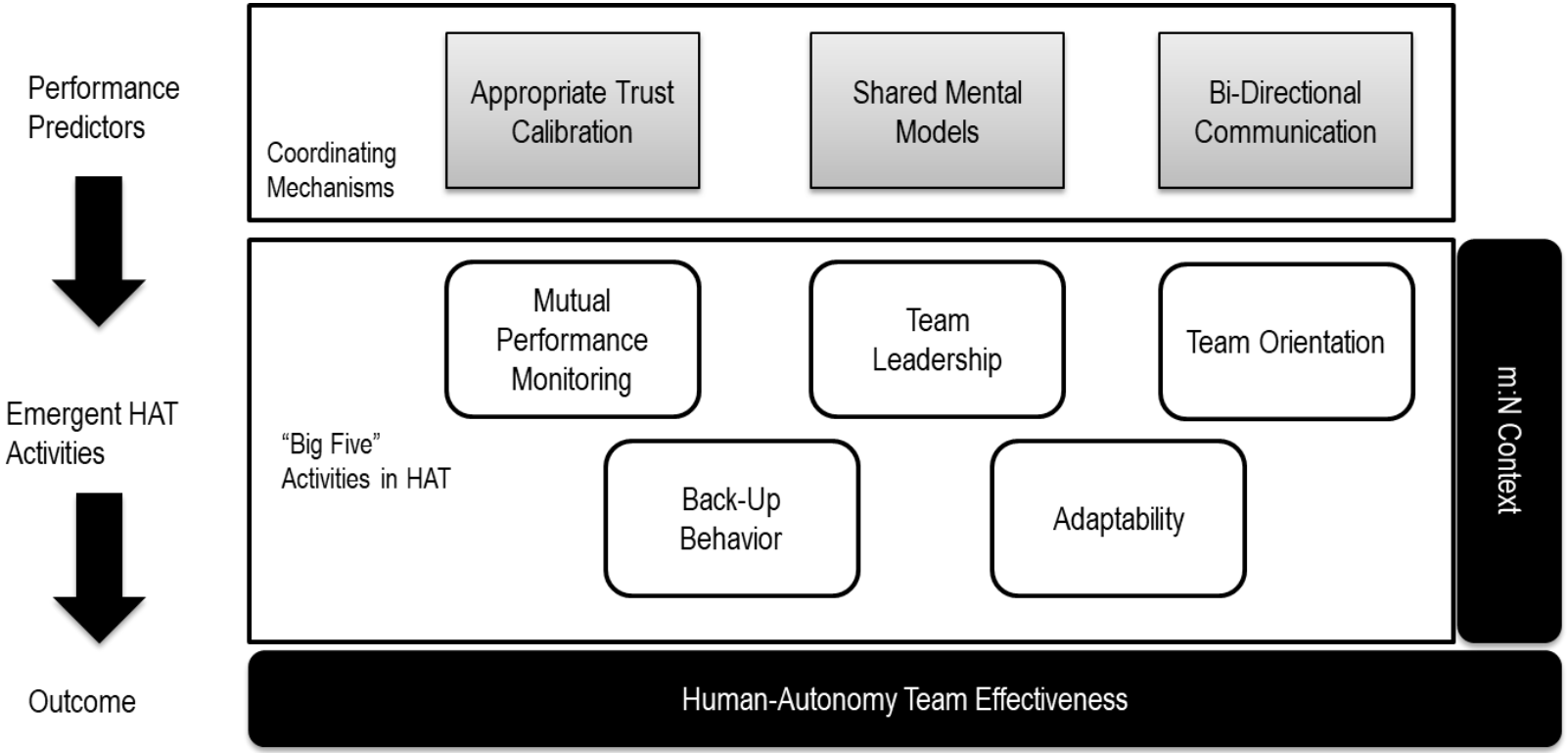
**UAS = Uncrewed Aerial Systems*
**UTM = UAS Traffic Management*

HAT Foundational Research Question

What HAT approaches (design principles, technologies) will facilitate fewer remote operators (m) to manage more increasingly autonomous vehicles (N) in AAM operations?

- HAT Definition: A distinguishable set of two or more *agents (human operator, increasingly autonomous system)* who interact dynamically, interdependently, and adaptively toward a common goal/objective/mission (adapted from Salas et al., 1992)
- HAT Research Goal: Humans and increasingly autonomous systems working and thinking better together (Holbrook et al., 2020)

HAT Framework



Adapted from Salas et al. (2005)

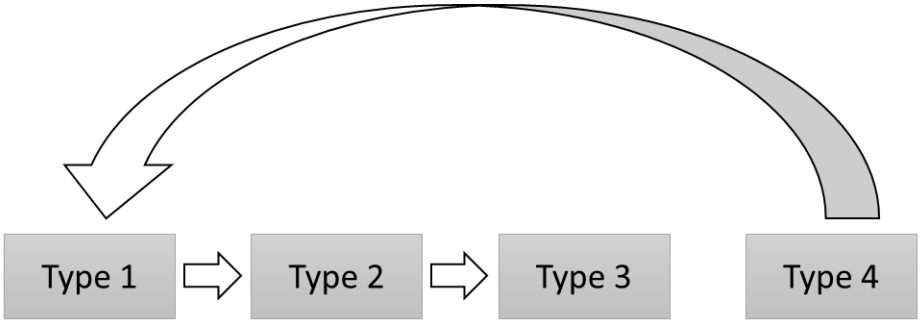
Grounding Basic Research in Practical Application

Research Type	Description
Type 1: Highly controlled laboratory experiments	Studies use simplified tasks in which variables are independently manipulated or held constant to investigate factors related to the phenomenon under study. Useful for competing theories to determine which provides a more correct explanation of the topic being studied.
Type 2: Less controlled but more complex laboratory experiments	Studies use tasks that are more complex than Type 1, losing experimental control to represent an operational setting and produce results that will better generalize to that operational setting more accurately.
Type 3: Evaluations conducted in high-fidelity simulators or in the field	Studies use tasks that are highly representative to the real-world environment and have less experimental control than Type 1 or 2 research. Useful to determine if the results obtained in Types 1 and 2 research overcome the myriad of additional factors that are not held constant.
Type 4: Qualitative, descriptive field studies	Field studies provide the ability to observe and document the pressing, significant issues that require research to understand. Also, field studies provide the basis to determine which factors should be manipulated in laboratory experiments (Type 1) and identifies which measures should be adopted to evaluate performance.

Adapted from Vicente (1997)

Grounding Basic Research in Practical Application

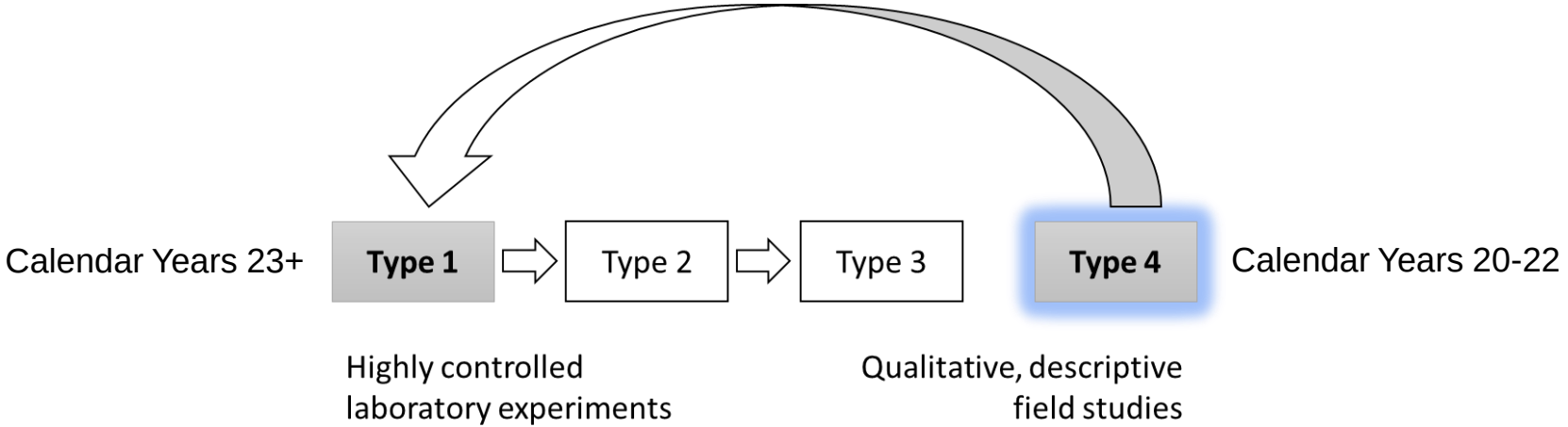
"An alternative model for defensible, generalizable human factors research"



Adapted from Vicente (1997)

Grounding Basic Research in Practical Application

"An alternative model for defensible, generalizable human factors research"

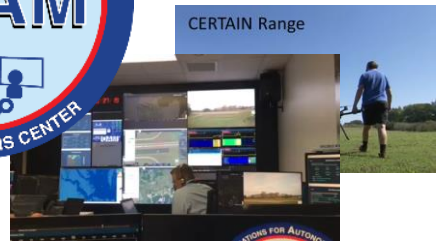


Adapted from Vicente (1997)

Type 4 Research: Applied, Field Studies

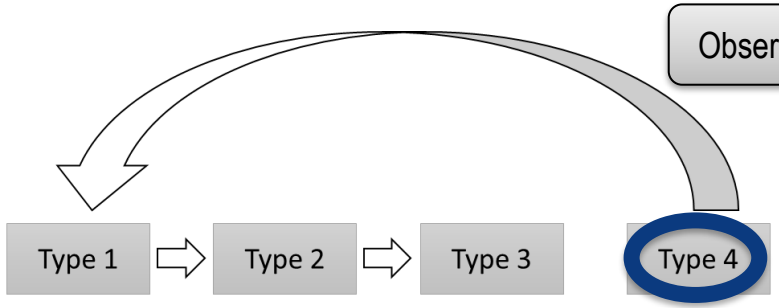
- NASA AAM/High Density Vertiplex Subproject Collaboration
  - ROAM Buildup: interviews, role-based ontology framework
  - Simulation & Live Flight Human-in-the-Loop Studies
    - Participant interviews and after-action reviews
    - Eye tracking
    - Questionnaires (situation awareness, workload, perceived risk, trust)
    - Usability assessment
- NASA MaRERA (Multi-Aircraft Remote Emergency Response Assessment) Collaboration (Sept. 2022) – m:N Live/Virtual Demonstration

(Remote Operations for Autonomous Missions)



MPATH
GROUND CONTROL STATION





Characteristics:
- Minimal-to-no control
- Real-world task
- Inductive, not deductive approach

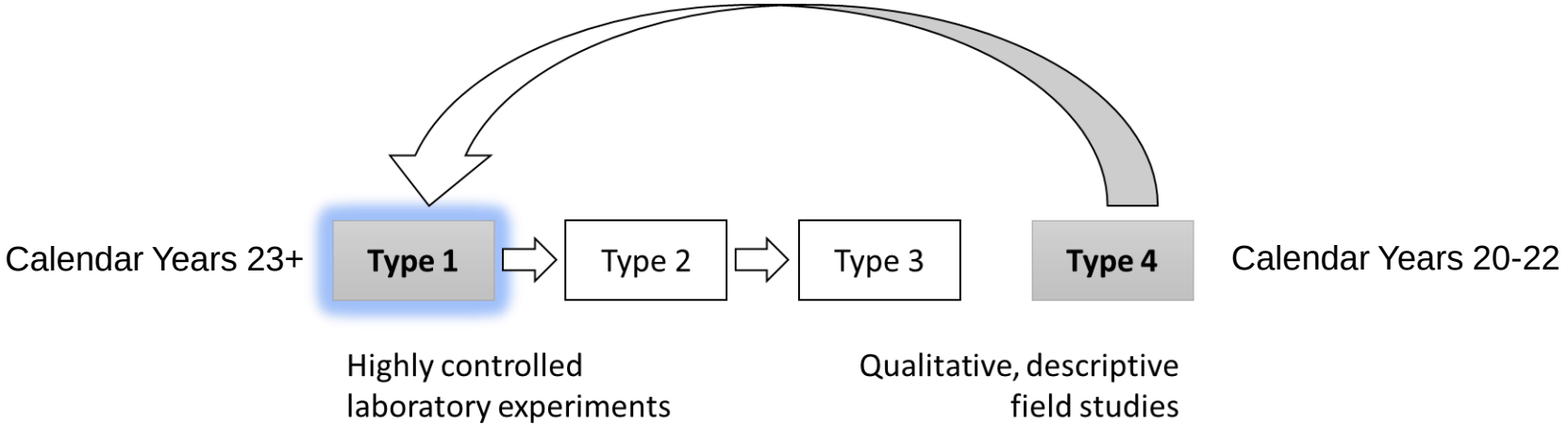
Goals:
- Generate hypotheses
- Find as many issues as possible

Issues Identified During Type 4 Research

- Automation Transparency
- Switching Between Vehicles (Multi-Vehicle Control)
- Nuisance and False Alarms
- Merging Visual Information
  - Proximity Compatibility Principle
- Displaying Vertical Position
  - Naïve Realism
- Shared Situation Awareness between Field and Operations Center Groups

Grounding Basic Research in Practical Application

"An alternative model for defensible, generalizable human factors research"

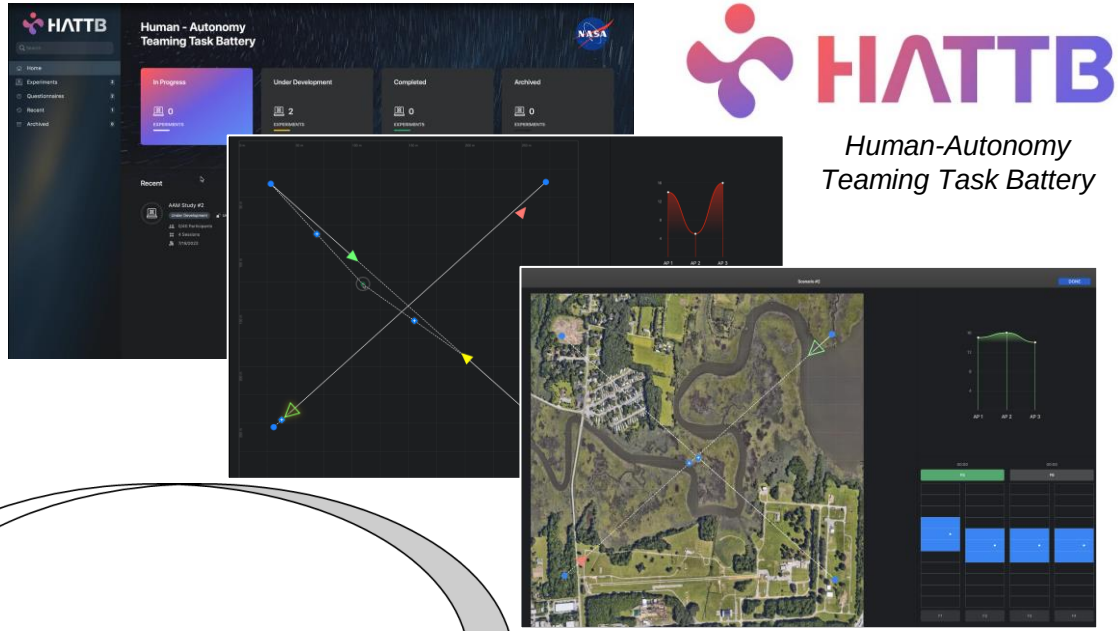


Adapted from Vicente (1997)

Type 1 Research: Controlled, Lab Studies

Planned HAT studies:

- Using mental models to predict trust and automation dependence
- The role of mental models in predicting multi-vehicle management performance
- Attentional limitations in multi-vehicle management



HATTB

Human-Autonomy Teaming Task Battery

Experiments (Basic)

Characteristics:

- Abstracted versions of real-world tasks
- High control over experimental manipulations and testing environment
- Do NOT require expert participants
- Low fidelity

Type 1 → Type 2 → Type 3 → Type 4

Highly controlled laboratory experiments

Qualitative, descriptive field studies

Conclusion

- Initial research and development work has focused on observational studies surrounding the buildup of a remote UAS operations center and GCS
  - Generates research questions and hypotheses
- Future research will focus on controlled laboratory experiments and HAT theory development
  - Trust
  - Mental Models

Questions?

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Session Papers:

- MPATH Ground Control Station
  - M. S. Politowicz, E. T. Chancey, B. K. Buck, J. Unverricht and B. J. Petty, "MPATH (Measuring Performance for Autonomy Teaming with Humans) Ground Control Station: Design Approach and Initial Usability Results," in AIAA SciTech, National Harbor, MD, 2023.
- ROAM UAS Ops Center
  - B. K. Buck, E. T. Chancey, M. S. Politowicz, J. Unverricht and S. C. Geuther, "A Remote Vehicle Operations Center's Role in Collecting Human Factors Data," in AIAA SciTech, National Harbor, MD, 2023.
- Live-Flight Human-in-the-Loop Study
  - J. Unverricht, E. T. Chancey, M. S. Politowicz, B. K. Buck, S. Geuther and K. Ballard, "Where is the human in the loop? Human factors analysis of extended visual line of sight unmanned aerial system operations within a remote operations environment," in AIAA SciTech, National Harbor, MD, 2023.
- Intelligent Change Detection System
  - V. E. Houston, E. T. Chancey, M. S. Politowicz and N. E. Jennings, "A preliminary development of the Intelligent Change Detection System (ICDS): Using machine learning to combat change blindness in remote operation environments," in AIAA SciTech, National Harbor, MD, 2023.

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- E. Salas, T. L. Dickinson, S. A. Converse and S. I. Tannenbauem, "Toward an understanding of team performance and training," in Teams: Their training and performance, Norwood, NJ, Ablex, 1992, pp. 3-29.
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