300 ft Runway Visual Range (RVR) – Experiment Overview

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Objective

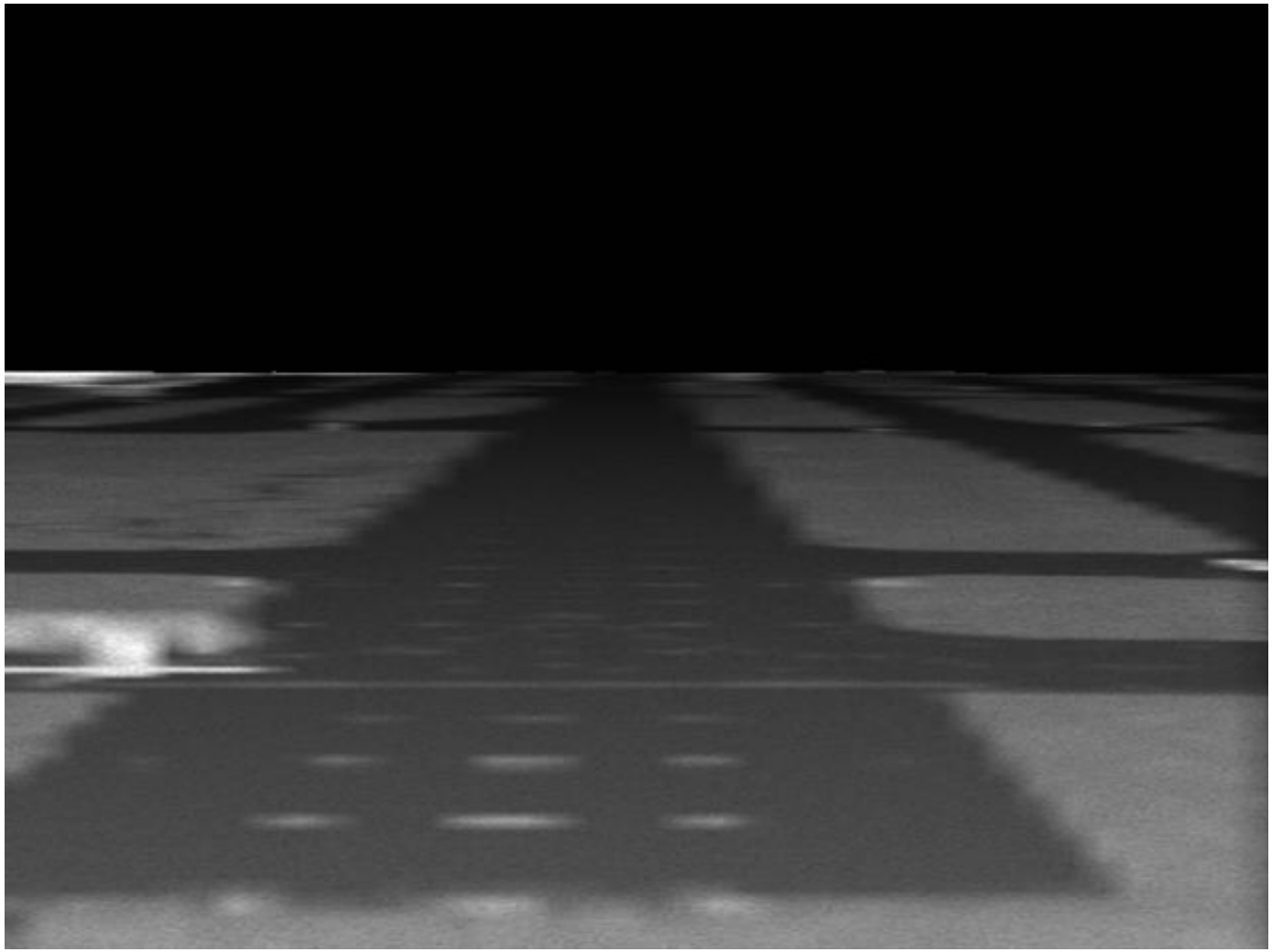
Evaluate the operational feasibility, pilot workload, and pilot acceptability of conducting straight-in instrument approaches with published vertical guidance to landing, touchdown, and rollout to a safe taxi speed in visibility as low as 300 feet runway visual range (RVR) by use of vision system technologies on a head-up display (HUD) without need or reliance on natural vision.

- 12 Crews Participating
- Research Flight Deck (RFD) with Cockpit Motion Facility
  - Dual HUDs with millimeter wave radar/forward looking infra-red (MMWR/FLIR) Imagery
  - New Memphis Out-the-window, Synthetic Vision (SV), FLIR and MMWR databases
  - Head-down Primary Flight Displays with MMWR/FLIR (used as alternate display in case of complete HUD failure)
- Image Fusion Processor Computers
- Smart Eye – Pilot Flying and Pilot Monitoring eye/head tracking capability

Research Flight Deck (RFD)

Simulated MMWR Imagery Example

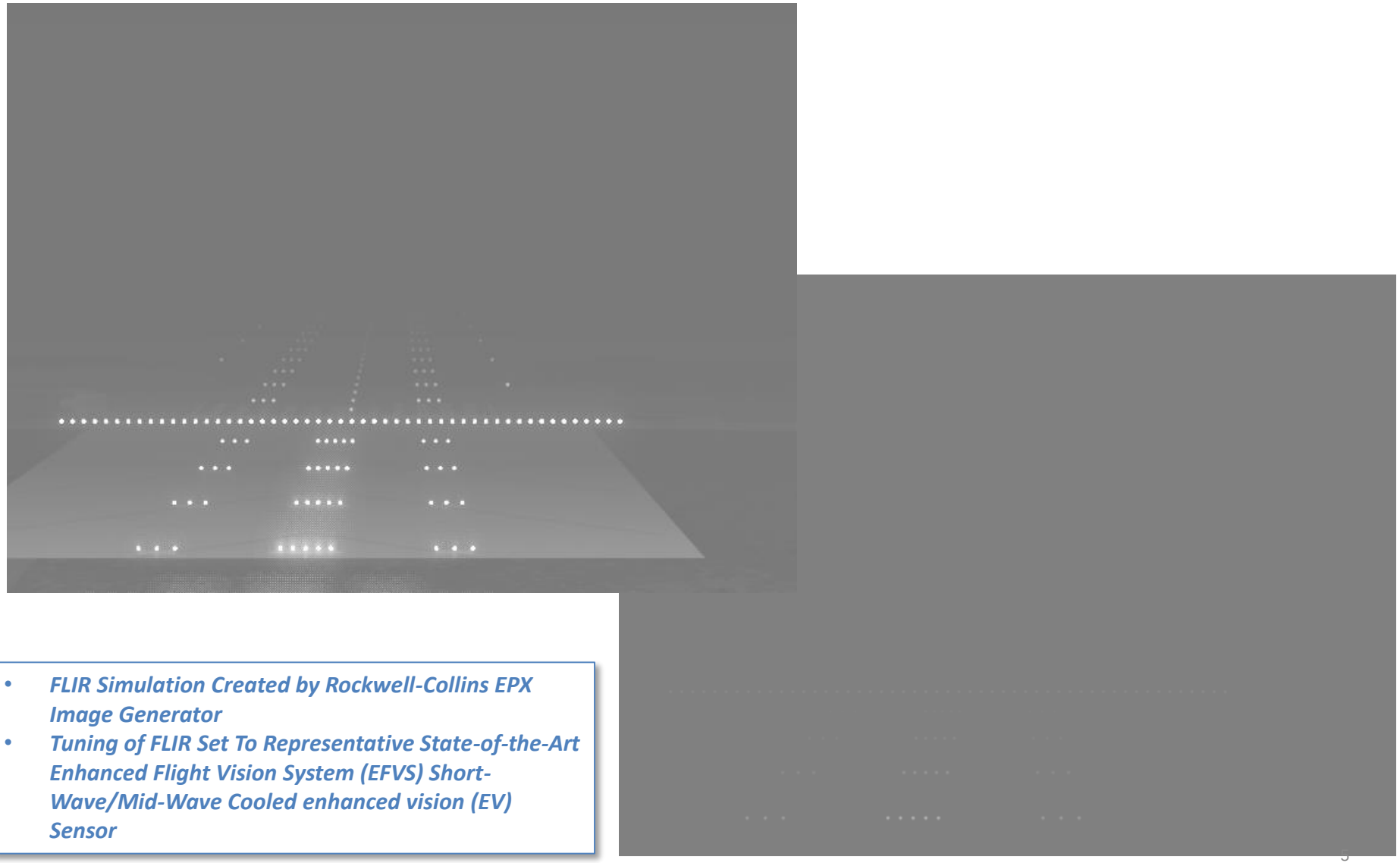
MMWR At 100 ft height above threshold (HAT) in 300 ft RVR conditions



Physics-based MMWR Simulation Developed By NASA LaRC

Simulated FLIR Imagery Example

FLIR At 100 ft HAT, in 700 ft and 300 ft RVR conditions



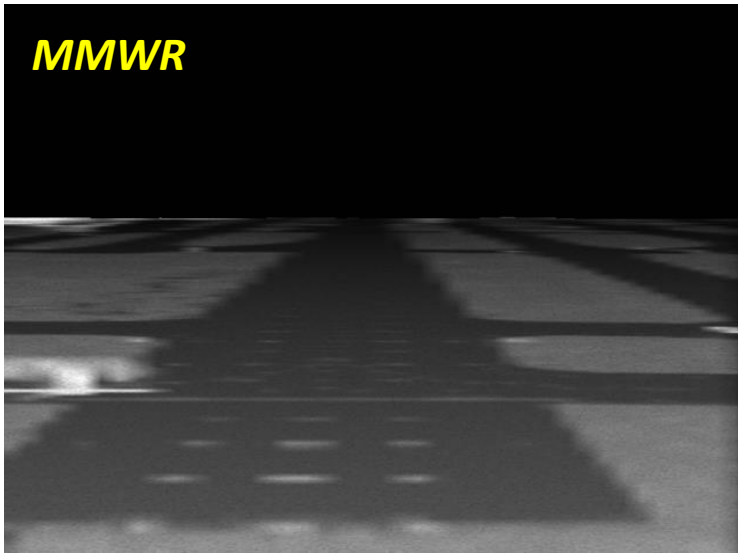
- *FLIR Simulation Created by Rockwell-Collins EPX Image Generator*
- *Tuning of FLIR Set To Representative State-of-the-Art Enhanced Flight Vision System (EFVS) Short-Wave/Mid-Wave Cooled enhanced vision (EV) Sensor*

Blending / Combining Sensor Concepts

Create a Optimal Single Image
Using Disparate Image Sources
Extract the Pertinent Information From Each Source
Without Degradation (Loss of Contrast, Distortion, etc.)
At Real-Time Rates (60 frames/sec)

- **Pixel-Averaging with Adaptive Contrast**
  - Direct Implementation using Existing Imaging Software Libraries
  - Amenable to Hardware Acceleration for Real-time Performance
  - Recovers Contrast Loss Comparable to More Extensive Methods
  - However, Some Contrast Loss Across Entire Image
- **Slant Range**
  - Use "Knowledge" of Sensors and Atmospheric Attenuation To Optimize Fusion (i.e., Minimize Contrast Loss)
  - Essentially No Contrast Loss in Single Source Areas; Contrast Identical to Pixel-Averaging Method in Dual Source Areas
  - Notable Seams in Imagery; Seams Positioned In Real-time

Blending MMWR/FLIR with Contrast Enhancement



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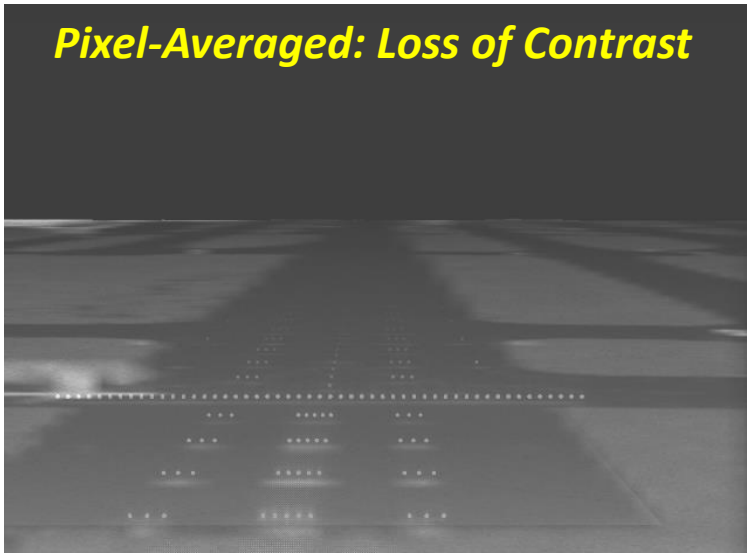
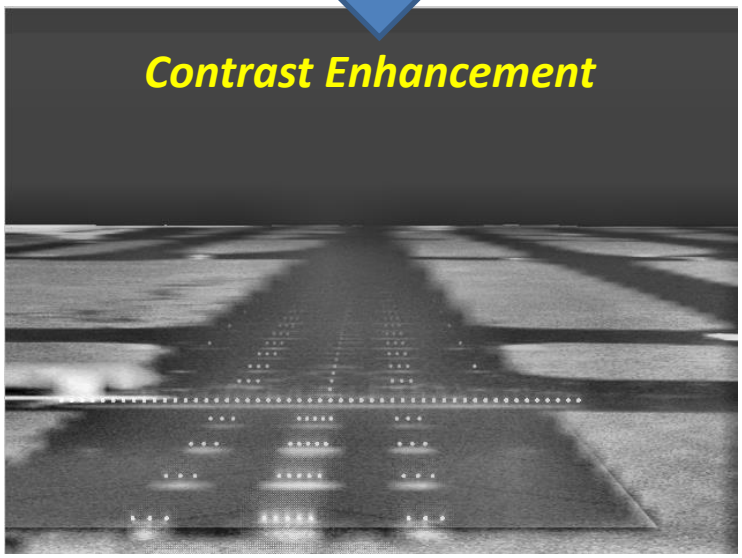
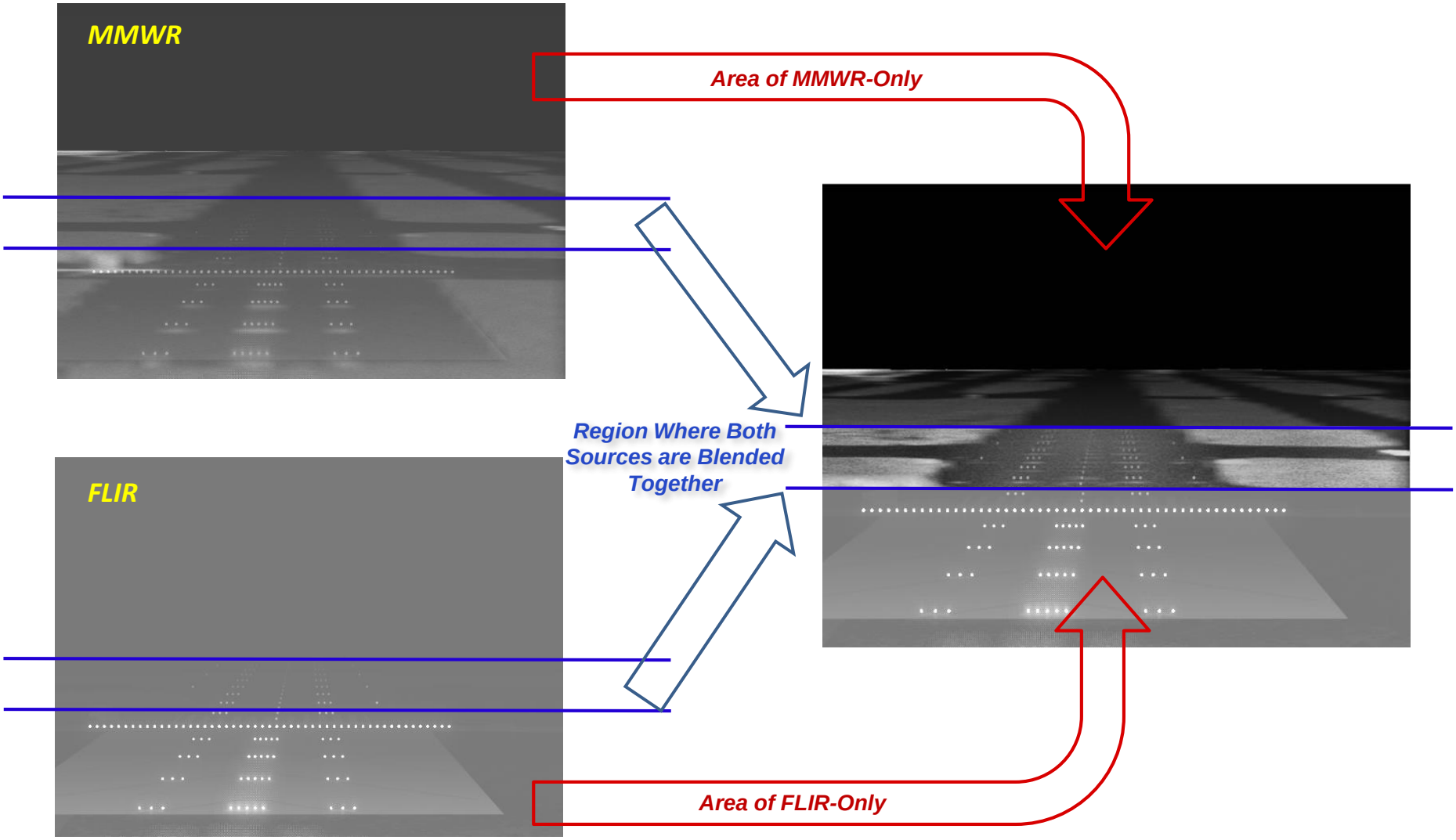




Slant Range Concept

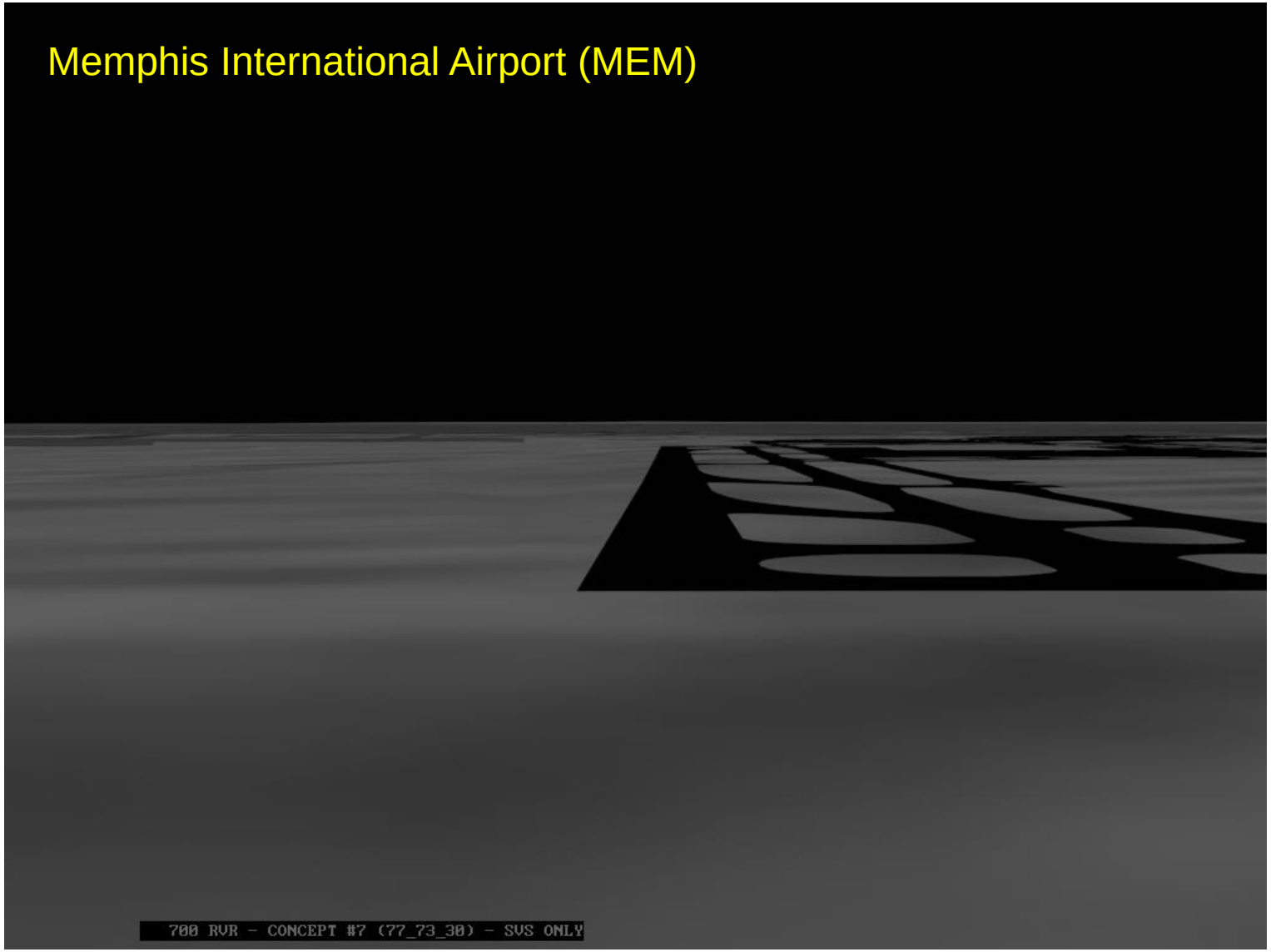


Combined Vision System (SVS+ EFVS) HUD Concepts

- Explore methods of adding Synthetic Vision System (SVS) to dual sensor EFVS for visual momentum
  - SVS and Blended MMWR/FLIR Combined Vision System (CVS)
  - SVS with Timed Insertion of Blended MMWR/FLIR CVS
  - Slant Range of SVS/MMWR/FLIR CVS

Test <u>complementary use of SVS</u> which is unaffected by weather or time of day <u>and EV Sensors</u> which offer real-time imaging detection of objects not in SV database

Synthetic Vision System (SVS) Imagery



SVS & Dual Sensor EFVS – Combined Vision System

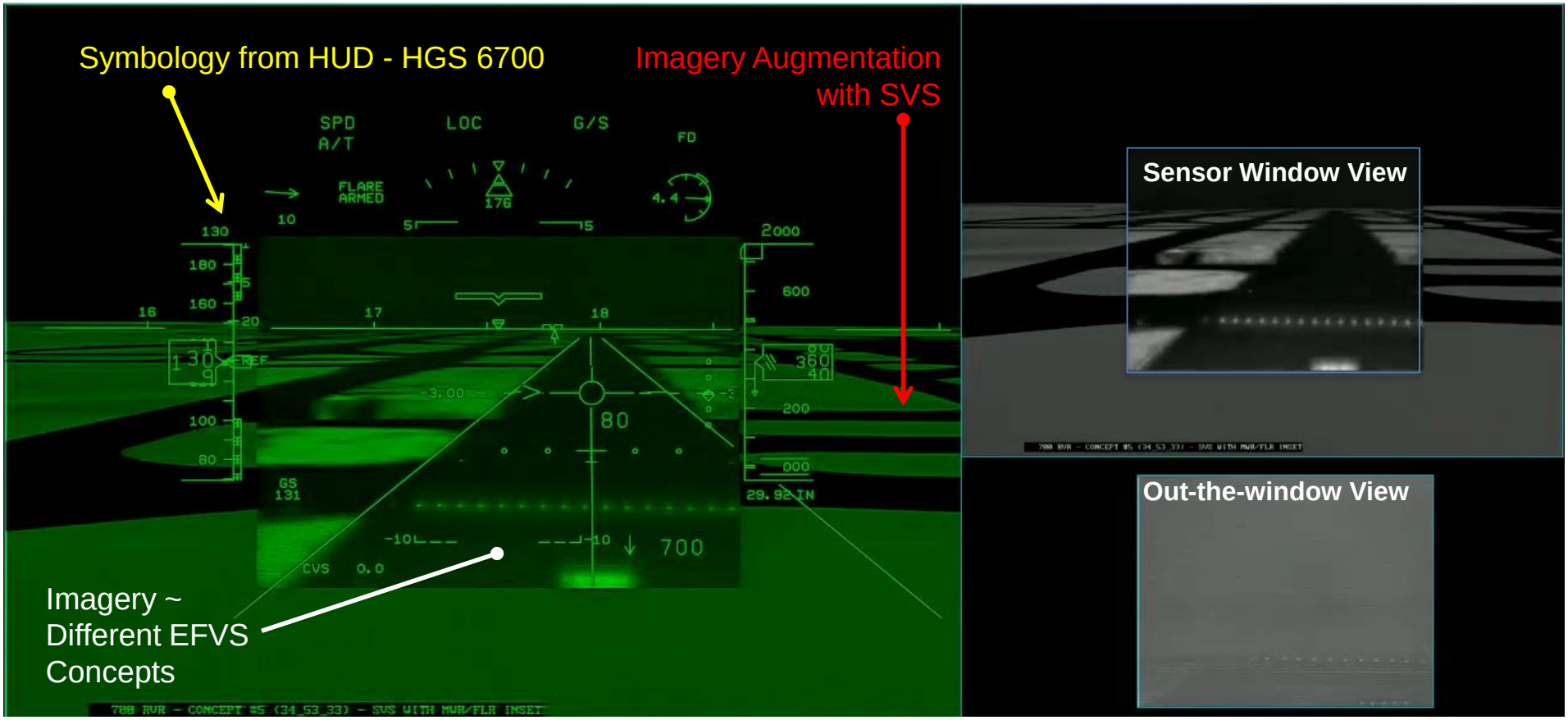
Enhanced Vision (MMWR/FLIR) Sensor Window (15 deg Vertical x 20 deg Horizontal)

- Left picture with Blended EFVS Concept
- Right picture with Slant Range EFVS Concept

SVS outside of sensor window

- Fills available HUD Field-of-View

Enhanced Vision and Natural Vision – 700 RVR



Nominal Approach Matrix

		Dual HUD Concepts						
	Vis Level (ft)	Conv HUD	FLIR EFVS	Blended EFVS	Slant Range EFVS	SVS and Blended EFVS	SVS with Timed Insertion of Blended EFVS	Slant Range SVS/MMWR/FLIR
Without TDZ/CL Lights	1800	✓	▮				▮	
	1000		✓	✓	✓			
	700		▮	✓	✓	✓	✓▮	✓
	300		▮	✓	✓	✓	✓	✓
With TDZ/CL Lights	700			✓	✓		▮	
	300			✓	✓		▮	

- *Operational Baselines for Comparison*
- *Presence/ Absence of TDZ/CL Lights*
- *Testing Effects of Adding SVS Imagery*

Nominal Departure Matrix

		Dual HUD Concepts				
	Visibility Level (ft)	Conv HUD	Blended EFVS	Slant Range EFVS	SVS and Blended EFVS	Slant Range SVS/MMWR/FLIR
Without Centerline Lights	300	✓	✓	✓	✓	✓
With Centerline Lights	300	✓				

- *Testing for Possible EFVS Operational Credit*
- *Operational Baselines for Comparison*