Inadvertent Instrument Meteorological Conditions

Real Threat
Lethal Consequences
Realistic Interventions

Richard Weber
Jacksonville Sheriff’s Office
Chief Pilot
904-226-3725

Bryan Smith
Safety Program Manager
safety@alea.org
239-938-6144
Who’s this guy?

Bryan Smith

AELA Safety Program Manager

Lee County Sheriff’s Office

IHST/USHST SMS Committee
Rich Weber
Jacksonville Sheriff’s Office
Chief Pilot
“The crate? The quality of the crate matters little. Success depends on the man who sits in it.”

~Manfred von Richtofen “Red Baron”
Flight Plan…

1. Review of problem
2. Analysis of factors involved in IIMC
3. Interventions (Solutions)
4. Discussion

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The information included in this presentation was obtained through project ALEA initiated with several industry experts to address the high rate of fatalities in our industry associated with IIMC into CFIT accidents.
The Problem
The Problem

- National Transportation Safety Board (NTSB) Jan’ 2005 - Aug’ 2008
  - 71 accidents related to spatial disorientation occurred
  - IIMC and darkness reported as causal factors in 82% of these accidents
  - Of the 71 accidents, 85% were fatal
The Problem

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**Inadvertent Entry into Cloud or Fog**

Comprehensive training on inadvertent flight into instrument meteorological conditions (IMC) is necessary for all rotorcraft helicopter training. This training should include, but not be limited to:

- Determination of enroute weather
- Avoidance of inadvertent flight into instrument meteorological conditions
- In-flight weather abbreviations
- Recovery from inadvertent flight into instrument meteorological conditions.

**Synthetic Training**

The use of simulations and ground instruction is highly recommended to improve instrument flying skills and proficiency. The training in instrument skills is a necessary component of all levels of rotorcraft helicopter training as these are considered to be perishable skills.

**IMC Immediate Actions**

A pilot's immediate actions after encountering inadvertent IMC will determine the outcome of the entire event. Pilots who possess a plan of action prior to encountering are less likely to experience a successful outcome (live) than those who are less trained and proficient in the recognition and recovery procedures.

If you hold an IR and are in current instrument flying practice and may wish to use the 4 "Cs": Control, Climbs, Course, and Communicate.

- **Control**: Fly the aircraft. Refocus the scan inside the cockpit to the primary flight instruments - airspeed, altitude, and attitude.

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**IMC Ground School**

A ground curriculum covers a full range of topics vital to avoiding and, when necessary, recovering from inadvertent IMC.

- **Air Safety Foundation**

**Recommendations**

- Simulator instruction reinforces ground school, providing an opportunity to apply policies and procedures and practice IMC recovery.
- Stay instrument current; use your IR and fly the 4 "Cs" (Control, Climbs, Course and Communicate).
- Apply company or pilot-limitation weather policies.
- Apply weather and terrain avoidance procedures.

**References**

More information about the IHST, its reports, its safety tools, and presentations can be obtained at its website: [www.IHST.org](http://www.IHST.org)
The Problem

Inadvertent IMC encounters are some of the most demanding, disorienting, and dangerous conditions a pilot can experience. These encounters result in the highest percentage of fatal injuries from helicopter accidents. NTSB 2011 figures show that 45 of the 52 IIMC accidents occurring that year were fatal—that is 86% giving you a 14% survivability rate if you go IMC!
The Problem

The Problem

By reference to the instruments, a controlled climb should be initiated. Inadvertent IMC
counters often occur at low altitudes where rising terrain poses a serious threat. The pilot
should initiate a straight ahead controlled climb to an altitude that will provide obstruction
clearance in the area of operation. Always

Stay Calm

● Climbing at a 60 degree angle is the most comfortable.<br>
● Due to the angle of the climb, it is easier to use the altimeter<br>
● The climb rate is low at 60 degrees, making it easier to adjust the power setting.

IIMC Ground School
A ground curriculum covers a full range of topics vital to avoiding and, when necessary, recovering from inadvertent IMC.

- Air Medical Resource Management (AMRM)
- Human Factors
- Situational Awareness

Downloadable Resources
- Air Safety Foundation
- International Helicopter Safety Team (IHST)
- National Transportation Safety Board (NTSB)

This document, and others, can be downloaded for free from the IHST website:
www.ihst.org
Planned Flight vs. Inadvertent IMC

Helicopter took off about 2313, intercepted and began to follow a true course of about 209° (close to the direct course back to Sunshine of about 193°).

About 2314, the helicopter turned left to a heading of about 139° and continued on this heading until it reached the Intertie.
About 2315, the helicopter turned right and flew south along the Intertie for about 30 seconds.

The helicopter then turned right to a heading of about 190° and continued on this heading for about 2 minutes.

At 2317:49, the helicopter was at an altitude of 1,060 msl (about 200 feet agl) with a groundspeed of 16 knots.
Planned Flight vs. Inadvertent IMC

The helicopter then entered a climbing left turn which continued through 360 degrees; this was followed by a series of erratic turns, climbs, and descents. The Garmin data for the accident flight ended at 2320:17; the duration of the flight was about 7 minutes; and the last position recorded placed the helicopter about 3 miles south of the takeoff point and 13 miles north of Sunshine.
“The pilot advised the SAR personnel to load quick, as he had no intentions of spending the night there...they lost sight of the helicopter about 50 feet agl. They continued to hear the helicopter to the time of a collision sound, followed by the sound of an avalanche.”

~Excerpt from a NTSB report of a law enforcement IIMC/CFIT accident with multiple fatalities
How about you?

- Have you ever went IIMC?
- Have you lost a friend(s) to this?
- What factors do you think were involved?
- Why are we losing so many of our peers to IIMC/CFIT?
Operational Pressure

1. Needs of a commercial operator to generate revenue
2. ‘Mission’ oriented minset
3. Presence of passengers - 54% higher frequency of IIMC accidents in aircraft with passengers
4. Perception of helicopter capabilities in industry and popular culture
5. Perception of pilot capability with certain experience and ratings based on fixed wing world
6. Operations conducted in locations and altitudes without complete weather reporting or forecasting coverage (ADDS HEMS Tool)
7. Aircraft design geared towards mission completion in VFR conditions. Why is a Cessna 152 IFR capable but most single engine helicopters are not?
The Problem
The Problem

- Helicopter operators share a common goal— to complete a mission and return to base

- Crews sometimes accept a mission when the weather is less than desirable, but still safe, or the weather deteriorates while on the mission

- Our weather limits often leave little room for conditions to lower and still be safe
The Problem

What is the second highest flight activity category?
The Problem
The Problem

Percentage of Accidents by Activity

- Instructional/Training: 22.8%
- Positioning/RTB: 13.2%
- Personal/Private: 12.4%
- Passenger/Cargo: 9.8%
- Aerial Application: 9.0%
- External Load: 7.6%
- Aerial Observation: 6.1%
- Air Tour/Sightseeing: 5.0%
- Ferry: 4.0%
- Maintenance/Test flight: 2.5%
- Law Enforcement: 2.5%
- Animal Control/Hunting: 1.7%
Are Instrument Ratings the Answer?

* Johns Hopkins Bloomberg School of Public Health’s Center for Injury Research and Policy / NTSB
Are Instrument Ratings the Answer?

- 10,693 hours
- Instrument rated
- Instrument rated trooper in the left seat (not trained TFO)
- 141 hours actual instrument, 247 simulated
- .5 actual in helicopter, 38 simulated
- 1738 hours SAR

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  - 1983-2005 77% accidents - spacial disorientation*

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Why do so many instrument rated pilots, flying instrument rated aircraft, crash after entering IMC inadvertently?

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* AOPA Nall report 2009
**Goh and Wiegmann, University of Illinois
Are Instrument Ratings the Answer?

- Analysis of the effect of total pilot time however was not found to be significant for most measures. The few statistically significant effects of pilot time in fact showed increasing errors with pilot time, not decreasing as one might expect.

(FAA Study on helicopter pilot IIMC performance in simulators)

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Planned Flight vs. Inadvertent IMC

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Planned Flight vs. Inadvertent IMC

**Planned out IFR flight**
1. Expectation of IMC conditions a low-key event
2. Time to prepare equipment, refresh skills, setup cockpit
3. Enter in level climb, on course
4. Conditioned exclusion of VFR flight techniques
5. Working to maintain Situational Awareness

**Unplanned IMC (or complete darkness)**
1. Neither equipment nor cockpit is set up
2. The pilot is caught off guard and not ready or expecting IMC - causing stress and sometimes panic
3. Often not in level flight or on course
4. Temptation to continue to utilize VFR flying techniques
5. Denial caused delay in response - most spatial disorientation accidents occur within 2 minutes of onset* (178 seconds to LOC)
6. Working to recover Situational Awareness

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Planned Flight vs. Inadvertent IMC

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This chart is from an FAA study on helicopter pilot performance in IIMC situations. The lines on the charts indicate the pilot’s input on the cyclic. The arrows show where visibility decreases from 1 mile to zero. Most helicopter pilots never train in true zero visibility conditions. Training ‘foggles’ usually only simulate 1/2-1/4 mile visibility, at best.

* Air Safety Foundation
IIMC and Stress
IIMC and Stress

Physiological Barriers
Physiological Barriers

IIMC and Stress

Heart Rate

Hearts Per Minute

Above 175 bpm:
- Irrational flight or flight
- Freezing
- Submissive behavior
- Voiding of bladder and bowels
- Gross motor skills (running, charging, etc. at highest performance level)

175 bpm:
- Cognitive processing deteriorates
- Vasconstriction (reduced bleeding from wounds)
- Loss of peripheral vision (tunnel vision)

160 bpm:
- Loss of depth perception
- Loss of near vision
- Auditory exclusion

155-145 bpm = optimal survival and combat performance level for:
- Complex motor skills
- Visual reaction time
- Cognitive reaction time

140 bpm:
- Complex motor skills deteriorate

120 bpm:
- Fine motor skill deteriorates

115 bpm:
- Fine motor skill deteriorates

80-89 bpm = normal resting heart rate

EFFECTS OF HORMONAL OR FEAR INDUCED HEART RATE INCREASE

Condition Black

Condition Gray

Condition Red

Condition Yellow

Condition White (Psychological Constituted)
IIMC and Stress

Physiological Barriers

- Vasoconstriction - Loss of fine motor skills
- Tunnel Vision - Loss of Situational Awareness
IIMC and Stress

Physiological Barriers

- Vasoconstriction - Loss of fine motor skills
- Tunnel Vision - Loss of Situational Awareness
- Bilateral Symmetry (Both sides of the body act in unison) - Unintentional control inputs
- Cognitive Shutdown - Inability to regain SA or apply Emergency Procedures
IIMC and Stress

Physiological Barriers

- Vasoconstriction: Loss of fine motor skills.
- Bilateral Symmetry: Unintentional control inputs.
- Cognitive Shutdown: Inability to regain situational awareness or apply emergency procedures.

These concepts are addressed in modern law enforcement training. Considerations for these factors have greatly increased officer performance in high stress scenarios. Once heart rate exceeds around 145bpm, these same factors will effect a pilot’s performance. Bilateral symmetry can cause an inadvertent control input in one control when the other is moved, for example. Vasoconstriction can make operating avionics (small buttons) difficult to impossible.
“Atlanta, this is Seven Nine X-ray. I’d like to deviate south. Weather.”

-Scott Crossfield’s last words shortly before radar contact was lost
IIMC and Planned IFR flight are not the same thing

A high percentage of IIMC/CFIT accidents were in instrument equipped aircraft with instrument rated pilots

We often enter IIMC in other than a wings level climb

There is an element of fear that limits decision making, situational awareness and fine motor skills

We are not actively in the IFR system with ATC

IIMC does not allow for preparation, avionics setting, briefing, etc.

We fly when we’re needed, not when it is most convenient for us.

We often launch when it is just above our wx minimums leaving little room for wx changes
One more note...
One more note...

- Total darkness can easily create Instrument Flying Conditions
- This is true even when equipped with NVGs
- Darkness can swap VMC to IMC just as quickly as weather conditions, sometimes faster (i.e. turn away from shoreline)
- Designated weather minimums to not offer us any risk management protection from entering IMC due to darkness
Flight Plan...

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The Solution - ALEA’s Involvement
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## Major Categories

### ALEA Database

- **CFIT / IIMC**: 8/6 (16)
- **LTE**: 6 (3)
- **Wire Strike**: 5* (6)
- **Training**: 22 (2)
  - Autos: 15
  - Hydr: 3
- **Mechanical Failure**: 13.5 (0)
- **Landing LOC (airplane)**: 6 (0)

## Accidents (Fatalities)
The Solution - ALEA’s Involvement

Major Categories

ALEA Database

➢ CFIT / IIMC  8/6 (16)
➢ LTE  6 (3)
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  • Hydr  3
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Accidents (Fatalities)

• Autos 15
• Hydr 3

Airborne Law Enforcement Association

Safety Program

Bryan Smith

IIMC Training Recommendations

1. The following document is a recommendation for safe and effective training to mitigate the risk of inadvertently entering instrument meteorological conditions (IIMC) in flight. The suggestions included here also cover training and emergency procedures that will help crew survive should they fail to avoid an encounter with IIMC. ALEA does not recommend flight training without proper training and experienced flight instructors. It is also highly recommended that no new training effort take place without preplanning and risk assessment on the ground.

2. The recommendations included here are the result of consultation with numerous safety professionals and flight instructors with the aviation industry.

3. IIMC training is different than planned IFR flight training in that:
   a) IFR flight allows for pre-planning and set up of avionics and radios
   b) Planned IFR flight is conducted in IFR certified aircraft
The Solution
The Solution

1. Avoid IIMC situations
2. Monitor WX trend during flight
3. Prepare for IIMC situation
4. Have an IIMC plan in place
5. Train and stay proficient (not just current)
6. Incorporate IIMC into your SMS
The Solution –

1. Avoid IMC Conditions
The Solution –

1. Avoid IMC Conditions

1. Most of our aircraft are not equipped for safe IMC flight

2. Set weather limits that allow a window to return to base, or land, when weather begins to drop.

3. Have offsite landing procedures, including logistics (fuel, transportation, securing aircraft) in place so crews feel authorized and compelled to land when it is the safe decision.
The Solution –

1. Avoid IMC Conditions
4. Reconsider your weather planning equipment.

5. Reconsider your in-flight weather monitoring capability

6. Use a Flight Risk Assessment Tool (FRAT) with specific wx information aimed at avoiding IMC conditions. (forecast weather, temp/dew spread, etc.)
   [https://easa.europa.eu/essi/ehest/2012/06/pre-departure-check-list/](https://easa.europa.eu/essi/ehest/2012/06/pre-departure-check-list/)

7. Codify weather minimums in policy to protect pilots

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The Solution – 1. Avoid IMC Conditions
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7. Codify weather minimums in policy to protect pilots.

This FRAT is available for free on the IHST (ESEST) website: [https://easa.europa.eu/essi/ehest/2012/06/pre-departure-check-list/](https://easa.europa.eu/essi/ehest/2012/06/pre-departure-check-list/)
2. Monitor Conditions During Flight
“Safety and fatal hazard are not separated by any sharp boundary line, but shade gradually from one into the other. The time for taking measures for a ship’s safety is while still being able to do so.”

Admiral Chester A. Nimitz
The Solution –

2. Monitor Conditions During Flight

- Many IIMC incident flights begin in VFR conditions
- Stay ahead of the weather, don’t wait until it becomes a problem
- Use CRM to maintain a real perspective on the situation
- Be willing to land and wait out the weather (many accidents occur while trying to return to base, bypassing suitable landing areas)
- Enroute Decision Points
The Solution –

3. Prepare for IIMC Situation

FLYING ON INSTRUMENTS
You’re doing it WRONG!!!!!
The Solution –

3. Prepare for IIMC Situation

- Set up cockpit before taking off
  - Radios
  - Avionics
  - Charts
- Have an IIMC Emergency Procedure checklist - preferably to be read by a crewmember.

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The Solution –

4. Have a IIMC Response Plan
The Solution –

4. Have a IIMC Response Plan

- IIMC is an **emergency**
- IIMC Procedures, Standard Operating Policy (SOP’s)- gives the pilot a plan
- Procedures must be developed and taught to ALL crew members
- Crew Resource Management (CRM)
- Aviate, Navigate, Communicate

*audio...*
The Solution –

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audio...
The Solution –

4. Have a IIMC Response Plan
The Solution –

4. Have a IIMC Response Plan

1. Verbally Announce Entry
2. Commit to Instruments (eyes in)
3. Level (roll, yaw, pitch)
4. Once stabilized - shallow climb
5. Communicate
6. Recover (IAP, ATC direction, etc)

When would a 180 deg turn fit into this formula?
The Solution –

4. Have a IIMC Response Plan

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When would a 180 deg turn fit into this formula?

“The failure of the pilot to maintain altitude and clearance from terrain during a turn to reverse direction after encountering instrument meteorological conditions.”

~NTSB Probable Cause statement for a fatal law enforcement IIMC/CFIT accident
The Solution –

4. Have a IIMC Response Plan
Recovery Plan

1. Trying to work with avionics will likely lead to loss of control

2. If you are not extremely familiar with your system, or already set up for an approach, try to enter an approach only as a last resort

3. Ask ATC for assistance

4. Use CRM with trained crew members to enter approaches, brief procedures, etc.

5. Use crew to monitor instruments and call out variations
The Solution –

5. Train

Advanced skills are the basics mastered.”

– Bruce Lee
The Solution –

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The Solution –

5. Train

- We must change the way we train for IIMC
- Realistic ‘scenario based’ training means:
  - Only the prep you do on a regular basis (cockpit setup, notice, etc.)
  - Element of surprise “Constructive Apprehension”
  - Enter in other than straight and level flight
- Consider simulator training - more realistic IMC conditions
- Make IIMC training as regular as your other emergency procedures training
- Include the crew in IIMC training
- Train to respond to an en route decision point and decide when to make a precautionary landing, or a 180
- YES - Get an instrument rating!
The Solution –

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YES – Get an instrument rating!

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IIMC and Stress

Physiological Barriers

• Vasoconstriction - loss of fine motor skills

• Tunnel Vision

• Bilateral Symmetry - both sides of the body act in unison

• Cognitive Shutdown
IIMC and Stress

Physiological Barriers

• Vasoconstriction - loss of fine motor skills

Emergency checklist items - Preloading

• Tunnel Vision

Train to scan - battlefield scan

• Bilateral Symmetry - both sides of the body act in unison

Emergency Procedures (turns) - Training

• Cognitive Shutdown

Stress Inoculation (LE hit rate increase from 20-90%)
The Solution –

5. Train

V Instructor Checklists

1. LESSON BRIEFING
   - Pre-mission risk assessment form complete
   - Route of flight
   - Establishment of ‘transfer of control’ protocol
   - Emergency procedure protocol
   - Review of avionics, charts, procedures

2. LESSON OBJECTIVES
   - Training Objectives
     - IIMC Avoidance
     - IIMC Initial Response Procedures
     - Returning to safe environment
   - Establish if the flight is a training flight or an evaluation
   - Review Completion or Evaluation Standards

3. PREFLIGHT PREP
   - Charts and GPS database up to date and accessible.
   - Battery check and backup for NVG’s if required
   - Other equipment:
     - Foggles
     - Charts
     - ________
     - ________

4. LESSON EXERCISES AND MANEUVERS – Pilot
   - Normal take off and climb to altitude (on NVGs if available)
   - IIMC Avoidance Exercise
   - IIMC Entry Simulation (unusual attitudes) x 3
   - IIMC Initial Response Procedure
     - Zero degrees roll
     - 500 fpm climb or 5 degrees nose up
     - Airspeed +/- 5 knots
     - Verbal notification to crew that they are in IIMC
     - Verbal verification of location, altitude and heading
   - ATC Communication (actual or simulated)
     - Declare an emergency
     - Ask ATC for frequencies and/or headings. (if applicable)
   - IIMC Recovery Plan (Utilization of CRM is recommended)
     - Set up approach (if applicable)
     - TFO duties (only as trained)
     - Type and location of approach
     - Radio frequencies
     - Navaid frequencies
     - Altitudes (initial, intercept, minimums, etc)
     - Begin navigation back to entry point for instrument approach or VMC conditions
       - <10 deg bank  
       - <500fpm  
       - Airspeed +/- 5 knots
     - Missed approach procedure brief
     - Final approach course heading
     - GPS signal status (terminal, approach, RAIM, etc.)
     - Landing configuration (flaps, lights, gear, etc)
     - Complete approach to airport (or VMC conditions as applicable)
     - Two approaches (or applicable IIMC recovery procedures)
     - Perform at least one ‘go-around’
     - <10 deg bank  
     - <500fpm  
     - Airspeed +/- 5 knots
     - Minimum power changes
     - Less than ½ scale deflection on instrument approach indicators
5. Train

1. LESSON EXERCISES AND MANEUVERS – TFO/Second Pilot

- IIMC Avoidance Exercise
  - TFO used CRM to convince pilot to perform 180° turn, land (rotocraft) or divert to the nearest airport with VMC conditions before entering simulated IIMC conditions.

- IIMC Initial Response Procedure
  - IIMC entry procedure from memory.
  - Inputs radio frequencies as requested by pilot.
  - Assist pilot monitoring aircraft orientation
    - Zero degrees roll
    - 500 fpm climb or 5 degrees nose up
    - Airspeed +/- 5 knots

- IIMC Recovery Plan (Utilization of CRM is recommended)
  - Set up approach
  - Type and location of approach
  - Radio frequencies
  - Navaid frequencies
  - Altitudes (initial, intercept, minimums, etc.)
  - Confirms course to entry point for instrument approach or VMC conditions
  - Assist pilot monitoring aircraft orientation
    - 10 deg bank <500fpm Airspeed +/- 5 knots
    - Missed approach procedure brief
    - Final approach course heading
    - GPS signal status (terminal, approach, RAIM, etc.)
    - Confirm landing configuration
  - Complete approach to airport (or VMC conditions as applicable)
    - Two approaches (or applicable IIMC recovery procedures)
    - Perform at least one "go-around"
    - TFO is able to call out crossing approach fixes
    - TFO calls out intercept altitude and/or every 100 feet within 800 feet of the ground.
    - Assist pilot monitoring aircraft orientation
      - 10 deg bank <500fpm Airspeed +/- 5 knots
      - Calls out deflection on instrument approach indicators in excess of ½ scale
The Solution –

6. Train AGAIN

- Being legally current does not mean one is proficient
- Instrument flying is one of the most perishable skills we have
- ‘Brother-in-law’ check flights kill
• **Checklists:**
  ✓ Create IIMC specific checklist based on CRM/ADM and
  “The program does not employ any policy guidance to aid the pilot in making risk managed decisions with respect to flight scheduling decision making."

~Excerpt from a NTSB report of a fatal law enforcement IIMC/CFIT accident

✓ Pilot involvement in mission, especially in marginal wx
• **Lead Indicators:**
  ✓ Repeated RTB due to weather
  ✓ Seasonal changes
  ✓ Change in mission/equipment

• **Environmental:**
  ✓ Avionics upgrades based on minimizing pilot workload
  ✓ Specific SOP on wx minimums, IIMC avoidance
  ✓ Solid planning for alternate landing areas, divert procedures
Flight Plan...

1. Review of problem
2. Analysis of factors involved in IIMC
3. Interventions (Solutions)
4. Discussion

“The crate? The quality of the crate matters little. Success depends on the man who sits in it.”

~Manfred von Richthofen “Red Baron”
Flight Plan

1. Review of problem

2. Analysis of factors involved in IIMC

3. Interventions (Solutions)

4. Discussion

"The crate? The quality of the crate matters little. Success depends on the man who sits in it."

~Manfred von Richtofen “Red Baron”
There are no new ways to crash an aircraft...

...but there are new ways to keep people from crashing them...

Bryan Smith
safety@alea.org
239-938-6144

Rich Weber
rich@webairaviation.com
(904) 226-3725
References

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