The FAA Center of Excellence for Technical Training & Human Performance

COE TTHP

RESEARCH ROADMAP 2016 - 2021

www.coetthp.org

FAA Center of Excellence for Technical Training and Human Performance

A Strategic Framework for the Future, Research Roadmap 2016-2021

In August 2016, through a national competitive process, the FAA awarded a Center of Excellence to a consortium of 16 core institutions, 10 affiliate institutions, and over 45 industry partners. This document serves as a draft of the Center's research roadmap designed to align the academic and industry research efforts to the priority needs of the FAA.

The COE TTHP initial mission was conducting front-line research to enhance training and technology that decreases the time to deployment of employees for all aviation professions with an emphasis on the needs of the FAA's Air Traffic Organization, NextGen, Flight Program Operations, and Flight Standards. From an August 2016 start-up to today, the FAA COE TTHP has completed 70+ research projects designed to ensure that the FAA will develop a highly trained technical workforce. By examining human factors issues and incorporating advanced training technologies to enhance performance, the FAA is better positioned to produce a higher level of mission-ready employees in the future.

After a thorough review by the FAA COE TTHP Executive Committee of our Center's initial two-year research scope and an analysis of our collective resources and the expertise of our core and affiliate members, in 2019 the Center's core institutions approached the FAA regarding our assistance with responding to the Congressional requirements for the *Title VI - Aviation Workforce* initiatives highlighted in the FAA Reauthorization Act of 2018 (H.R. 302). Expansion areas of Center research regarding *pilots, mechanics, and UAS training* complement the existing mission of our research consortium to explore approaches for modernizing and improving employee performance via the delivery of more efficient and effective technical training of aviation professionals. The FAA COE TTHP is confident that the academic and industry partners within our consortium demonstrate the specific past performance and present capacity to easily and swiftly respond to and meet any new research requirements affiliated with the *Title VI - Aviation Workforce* needs mentioned within H.R. 302.

FAA Center of Excellence Program Overview

The FAA COE program was established by the Ominibus Budget Reconciliation Act of 1990, Public Law 101-508, Title IX, Aviation Safety and Capacity Expansion Act. COEs are established through cooperative agreements with the nation's premier universities and their members and affiliates, who conduct focused research and development and related activities over a period of 10 years. The COE program facilitates collaboration and coordination between government, academia, and industry to advance aviation technologies and expand FAA research capabilities through congressionally required matching contributions. COE members match FAA grant awards to establish; operate; and conduct research, dollar-for-dollar, with contributions from non-federal sources and may also provide additional contributions through cost-share contracts. Over the life of the program, the COE universities, with their non-federal affiliates, have provided more than $300 million in matching contributions to augment FAA research efforts. Through these long-term, cost-sharing activities, the government and university-industry teams leverage resources to advance the technological future of the nation's aviation industry while educating and training the next generation of aviation researchers and professionals.

Currently, the FAA oversees the following active COEs:

Center of Excellence Title/Area	Lead Institutions	Established
Joint Center for Advanced Materials Research	Wichita State University and University of Washington	2004
Commercial Space Transportation	Florida Institute of Technology	2010
General Aviation Safety	Purdue University	2012
Alternative Jet Fuels and Environment	Massachusetts Institute of Technology and Washington State University	2014
Unmanned Aircraft Systems	Mississippi State University	2015
Technical Training and Human Performance	Embry-Riddle Aeronautical, University, University of Oklahoma, and Wichita State University	2016

The COE members have assisted in mission-critical research and technology areas that have focused on the following topics:

- Technical training and human performance
- Unmanned aircraft systems
- Alternative jet fuels and environment
- General aviation safety, accessibility, and sustainability
- Commercial space transportation
- Advanced materials
- Airliner cabin environment and intermodal transportation research
- Aircraft noise and aviation emissions mitigation
- Airworthiness assurance
- Operations research
- Airport technology
- Computational modeling of aircraft structures

FAA COE for Technical Training and Human Performance Overview

The FAA Center of Excellence for Technical Training and Human is focused on research and development for air traffic controllers, aviation safety inspectors, engineers, technicians, and pilots. Six original goals were identified by the Air Traffic Organization as priorities in 2016. The COE TTHP aligned the initial research projects to the goals listed below:

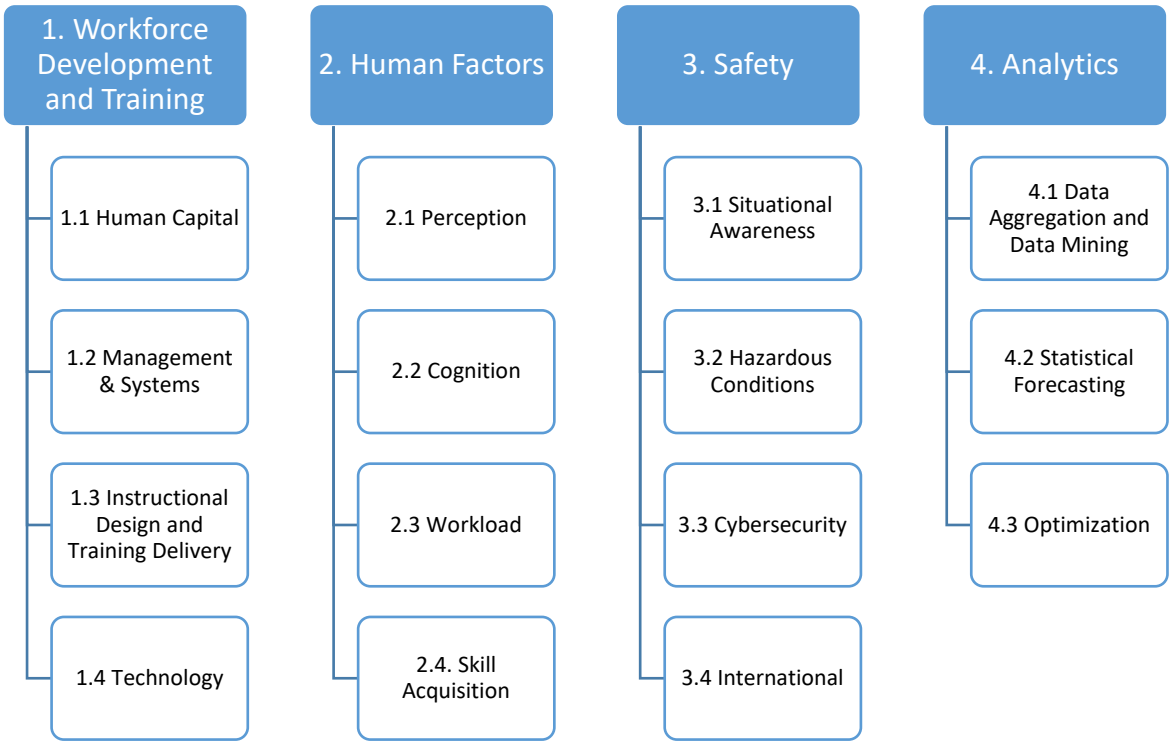
1. Redesign the platform for content management and development;
2. Update the development processes for course management and maintenance;
3. Expand and enhance the partnerships among FAA, academia, and industry to define future learning;
4. Develop implementation and integration strategies to utilize available technology that will improve the learning environment;
5. Establish communication and transparency with stakeholders; and
6. Continually align business goals to organizational requirements for growth and development.

Research Roadmap

Over the past three years and through a variety of mechanisms, including surveys, focus groups, and industry association conferences, the FAA COE TTHP has collected an expansive list of research questions and organized them into four main research themes focusing on (1) workforce development and training, (2) human factors, (3) safety, and (4) analytics. The updated research themes, illustrated in the figure below, provide a structure to guide the effort of the Center. These themes also organize a catalog of compelling research questions and help align the research capacity of the Center so that the Federal Aviation Administration, other units of government, and industry, can easily identify researchers who can provide analysis and solutions.

The themes and research questions identified to date indicate the broad scope of the FAA COE TTHP's capacity and interests. Rather than seeing this as a departure from the Center's beginnings, which focused on questions related to the technical training and human performance needs of primarily the FAA's Air Traffic Organization, the broadening of the scope reflects significant efforts by the FAA COE TTHP's academic, industry, and government stakeholders to identify salient research questions in the areas of technical training and human performance especially where those questions addressed shared concerns across the aviation field and aligned with the capabilities and interests of researchers who contribute to the Center's capacity.

Main Research Themes



The **Workforce Development and Training** theme addresses the need modernize content and course delivery using new technology and develop instructional design strategies with an emphasis on linking curriculum to specific competencies and job tasks. In addition, the theme targets the identification of improvements to recruitment, hiring, pre-screening, on-boarding, and placement practices.

The **Human Factors** theme focuses on the human factors that affect job performance such as perception, cognition, and environmental factors that impact the safe and effective performance of jobs and tasks.

The **Safety** theme focuses on the relationships among safety, technical training, and human performance, and seeks to develop methods of mitigating unacceptable levels of risk in identified areas.

The **Analytics** theme considers the development of data analytics tools and applications to collect, manage, and analyze data from curricula, training performance records, and other sources to develop improved training solutions and enhanced operational performance metrics.

Cross-Cutting Research Themes

Given the nature of the research themes and the questions that emerge from those themes, there are, not surprisingly, a number of cross-cutting themes within which a number of questions could be organized.

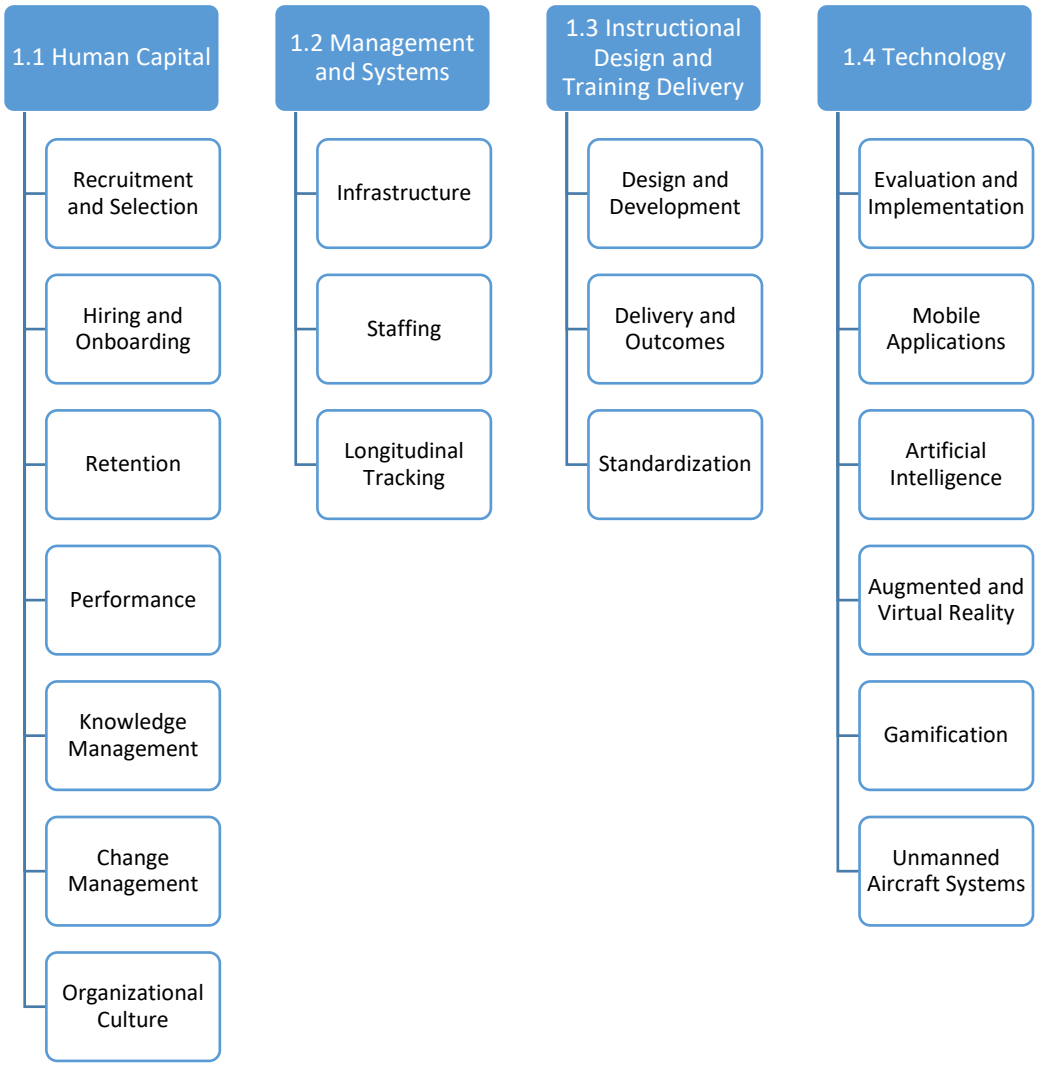
These themes are:

- **Generational Transitions and the Analysis of Human Performance –** this theme cuts across the issues related to generational differences within the workforce, especially workers nearing retirement and workers new to field.
- **Workload, Fatigue, and Stress –** this theme cuts across the issues related to factors that adversely affect human performance, safety, and the well-being of the workforce.
- **Monitoring Human Performance through Enhanced Technology and Analytics –** this theme cuts across the tools and techniques that may be used to monitor, analyze, and ultimately improve human performance and training.
- **Cognition –** this theme is a broad cross-cutting category for questions involving the various factors that affect cognition in the areas of human performance and technical training.
- **Technology –** this theme is a broad cross-cutting category for questions involving the development, implementation, and evaluation of technologies in monitoring and improving human performance and safety.
- **Training –** this theme is a broad cross-cutting category for questions about training that span the breadth of our current and evolving understanding of training practices and evaluation.

Key Research Questions

The narrative that follows populates the four research themes with lists of specific research questions drawn from academic, government, and industry present at the FAA COE TTHP administrative and technical meetings from 2016 to present and the research roadmap workshop held in Norman, OK on June 4-5, 2018.

1.0 Workforce Development and Training – this research seeks to modernize content and course delivery using new technology and instructional design strategies with an emphasis on linking curriculum to specific competencies and job tasks. In addition, the research seeks to identify improvements to recruitment, hiring, pre-screening, on-boarding, and placement practices. Key overarching topics within this theme include skill development and transfer, system-level training, and developing consistencies in nomenclature, training methods, and problem solving approaches throughout aviation organizations.



1.1 Human Capital – this research examines the skills, knowledge, communication styles, and/or other assets of individuals that can be used to create value for the individuals and their employers in an effort to enhance organizational culture and work environment.

Recruitment and Selection:

- How can a comprehensive pre-employment screening process (e.g. review of credentials, assessment of cognitive skills, classification of personality types and leadership styles, and/or review of prior experience) be incorporated into the information used during the recruitment and selection process?
- What are the best practices for successful early engagement in the aviation field within the K-12 educational system (e.g., formal and informal STEM programming, Junior ROTC Program, internships, mentoring, etc.)?

Hiring:

- How can performance assessment results of FAA internship candidates be tracked and incorporated (e.g., prior learning and/or experience credit) into the information used during the hiring and onboarding process?
- How do you create and implement an adaptive training model aligned with pre-screening findings identified in the hiring process to address the specific skill development needs of each employee?
- How can prior learning credits be used to expedite the time to certification of aviation professionals transitioning from the military to the FAA?

Retention:

- What are the retention rates associated with current candidate selection processes, on-boarding techniques, and other training approaches?
- What is the impact on retention if training candidates are pre-assigned to trainers of same or similar learning styles and personality types?
- What is the impact on retention if aviation professionals participate in cohort learning organized around same or similar learning styles and skill levels?

Performance:

- To what extent can personal background, prior professional experience, and prior training and qualifications predict and/or explain initial training performance and early on-the-job performance?

Knowledge Management:

- How can the FAA implement a knowledge management plan to capture the performance trends and experience lessons of professionals prior to retirement?
- What is the best strategy for translating the high performance strategies of expert professionals to content and process updates within the experiential training environment?

Change Management:

- What are the best change management process recommendations for significantly improving the acceptability and support of training administrators and trainers in the use of technology and innovative training practices for next generation aviation professionals?

Organizational Culture:

- How do you improve the intergenerational culture and communication preferences of a diverse trainer/trainee learning environment and maintain training quality?
- What are the advantages of emphasizing measures of success rather than measures of failure in the training feedback model?
- How do you transform the training feedback model from an emphasis on measures of failure to an emphasis on measures of success?
- How do you provide early positive exposure and integration into the FAA's organizational culture within a privatized training environment?

1.2 Management and Systems – this research explores the effectiveness of systems that organize training curricula, schedules, grading, records, and training history as well as the effective delivery of e-learning courses.

- What solutions can be implemented to assist the FAA in reaching its desired state for the Enterprise Learning model?
- What is the infrastructure capacity by facility and across facilities for the accommodation and successful implementation of the deployment of new training technologies?
- What is the staffing capacity by facility and across facilities for the accommodation and successful implementation of the deployment of new training technologies?
- Are existing FAA systems (e.g., CEDAR, FALCON, TSS) being utilized to the fullest extent of their capabilities? If not, what are the impediments or constraints to full and effective utilization?
- What reengineering is required to continue utilizing existing FAA systems (e.g., CEDAR, FALCON, TSS) for emerging needs?
- What are the best practices for archiving training content (e.g., catalogs, manuals, courses, materials)?
- What best practices exist for tracking the lifecycle of employee learning (e.g., from recruitment to retirement, initial training, advanced training, remedial training, refresher training)?
- How can data from the effective tracking of the lifecycle of employee learning be used to improve training and learning?
- How can a tracking system of new and/or evolving technologies help determine the priority of selection for implementation within the training environment?

1.3 Instructional Design and Training Delivery – this research explores solutions for increasing the effectiveness of training design and development as well as enhancing training delivery and outcomes across all aviation sectors.

Design and Development:

- What is the feasibility of applying the agile model to the instructional design of aviation courses across professions?
- How can current training be redesigned and enhanced by incorporating adaptive instruction?
- How can current training be redesigned to incorporate future competencies needed for NextGen?

Delivery and Outcomes:

- What are the best practices for increasing the readiness of the training organization to deliver training across multiple modalities (e.g., mobile apps, e-learning platforms, simulations)?
- What is the impact on training outcomes per modality when content is delivered via multiple modalities (e.g., mobile apps, e-learning platforms, simulations)?
- Does the sequencing of modality training improve training outcomes?
- Are certain modalities more appropriate for initial training versus recurrent or refresher training?
- Which courses or topics are most cost-effectively delivered in-person?
- Which courses or topics are most cost-effectively delivered virtually?
- What impact does facility location and/or facility type have on the performance of training candidates (e.g., time to certification, safety of the NAS, etc.)?
- What is the impact on training outcomes if aviation professionals participate in an initial training program with curricula drawn from professions with same or similar competencies?
- What is the impact on training outcomes if aviation professionals participate in competency and facility-based advanced training?
- What is the impact on training outcomes if aviation professionals increase participation in just-in-time (micro learning) training?
- What is the impact on training outcomes if aviation professionals participate in cohort learning within same or similar skill levels?

Standardization:

- How can core and/or basic skills be introduced consistently throughout the training continuum (e.g. K-12 to vocational to 2-year or 4-year degree to placement within an aviation career)?
- What are the best practices for standardization of core competency training?
- What is the feasibility of standardizing training of core competencies within specialized training areas (e.g., En Route, Tower, TRACON)?
- What are the best practices for standardization of training evaluation procedures across facilities?
- How can best practices from the DoD training organization be incorporated in the instructional design and training delivery efforts of FAA training organizations?

1.4 Technology – this research seeks to transform the training environment by incorporating new and future innovations in training technologies in an effort to enhance human performance.

Evaluation and Implementation:

- What are best practices for identification and prototyping of new training technologies?
- What is the interoperability between varying learning technologies for the same area, topic, and/or course?
- How do we incorporate a cost/benefit life cycle analysis into the identification and selection of new technologies (e.g., long-term maintenance costs, training costs, etc.)?
- What technology is best suited for performance support systems vs. training applications?
- What are best practices for using technology to connect elements of training (e.g., blended learning)?
- How can you create the appropriate level of fidelity for each advanced training technology to ensure effective transfer of learning for each professional area?
- What are the technological advances in hazardous weather information dissemination across professions?
- How can advances in training technology assist with measuring and tracking certification of performance?
- How effectively do advanced technologies help overcome physical constraints on human performance that have historically led to the disqualification of otherwise trainable candidates (e.g., color blindness, prosthetics, etc.?)
- What are the lessons learned from incorporating new and/or evolving technologies across agencies (e.g., FAA, DoD, NASA)?

Mobile Applications:

- How can just-in-time (micro learning) training for remedial or refresher curricula be delivered via mobile applications?
- How can just-in-time (micro learning) training for facility specific curricula be delivered via mobile applications?

Artificial Intelligence:

- How can artificial intelligence support adaptive learning within the simulation environment (e.g. scenarios based on high traffic, hazardous conditions, etc.)?
- How can artificial intelligence reduce deviations from standard operating procedures?
- How can artificial intelligence be used within e-learning modules to enhance soft skills and/or leadership training of aviation professionals (e.g., stress management, change management, accountability, etc.)?

Augmented and Virtual Reality Simulation:

- What are the benefits of utilizing augmented reality and/or virtual reality as a learning tool?
- Can augmented reality and/or virtual reality be used to improve remedial or refresher training?
- How does utilizing augmented reality and/or virtual reality in remedial or refresher training impact intergenerational learners?
- What specific training areas or topics are ideal for utilizing virtual reality technology vs. full simulation technology in an effort to decrease training costs while maintaining training outcomes?
- How can just-in-time (micro learning) training for remedial or refresher curricula be delivered via augmented or virtual reality simulation?
- How can just-in-time (micro learning) training for facility specific curricula be delivered via augmented or virtual reality simulation?
- How can virtual reality training applications increase the readiness of training candidates for hazardous airport environments (e.g., mountainous terrain; hazardous weather – ice, snow, tornadoes, hurricanes; and wildlife hazards)?
- How can successful implementation of augmented or virtual reality learning tools be applied from one aviation sector to another (e.g. technicians to safety inspectors, etc.)?

Gamification:

- What is the appropriate level of application of gamification within the training environment across aviation professions?
- What are best practices for implementing game mechanics into the training environment?

Unmanned Aircraft Systems:

- What is an adequate level of exposure to sUAS training curricula to ensure the safety of the NAS by aviation profession?
- How can sUAS be utilized to supplement live instruction within the training environment (e.g., aircraft inspection)?
- How can sUAS assist with hazardous weather or hazardous terrain training to improve data collection and communications across aviation professions?

1.5 International Harmonization – this research focuses on the globalization of standards in the areas of training, operations, safety, and security. Research questions in this area emphasize the need to align training with local needs while maintaining global standards for performance.

- What are the best practices for finding a common nomenclature for training in areas across the field of aviation?
- How can we maintain respect for local and national customs and practices while effectively harmonizing essential operational practices?
- How is the status of collaboration and coordination among international aviation organizations contributing to the reduction of safety risks?

2.0 Analytics – This research involves the development of data analytics tools and applications to collect, manage, and analyze data from curricula, training performance records, and other sources to develop improved training solutions and enhanced operational performance metrics.

2.1 Data Aggregation and Data Mining

- What are the best practices and strategies for integrating data systems so that training records are consistent and can be used across the enterprise?
- How might a data lake of training data be utilized to promote better utilization of training data and easier use of that data for the improvement of training efforts?
- What are the best practices for the collection, management, and analysis of training and safety data to improve decision making, training, and operational outcomes?
- What roles might artificial intelligence (AI) play in the use of the collection, management, and analysis of data across various elements of the aviation enterprise?
- What is the current state of data collection, management, and analytics and how might improvements be implemented to improve interoperability of systems?
- What needs to be done to improve the collection, management, and analysis of recruitment, selection, and retention data to improve all elements of these staffing processes?
- What are the best practices for anonymizing data related to training and staffing?
- What restrictions or limitations are placed on the collection and analysis of training data by the FAA Institutional Review Board?
- What are the best practices for the integration of data from various systems to aid in the identification and mitigation of risks and safety hazards?

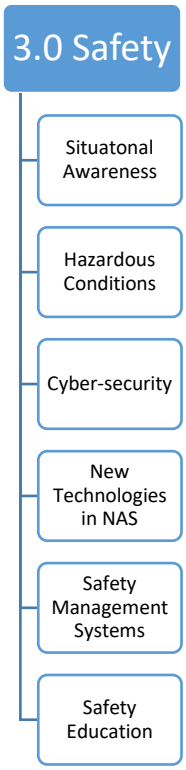
2.2 Statistical Forecasting

- How can we use data analytics to identify and understand the indicators of at-risk trainees so appropriate intervention plans and mitigating strategies can be developed and implemented?
- How might data analytics be employed to identify potential expertise gaps due to retirements so that training can be developed and implemented proactively.
- How might data analytics be employed to better identify and understand the gaps in the instructor pool and how those gaps can be filled most efficiently?
- What data should be collected and analyzed to inform decisions about adaptive learning and other aspects of training?
- How can quantitative data be used to validate expert opinions and how might expert option better inform the collection and analysis of data?
- What are the best practices for documenting successes and failures within training to avoid an emphasis on deficiencies instead of proficiencies of trainers and trainees?

2.3 Optimization

- How can we use data analytics to optimize training schedules to maximize throughput of trainees and maximize learning?
- Where can data analytics be used to augment, complement, and improve research in the other core areas?
- How might subjective and objective performance evaluations of be integrated to improve learner engagement and learning outcomes?
- How might sequential updating algorithms be used to estimates system failures and other events?
- How do reward systems such as badges in the gaming environment influence learner motivation and learning outcomes?

3.0 Safety – This research examines the relationships among safety, technical training, and human performance, and proposes methods of mitigating unacceptable levels of risk in identified areas. Workforce safety is a critical issue across aviation and other fields. Many of the occupations are inherently dangerous. Important questions about mitigating complacency and appropriately implementing new training and other technologies have emerged in recent years. Additional questions about personal safety are also important to the aviation workforce where the fatigue and stress of the work environment can lead to safety problems after work and off site.



3.1 Situation Awareness

- How might virtual and augmented reality be used to improve air traffic awareness for tower and ground controllers and operators?
- What are the best practices for implementing data link technologies for improving air traffic control to flight crew communications?
- How might sensing technology be employed to improve detection and reduce the probability of collisions and incursions on the airfield?

3.2 Hazardous Conditions

- What are the most effective ways to communicating new or changing information about hazards, especially in-flight hazards?
- What are the most appropriate and promising research methods and strategies for improving weather hazard awareness?
- What are the best practices for communicating hazardous conditions to airport users?

3.3 Cyber-security

- How might a reliance on digital systems and automation put the air traffic system be put at risk for cyber attack?
- What might be some of the methods and strategies to mitigate risks to cyber security?
- How should training curricula incorporate the topic of cyber security?

3.4 Safe Implementation of New Technologies in the NAS (NextGen, UAS, etc.)

- What safety issues have emerged or will arise from the implementation of NextGen technologies and processes?
- Are there any unintended consequences from the implementation of technologies such as ADS-B and TCAS that adversely affect pilot decision making, communications, and safety?
- Has the integration of ADS-B equipped aircraft into the NAS had an impact on workload, decision-making, and safety?
- How can UAS be safely and effectively integrated into the NAS?
- Who are the relevant stakeholders and how are they best engaged in the process of safely and effectively integrating them and their UAS operations into the NAS?
- What technologies and strategies are best suited for the improvement of sensor-based avoidance for UAS?

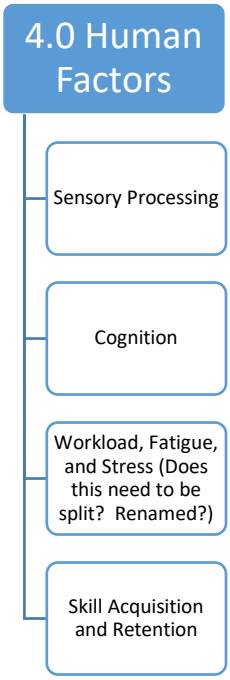
3.5 Safety Management Systems

- What are the best practices for Safety Management Systems and how might they be adapted and applied to the variety of operators functioning in the aviation system?
- How might trend analysis be used to improve SMS?
- Do SMS self-reporting mechanisms work effectively to mitigate risks and improve safety?
- What are the best practices for employee self-reporting systems?
- What improvements can be made in the collection, management, and analysis of self-reporting data to enable managers to reach safety goals?
- How does an employee's interpretation and understanding of safety culture correlate with acceptance of new procedures, training methods, and processes designed to improve safety?
- What are the best methods for measuring and establishing a baseline for safety culture?
- What are the best practices for sustaining a robust safety culture while continuing to introduce new training innovations and technologies?

3.6 Educational Tools to Improve Safety

- How might predictive modeling inform education and training initiatives to proactively avoid problems by adapting and implementing best practices in training?
- What is the relationship between safety and human performance? In other words, does an emphasis on safety improve or diminish human performance, and if so how and to what extent? Just as important, in which job functions or operational tasks is this a greater challenge?

4.0 Human Factors – research determines and analyzes perception, cognition, and environmental factors that impact the safe and effective performance of jobs and tasks. This theme focuses on the areas of auditory and visual perception, cognition, workload, and skill acquisition.



4.1 Sensory Processing

- What are the appropriate auditory and visual evaluation standards across the different generations of workers?
- What should be the perception standards for waivers to work beyond current age limits?
- What are the impacts of various work schedules (day/night, rotating, and 2-2-1) on auditory and visual perception?
- How does work schedule affect perception across different aviation job areas, such as pilots, controllers, and maintainers?
- How can technology, such as eye movement tracking, help us better understand differences in visual perception within and across different aviation job areas?
- How can eye movement tracking help us better understanding learning and identify appropriate techniques and strategies for training?
- How might technologies be used to mitigate or overcome the impact of various disqualifying physical disabilities such as colorblindness and the use of prosthetics?
- What lessons can be learned through the evaluation of the visual, auditory, and cognitive patterns of high performing professionals? How can these lessons (learned from the observation of high performers) be applied to improve training techniques and strategies?

4.2 Cognition

- What can be learned from conducting cognitive impact analysis of workers approaching mandatory retirement age?
- What are the cognitive evaluation standards for aviation workers in other countries with higher mandatory age limits?
- Are there generational or other differences among individuals that influence their capacity to process information simultaneously from competing sources?
- Can human errors of perception and cognition be identified and tracked in the simulated training environment to provide data for analysis of errors and development of new training approaches?
- What is the impact of cultural or generational difference on the use of technology in the processing of information and decision making?

4.3 Workload, Fatigue, and Stress

- What is the impact of new technologies on more experienced aviation professionals who have mastered their craft without the use of these technologies?
- How can fatigue be studied and mitigated in a non-punitive way?
- What are the best practices for staffing models that provide appropriate levels of staff while mitigating the adverse impacts of fatigue and stress?
- What stimulants (light, temperature, humidity, etc.) or other mitigating techniques can be used to safely overcome fatigue?

- How does the use of artificial intelligence and automation influence the impact of fatigue, stress, and distraction on decision making in the ATC and flight environments?
- Can biometric scanning be used to recognize fatigue?
- Could the implementation of a Human Factors Analysis Classification System (HFACS) to better identify and understand human errors as a function of the organization's structure lead to increased safety and less stress on individuals?
- What are the costs to the individual and the organization in terms of safety and performance when risks are not mitigated and human errors occur?
- What are the best practices for training frontline managers to recognize the indicators of fatigue, distraction, and excessive stress?
- How might technologies (EEG, brain wave monitoring, eye movement tracking, and blood pressure monitoring) be used to track indicators of fatigue and stress in real time?
- What impact can artificial intelligence and automation have on the reduction of stress in the aviation working environment?
- How does the use of artificial intelligence and automation influence the impact of fatigue, stress, and distraction on decision making in the ATC and flight environments?
- How does ergonomics in the current and proposed work environments (physical and virtual) adversely or positively impact stress and fatigue for aviation professionals?
- Is it possible in the training environment to genuinely replicate through simulation the levels of risk and stress encountered in the real world air traffic control environment?

4.4 Skill Acquisition and Retention

- To what extent do former aviation workers suffer from a disqualifying medical event or condition within 5 years of mandatory retirement? In other words, to what extent does the retiring workforce stay healthy beyond the mandatory age limit?
- How do aviation professionals manage the physical demands of their work as they age?
- Does the use of risk assessment tools such as the IAMSAFE checklist improve safety and performance by providing the individual with live feedback and awareness of job readiness?
- What are the best ways to train aviation professionals in the area of crew resource management?
- What is the best way to integrate the technological tracking of human factors in the simulated training environment?
- How might the data gathered through the tracking of human factors in the training environment be used to improve training and performance?
- What can be learned from other industries about the intended and unintended consequences of technology implementation similar to what is being proposed in aviation (e.g. NextGen and Trajectory Based Operations)?
- Would a more realistic level of risk and stress in the simulated training environment effective accelerate training, increase skill acquisition, and reduce time to certification?
- What are the best practices for introducing human factors curriculum and content into current training?

Cross-Cutting Research Questions

The following questions are prime examples of how the work of the FAA COE TTHP cuts across disciplines, organizations, and segments of the aviation community:

Generational Transitions and the Analysis of Human Performance:

- What are the appropriate auditory and visual evaluation standards for older workers?
- What should be the perception standards for waivers to work beyond current age limits?
- What can be learned from conducting cognitive impact analysis of workers approaching mandatory retirement age?
- What are the cognitive evaluation standards for aviation workers in other countries with higher mandatory age limits?
- To what extent do former aviation workers suffer from a disqualifying medical event or condition within 5 years of mandatory retirement? In other words, to what extent does the retiring workforce stay healthy beyond the mandatory age limit?
- What is the impact of new technologies on more experienced aviation professionals who have mastered their craft without the use of these technologies?
- Are there generational or other differences among individuals that influence their capacity to process information simultaneously from competing sources?
- How do aviation professionals manage the physical demands of their work as they age?

Workload, Fatigue, and Stress:

- What are the impacts of various work schedules (day/night, rotating, and 2-2-1) on auditory and visual perception?
- How does work schedule affect perception across different aviation job areas, such as pilots, controllers, and maintainers?
- How can fatigue be studied and mitigated in a non-punitive way?
- What are the best practices for staffing models that provide appropriate levels of staff while mitigating the adverse impacts of fatigue and stress?
- What stimulants (light, temperature, humidity, etc.) or other mitigating techniques can be used to safely overcome fatigue?

Monitoring Human Performance through Enhanced Technology and Analytics:

- How can eye movement tracking help us better understand differences in visual perception within and across different aviation job areas?
- How can eye movement tracking help us better understanding learning and identify appropriate techniques and strategies for training?
- Can human errors of perception and cognition be identified and tracked in the simulated training environment to provide data for analysis of errors and development of new training approaches?
- Can biometric scanning be used to recognize fatigue?
- Could the implementation of a Human Factors Analysis Classification System (HFACS) to better identify and understand human errors as a function of the organization's structure lead to increased safety and less stress on individuals?
- What are the costs to the individual and the organization in terms of safety and performance when risks are not mitigated and human errors occur?
- Does the use of risk assessment tools such as the IAMSAFE checklist improve safety and performance by providing the individual with live feedback and awareness of job readiness?

- What are the best practices for training frontline managers to recognize the indicators of fatigue, distraction, and excessive stress?
- How might technologies (EEG, brain wave monitoring, eye movement tracking, and blood pressure monitoring) be used to track indicators of fatigue and stress in real time?
- What is the best way to integrate the technological tracking of human factors in the simulated training environment?
- How might the data gathered through the tracking of human factors in the training environment be used to improve training and performance?

Cognition:

- Is it possible to change someone's cognitive ability through training? For example, can the cognitive ability or capacity of air traffic control developmentals be improved or enhanced through new training practices?
- What are the best practices for integrating evaluation of visual and auditory perception as well as cognitive capacity into the selection process for new aviation professionals?
- What are the impacts of distraction on safety and human performance?
- What are the impacts of selected or divided attention on safety and human performance?

Technology:

- What impact can artificial intelligence and automation have on the reduction of stress in the aviation working environment?
- How does the use of artificial intelligence and automation influence the impact of fatigue, stress, and distraction on decision making in the ATC and flight environments?
- How might technologies be used to mitigate or overcome the impact of various disqualifying physical disabilities such as colorblindness and the use of prosthetics?
- What is the impact of cultural or generational difference on the use of technology in the processing of information and decision making?
- What can be learned from other industries about the intended and unintended consequences of technology implementation similar to what is being proposed in aviation (e.g. NextGen and Trajectory Based Operations)?
- How does ergonomics in the current and proposed work environments (physical and virtual) adversely or positively impact stress and fatigue for aviation professionals?

Training:

- What are the best ways to train aviation professionals in the area of crew resource management?
- What lessons can be learned through the evaluation of the visual, auditory, and cognitive patterns of high performing professionals?
- How can these lessons (learned from the observation of high performers) be applied to improve training techniques and strategies?
- Is it possible in the training environment to genuinely replicate through simulation the levels of risk and stress encountered in the real world air traffic control environment?
- Would a more realistic level of risk and stress in the simulated training environment effective accelerate training, increase skill acquisition, and reduce time to certification?
- What are the best practices for introducing human factors curriculum and content into current training?

Academic Core Institution Capacity

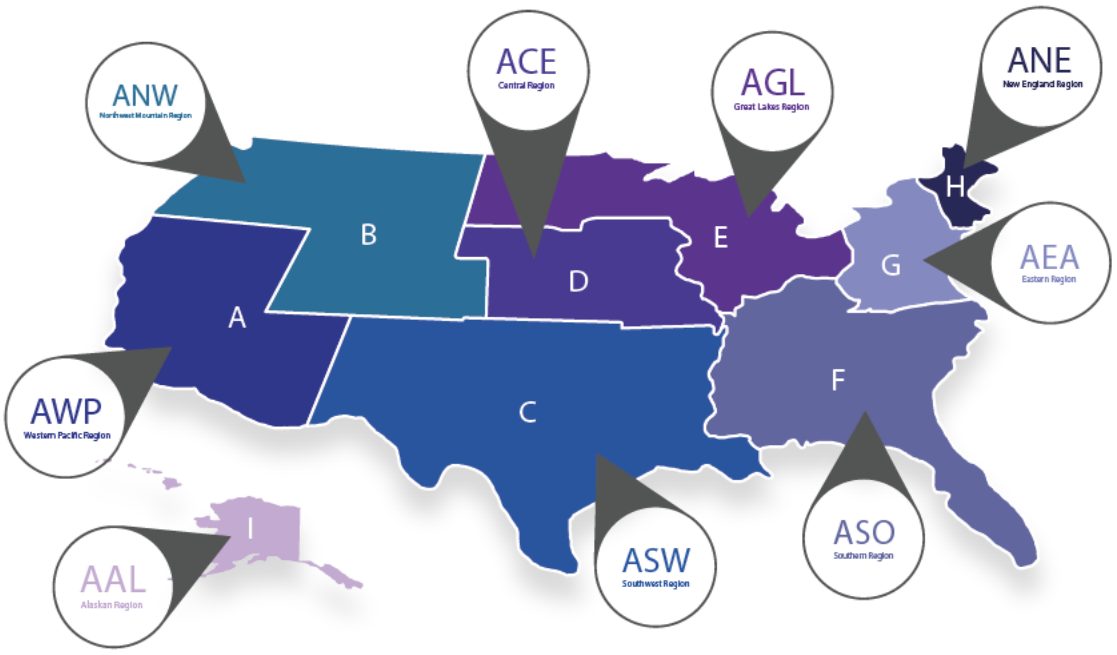
The academic core institutions of the FAA COE TTHP provide a wide range of strengths in faculty, students, and infrastructure that address the Center's research needs for FAA's customers. The figure below provides an illustration of the strengths of each core institution for the research themes areas.

Rating of university strengths in COE TTHP Research Themes (Blue - Very Strong, Yellow = Moderately Strong):

	Workforce Development	Human Factors	Safety	Analytics
Auburn University				
Drexel University				
ERAU Daytona				
ERAU Prescott				
Inter American University				
Purdue University				
The Ohio State University				
Tulsa Community College				
University of Akron				
University of Nebraska – Omaha				
University of North Dakota				
University of Oklahoma				
Western Michigan University				
Wichita State University				

Industry Partners by State

1st American Systems and Services	DC
Adacel	FL
Addx Corporation	VA
American Airlines	TX
ATA Full Stack Data Science, LLC	VA
ATAC	CA
AVT Simulation	FL
C² Technologies	VA
Choctaw Nation of Oklahoma	OK
Christiansen Aviation	OK
CNI Aviation, LLC	OK
Computer System Designers	OK
CSSI, Inc	DC
Delta Air Lines	GA
Eduworks Corporation	OR
Florida NextGen TestBed	FL
Frasca International, Inc.	IL
General Dynamics Information Technology	VA
Harris Corporation	FL
Heartwood 3D	CA
Hucon Global / American Defense International, Inc.	NY
Instructure	UT
JMA Solutions	DC
KeyBridge Technologies	OK
Leidos	DC
Metacraft	VT
Northrop Grumman	VA
Orion America Technologies, LLC	OH
Rigil Corporation	VA
Robinson Aviation, Inc.	OK
Stinson Associates, LLC	GA
Tetra Tech	CA
Textron Systems	FL
The Washington Consulting Group, Inc	MD
TransLumen Technologies, LLC	IL
UFA, Inc	MA
Veracity Engineering	DC



INDUSTRY PARTNERS

Western Service Area

AWP
Western Pacific Region

Heartwood 3D (San Mateo, CA)
TetraTech (Pasadena, CA)

ANW
Northwest Mountain Region

Eduworks Corporation (Corvallis, OR)
Instructure, Inc. & Canvas Network (Salt Lake City, UT)

AAL
Alaskan Region

Central Service Area

ASW
Southwest Region

Air traffic Simulations, Inc (Edmond, OK)
American Airlines (Dallas, TX)
Chickasaw Nation Industries (Norman, OK)
Christiansen Aviation (Tulsa, OK)
Computer System Designers* (Oklahoma City, OK)
KeyBridge Technologies (Oklahoma City, OK)

ACE
Great Lakes Region

AGL
Great Lakes Region

Frasca International, Inc. (Urbana, IL)
TransLumen Technologies (Chicago, IL)

Eastern Service Area

ASO
Southern Region

Adacel (Orlando, FL)
AVT Simulation (Orlando, FL)
CI² Aviation (Dunwoody, GA)
CSSI (Coconut Creek, FL)
Crew Training International (Memphis, TN)
Florida NextGen Test Bed (Daytona Beach, FL)
Raydon Corporation (Port Orange, FL)
Skymantics LLC (Melbourne, FL)

AEA
Eastern Region

1st American Systems and Service (Washington, DC)
Addx Corporation (Alexandria, VA)
American Institutes for Research (Washington, DC)
C² Technologies (Vienna, VA)
General Dynamics IT (Fairfax, VA)
Infina, Ltd. (McLean, VA)
JMA Solutions (Washington, DC)
Leidos (Reston, VA)
Northrop Grumman (Falls Church, VA)
UFA, Inc (Burlington, MA and Washington, DC)
Washington Consulting Group, Inc.* (Bethesda, MD)
Veracity Engineering (Washington, DC)

ANE
New England Region

Metacraft (Colchester, VT)
Robinson Aviation (East Haven, CT)
Textron Systems (Providence, RI)
Volpe Center (Cambridge, MA)

Center's Funding Sponsors

The FAA COE TTHP has identified a number of potential funding sponsors with interests in the above main research and cross-cutting research themes for its research and development efforts. Within the FAA, the Center has the capacity to provide research services in the following substantive areas or lines of business: Technical Operations, Air Traffic Control, Flight Standards, Airports (Design and Safety), as well as Management and Administration. Outside the FAA, the Center is well positioned to support research relevant to the Department of Defense and the National Aeronautics and Space Administration.

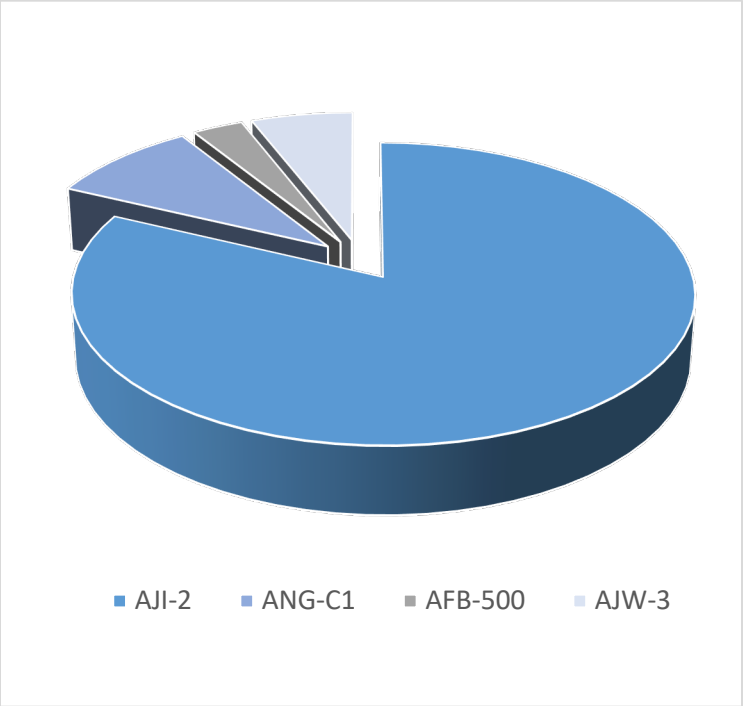
From 2016 through 2019, the distribution of FAA research dollars by active funding sponsor includes:

FAA Air Traffic Organization, ($6.5M): curriculum needs analysis, learning management system analysis, course development, training standardization, augmented and virtual reality training, gamification prototypes

FAA Flight Program Operations, ($600K): fleet modernization, unmanned aircraft system flight inspection feasibility, part 141 pilot school feasibility

FAA NextGen, ($600K): emerging pilot workforce training enhancements

FAA Flight Standards, ($250K): adaptive learning capabilities, competency-based learning strategies, employee hiring and development best practices, training content management, training technology best practices



FAA UAS Office, ($TBD): UAS CTI program criteria and launch, UAS training standardization

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It is important to note that the Center's leadership, core members, affiliate institutions, and industry partners who make up the FAA COE TTHP recognize that technical training and human performance are moving targets in aviation and other industries where technology is evolving quickly, work forces are in transition, and the demands placed on the infrastructure and the people who operate within it and maintain it are challenging efforts to operate safely and efficiently. This Research Roadmap should not be seen as a static document, but rather a draft or framework to continuously assess both the salient research needs with aviation and the evolving capabilities within the Center to address those needs with compelling analysis and cutting-edge solutions.