

Future Aviation Safety Risk Tall Poles

A Qualitative Study

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YEARS
1970 - 2020



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Volpe Center

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Outline

- Scope and Objectives
- Future Safety Risk “Tall Poles”
 - Existing Risks Expected to Continue
 - Emerging Threats
- Impacts of COVID-19 Pandemic
- Questions

Study Scope and Objectives

- Scope

- This report is the outcome of a NASA initiative that began in 2010 to periodically identify and assess developments in the aviation community with regard to safety trends and issues and emerging areas of safety risk.
- The study is a compilation of information and opinions from multiple external sources and is not a definitive scientific study.

- Objectives

- Document the results of a high-level qualitative study to identify areas of future and emerging aviation safety risk and assess the potential impacts to the NAS of these risks.
- Changes in technology, aircraft fleet composition, and flight mission profiles, along with projected, increased traffic in the NAS result in the need for a new or updated examination of safety risks.

Future Aviation Safety Risk Tall Poles

- Existing – and Future – Safety Risks
 - Loss of Control Inflight
 - Runway Safety
 - Approach and Landing Accidents and Incidents
 - Flight Deck Automation – Complexity and Overreliance
- Emerging Threats
 - Mixed Fleet Equipage and Aircraft Performance Capabilities
 - Separation Management
 - Integration of Small Unmanned Aircraft Systems into the NAS
 - New Entrants in Civil Airspace
 - Cybersecurity
 - Pilot Demographics

Loss of Control Inflight

LOC-I Causes / Contributing Factors

- May result from upset condition due to hazardous weather (atmospheric turbulence, convective weather, icing), severe wake turbulence, system/component or flight control failure/malfunction, or loss of airplane state awareness.
- Loss of attitude awareness (spatial disorientation) – mismatch between the actual airplane attitude (pitch or bank angle or rate) and the attitude perceived by the pilot flying.
- Loss of energy awareness – characterized by a failure to monitor or understand energy state indications (combination of airspeed, altitude, vertical speed, thrust, and airplane configuration) and a resultant failure to accurately forecast the ability to maintain safe flight.

Technologies for Airplane State Awareness

- NASA research supports Commercial Aviation Safety Team (CAST) Airplane State Awareness Safety Enhancements
 - SE 200 - Design of Virtual Day / VMC Displays
 - SE 207 - Attitude and Energy State Awareness Technologies
 - SE 208 - Flight Deck Systems to Enhance Crew Awareness
 - SE 209 - Simulator Fidelity for Full Stall Recovery Training
 - SE 210 - Collection/Analysis of Flight Crew Performance Data
 - SE 211 - Training Methods and Scenarios for Attention Management

Runway Safety

Runway Incursions

- Common Contributing Factors
 - Weather / low visibility
 - Airport design
 - Multiple simultaneous lineups
 - Simultaneous use of intersecting runways
 - Late change to departure clearance
 - Pilot workload (after landing or before departure)
 - Controller workload

Runway Excursions

- Departing the end (overrun) or side (veer-off) during takeoff or landing
- Most common type of runway accident, though generally not fatal
- Contributing factors
 - Wet/contaminated runway
 - Adverse weather (heavy rain, tailwind, low visibility)
 - Loss of directional control (crosswind)
 - Unstable approach
 - Long landing or high touchdown speed
 - Mechanical failure
- Design mitigations for landing overruns

Wrong Surface Events

- Definition: When an aircraft lands or departs on the wrong runway, a taxiway, or at the wrong airport.
- Near catastrophic incident involving Air Canada 759 at SFO elevated this risk area to an FAA top priority.
- Airport geography/geometry, miscommunication, lack of familiarity, and expectation bias are common precursors.
- FAA is implementing the ASDE-X Taxiway Arrival Prediction (ATAP) enhancement.
 - Modification to ASDE-X system to detect, and issue alerts on, aircraft that are aligned with a taxiway.
 - ATAP is planned to be installed at all 35 ASDE-X airports by the end of 2020.

Approach and Landing Accidents and Incidents

Approach and Landing Account for 65% of All Accidents

(Source: Flight Safety Foundation, https://flightsafety.org/wp-content/uploads/2017/03/Go-around-study_final.pdf)

- Contributing factors to approach & landing accidents
 - Inadequate flight crew interaction with automatic flight systems
 - Incorrect or inadequate ATC communication and instruction to the flight crew
 - Failure in crew resource management (crew coordination, cross check, and backup)
 - Unstabilized approaches involving incorrect management of aircraft energy condition (i.e., approaches conducted either low/slow or high/fast).
 - Failure to recognize the need for and to execute a missed approach
 - Spatial disorientation and visual illusions (visual approaches at night typically present a greater risk)
- Unstable approach is a primary cause of landing excursions
- 83% of landing excursions could be avoided by decision to go around
- Only about 3% of unstable approaches result in industry go-around policy compliance

Flight Deck Automation - Complexity and Overreliance

Flight Deck Automation Risk Factors

- Loss of situational awareness of aircraft automation mode
- Misunderstanding of interaction between automation mode and phase of flight
 - Can lead to mismanagement of energy state or deviation from intended flight path
- Inappropriate response to automation errors
- Pilots spend excessive time in monitoring role
 - Pilot's role is focused on processing of information, not flying the airplane
 - New sources of risk introduced as pilots are required to interact with more information

Flight Deck Automation Risk Mitigations

- Operational procedures to help flight crews recognize and correct automation errors and intervene when necessary.
- Design guidelines to help minimize the potential for design-induced error and facilitate positive human intervention in the event of system failures.

Mixed Fleet Equipage and Aircraft Performance Capabilities

Mixed Fleet Equipage / Performance Characteristics

- Air traffic composed of aircraft of different size, speed, complexity, and level of equipage
- ATC coordination problems when low-technology aircraft are mixed with high technology aircraft in high-technology airspace
- Loss of separation of mixed technology aircraft sharing same airspace
- NextGen advanced air traffic management concepts rely on a critical mass of aircraft equipped with similar technologies
- In the longer-term future, the airspace may contain a much more heterogeneous mix of vehicles than exist today
- These fleets will include conventionally piloted subsonic and supersonic, remotely piloted, and fully autonomous vehicles that have large variations in speed, altitude, mass, and operating characteristics.

Separation Management

Separation Management

- Technologies and procedures enabling reduced separation.
- Separation standards may decrease between runways, between aircraft, between landing operations, and for vertical separation.
 - Reduced aircraft separation will require a move to trajectory-based operations (TBO), performance-based navigation, and a new allocation of responsibilities between humans and automation.
 - TBO is an operational transformation that bases safe separation on higher levels of automation.
- Shift in responsibility for separation assurance from ATC to flight crew
 - Changing the role of the controller from tactical separation to traffic flow management is a source of potential risk in the NAS.
- Increasing reliance on satellite-based systems for CNS Air Traffic Management functions - ADS-B is key enabling technology.

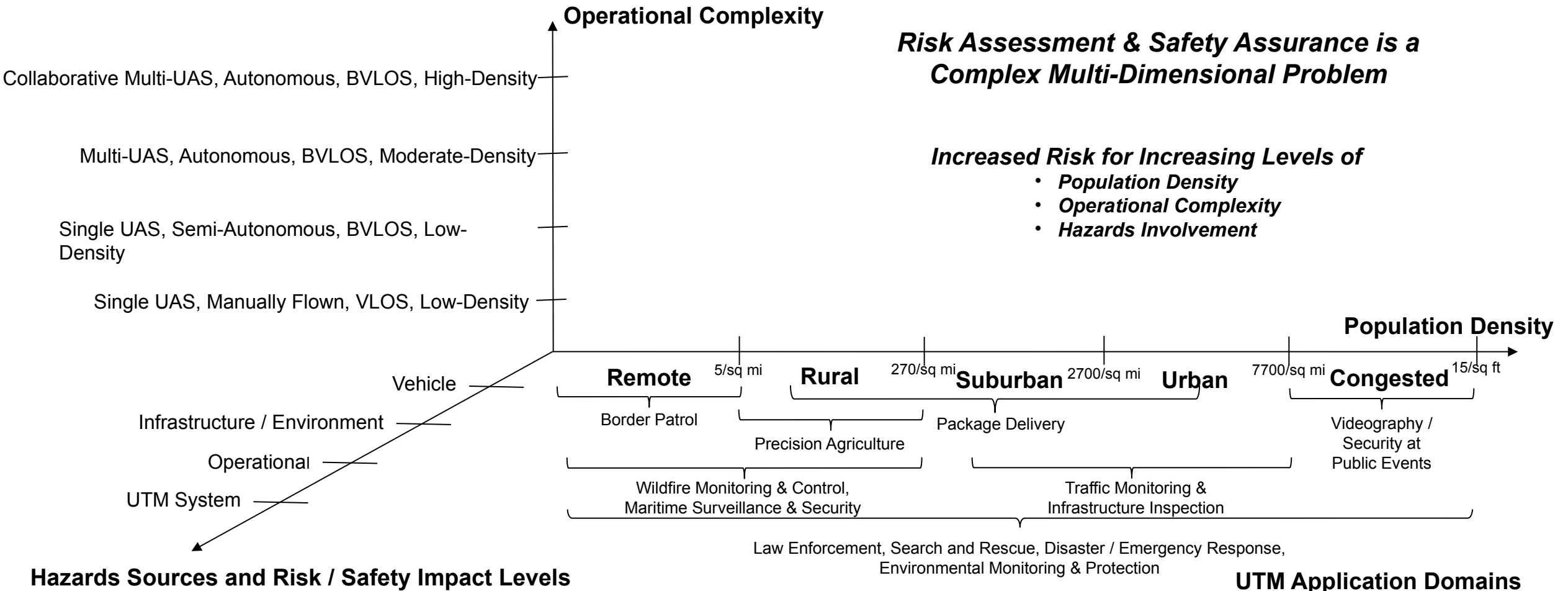
Integration of Small Unmanned Aircraft Systems into the NAS

Facilitating Safe Integration of sUAS

- Regulatory efforts and program initiatives
 - Title 14 Code of Federal Regulations Part 107 – Small Unmanned Aircraft Systems
 - Low Altitude Authorization and Notification Capability (LAANC)
 - Remote Identification
 - UAS Integration Pilot Program (IPP)
 - Unmanned Aircraft System Traffic Management (UTM)
 - UTM Pilot Program (UPP)
- Technology and Public Policy Challenges
 - Command and Control (C2) Link
 - Appropriate Management of Frequency Spectrum
 - Standards Development to Ensure Safety, Efficiency, and Reliability
 - Operational Concepts for Air Traffic Management of UAS (i.e., UTM)
 - Public Outreach and Education
 - Physical Security and Cyber Security
 - Privacy

Assessing Risk and Ensuring the Safety of sUAS Operations

Source: <https://utm.arc.nasa.gov/docs/2017-Belcastro> Aviation 2017-3269



Hazards Sources and Risk / Safety Impact Levels

(Known / Anticipated and Emerging / Unanticipated Hazards at Each Level)

UTM Application Domains

New Entrants in Civil Airspace

Advanced Aerial Mobility

- The AAM market sector is generally described as meeting future demand for regional aerial trips ranging from 30 miles to 300 miles.
- Barriers to entry to AAM market:
 - **Safety and Security** – Includes regulation and certification of vehicles and operations, cybersecurity, a robust air traffic management system, and collision avoidance.
 - **Economics** – Includes package handling for last-mile parcel delivery services; charging stations and vertiports for air taxi services; and operating cost reduction for advanced technologies such as electric propulsion and autonomous flight. Value per seat-mile or freight cost per mile are key businesses metrics.
 - **Demand for Transportation** – Competition from other modes.
 - **Public Acceptance** – Includes perceived safety (a proven safety record) and environmental/societal concerns (noise, emissions, privacy, visual disruption).

Supersonic Commercial Transports

- NASA X-59 Quiet Supersonic Technology (QueSST) demonstrator
 - Test flights to begin at AFRC in summer 2022
 - Supersonic flights over U.S. communities in 2024
- Aerion Supersonic AS2 Business Jet
 - First flight of AS2 scheduled for 2025 with certification and entry into service following within two years
- Boom Supersonic Overture Transport Aircraft
 - 55- to 75-seat aircraft will focus on transoceanic routes at Mach 2.2
 - Overture will begin test flights in the mid-2020s and enter service by 2030

Commercial Space Operations

- FAA expects to license around 56 space vehicle launches and reentries in 2021.
- By some forecasts, commercial space is expected to become a \$2.7 T business by 2050.
- Large areas of airspace must be closed to other traffic for safety reasons.
- As UAS, space tourism, suborbital, and orbital operations grow in number and diversity, mixed use of the aerospace domain will be essential to manage the safety risk.
- Shared information is the key to managing the risk while also improving the efficient use of airspace.
- FAA is developing the Space Data Integrator (SDI) concept to automate the information sharing process and allow for improved situational awareness and improved airspace management decision making.

Cybersecurity

Cybersecurity Threat to Aircraft

- Cybersecurity threats to the NAS are rapidly evolving and could threaten the connectivity of an increasingly complex aviation infrastructure.
- Avionics systems (e.g., flight control systems, data communications between pilots and controllers, EFBs, and in-flight electronic databases) could be at risk of a variety of potential cyberattacks.
- Vulnerabilities could occur due to:
 - Not applying modifications (patches) to commercial software
 - Insecure supply chains
 - Malicious software uploads
 - Outdated systems on legacy airplanes
 - Flight data spoofing

FAA Cybersecurity Initiatives

- The Aviation Cybersecurity Initiative (ACI) was chartered in 2019 as a tri-chaired interagency (FAA, DoD, DHS) with the mission “to identify cybersecurity vulnerabilities, reduce cybersecurity risks, and to improve cyber resilience to support safe, secure, and efficient operations in the Nation’s ‘Aviation Ecosystem’.”
- FAA Cybersecurity R&D plan emphasizes the following research areas:
 - Security and resiliency
 - Data analytics
 - Human behavior / Human factors
 - System wide safety assurance

Pilot Demographics

Pilot Shortages

- Finding a sufficient number of new pilots to fill slots and allocating enough time and resources for comprehensive training of new hires are major challenges.
- Boeing projected that over 800,000 new civil aviation pilots will be needed worldwide over the next 20 years due to expanding passenger demand (over 200,000 in North America).
- Pilots will also be needed in the emerging AAM market until the public becomes comfortable with fully autonomous vehicles.

Pilot Training

- Shifting demographics from military to civilian trained pilots
- Diminished basic airmanship and manual handling skills among non-military trained pilots
- Lack of aircraft system knowledge and diagnostic skills by air crew
- Economic pressures to recruit needed pilots will accelerate the transition of pilots from simple to complex aircraft
- Inability to operate advanced aircraft in abnormal situations and attitudes
- Crew Resource Management

Impact of COVID-19 Pandemic

Impact on Future Travel Demand

- U.S. airline ticket sales may not rebound to pre-pandemic levels until 2025
- IATA: Overall domestic air traffic is down 70% worldwide.
- One travel industry news publication is expecting air travel to return to early 2020 levels in 5 years.
- Boeing CEO: “I believe it's three full years before we return to the traffic levels that we had just in 2019, and then probably another two before we begin to return to the growth rates that we used to have.”
- McKinsey & Co.: Air travel demand drops by about 60 to 70 percent in 2020 and does not recover to pre-crisis levels until 2023 or even later.
- By 2035, RPKs could be one-third lower than the 15 trillion expected before the crisis - actual growth rate of 3.8% vs. pre-pandemic predicted rate of 4.9%.

Impact on Anticipated Pilot Shortages

- Just months ago Boeing was forecasting a global need for 804,000 commercial pilots over the next 20 years
- Industry observers expect the U.S. air transport industry to contract by about 30% in the short term, and a bounce-back could take up to 5 years. Consequently, the pilot shortage that the industry had long planned for is now on hold.
- U.S. pilot hiring could begin again in 2 to 3 years due to early retirements, but that makes it a difficult market for pilots finishing their training earlier.
- The COVID-19 crisis has transformed the worldwide shortage of pilots into a pilot surplus.

Other Impacts

- Cargo Operations
 - The 3 largest U.S. carriers repurposed idle passenger planes and started running cargo-only flights in March to offset large revenue losses.
- UAS and Advanced Air Mobility Outlook
 - The COVID-19 crisis has highlighted the possible utility of sUAS in BVLOS operations for the remote delivery of medical and other supply payloads.
 - FAA waiver process may permit companies and government agencies to respond to COVID-19 for operations not currently allowed by Part 107.
 - Short-term impact on eVTOLs and AAM: Disruption of funding, flight testing schedules, and production timelines

Commercial Carrier Operational Safety Events During COVID-19

- Lack of recent flight experience is reported as the most frequent contributing factor in multiple navigational and procedural errors inflight and on the ground.
 - Degraded flying proficiency is causing errors during high workload periods and at unfamiliar airports.
- Flight crews report time spent accomplishing COVID-related procedures is causing compressed preflight planning time and leading to errors.
- Air traffic controllers report that COVID staffing levels are causing high (sometimes unmanageable) workload putting flight operations at risk (loss of separation events).
- Flight crews are reporting anomalies with aircraft returning from storage.
- Unexpected aircraft performance due to light passenger loads have resulted in missed altitude restrictions, speed deviations, tail strikes, and hard/bounced landings.

QUESTIONS ?