REDAC / Human Factors

Name of Program: NextGen Air Ground Integration Human Factors

BLI Number: 111110

Presenter Name: Dr. Victor Quach

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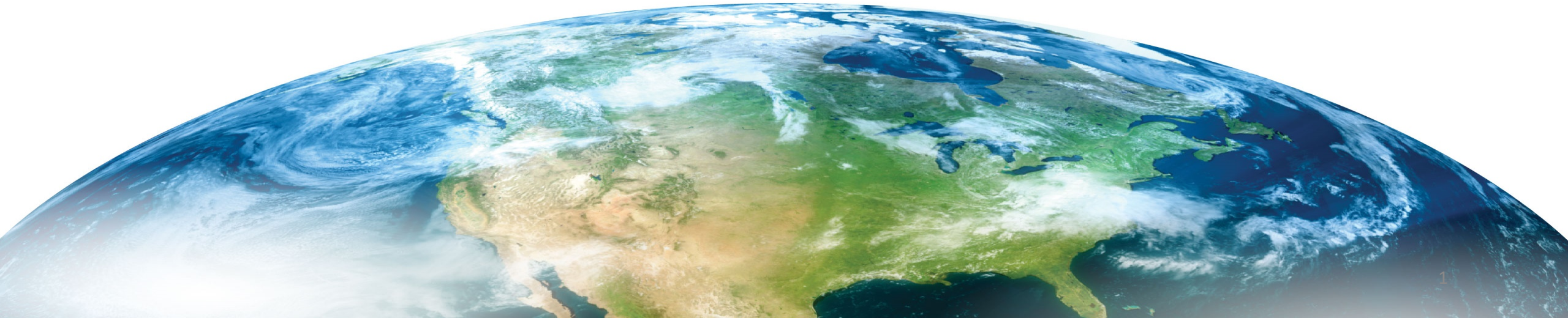


NextGen Air/Ground Integration Human Factors Overview

Program Scope

- This program addresses research, engineering, and development requirements defined by technical sponsors in the Aviation Safety Organization (AVS). Requirements are driven by the intersection points between FAA policy documents, NextGen changes, and enabling flight deck technologies and procedures

FAA Benefits

- Program outputs are transferred to AVS technical sponsors to develop and maintain, as appropriate, human factors-related rules, guidance, procedures, Orders, standards, job aids, and other materials
- Work products benefit Aircraft Certification and Flight Standards personnel who evaluate and approve emerging aircraft systems (e.g., displays, devices, controls), procedures, and operations which may not be covered by existing human factors documentation

Measures of Success

1. Sponsor Satisfaction – did the research meet AVS's needs?
2. Access to Research – is there sufficient awareness/access to results?
3. Application of Results – did the research support or inform a data-driven decision?
4. NextGen Benefits – how did the research contribute to safety, capacity, and/or efficiency?

NextGen Air/Ground Integration Human Factors Program Managers and Researchers

Program Managers

- Tara Gibson, Division Manager (Tara.M.Gibson@faa.gov)
- Dr. Victor Quach (Victor.K.Quach@faa.gov)
- Dr. Bill Kaliardos (Bill.Kaliardos@faa.gov)
- Karl Kaufmann (Karl.Kaufmann@faa.gov)

Researchers and Laboratories

- FAA Civil Aerospace Medical Institute
- FAA William J. Hughes Technical Center
- NASA Ames Research Center
- Volpe National Transportation Systems Center, DOT
- MITRE Corporation
- Honeywell
- University of Central Florida
- University of Michigan

NextGen Air/Ground Integration Human Factors Accomplishments in FY21

Project	Description/Product
NextGen Procedures, Tasks, Skills and Training for Air Carrier Pilots	
Cognitive Skill Degradation – Verification and Validation	**Completed data collection (cognitive walkthroughs).** Identified cognitive skills and knowledge required for Flight Path Management (FPM) tasks in transport category aircraft during 14 CFR Part 121 flight operations. Identified the strategic impact of enabling technologies/procedures to baseline cognitive skills and knowledge.
NextGen Human Factors for Aircraft Systems, Displays, and Controls	
Validation of CDTI Display Features in a Metered and Non-Metered Environment – Dependent Staggered Approaches (DSA)	**Developed draft research report.** Draft research data on the operational acceptability of multiple CDTI display requirement implementations defined in avionics standards (RTCA), and draft research data on sequential IM clearances using multiple modes of communication.
NextGen Human Error and Complex Systems	
Human-System Safety / Human Factors Risk Analysis Method Alternatives	**Developed draft research report.** Draft research data on the applicability and use of alternative methods to factor human behavior in system-safety / risk assessments during an initial set of certification-based scenarios .
Pilot Response to Unexpected Events	**Complete data collection (agenda-based discussions).** Obtained data from 50 pilot participants (Part 121, 135, 91K) on startle and surprise events to support future development of a research plan for an empirical study.
NextGen Advanced Vision Systems	
EFVS Visual Advantage Operational Data Collection	**Developed draft interim research report.** Reports of actual enhanced flight vision system (EFVS) performance during low visibility approach, landing, and rollout operations. Created an interactive dashboard to visualize and filter results.

Pilot Tasks, Skills, Procedures, and Training Research

Objectives

- Provide research data to support human factors needs of FAA personnel who evaluate, approve, and oversee pilot training and qualification programs, operations, and procedures
- Identify pilot tasks, skills, and proficiency needs for the operational use of aircraft systems, avionics equipment, and procedures
- Examine the operational effectiveness of training and related technology
- Research does not develop training programs

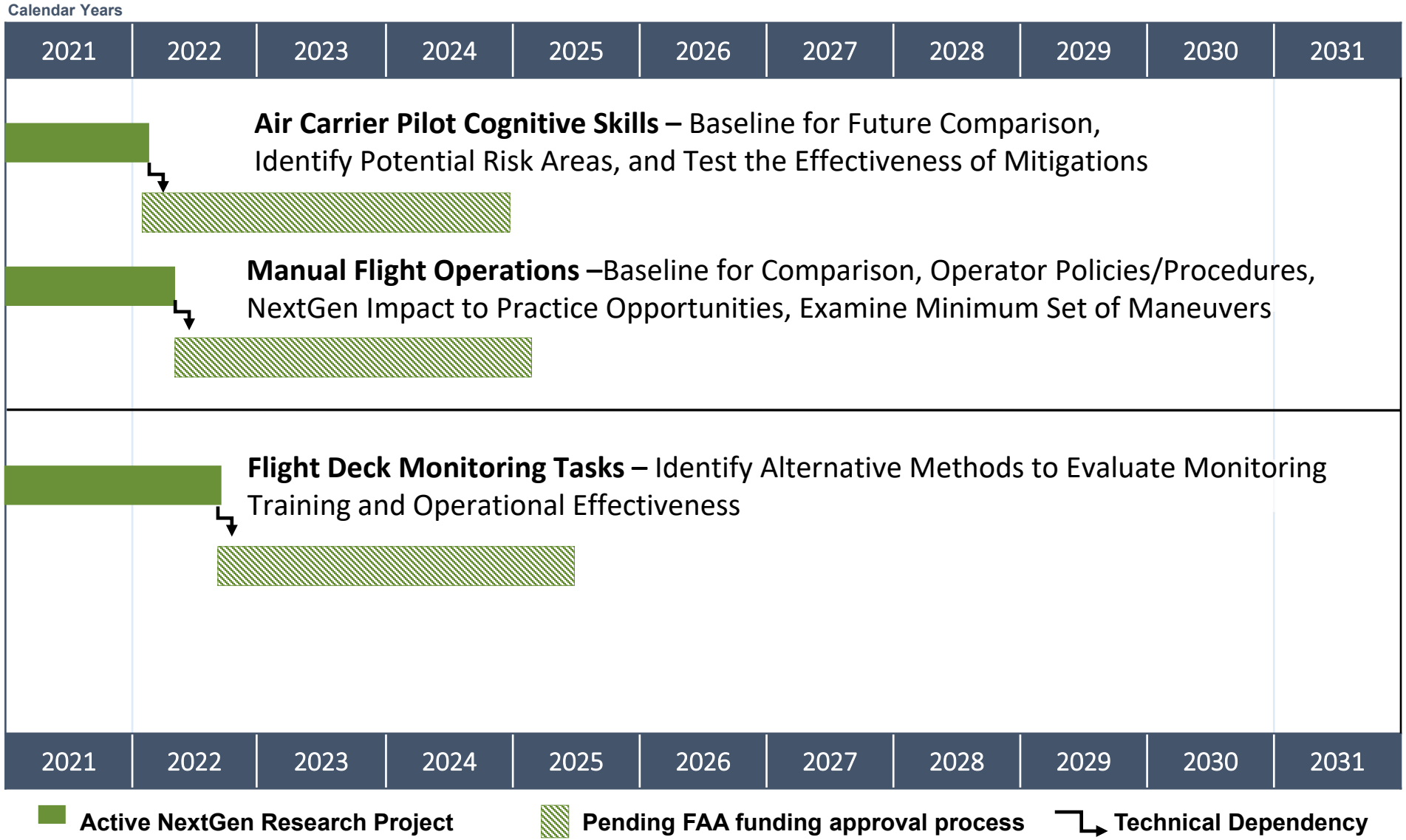
How Results are Use

- Informs FAA personnel who develop evaluation criteria for pilot tasks and skills and incorporate this information into human factors – related regulations, guidance material, and other work products for FAA use. Outputs may also benefit industry.

Focus Areas

- Cognitive and Psychomotor Skills
- Training Methods and Technologies

Pilot Tasks, Skills, Procedures, and Training Research



Pilot Tasks, Skills, Procedures, and Training Research

On-going and planned research in FY22+

Project	Description/Product	Vendor	Est. Completion
Manual Flight Operations	• **Technical Report** on the current state of low altitude manual flight operations (MFO) in the NAS, industry line/training policies and procedures for MFO, and the potential impact of enabling technologies to MFO practice opportunities in future NextGen line operations.	**MITRE**	**FY22 Q2**
↳ Validation Study (tentative)	• **Human Factors Verification and Validation Plan** for a Minimum Set of Manual Flight Operation Maneuvers with Maximum Task, Knowledge, Skill Coverage • **Final Technical Report** on Criteria to Evaluate Manual Flight Operation Tasks, Knowledge, Skills and New NextGen Training and Qualification Needs	**MITRE**	**FY24 Q1**
Cognitive Skill Degradation	• **Technical Report** on baseline cognitive skills and knowledge required to complete flightpath management (FPM) tasks in current Part 121 operations, including the use of automated systems and potential risks related to development/retention of skills.	**Honeywell**	**FY22 Q2**
↳ Mitigation and Training Recommendations (tentative)	• **Human Factors Research Plan** for NextGen Cognitive Skill Degradation Mitigations • **Final Technical Report** on Criteria to Evaluate Cognitive Skills for NextGen Flightpath Management Tasks and the Operational Effectiveness of Mitigations	**Industry**	**FY24 Q1**
Techniques to Evaluate Monitoring Training and Monitoring Performance	• **Technical Report** on a range of viable methods/techniques which could be used to evaluate monitoring tasks, training, and performance during line operations, including a recommended subset for future verification and validation.	**NASA AMES**	**FY22 Q4**
↳ Verification and Validation Study (tentative)	• **Human Factors Verification and Validation Plan** for Alternative Methods to Evaluate Monitoring Training and Operational Effectiveness • **Final Technical Report** on Criteria to Evaluate Innovative Training Methods for New NextGen Monitoring Tasks and the Operational Effectiveness of Training	**NASA AMES**	**FY24 Q1**

Pilot Tasks, Skills, Procedures, and Training Research

Potential research plans FY22+

Project	Description/Product
NextGen Changes to Tasks, Knowledge, Skills, and Abilities (KSA)	**Advanced Technologies & Procedures** Phase 1 of 3, Baseline Tasks, Knowledge, & Proficiency Needed to Use Systems/Equipment for Full/Dynamic Trajectory Based Operations (FY22+/23+) Phase 2 of 3, Identify & Evaluate Potential Barriers/Training Needs to Participate in Full/Dynamic TBO (FY23+/24+) Phase 3 of 3, Provide Data to Inform Training and Qualification Criteria for TBO Impacts (FY24+/25+)
Extensible Traffic Management (xTM) Impacts to Pilot Training and Qualification	**Expansion of Diverse Flight Operations** Phase 1 of 3, Plan to Identify the Impact of New Entrants/Operations (dynamic separation of airspace) to Air Carrier Pilot KSAs (FY23+/24+) Phase 2 of 3, Examine the Impact of xTM to Baseline KSAs and Training and Qualification Needs (FY24+/25+) Phase 3 of 3, Provide Data to Identify New/Changed KSAs and Inform Human Factors Evaluation Criteria (FY25+/26+)

Flightcrew Displays and Interfaces Research

Objectives

- Provide research data to support human factors needs of FAA personnel who evaluate and approve emerging aircraft systems, displays, and controls, including their intended function and operation.
- Understand potential installation and integration issues that could arise when introducing or combining next generation aircraft changes with current systems, displays, controls, and their respective modes of operation.

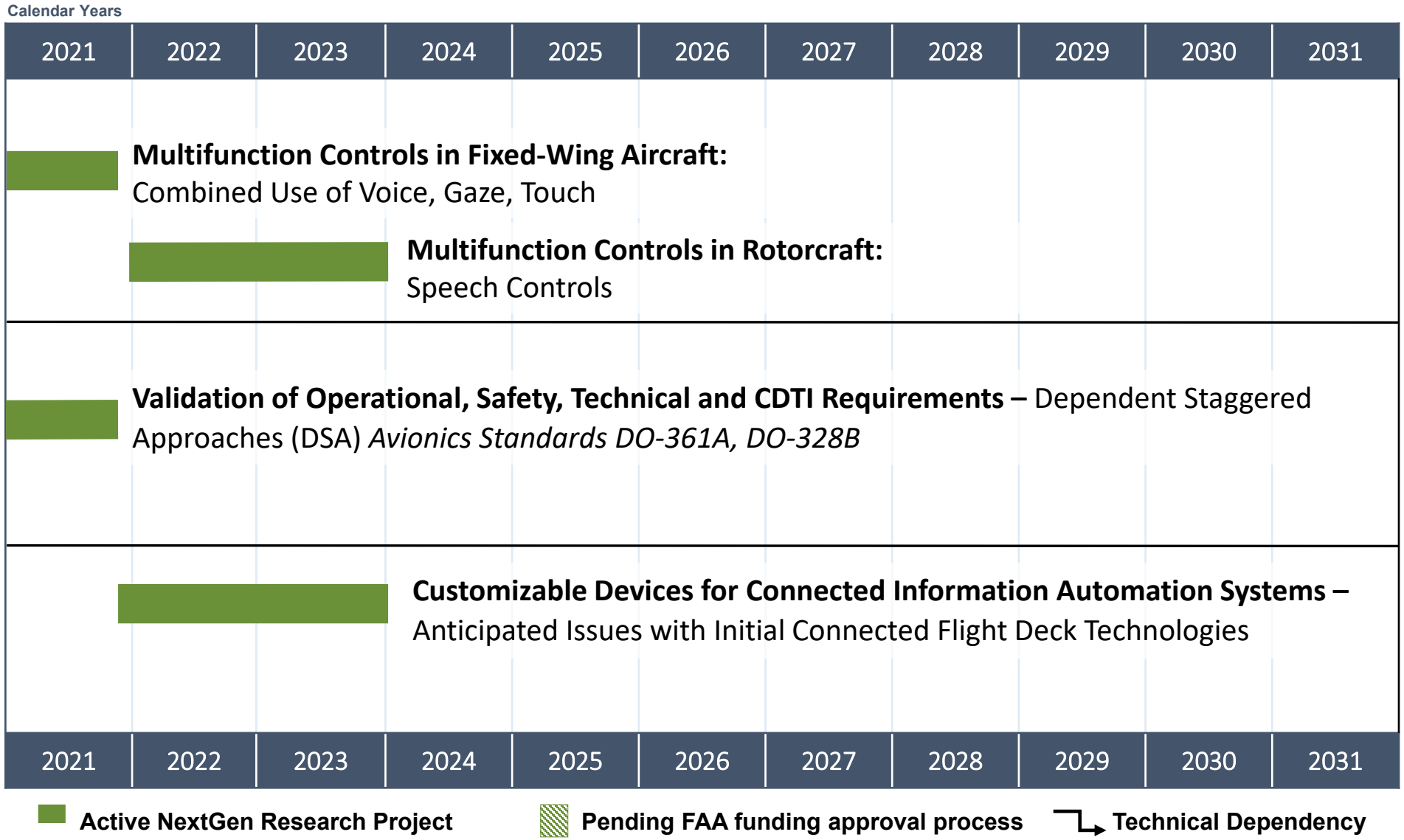
How Results are Use

- Informs FAA personnel who develop evaluation criteria for aircraft systems, displays, and controls and incorporate this information into human factors – related regulations, guidance material, and other work products for FAA use. Outputs may also benefit industry.

Focus Areas

- Controls for flight deck systems
- Avionics standard integration

Flightcrew Displays and Interfaces Research



Flightcrew Displays and Interfaces Research

Ongoing and planned research in FY22+

Project	Description/Product	Vendor	Est. Completion
Validation of CDTI Display Features in a Metered and Non-Metered Environment – Dependent Staggered Approaches (DSA)	• **Final Technical Report** describing results of a HITL simulation to evaluate various implementations of the minimum CDTI display requirements, defined by RTCA SC-186 WG4, for IM DSA flight operations in a metered and non-metered Terminal environment.	**MITRE**	**FY21 Q4**
Human Factors Considerations for Multi-Modal Controls (Combined Controls) – Fixed Wing	• **Final Technical Report** describing the results of a HITL simulation which examined the human factors aspects of multi-function aircraft controls; specifically multi-touch touchscreen controls and voice activated/recognition controls.	**Honeywell**	**FY21 Q4**
Human Factors Considerations for Multi-Modal Controls (Speech Controls) – Rotorcraft ***(Pending)***	• **Technical Report** with research data characterizing single/dual pilot performance and human factors considerations when using multifunction controls with new methods of operation in rotorcraft – specifically various combinations of voice/speech controls.	**Industry**	**FY22 Q4**
Customizable Devices for Connected Information Automation Systems ***(Pending)***	• **Technical Report** on anticipated human – machine interface and interaction issues with connected flight deck technologies that combine and present information wholly or partially derived from uncertified data.	**CAMI**	**FY24 Q2**

Flightcrew Displays and Interfaces Research

Potential research plans FY22+

Project	Description
Multifunction Controls with New Methods of Operation	**Rotorcraft Electronic Displays and Controls** Phase 2 of 3, Provide Data on the Design and Use of Speech/Voice + Touch Controls in Current & NextGen Flight Operations (FY22+/23+) Phase 3 of 3, Provide Data on the Design and Use of Combined Controls in Current & NextGen Flight Ops (FY23+/24+)
Simplified Controls	**Highly Automated Aircraft** Phase 1 of 3, Rotorcraft Human-Machine Interface & Pilot Interaction Technology/Concept of Use Analysis (FY22+/23+) Phase 2 of 3, Fixed-wing Human-Machine Interface & Pilot Interaction Technology/Concept of Use Analysis (FY23+/24+) Phase 3 of 3, Advanced analysis scope is dependent on research outputs from earlier phases (FY24+/25+)
Next Generation Aircraft Display Features and Functions	**Aircraft Display Features and Functions for Integrated NextGen Flight Ops** Phase 1, Integration of Avionics Standards for Time-Based Flight Operations – Interval Management, Required Time of Arrival (FY22+/23+)
Connected Aircraft	**Connected Information Automation Systems** Phase 2 of 3, Design & Training Mitigations for User Interactions with Data Wholly/Partially Derived from Uncertified Sources (FY22+/23+) Phase 3 of 3, Provide Data to Inform Human Factors Evaluation Criteria for Display/User Interactions w/ Uncertified Data (FY23+/24+)

NextGen Instrument Procedures

Objectives

- Provide research data to support human factors needs of FAA personnel who evaluate, approve, and oversee pilot procedures and flight deck operations for performance – based navigation (PBN) procedures
- Understand the human factors impact of advanced procedure flyability/acceptability, charting, use of automated systems, and pilot competencies

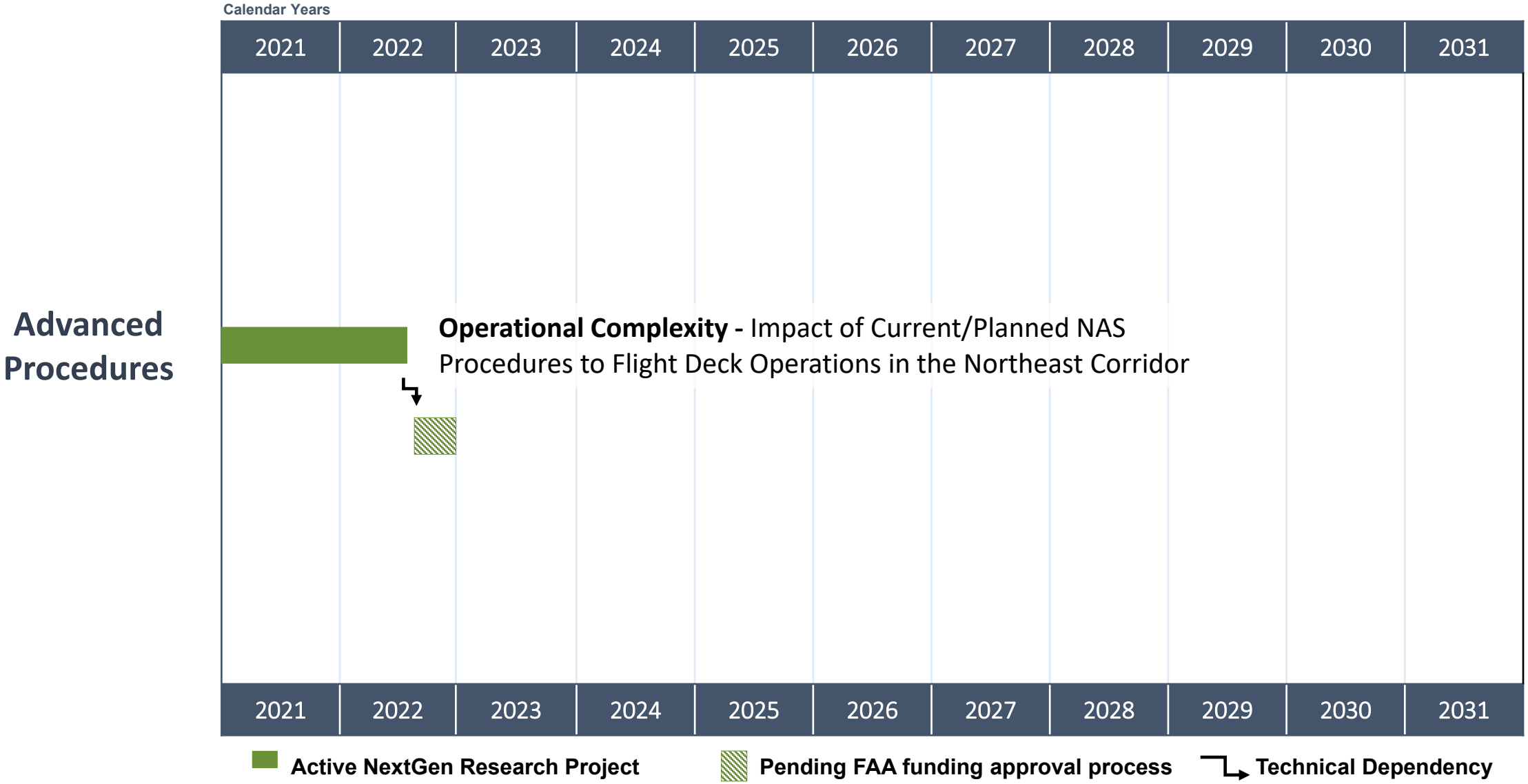
How Results are Use

- Informs FAA personnel who develop and maintain human factors portions of PBN-related regulations, guidance material, procedures, standards, job aids, and other documentation to support the safety and efficiency of flight operations.
  - Design of PBN procedures to ensure they can be flown safely
  - Documentation of PBN procedures (paper/electronic charting)
  - Other activities that support instrument flight procedure validation.

Focus Areas

- Advanced procedures (performance-based navigation)

NextGen Instrument Procedures



NextGen Instrument Procedures
Ongoing and planned research in FY22+

Project	Description/Product	Vendor	Est. Completion
Flight Deck Impacts of Procedure-Based Concepts, including Established on Required Navigation Performance (RNP) and Multiple Airport Route Separation (MARS)	• **Technical Report** on the effect of operational complexity to pilot performance and flight deck procedures during arrival to approach operations and how these impacts might change if concepts such as Multiple Airport Route Separate (MARS) or others are implemented in high density airspace, such as the northeast corridor.	**Volpe**	**FY22 Q2**
↳ Phase 2A of 3 – Research Plan for NextGen Procedure Flyability/Human Factors Issues	• **Research Plan** to identify and evaluate potential flyability/human factors considerations for new PBN arrival and departure procedures with reduced areas of separation (e.g., segment of 2 authorized procedures less than 3NM apart and ATC uses monitored procedural separation)	**Volpe**	**FY23 Q2**

NextGen Instrument Procedures
Potential research plans FY22+

Project	Description/Product
Performance-Based Navigation (PBN)	**Flight Deck Impacts of Advanced Procedures** Phase 2B of 3, Flyability/Operational Acceptability of Multiple Airport Route Separation (MARS) Concepts (FY22+/23+) Phase 3 of 3, Lessons Learned from Advanced PBN Implementations (FY23+/24+)

Human Error and Complex Systems Research

Objectives

- Provide research data to support human factors needs of FAA personnel who evaluate, approve, and oversee technologies and equipment, pilot training and qualification programs, operations, and procedures
- Understand how aircraft systems, operations, and procedures will impact the role of pilots and the expectations placed on them

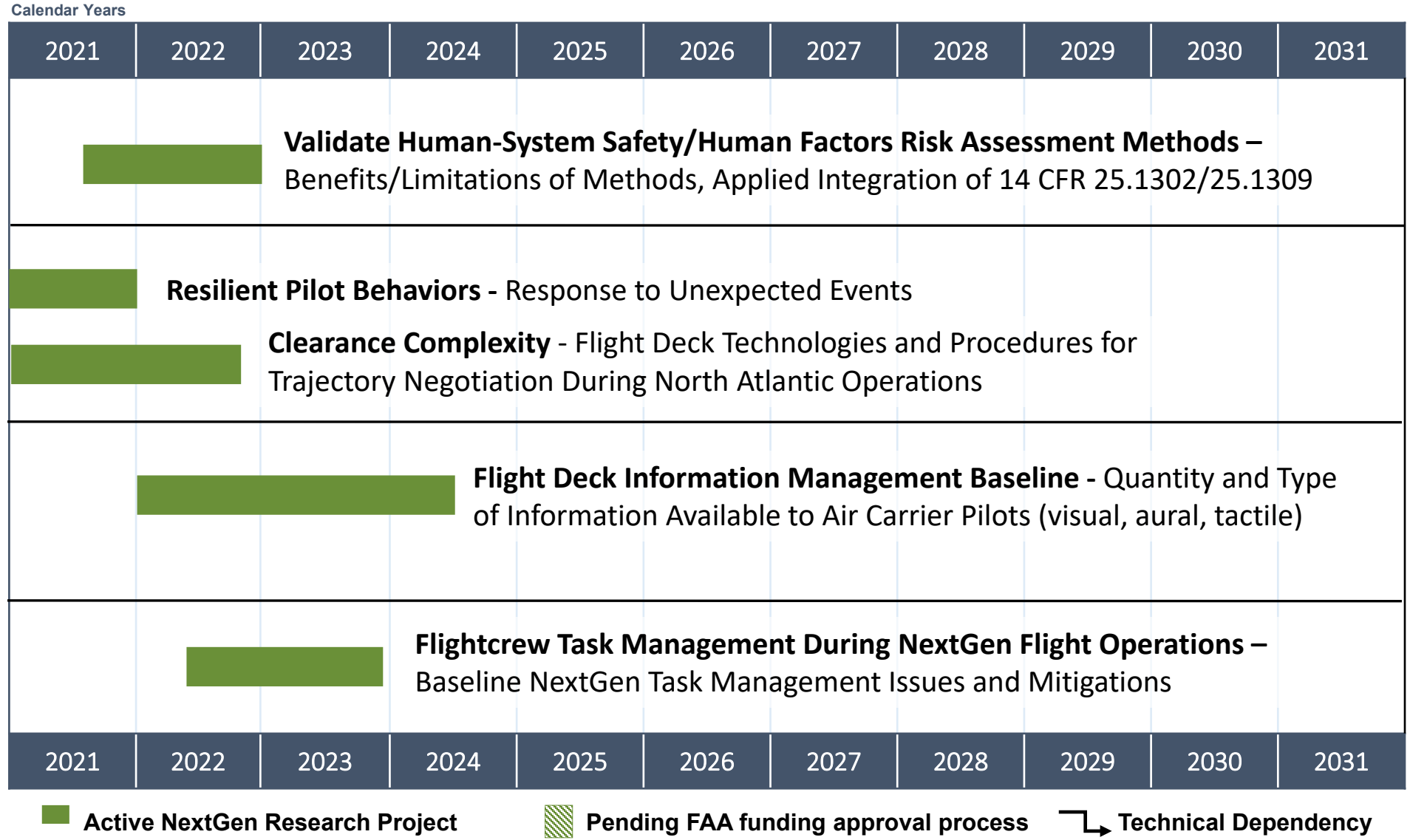
How Results are Use

- Informs FAA personnel who develop evaluation criteria for pilot tasks, skills, systems, and equipment and incorporate this information into human factors – related regulations, guidance material, and other work products for FAA use. Outputs may also benefit industry.

Focus Areas

- System-safety / risk assessment methods
- Resilient behaviors
- Information quantity and accessibility

Human Error and Complex Systems Research



Human Error and Complex Systems Research

Ongoing Research and Anticipated in FY22+

Project	Description/Product	Vendor	Est. Completion
Pilot Response to Unexpected Events	• **Final Technical Report** with research data on potential training interventions which could support resilient crew behavior(s) during unexpected events.	**University of Central Florida**	**FY22 Q1**
Human-System Safety / Human Factors Risk Analysis Method Alternatives	• **Final Technical Report** on the verification and validation of methods to factor human behavior in system-safety / risk assessments, the benefits and limitations of each method evaluated, and evidence-based recommendations to support the applied integration of 14 CFR 25.1302 and 25.1309.	**NASA Ames**	**FY22 Q4**
Impact of Clearance Complexity and Flight Deck Procedures to Pilot Error in North Atlantic Flight Operations	• **Final Technical Report** with research data on causes of gross navigational errors and large height deviations attributed to an air/ground misunderstanding during clearance negotiation, methods used by pilots to avoid errors when responding to lateral flightpath changes issued by ATC on/off oceanic track route assignments, and recommendations to perform clearance negotiation using CPDLC.	**Volpe**	**FY22 Q4**
Flight Deck Information Management – Phase 1 Baseline Assessment ***(Pending)***	• **Technical Report** on the quantity and type of information available to air carrier pilots (visual, aural, tactile) in modern aircraft, how air carrier pilot tasks have changed to manage this information, and mitigations successfully and/or unsuccessfully applied to address current-day information management vulnerabilities.	**University of Michigan**	**FY24 Q2**
Flightcrew Task Management During NextGen Flight Operations ***(Pending)***	• **Technical Report** on the current state of NextGen task management vulnerabilities and human factors mitigations which relate to monitoring, management of system malfunctions, and ATC interventions that effect flightpath management.	**Industry**	**FY24 Q2**

Human Error and Complex Systems Research

Potential research plans FY22+

Project	Description/Product
Task Management During NextGen Flight Operations	**Air Carrier Pilot Task Management** Phase 2 of 4, Complexity Impacts of Trajectory Based Operations to the Management of Tasks & Use/Function of Systems (FY22+/23+) Phase 3 of 4, Test & Evaluate the Effectiveness of Human Factors Mitigations for Task Management Vulnerabilities (FY23+/24+) Phase 4 of 4, Provide Data to Inform Lessons Learned and Human Factors Operational Evaluation Criteria (FY24+/25+)
Flight Deck Information Management Vulnerabilities	**Flight Deck Information Management Vulnerabilities** Phase 2 of 3, Human Factors Evidence of Interdependent System Impacts to Pilot Performance (FY22+/23+) Phase 3 of 3, Provide Data to Inform Lessons Learned for the Design and Use of Future Systems/Flight Deck Enablers (FY23+/24+)
Human Factors of Automated Systems	**Human Factors of Automated Systems** Phase 1 of 4, Impact of Enabling Technologies and NextGen Concepts of Operation to Pilot Roles & Expectations Placed on Them (FY22+/23+) Phase 2 of 4, Evaluate Human Factors Vulnerabilities and Risks (FY23+/24+) Phase 3 of 4, Identify Potential Regulatory & Guidance Material Gaps that Could be Supported with Research Data (FY24+/25+) Phase 4 of 4, Provide Data to Support Early Integration of Human Factors in Complex System Design & Operational Evaluation (FY25+/26+)
Resilience	**Human – System Performance** Phase 1 of 3, Identify Resilient Automated System Behaviors (FY23+/24+) Phase 2 of 3, Examine Unexpected Events Involving Flight Deck Technologies that Enable Full/Dynamic Trajectory Based Operations (FY24+/25+) Phase 3 of 3, Evaluate the Effectiveness of Mitigations to Manage Unexpected Events with Enabling Flight Deck Technologies (FY25+/26+)
Integration Communication, Navigation, Surveillance (CNS) Capabilities	**Combined Use of CNS Capabilities** Phase 1 of 4, Develop a Research Plan to Examine HF Impacts Related to the Combined Use of CNS Capabilities (FY23+/24+) Phase 2 of 4, Provide Data on the HF Impact of CNS Capabilities to Pilot Performance (FY24+/25+) Phase 3 of 4, Scope is dependent on research results (FY25+/26+) Phase 4 of 4, Scope is dependent on research results (FY26+/27+)
Advanced Pilot – Air Traffic Interactions	**Clearance Complexity** Phase 2 of 4, Impact of 4-Dimensional Trajectory (4DT) Clearances & New Negotiation Procedures to Pilot Tasks/Performance (FY22+/23+) Phase 3 of 4, Mitigations to Avoid Pilot Errors & Manage 4DT Clearance/Negotiation Risks (FY23+/24+) Phase 4 of 4, Scope is dependent on research results (FY24+/25+)
	Communication Technology Design & Use Phase 1 of 4, Review & Analysis of Data from Research on Digital Communication Technologies (FY23+/24+) Phase 2 of 4, Pilot Performance Impact of Planned Communication Technologies & Concepts of Operation (FY24+/25+) Phase 3 of 4, Research Plan to Address Regulatory and Guidance Material Gaps (FY25+/26+) Phase 4 of 4, Scope is dependent on research results (FY26+/27+)

Advanced Vision Systems

Objectives

- Provide research data to support human factors needs of FAA personnel who evaluate, approve, and oversee the use of advanced vision systems
- Understand the contribution of advanced vision system technologies to pilot performance during new low visibility concepts of operation

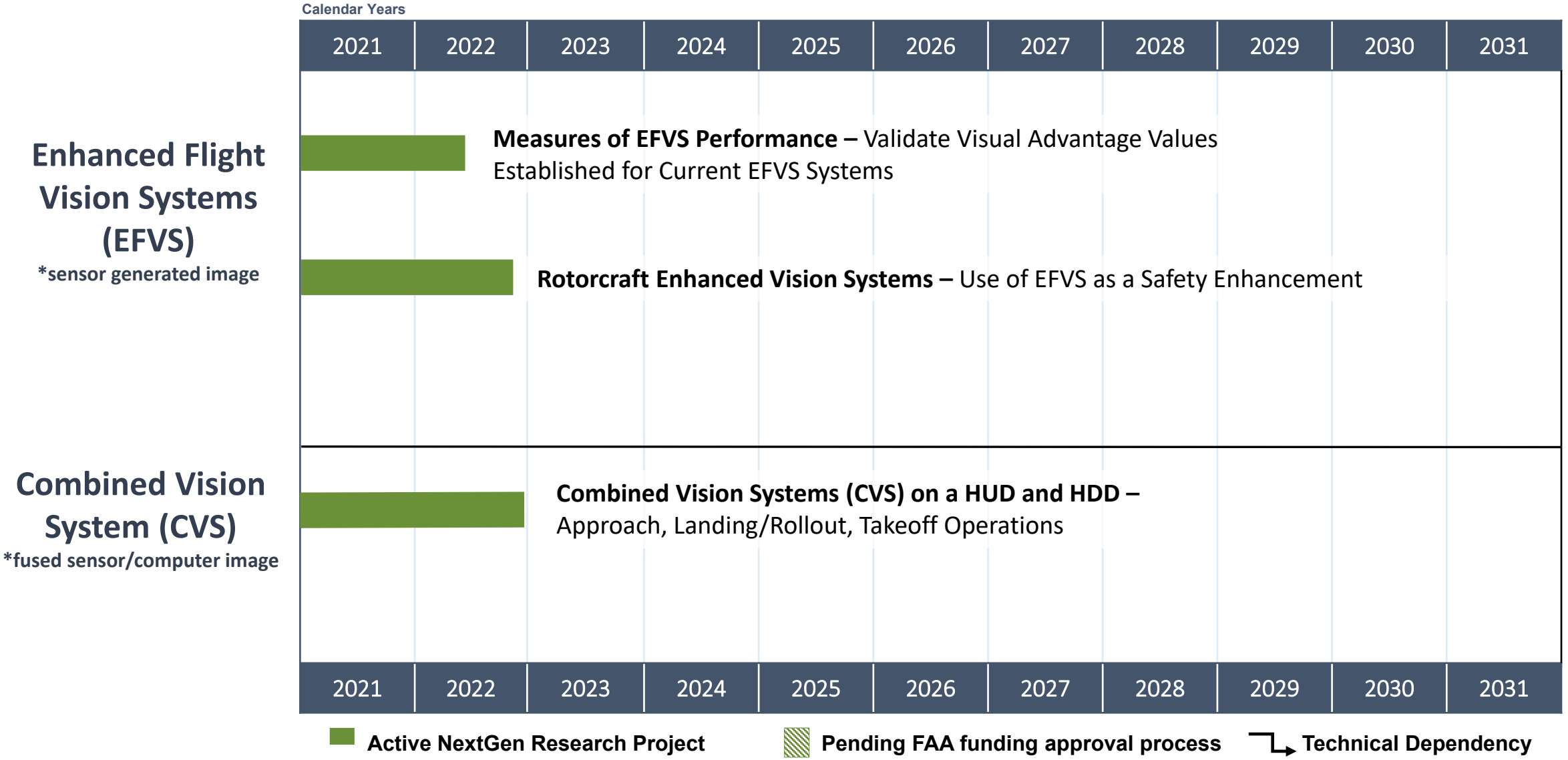
How Results are Use

- Informs equivalent level of safety decisions and policy changes that can increase the number of viable airports/runways for low visibility approach, landing, rollout, and takeoff operations (expand operational credit)
- Informs FAA personnel who develop evaluation criteria for the use of advanced vision system technologies and incorporate this information into human factors – related regulations, guidance material, and other work products for FAA use. Outputs may also benefit industry.

Focus Areas

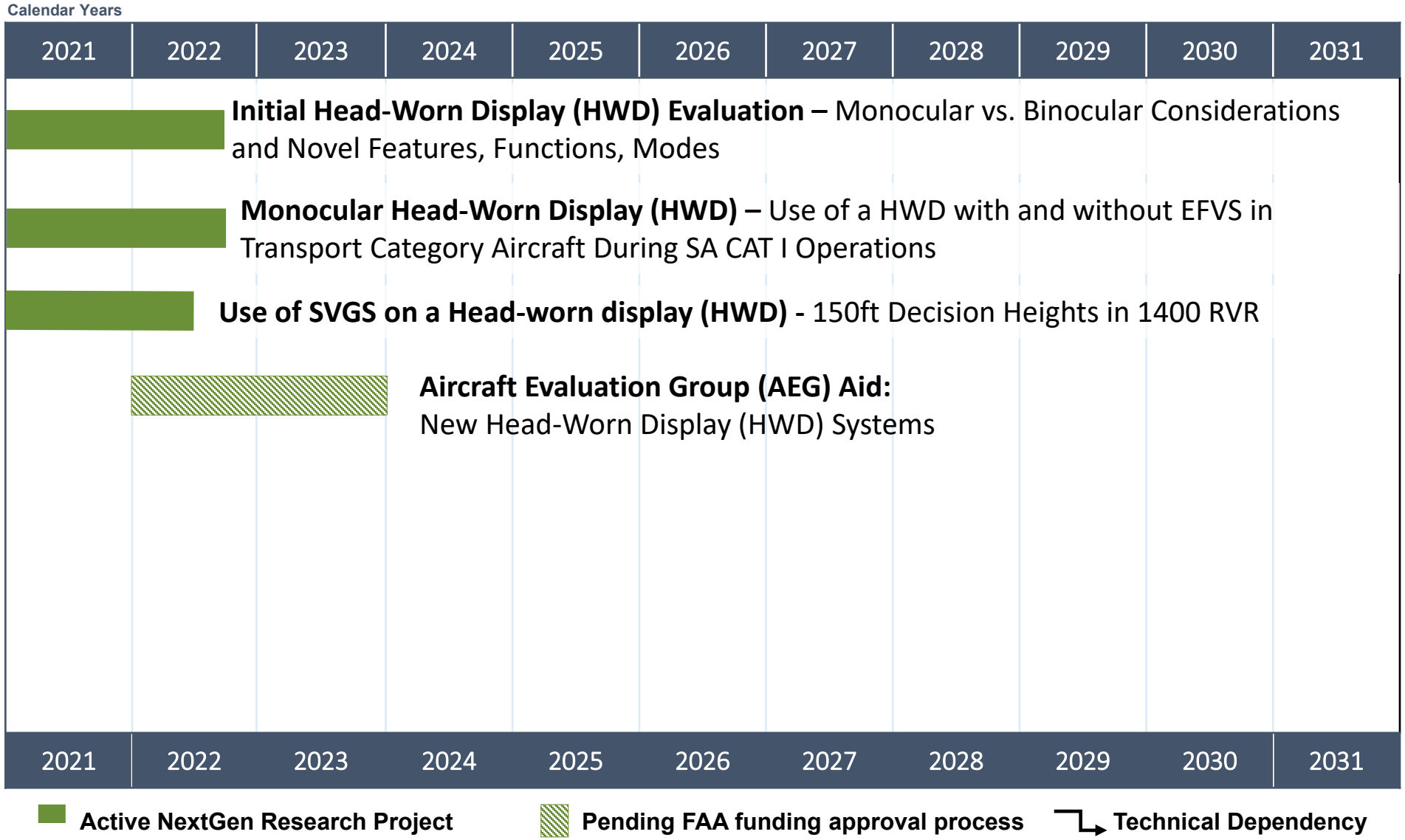
- Enhanced Flight Vision Systems (EFVS), Synthetic Vision Guidance Systems (SVGS), Combined Vision Systems (CVS)
- New ways of using approved equipment
- Use of novel display technologies

Advanced Vision Systems (1 of 2)



Advanced Vision Systems (2 of 2)

Use of Novel Display Technology



Advanced Vision Systems

On-going research in FY22+

Project	Description/Product	Vendor	Est. Completion
EFVS Visual Advantage Operational Data Collection	• **Final Technical Report.** Research data characterizing actual/reported enhanced flight vision system (EFVS) performance during low visibility approach, landing, and rollout operations. Data will support validation of visual advantage values established for existing EFVS models (Infrared-based sensors) and support on-going implementation of the new EFVS rule which broadly accommodates existing and future EFVS systems/sensors not yet evaluated.	**CAMI**	**FY22 Q2**
Human Factors Aspects of Emerging Head-Mounted Display (HMD) Applications – Small Aircraft	• **Final Technical Report.** Data on pilot performance and human factors considerations associated with the use of an HMD during approach and landing operations. The report will also include data that indicates whether an operationally significant difference exists between monocular and binocular HMDs, and the potential impact of eye dominance.	**CAMI**	**FY22 Q3**
HWDs with Flight Info. Only & use of HWD with EFVS to Conduct Lower than Standard Approach and Landing Minima Flight Operations – SA CAT I	• **Technical Report.** Results from the evaluation of a monocular HWD with flight information only vs. a monocular HWD with EFVS during approach, landing, and rollout operations in low visibility conditions (SA CAT I).	**CAMI**	**FY22 Q3**
Low Visibility Operations Using Synthetic Vision Guidance System (SVGS) Information on HMDs	• **Final Technical Report.** Results from the evaluation of SVGS on a head-down display during low visibility flight operations (SA CAT I, SA CAT II, CAT II minima) to airports/runways with reduced infrastructure.	**CAMI**	**FY22 Q4**
Enhanced Helicopter Vision System (EHVS) Technologies	• **Technical Report.** Contribution of emerging EHVS technologies to pilot performance, including use as a potential safety enhancement and to potentially conduct low visibility approach and landing operations.	**WJHTC**	**FY23 Q1**
Combined Vision Systems (CVS)	• **Final Technical Report**. Results from the evaluation of a Combined Vision Systems (CVS) on a head-up display (HUD) and a CVS on a head-down display (HDD) during low visibility flight operations (takeoff, approach, landing, touchdown/rollout) to airports/runways with reduced infrastructure.	**CAMI**	**FY23 Q1**

Advanced Vision Systems

Potential research plans FY22+

Project	Description
Enhanced Flight Vision System (EFVS) Operations Below 1,000 Runway Visual Range (RVR)	**Approach, Touchdown, and Rollout at Airports with & without Runway Visual Aids** Phase 1 of 2, EFVS Operations Down to 600 RVR (FY22+/23+) Phase 2 of 2, EFVS Operations Down to 300 RVR (FY23+/24+)
Aircraft Evaluation Group (AEG) Pilot Evaluation Aids for New Technology	**Operational Evaluation of Technology** Phase 1 of 1, Develop & Verify a Human Factors Process to Evaluate Combined Vision System Technologies and Operations (FY22+/23+)
Novel Display Technologies, Implementations, and Concepts of Use	**Head-Worn Displays (HWD)** Phase 2 of 2, Implementation and Use of EFVS on a Monocular Head-Worn Display (FY22+/23+)
	Head-Worn Displays (HWD) Phase 1 of 1, EFVS on a HWD for Lower than Standard Takeoff (FY22+/23+)
	Hybrid Installation & Use of Technology Phase 1 of 1, Hybrid HWD/Head-up display (HUD) and Dual HWD Installation & Use (FY23+/24+)

Victor K. Quach, Ph.D.
Program Manager, Air/Ground Integration Research
NextGen Human Factors Division (ANG-C1)
Victor.K.Quach@faa.gov
202.267.3585