Sensor-Based Technology for Rotary Wing Aircraft in Low Visibility Environments

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Approved for Public Release
April 4, 2017 Oslo Norway; April 6, 2017 Braunschweig Germany;
April 24, 2017 Ft. Rucker, Alabama USA

Agenda

- Operational Problem
- Sensor Technology Efforts for DVE
- Conclusions

Operational Problem Statement

Operational Problem:

Helicopter mishaps due to Degraded Visual Environments (DVE) including brownout, wire/object strike, and Controlled Flight Into Terrain (CFIT)

Impact:

During OEF/OIF there were 266 aircraft lost and 329 fatalities from combat/non-hostile and non-combat mishaps compared to 65 aircraft and 140 fatalities from combat/hostile action

Supporting Evidence*:

80% of all helicopter mishaps are due to non-hostile action
58% (of 80%) losses and 52% (of 80%) fatalities due to DVE, CFIT, wire/object strike, dynamic rollover, or hard landing

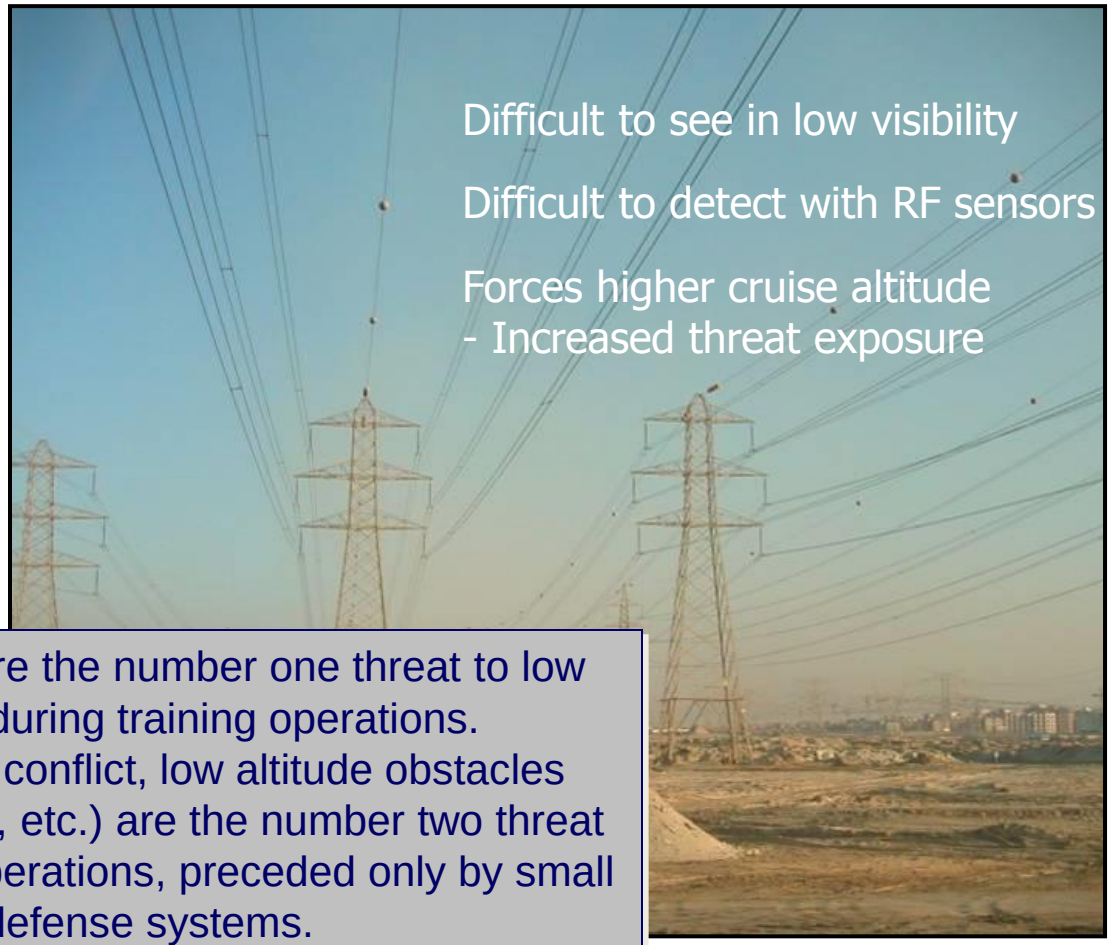
Resource Management Directive 700:

Directs services to acquire Helicopter Terrain Awareness and Warning System (HTAWS) capability for all fleet helicopters as solution to CFIT

* Rotorcraft Survivability Study, Joint Aircraft Survivability Program Office, 2009

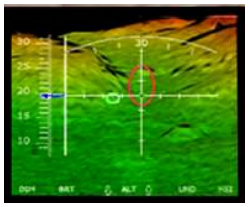
Cable Warning/Obstacle Avoidance

Additional Operational Need



Wire strikes are the number one threat to low flying aircraft during training operations. During armed conflict, low altitude obstacles (wires, towers, etc.) are the number two threat to low level operations, preceded only by small arms and air defense systems.

LZ Situation Awareness S&T Programs

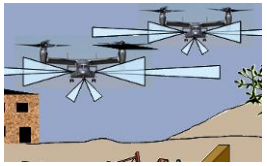


HALS – Helicopter Autonomous Landing System

- US Army UH-60 flight demonstration Program (Sierra Nevada Corp)
- MMW Radar (94 GHz) with added cockpit display & pilot symbology
- Designed to support brownout landing and TF/TA requirements

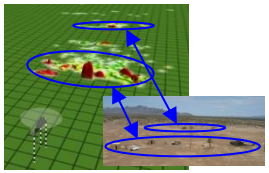
Sandblaster

- DARPA UH-60M centric demonstration program (Sikorsky)
- Advanced flight controls to aid aircraft guidance and pilot workload
- Open system architecture with evidence grid processing and E/SVS displays, with demonstration of MMW Radar sensor



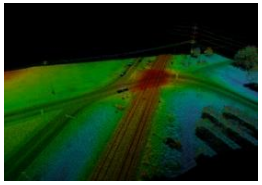
Electronic Bumper

- AF Non-Imaging RF for 360 deg situation awareness
- AF and Navy Phase II SBIRs on contract



BLAST – Brownout Landing Aid System Technology

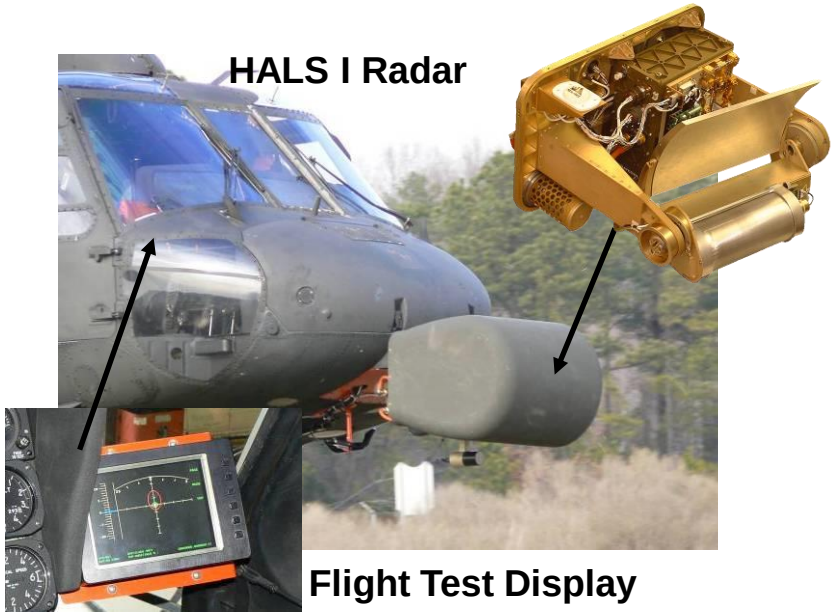
- BAE and AF/DARPA lightweight radar solution
- Risk reduction accomplished through flight data collection



3D-LZ

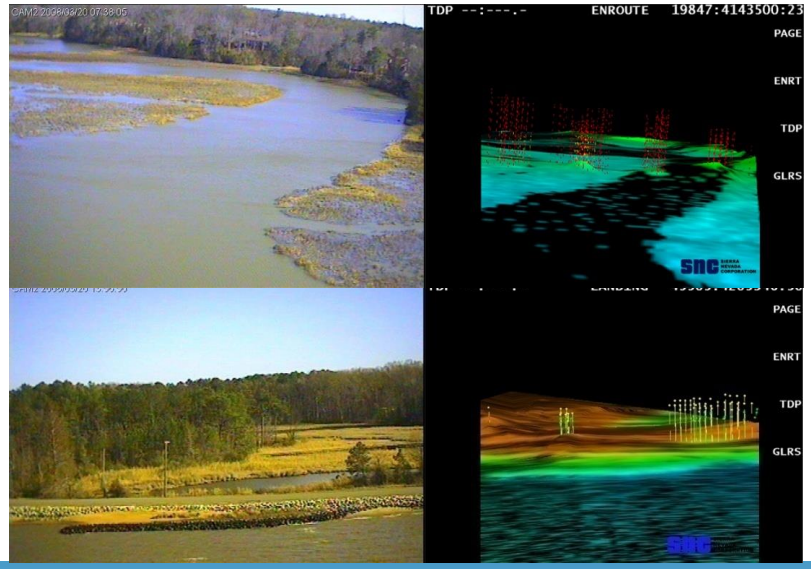
- AF high performance imaging ladar (HN Burns Eng)
- Joint service flight test – full brownout landings in proximity to obstacles
- Designed to support brownout landing and CW/OA requirements

Helicopter Autonomous Landing System (HALS)

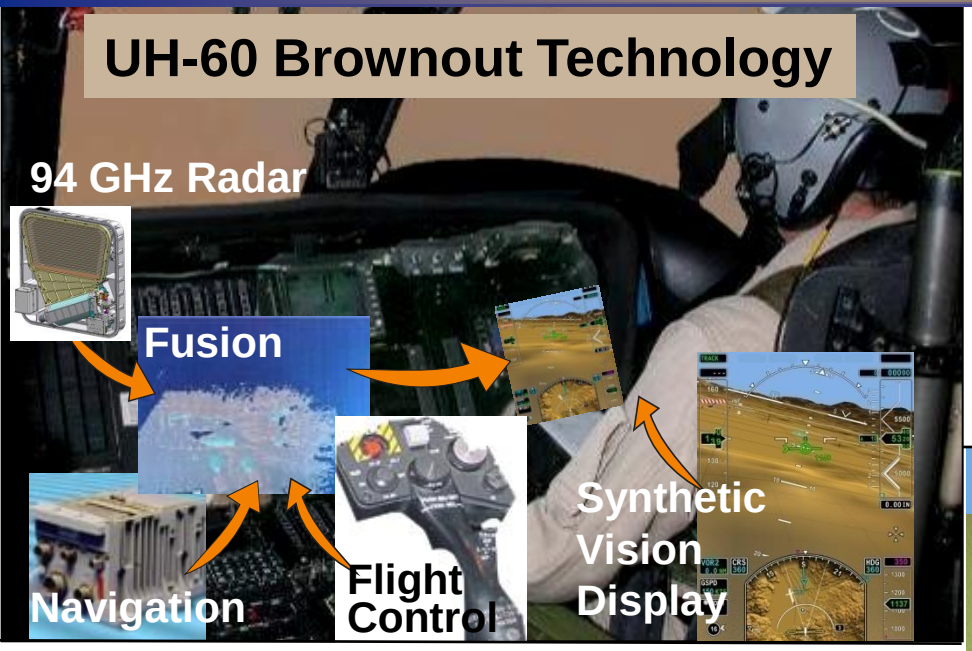


Technologies

- Radar
  - 3D scan, 1 deg pencil beam, 94 GHz pulsed radar
  - 30° x 30° field-of-view
  - Gimbaled antenna for enroute, landing, hover, and sling load capability
- Perspective display
  - "First return" signal processing, terrain mapping, and 3D-display



UH-60 Brownout Technology



Four Pillar Design Approach

- Advanced flight control
  - Flight Director
  - Predictive flight path guidance
- Enhanced synthetic vision
  - Perspective synthetic imagery
  - Enhanced symbology
- See-through sensing
  - 94 Ghz MMW radar
- Knowledge fusion
  - Sensor-driven external evidence grid
  - On-board terrain map, obstacle map
  - Open Architecture

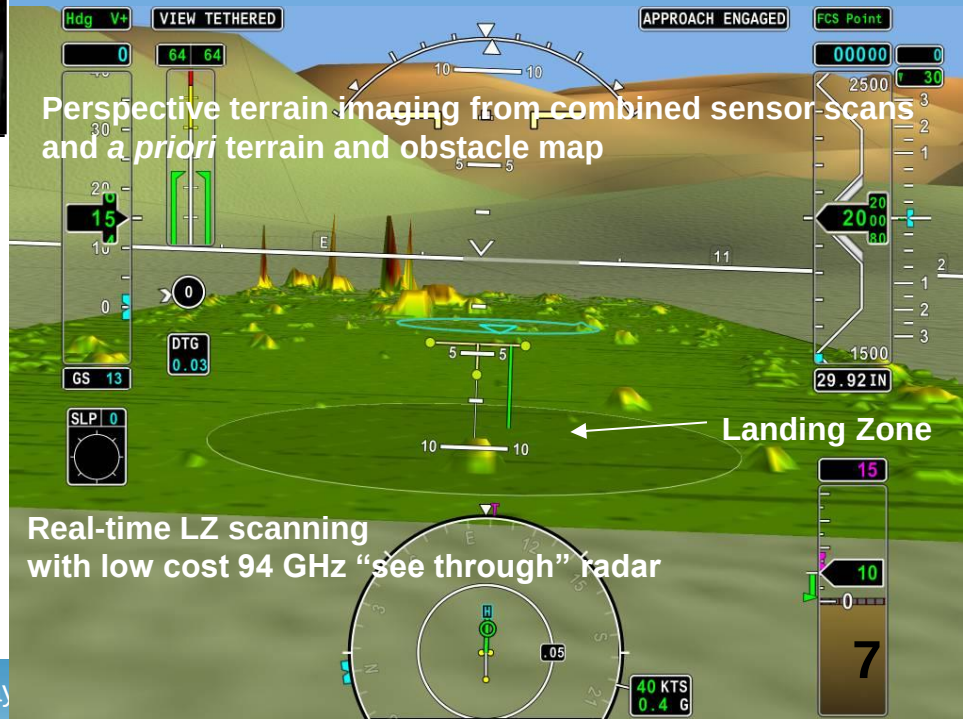
DARPA Sandblaster

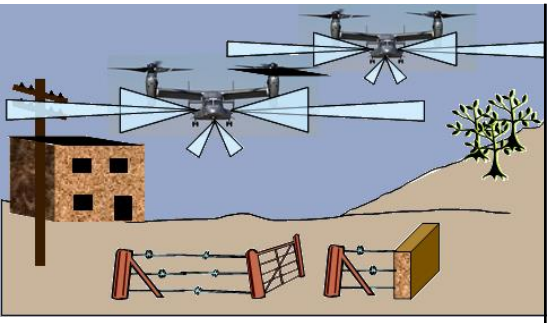
FY06 FY07 FY08 FY09

DARPA Sandblaster

AFDD "RASCAL" Flight Test (6)

Capability – Integrated Brownout Solution



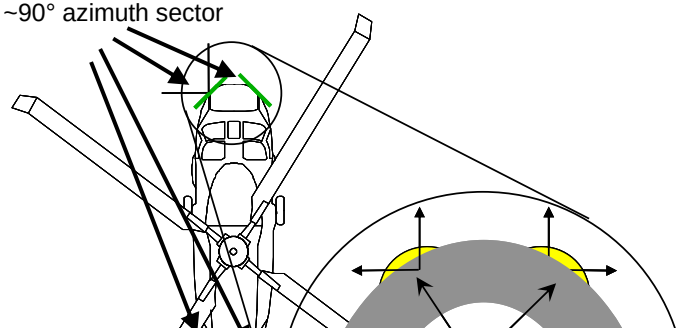


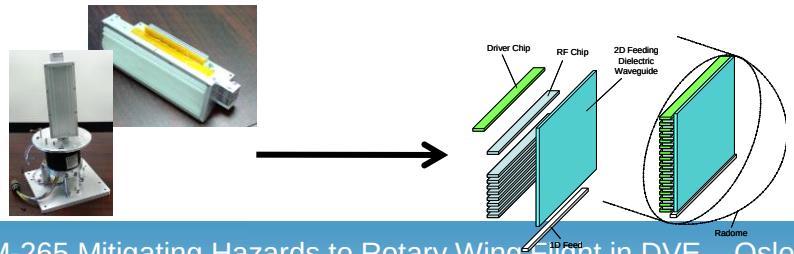
"Electronic Bumper" Radar

Sensor Technologies

- **Electronically Reconfigurable Antenna (ERA)**

each unit covers
~90° azimuth sector

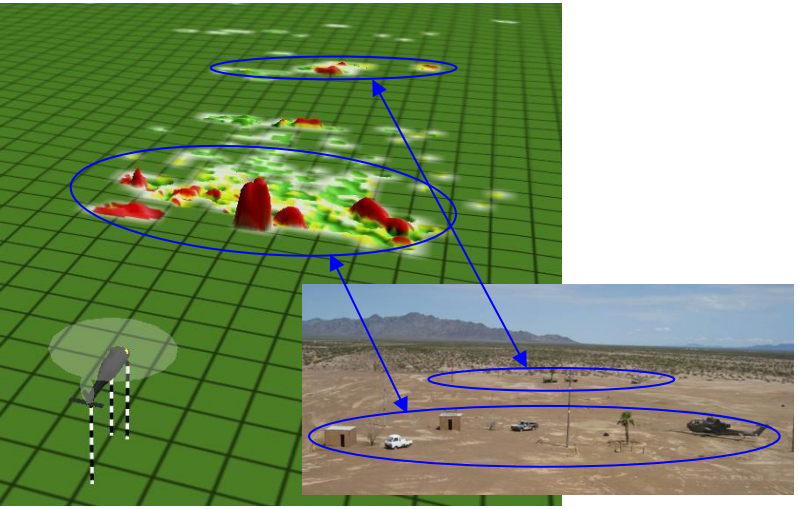




Capability

- Low cost, safety-of-flight landing aid
  - Goal: 10 lb and $10K /ship set!
  - Hemispherical coverage
  - Detection of stationary/moving obstacles/aircraft
- Cable Warning / Obstacle Avoidance (CW/OA) during low level penetration
- Goal of common processing architecture for Electronic Bumper, CW/OA, and RadAlt
- Low cost "strap-on" kit for legacy aircraft – integrated solution with ladar for advanced aircraft

"Rubber Band" Display Concept



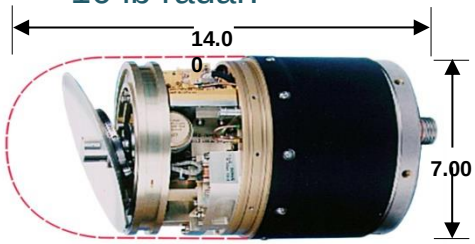
"BLAST" Radar

Sensor Technologies

- Radar
  - 1 deg pencil beam, 94 GHz FMCW radar
  - 2D mechanical scan (+/- 34º both axes)
  - Circular polarization
  - Dual axis Monopulse
    - -- 10:1 improved angular accuracy with 15 dB SNR!
    - -- Spatial filtering of side-lobe returns
  - Scan pattern optimized for target area/LZ
- Perspective display
  - "Valley View" Terrain Rendering
    - -- Good definition of obstacle shapes

Capability

- Lightweight, safety-of-flight landing aid
  - 10 lb radar!



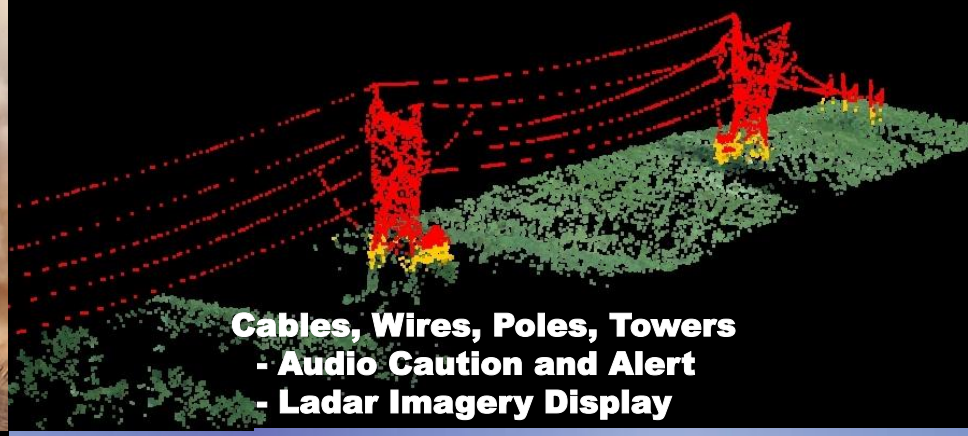
- Obstacle detection and terrain measurement during approach to landing
- Cable Warning / Obstacle Avoidance (CW/OA) during low level penetration

3D-LZ OV-1

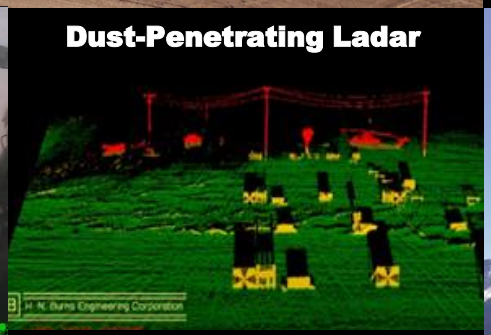
Brownout

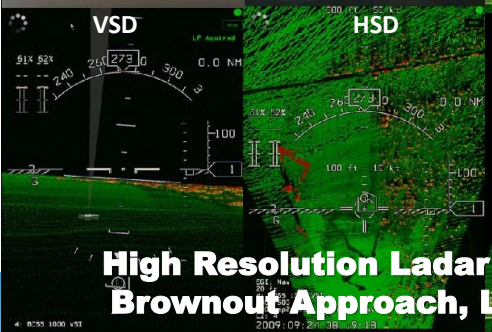
BOSS-LG Landing Guidance
- Manual Approach and Landing
- Fully Coupled Approach and Landing

Cable Warning/ Obstacle Avoidance



Cables, Wires, Poles, Towers
- Audio Caution and Alert
- Ladar Imagery Display



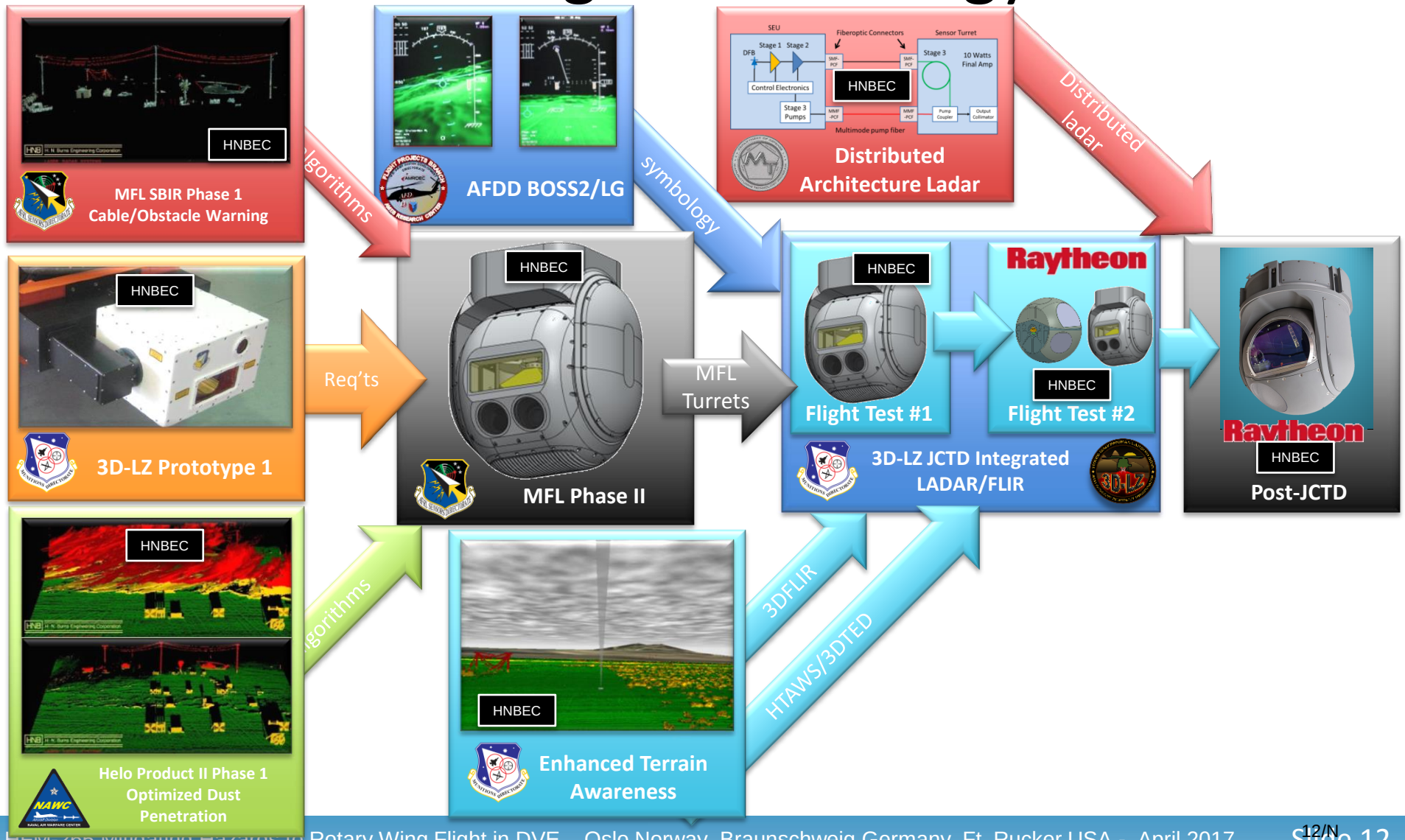


High Resolution Ladar Imagery Throughout Brownout Approach, Landing, And Takeoff

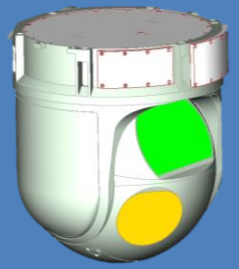
Helicopter Terrain Awareness and Warning System (HTAWS)

Ladar Imagery and DTED Integration
- Audio Caution and Alert
- Fused Ladar Imagery and DTED Display

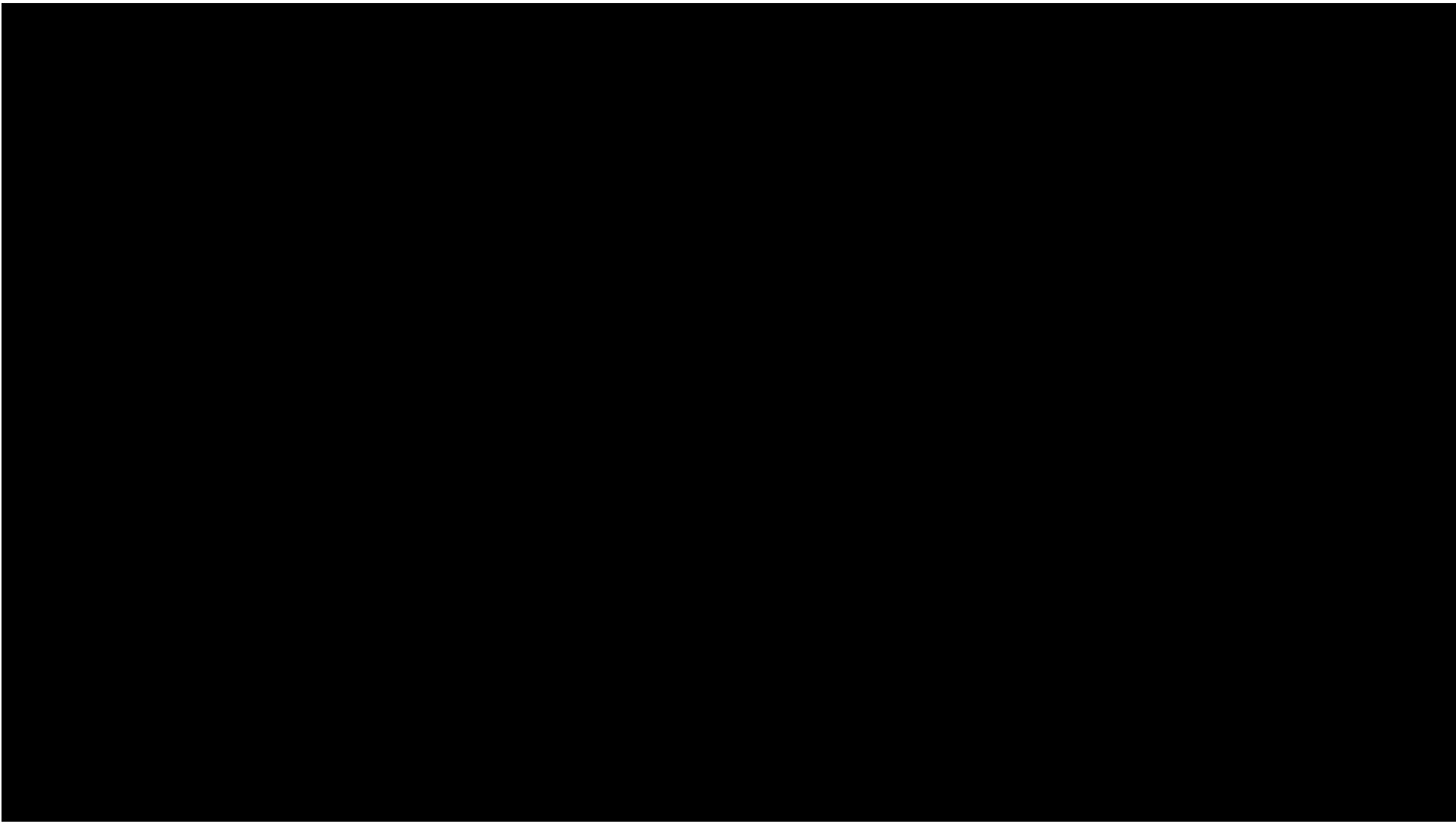
Leveraged Technology



Ladar Functionality Comparison

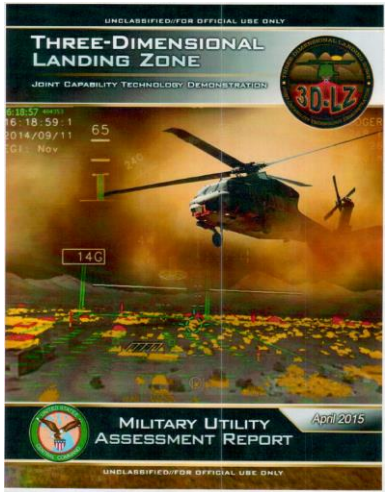
MFL (2013)	MFL+ (2014)	Q-29 LADAR (2016)
		
Real-time geo-referenced imagery with colored obstacles		
Real-time dust rejection		
True reflectance colored imagery		
Limited dust penetration	Enhanced dust penetration	
Limited wire detection	Real-time wire/obstacle detection	
Virtual runway	Full 3D Landing Pad	
Wingman view	Multiple selectable views	
	Helicopter Terrain Awareness and Warning System	
	Integrated Digital Terrain Elevation Data	

2014 MUA Video



Military Utility Assessment Report

- **CENTCOM released the MUA report in April 2015**



- **COI 1: Does 3D-LZ improve an aircrew's ability to execute landing zone operations in a degraded visual environment?**
- **COI 2: Does 3D-LZ improve an aircrew's ability to detect and avoid hazards during cruise operations?**
- **COI 3: Can the 3D-LZ solution integrate with existing flight operations?**

USCENTCOM Military Utility Rating Scale

- ▲ **Demonstrated military utility; minor changes are required.**
- ▲ **Demonstrated limited military utility; moderate changes are required.**
- ▼ **No military utility; major changes are required.**

- **No quick-look and no draft was provided. No coordination of the report was conducted.**
- **Findings directly contradict the observations of the evaluation pilots**

Pilot Feedback to 3D-LZ/BOSS

- When asked how does 3D-LZ compare to traditional brownout landings, he said *It's definitely a lot safer. It was outright dangerous what we have done. I never felt unsafe. This is way better…**LADAR is the best I've ever seen.** The obstacles are accurate. Compared to everything I've seen, the LADAR is pretty great.* – Maj Joe Davis, US Army 3D-LZ MUA Evaluation Pilot (9 SEP 14 Post-Mission Brief)
- *3D-LZ really simplifies what the pilot has to think about. **Everything is there to give the pilot the situational awareness he needs**. The LADAR is giving you pretty good imagery of what's out in front.* – CW4 Todd Buller, US Army 3D-LZ MUA Evaluation Pilot (11 SEP 14 Post-Mission Brief)
- When asked if the system is better than what we have now he responded, "Absolutely. **I'll take it right now**." - Maj Joe Davis, US Army 3D-LZ MUA Evaluation Pilot (12 SEP 14 Post-Mission Brief)
- *I like all four systems [BOSS, HTAWS, LADAR, MCLAWS]. All four combined make **an amazing product. It's revolutionary**. The new technology is amazing.* – Maj Eric Vanley, USAF HH-60G pilot, 3D-LZ MUA Evaluation Pilot (20 SEP 14 Post-Mission Brief)
- *Three systems [BOSS, HTAWS, LADAR] work very well together. Performance like that in a heinous brownout speaks volumes and builds confidence. LADAR stuff I really enjoy. **Combining the three is a game changer for surviving**. I had a challenging week but it was a blast.* – Maj Tom Harley, USAF HH-60G pilot, 3D-LZ MUA Evaluation Pilot (20 SEP 14 Post-Mission Brief)
- *The 3DLZ system **significantly increases safety and situational awareness** while conducting mission representative approaches to a hover and/or landing in moderate to severe brownout conditions*. - Maj Eric Vanley, USAF HH-60G pilot, 3D-LZ MUA Evaluation Pilot (trip report)

FLIR/LADAR Q-29 Turret

- **JCTD advanced the integrated FLIR/LADAR design to CDR**
- **Post-JCTD program with Raytheon fabricated the modified Q-29 turret to marry with the HNBEC LADAR sensor head**
- **FLIR portion of the turret contains an SLA FLIR assembly**
- **Raytheon/HNBEC tour of turret**

Conclusions

Many sensor technologies exist or are being developed for DVE

- All sensors have their own strengths and weaknesses
  - Optimal solution will vary with mission/application
- US Air Force needs high resolution capability to meet mission requirements (wire/small obstruction detection)
  - The high performance LADAR sensor meets these requirements
- MUA report determined the 3D-LZ system has no military utility
  - This is in stark contrast to the evaluation pilot performance and subjective feedback