Spatial Disorientation, Army Helicopter Crash Case Reports, and Potential Countermeasures

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UH-60 Mishap #1

- Multi-ship training flight
- Light rain, mist
- Moon below horizon
- Night vision goggles
- Flight of two aircraft entered orbit while waiting to enter gunnery position at range

US Army Photo

UH-60 Mishap #1 (con't)

- On the second turn in holding, #2 rolled right and impacted the ground nearly inverted
- All 5 crew perished

UH-60 - Mishap #2

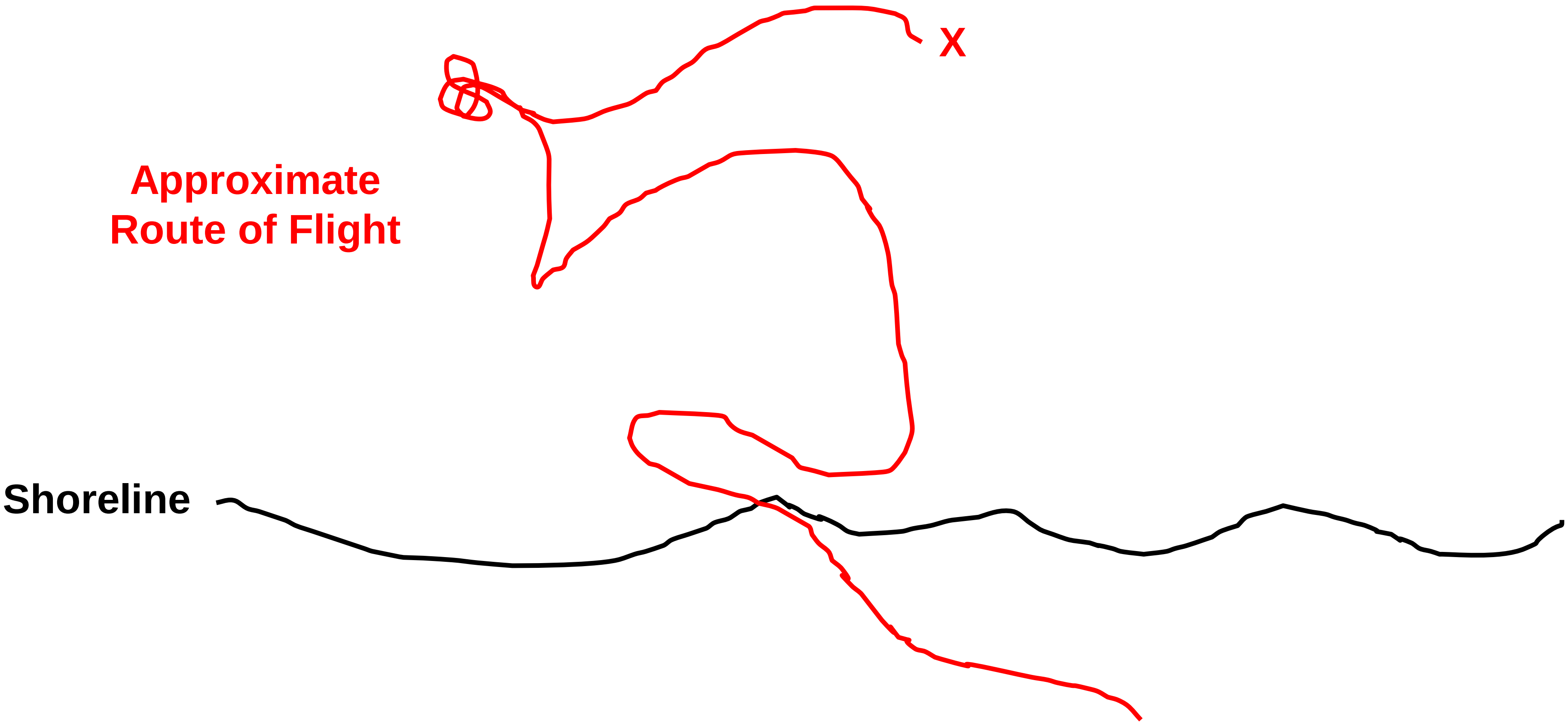
- Two-ship training flight
- Thick sea fog offshore
- Weather worse than briefed
- Night vision goggles

UH-60 - Mishap #2 (con't)

- One aircraft turned back
- Flight became erratic
- Crashed into water
- All crew and pax killed

www.washingtonpost.com

UH-60 - Mishap #2 (con't)



"Formation flying in adverse weather under NVG is the most likely of all situations to produce disorientation"

-Ercoline, et al., 2000

Why is formation flight w NVGs disorienting?

- Pilots must rely on lead acft for orientation
- Tend to rely on vestibular cues
- Poor instrument cross-check

Common Elements in These Accidents

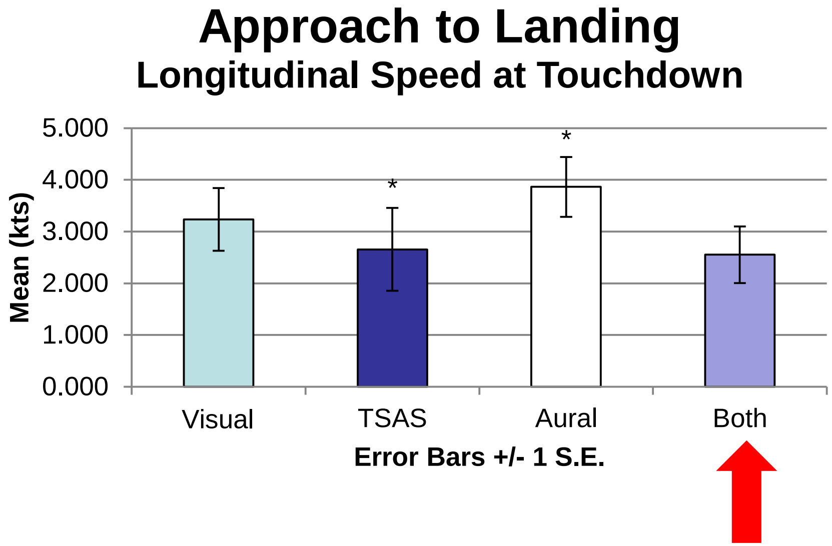
Two Points for Discussion

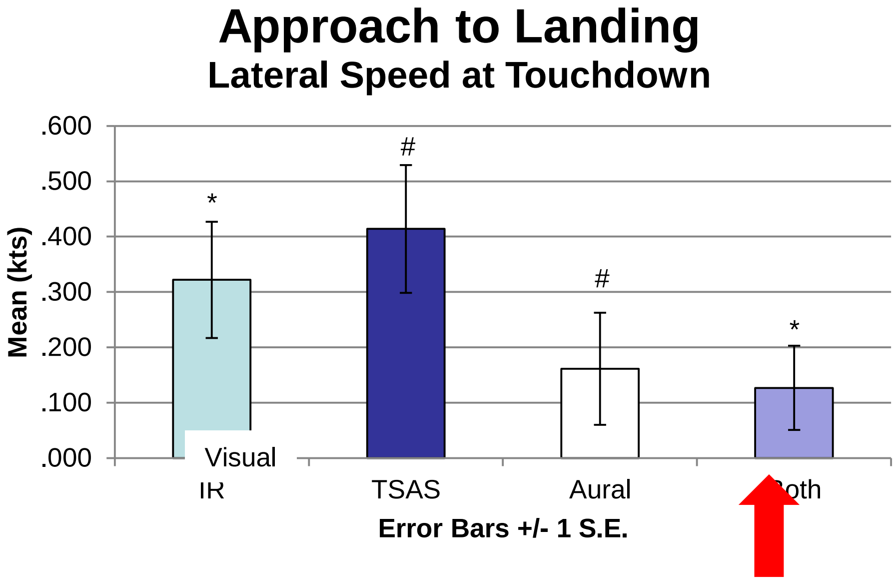
- Reliance on pilot to sense orientation and fix
- Emphasis on vision channel for orientation cues
  - Visual inputs come from entire 3D space
    - Sound comes from localized points
  - Central vision provides high resolution
    - Order of magnitude better than auditory
  - Visual inputs do not habituate
    - Unlike vestibular

But the vision channel can be saturated…

Complementary Cueing
"Multisensory"

Tactile Cues





IN THE AIR

TSAS

Workload Reduction via the Sense of Touch

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A recent accident illustrates that no aviation community is safe from spatial disorientation (SD) accidents. Unfortunately, many top-shelf pilots have fallen victim to this loss of reference, and statistics suggest more mishaps will occur in the future.

In today's Army aviation community, there is an added emphasis on night flying, all-weather capability and low-altitude missions, which are all scenarios that increase SD. Aviation SD mishaps increase dramatically in times of conflict. The sharp spike in SD mishaps during Operation Desert Storm recurred with the onset of wars in Iraq and Afghanistan. These theaters of engagement are associated with conditions of degraded visual environments (DVE), primarily brownout. However, SD is also a leading cause of noncombat aircrew fatalities. The costs of SD mishaps include mission failure, the impairment of mission effectiveness, the monetary value of aircraft/equipment lost and fatalities and disabilities.

Pilot workload is a factor closely associated with SD under conditions of DVE. In contrast with the older training and legacy aircraft, new helicopters and updated legacy aircraft possess many more sensors to provide pilots with the necessary information to land under DVE conditions. The problem is, all this information is shown on multifunction displays to an already overloaded pilot. As many pilots have noted, there is often simply too much information to assimilate under the highly dynamic conditions of DVE. Many aircraft manufacturers and research groups are actively developing visual displays to present that information in a format that can be used by pilots.

Unless the pilot is provided sufficient flight parameter information intuitively, the only solution would be to remove the pilot from the loop and use automated procedures to land under brownout or other DVE conditions.

The U.S. Army Aeromedical Research Laboratory (USAARL) is developing the Tactile Situational Awareness System (TSAS) to use the sense of touch to provide spatial orientation and situational awareness information to the pilot. The system consists of a matrix of tactile stimulators (tactors) embedded into a lightweight cooling garment that maintains the tactors in close proximity to the torso.

Using data from existing aircraft sensors or a custom self-contained sensor package for non-bus aircraft, TSAS obtains the aircraft position, velocity, attitude, altitude and threat information. Similar to pages of a multifunction display, TSAS has the following modes for displaying critical information during various phases of flight:

- In the hover mode, TSAS provides horizontal drift velocity and vertical altitude information.
- In the forward flight mode, TSAS provides attitude and altitude cueing. It can also provide navigational cueing in conjunction with existing navigation displays.
- In the approach mode, TSAS provides glide slope and course information, as well as airspeed deceleration information.
- In the threat mode, TSAS provides the threat direction and general distance to the pilot without the pilot actually having "eyes-on" information. As the pilot turns and maneuvers the aircraft, the tactors continuously provide threat relative position and distance information. This mode of operation permits the pilot to fly with eyes outside the aircraft in a hostile environment.

The TSAS has been flight tested in the UH-60A, MH-53M and Canadian Bell 205 aircraft, as well as CV-22, MH-47, MH-53M and MH-60K simulators. Pilots participating in the simulator and in-flight testing agree that TSAS reduces pilot workload and increases flight safety by decreasing instrument scanning requirements during degraded visual conditions. Both qualitative and subjective data demonstrate that hover performance improved with the use of TSAS.

The TSAS is intuitive and quick for pilots to learn. Within 10 minutes, pilots could hover without the aid of visual instruments.

A USAARL scientist recently conducted a study demonstrating that fatigued pilots perform considerably better when TSAS is available to provide orientation cues. Since fatigue is a contributing factor in many SD-related mishaps, TSAS may provide a countermeasure to reduce mishaps.

With the widespread use of night vision goggles, Army aviation can justifiably claim to "own the night." New technologies such as TSAS, in conjunction with recently developed sensors, will help provide Army pilots with the ability to fly safely under conditions of DVE. «

12 August 2009 KNOWLEDGE https://safety.army.mil

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Should we rely on pilots to sense and fix themselves?

- We do…

We train our pilots to avoid and cope with disorientation…

Flightfax

June 2017

Mishap Review: UH-60L Spatial Disorientation

While conducting a training mission, the pilot, in a right-hand orbit, lost spatial awareness and placed the aircraft in an unrecoverable attitude. The aircraft impacted the ground inverted, fatally injuring the five crew members. The aircraft was destroyed.

History of Flight.

The mission was a single /multi-ship training flight to accomplish day, night, and NVG RL progression training for the newly assigned pilot (PI) and progression for a CE and door gunner. Weather reported at the time of the accident was 5-knot winds from the west, light rain with mist, ceilings at 7,000' feet and visibility 9,000 meters. The moon was below the horizon for the time period of the training resulting in a "red illum" condition. Location of the NVG multi-aircraft portion of the training was over an agrarian area with limited cultural lighting.

The accident crew started their duty day at 1500L. The aircraft departed at approximately 1700L conducting traffic pattern work at the airfield. The day portion of training was completed at 1830L. At 2030 the accident crew again departed for the NVG portion of the training flight. Following one hour of training at the airfield, the accident aircraft linked up with a sister ship to complete some NVG multi-aircraft training and door gunner iterations.

The flight of two departed the airfield en route to the local test fire area to fire the door guns with the accident aircraft in staggered left formation. Nearing the range the flight entered a right orbit holding pattern to await departure of two aircraft currently occupying the range firing .50 cal. and illumination rockets. On the second turn in holding, just after an illumination round had extinguished, Chalk 2 entered a rapid uncorrected right roll impacting the ground nearly inverted. The impact destroyed the aircraft and fatally injured the five crewmembers.

Crewmember Experience.

The IP had 1,250 total hours and 1,170 in the UH-60, with 285 as an IP and 385 NVG hours. The PI had 430 total hours with 350 in the UH-60 and 40 NVG. The FI had 620 hours total with 240 NVG. The CE undergoing progression had 11 hours total and two hours NVG. The OR had records indicating 97 hours total with 38 hours NVG.

Commentary.

According to experts in spatial disorientation (Ercoline, Devilbliss, Yauch, and Brown), formation flying in adverse weather conditions (low visibility or zero illum) under NVG is the most likely of all situations to produce disorientation. The three reasons why are: (1) pilots must rely on the lead aircraft for orientation information, (2) the unavailability of visual cues means the pilots rely on vestibular cues which are often unreliable in flight, and (3) the extended period of time in which instrument cross check is broken. Inexperience also plays a factor in an increased risk for SD. Inexperienced pilots, particularly those lacking in hood and weather time, break down their scan more readily and try to rely on their vestibular cues.

Leaders and those in the mission briefing chain must ensure proper risk assessments are completed accurately and match the experience of the crew and tasks being completed with the conditions being encountered to avoid placing crewmembers in a situation beyond experience and readiness levels. ■

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Should we rely on pilots to sense and fix themselves?

- Unrecognized SD accounts for most accidents and fatalities (although “recognized” is more frequent)

- 54.9% of fighter ejections are “delayed” (Miles, 2015)

Should we rely on pilots to sense and fix themselves?

- Automatic Ground Collision Avoidance System (Auto-GCAS)
  - Aimed at reducing CFIT accidents by 90%
  - 4 confirmed saves (Oct 2016)

https://youtu.be/WkZGL7RQBVw

Should we rely on pilots to sense and fix themselves?

- In one of the accidents presented, autopilot was engaged but too late
- Helicopters lack true auto-recovery systems
  - Autohover - Autopilot
- When to give up control?
  - To copilot
  - To automation

TRUST?

Adaptive Automation

3 main approaches

- Critical event strategy
  – Assumes workload goes high when critical events occur
- Performance measurement strategy
  – Examines operator performance and infers workload
- Neurophysiological measurement strategy
  – Preferred but most difficult
  – EEG, fNIR, fMRI, ECG, GSR

Conclusions

- Disorientation remains a killer
- Augmenting the visual sense can preserve orientation
- Pilots won’t fix a problem they don’t notice
- Assisting the pilot with technology can save lives
- Research needed to mature the technologies

Questions?