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Weather Hazard Requirements for NGATS Aircraft

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Motivation

- **The Next Generation Air Transportation System (NGATS) Concept of Operations for the National Airspace System (NAS) is currently being defined**
- **What do pilots currently consider as aviation weather hazards? ... what about for NGATS?**
- **What new communications, navigation, or surveillance (CNS) technology can change how pilots deal with aviation weather hazards in NGATS?**

Reduced Surface Visibility

- May result in collision with...
 - Other aircraft
 - Ground Vehicles
 - Buildings
 - Running off runways and Taxiways
- Can Result in...
 - Spatial Disorientation
 - Slower taxi speeds
 - Increased Separation between traffic
 - Loss of Visual References → Loss of Control
- **NGATS:** Improved autopilot landing and taxi in low visibility
 - Augmented Reality, HUDs, etc. needed for zero visibility
 - Need datalink to quickly distribute info. to/from aircraft



Reduced En Route Visibility

- Nature of the Hazard:

- Loss of see and avoid
- Loss of references
 - Surface Features
 - Horizon
 - Visual Landmarks needed for Navigation



- Results:

- IFR are OK; VFR GA pilots may result in loss of control
- Loss of references could lead to inappropriate control inputs
- Could run out of fuel before getting to destination
- TCAS needed as a backup to See and Avoid

Surface Winds

- Nature of Hazard:
 - Runway Crosswind > 30 Kts
 - Runway Tailwind > 10 Kts
 - Wind Gusts
 - Total Wind > 50 Kts
- Can Result in...
 - Crosswind controls exceed aircraft design exiting runway side boundaries
 - Tailwind increases ground speed which may exceed takeoff performance capability or brake energy limits
 - 50 Kt winds generally dangerous
- **NGATS**: Accurate forecasts of Magnitude and Direction needed 5 min to 30 minutes in advance



Wind Shifts

- **Nature of Hazard:**
 - Sustained change in ave. wind direction of 45° or more
- **Results:**
 - Can change a headwind into a tailwind or crosswind
 - Could suspend runway operation
 - Configuration change needed
 - Impact: Takes time to re-taxi aircraft to new runways or to make runway configuration changes
- **NGATS:** Accurate forecasts of Magnitude and Direction needed 5 min to 30 minutes in advance



Convective Induced Turbulence (CIT)

- **Nature of Hazard:**
 - Updrafts and Downdrafts associated with convective activity
 - Light, Moderate or Severe
 - Detection assumed with precipitation radar returns
- **Results in...**
 - Personal Injury
 - Aircraft Damage
 - Temporary loss of control
- **NGATS:** Magnitude and boundaries need to be detected and displayed



Clear Air Turbulence (CAT)

- **Nature of Hazard:**
 - Updrafts and Downdrafts associated with non-convective activity typically jet stream and frontal boundaries
 - Light, Moderate or Severe
 - No detection capability
- **Results in...**
 - Personal Injury
 - Aircraft Damage
 - Temporary loss of control
 - Reduced altitude capability due to G-loading
- **NGATS:** Magnitude and boundaries will need to be detected and displayed



Mountain Waves

- **The Hazard:**
 - Clear Air Turbulence (CAT)
 - Above and downwind of mountain ranges
 - Wave can travel 20,000 ft over mountain tops
 - Produces moderate to severe turbulence
- **Results in...**
 - Personal Injury
 - Aircraft Damage
 - Temporary but often violent loss of control
- **NGATS:** Magnitude and boundaries will need to be detected and displayed



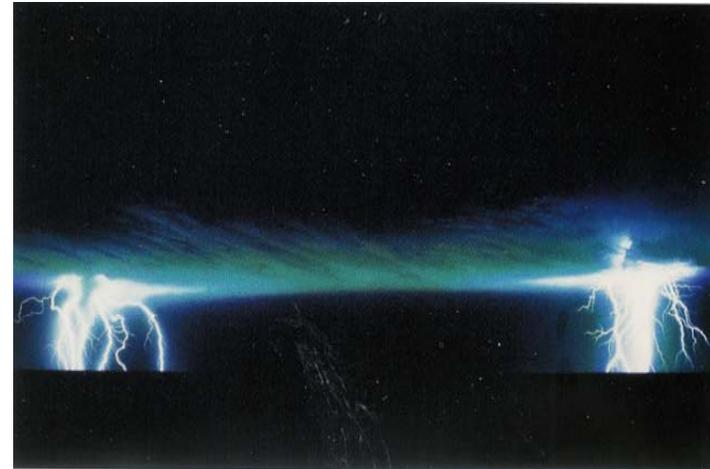
Aircraft Icing

- Nature of Hazard:
 - Accumulation of Frozen precipitation
 - Changes airfoil shapes
 - Changes engine airflow
 - Clogs sensors
- Results in...
 - Loss of lift and control
 - Loss of thrust
 - Increased weight
 - Anti-icing and de-icing systems increase fuel burn
 - Less climb performance, reduced altitude capability
- **NGATS**: Better prediction and detection needed



Lightning

- Nature of Hazard is rare:
 - Aircraft do not naturally attract lightning
 - Areas of lightning can easily be seen and avoided
 - Avoid areas of Convection
- Hazard Effect:
 - Could temporarily blind the pilot
 - Aircraft damage is usually negligible
 - Momentary interruption and degradation of radio signals for communications and navigation
 - Safety issue for ground crews
- NGATS Goal: Predict 20 minutes in advance for avoidance



Clouds

- **Nature of the Hazard:**
 - Frequent and Year Round
 - Primarily an en route visibility hazard
 - If cold enough, could become an icing issue
 - Could mask terrain
- **NGATS Goal:**
 - 4D requirements needed NAS-wide
 - Driven by different aircraft types and pilot qualifications (VFR vs IFR), especially GA concerns
 - Research is primarily in the vertical dimension



Fog and Rain

- Nature of the Hazard:
 - Primarily a Surface Visibility Issue
 - Rarely coupled with any significant Winds
 - Runway surfaces become wet with rain and fog if visibility is less than 1 mile – reduced braking action must be addressed → increases separation requirements → lowers the AAR → may cause a need for a GDP
- NGATS Goal:
 - Statistics required for fog burnoff time (e.g., *cdf*) +/- 5 to 10 minutes desirable
 - Requires dedicated equipment at select airports (SFO)
 - Need to get estimates of fog burnoff 3-6 hours ahead of time to plan AARs and GDPs



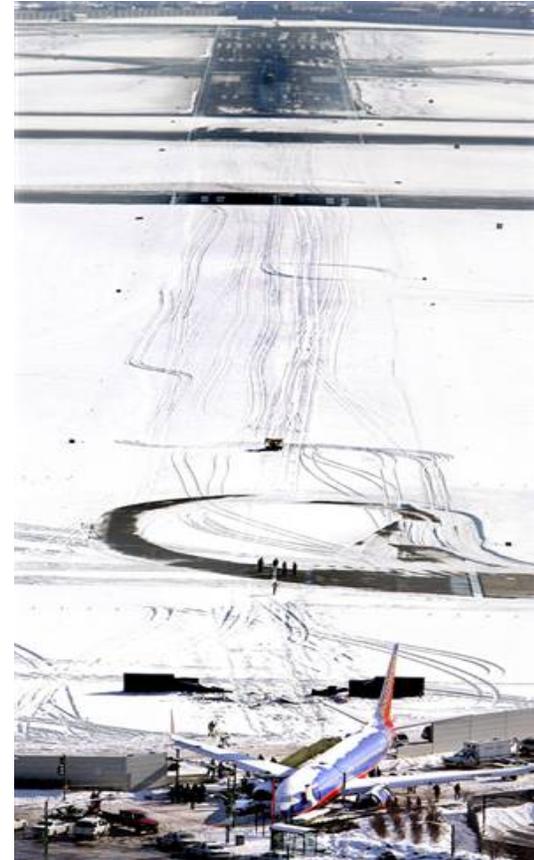
Snow

- Nature of Hazard:
 - Aircraft Icing
 - Reduced Visibility
 - Runway and Taxiway Icing
- Results in...
 - Use of Anti-icing systems
 - Low visibility procedures
 - Reduced directional control → lower crosswinds
 - Increased stopping distance → longer runways needed
 - Ground de-icing delays
- **NGATS**: Reduce ground delays after ground de-icing; eliminate de-icing more than once via better information



Runway Precipitation Contamination

- Nature of Hazard:
 - Rain, Heavy Rain
 - Fog induced condensation
 - Snow, Sleet...
- Results in...
 - Hydroplaning
 - Reduced directional control
 - Reduced stopping capability
 - Reduced crosswind limits
 - Increased stopping distance for takeoff aborts and landing
- NGATS:
 - Accurate Measurement of Runway Friction
 - SWIM/datalink to distribute runway Braking Action Reports



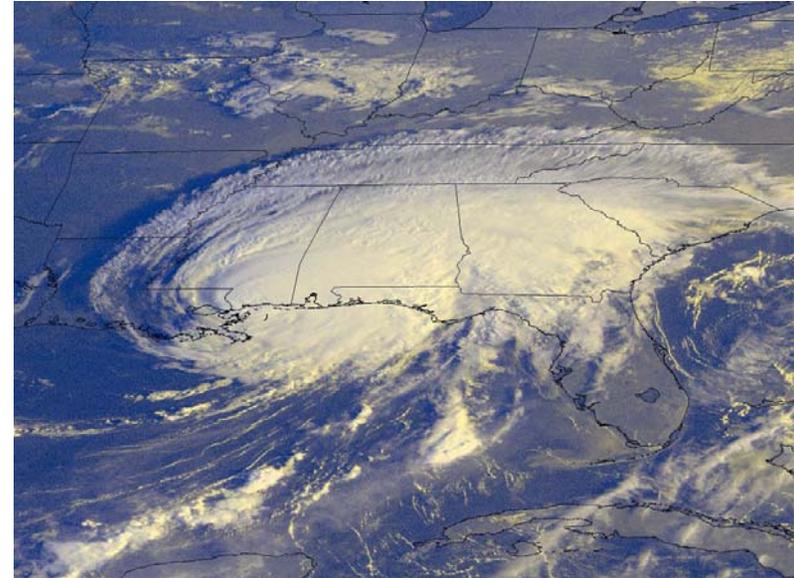
Blizzard

- Nature of Hazard:
 - Strong Winds
 - Airborne Icing
 - Surface Snow Accumulation
 - Reduced Visibility
- Results in...
 - Combination of hazards
 - Operations typically suspended due to negative synergistic effects from reduced directional control on the ground, high winds, and low visibility procedures
- **NGATS**: Better Prediction of hazardous weather conditions



Hurricane

- **Nature of Hazard:**
 - Strong Winds
 - Heavy Rain
 - Severe Convection
(Tornadoes, Thunderstorms, Turbulence)
- **Results in...**
 - Combination of hazards over a wide area
 - Flooding
 - Wide area avoided
 - Operations suspended
- **NGATS:** Define boundaries for safe operations
- Evacuation plans to avoid loss of life, aircraft, assets



Tornado/Waterspout

- **Very Dangerous**
 - High Velocities cause loss of control
 - Flying Debris can damage aircraft in the air or on the ground
 - Completely avoiding tornados and waterspouts is the only practical solution
- **NGATS:**
 - More airports will have sensors data linked to aircraft and airport personnel via SWIM
 - Better forecasting expected for convective weather



Volcanic Ash

- Nature of Hazard:
 - Visibility Restriction
 - Abrasion Effects
 - Engine Ingestion Effects
- Results in...
 - Procedures for low visibility
 - Gradual degradation of visibility due to wind screen turning translucent
 - Jet engine combustion melts the ash then the molten lava deposits on the turbine blades
 - Reduce thrust or Flameouts
- **NGATS**: Detection and display of safe boundaries



Conclusions

- **Communications:** In NGATS, there is a need for a Net-Centric Operation (NCO) with System-Wide Information Management (SWIM) to collect weather data and distribute weather information (e.g., forecasts and alerts) in a timely manner
- **Navigation:** New equipment is needed for flying in low and zero visibility conditions, improved autopilots for controlling aircraft through gusts and abrupt changes in winds, and to automatically connect FMS & pilot to 4D weather hazard constraints
- **Surveillance:** needed for many varieties of weather hazards and data link required to quickly get this information to the pilots, controllers, and airline personnel who need to know