Vision Systems Research Activities

• **Research Purpose**
  – Investigate Enhanced Helicopter Vision Systems technologies to determine if they can improve the safety of flight and could provide operational credit/benefit for rotorcraft operations

• **Sponsors & Key Stakeholders**
  – Flight Standards (AFS), Aircraft Certification/Rotorcraft Directorate (AIR/ASW)
  – United States Helicopter Safety Team (USHST)
  – International Helicopter Safety Foundation (IHSF)
  – EUROCAE WG-79/RTCA SC-213, SAE G10/A4
End Goals

- FAA is looking to develop operational and performance criteria for Helicopter Vision Systems Technology for enhancing safety or pursuing operational concepts for providing operational credit.

- Federal Aviation Regulations that may be informed by the results of this Research:
  - 91.176 – Amended for Helicopter Operations
  - 8260.42B – FAA Order
  - AC 90-80C – FAA Advisory Circular (Offshore Instrument Criteria)
  - 14 CFR Parts 27, 29, 43, 49, 60, 61, 67, 91, 135, 137, 141, and 145
  - AC 90-106, Enhanced Flight Vision Systems
  - AC 23-26, Synthetic Vision and Pathway Depictions on the Primary Flight Display
The ability of the sensor to provide a visual advantage may allow operations in visibilities where operations might not be permitted using natural vision.
# Helicopter Enhanced Flight Vision System

<table>
<thead>
<tr>
<th>Sensor &amp; Computer</th>
<th>Display</th>
<th>H-EFVS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FLIR, MMWIR, LIDAR, etc.)</td>
<td>(HWD, HMD, HUD, HDD, etc.)</td>
<td></td>
</tr>
</tbody>
</table>

- **Sensor & Computer**: FLIR, MMWIR, LIDAR, etc.
- **Display**: HWD, HMD, HUD, HDD, etc.
- **H-EFVS**: Helicopter Enhanced Flight Vision System
Vision Systems Components Terminology

- HUD = Heads-up-display
- HWD = Head-worn-display
- HMD = Head-mounted-display
- EVS = Enhanced Vision System (EVS uses sensor imagery (i.e. infrared cameras or millimeter wave radar or LIDAR) to display features like runway obstructions and terrain in bad weather or on a dark night)
- SVS = Synthetic Vision System (SVS uses information from a look-up database (i.e. terrain, airports/heliports) to create an artificial rendering of the outside world)
- CVS = Combined Vision System (CVS combines elements of EVS and SVS imagery to create a fused image of the flight environment)
Enhanced Flight Vision Systems (EFVS)

- EFVS = An installed aircraft system that uses a HUD or equivalent display to present:
  - Aircraft Information, Flight Symbology, Electronic real-time sensor image of the forward external scene
    (Note: Imaging sensors can be forward-looking infrared, millimeter wave, radiometry, millimeter wave radar, low-light level image intensification or other real-time imaging technologies)
Heads-Up Display (HUD)

- HUD: Heads-Up Display with flight symbology and SVS, EVS, and/or CVS information overlaid at various levels of transparency with the outside visual scene
Head-Worn Display (HWD)

- HWD: Essentially a HUD but wearable by the pilot, capable of rendering the same information as a fixed HUD but information moves with the pilot’s head
Helmet-Mounted Display (HMD)

- HMD = Same as an HWD but the display is mounted to the helmet, some devices can be used with Night Vision Goggles (NVG’s) and some cannot
Enhanced Vision System (EVS)

- EVS: Enhanced Vision Systems use sensor imagery (i.e. infrared (IR) cameras, millimeter wave radar (MMWR), LIDAR, etc.) to display features like runway obstructions and terrain in low visibility/bad weather or at night.
**Synthetic Vision System (SVS)**

- SVS = Synthetic Vision System (SVS uses information from a look-up database (i.e. terrain, airports/heliports) to create an artificial rendering of the outside world)
- Used today by commercial airlines, corporate General Aviation aircraft, and some rotorcraft
Combined Vision System (CVS)

- CVS: Combined Vision System (CVS combines elements of EVS and SVS imagery to create a fused image of the flight environment)
Night Vision Goggles (NVG)

- NVG: Work to illuminate the external scene at night via light amplification and traditionally are available in green or white phosphor monochrome color. *(Note: NVG’s are not currently approved for IFR operations in the U.S.)*
Relationship to Regulators, Standards Groups, Safety Organizations

• EUROCAE WG-79/RTCA-SC213

• United States Helicopter Safety Team (USHST)
  – Helicopter Safety Enhancement #91 – Vision Systems Technologies
  – Helicopter Safety Enhancement #127A – Spatial Disorientation

• Vertical Aviation Safety Team (VAST)
  – Helicopter Safety Technology Survey

• FAA, EASA, Other Regulators/Civil Aviation Authorities
Helicopter Safety Enhancements

USHST
United States Helicopter Safety Team
Active USHST Safety Enhancements

Technology Initiatives

- Stability Augmentation System & Autopilot (70)
- Helicopter Flight Data Monitoring (82)
- Enhanced Helicopter Vision Systems (91)
Enhanced Helicopter Vision Systems (H-SE #91)

“FAA and industry to research, develop, and promote the use of enhanced helicopter vision systems (EHVS) technologies (e.g. Night Vision Goggles, Enhanced Vision Systems, Synthetic Vision Systems, Combined Vision Systems, etc.) to assist in recognizing and preventing unplanned flight into degraded visibility conditions due to weather and to increase safety during planned flight at night.”
H-SE #91 Team Members
EUROCAE WG-79/RTCA SC-213
SG-4 Helicopter
Combined Vision Systems (CVS)

Working Group 79/SC-213 - Subgroup 4

- Meets biweekly (alternating meetings with USHST H-SE #91
- Composed of SME’s from Vision Systems Technology Industry Manufacturers, Helicopter OEM’s, and Government Agencies (i.e. FAA/EASA)
- CVS MASPS Document (In Progress to be completed before the end of 2022)
- Held Joint Industry Vision Systems One-Day Summit with USHST H-SE#91 in Jun. 2021
Vision Systems Research Questions

• Does a HDD or HWD/HMD with EVS allow pilots to maintain or enhance pilot performance and increase flight technical accuracies during specified instrument approach procedures?
• Does using a HDD or HWD/HMD with EVS have an effect on pilot workload during specified instrument approach procedures?
• What are the visual references/cues a helicopter pilot needs to acquire to proceed to land?
• How do you characterize sensor performance for different sensors in various mission segments (Helicopter Air Ambulance (HAA), Offshore, Search and Rescue, etc.) and weather conditions?
• What is the minimum EVS sensor FOV required to safely approach and land a helicopter to a runway? To a heliport?
• How do you examine Display Technologies and Concepts (i.e. Head-Worn Display - HWD) at various helipads (Rooftop, Offshore, Land-Based, Accident Scene, etc.)?
Current & Planned Future Vision Systems R&D Work

- Updated Literature & Product Technology Reviews
- VAST IFR Technology Survey (includes Vision Systems)
- Vision Systems Summit Follow-On (Summer/Fall 2022)
- Simulator Experimental Trials
  - FAA WJHTC S76 Simulator
  - Contact Cliff Johnson if interested in participating
- Flight Trials
  - Iowa University Operator Performance Laboratory (OPL) & USAF Test Pilot School
  - Demonstration Efforts with European Operators, Helicopter OEM’s, and Vision Systems Manufacturers
  - FAA WJHTC Flight Trials
  - Lifeflight of Maine Flight Trials (as part of IFR Infrastructure Project)
EHVS Experimental Trial

Double Click Icon to Play Video
EHVS Experimental Trial

Experimental Conditions:
- FATO/TLOF Lights On
- Night
- EVS
- HWD (worn by Pilot Flying)

<table>
<thead>
<tr>
<th>Source</th>
<th>Reference</th>
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<th>Altitude (ft)</th>
<th>Groundspeed (kn)</th>
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<td>Helipad</td>
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<td>825</td>
<td>78</td>
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<tr>
<td>Pilot EV1</td>
<td>FATO/TLOF Lights</td>
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<td>Pilot V2</td>
<td>FATO/TLOF Paint</td>
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</table>
Video Clips: Helipad Approaches – Fog and Night

HDD During Flight In Fog
Symbology + EVS (voxels)

HMD During Night Approach To Helipad
Symbology + EVS (voxels) + SVS (DTED)
FAA Rotorcraft Flight Simulator

Sikorsky S76-D Flight Simulator
FAA Rotorcraft Flight Simulator

- Integrated with FAA's William J. Hughes Technical Center Simulation Labs
- Paired with Aviation Weather/Navigation Apps (i.e. Foreflight, etc.)
- Tailorable for various Weather Conditions
- HoloLens HWD/HMD – (developed in partnership with Rowan University Engineering)
- Displays are configurable
- Eye-trackers/cameras installed
- Remote testing accomplished via Zoom
- Supports multiple rotorcraft & eVTOL research projects including Vision Systems R&D

Sikorsky S76-D Flight Simulator

Double Click Icon to Play Video
HoloLens HWD
FAA Experimental Helipad (HPM77)
Final Program Goals and Objectives

- Summarize the state of the market for new helicopter vision systems technologies.
- Conduct a study on pilot performance and human factors aspects of vision systems displays and sensors via flight and simulator testing.
- Identify rotorcraft operations of interest that would benefit from enhanced safety and operational credit and target research activities to support these operations.
- Pursue the least arduous path (i.e. policy, guidance, best practices, or other non-regulatory materials) to promote and allow availability of some level of vision-enhancing technologies for rotorcraft.
- Develop outreach program (includes materials such as videos, mobile applications, trifolds, brochures, slogans/messaging, etc.) and conduct outreach with industry trade associations, at industry forums/conferences, and through other targeted methods for specific mission segments.
Questions?
Thank You for Your Interest. Want to Join the Effort?

- [http://www.ushst.org](http://www.ushst.org)
- Send your feedback to [safety@rotor.org](mailto:safety@rotor.org)
- If you have subject matter expertise that you would like to contribute to this project, email: [charles.c.Johnson@faa.gov](mailto:charles.c.Johnson@faa.gov)