

Introduction



Smart Icing Systems Review, September 30 – October 1, 2002

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Smart Icing Systems

NASA Review

Sept. 30 – Oct. 1, 2002

Outline



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- Background
- Objective
- Smart Icing System solution
- Timeline and research review
- Schedule of the presentations
- Results from June 2001 review

Aircraft Icing Accidents



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Accidents

- Air Florida - takeoff accident - performance and S&C.
- United Express Jetstream - tail stall - longitudinal S&C.
- Roselawn ATR - roll upset - lateral S&C.

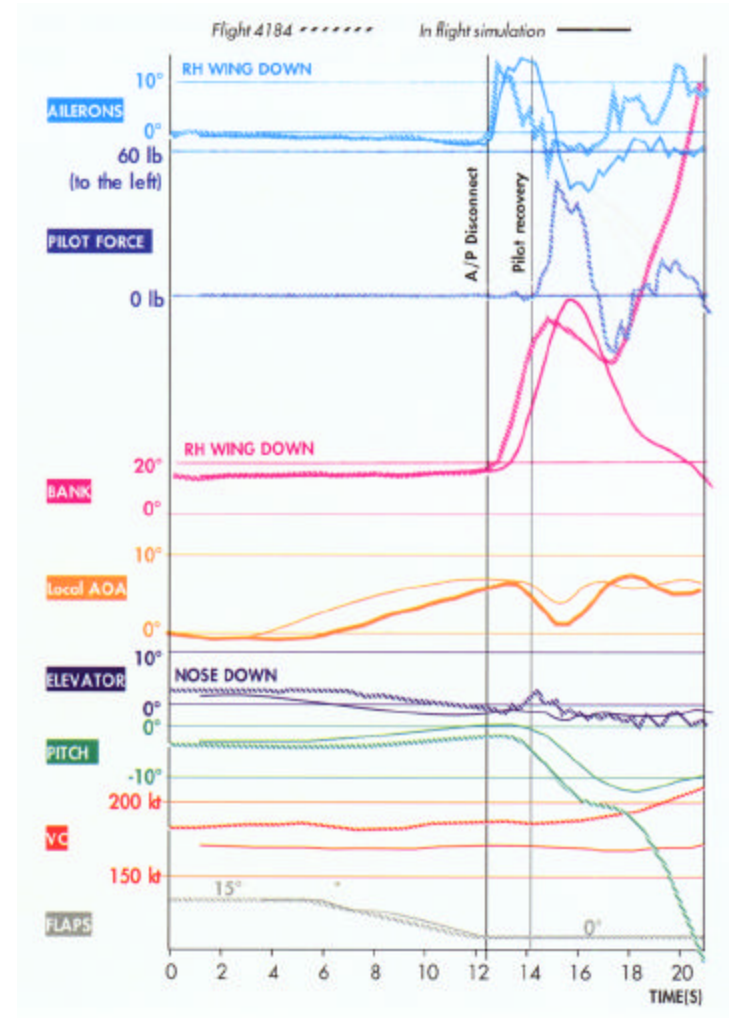
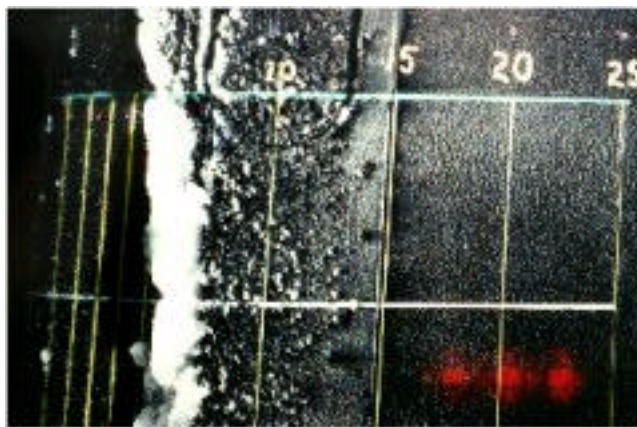
Common Features

- Ice accretion.
- Aerodynamic effect leads to degradation in *performance and handling qualities*.
- Pilot is unaware of the full effect of ice on aircraft.
- Accident occurs.

ATR 72 Roselawn Accident



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Smart Icing Systems



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Goal

- To improve the safety of aircraft operating in icing conditions.

Objective

- To develop a human-centered automated system, to characterize icing effects, operate the IPS, provide envelope protection and control adaptation.

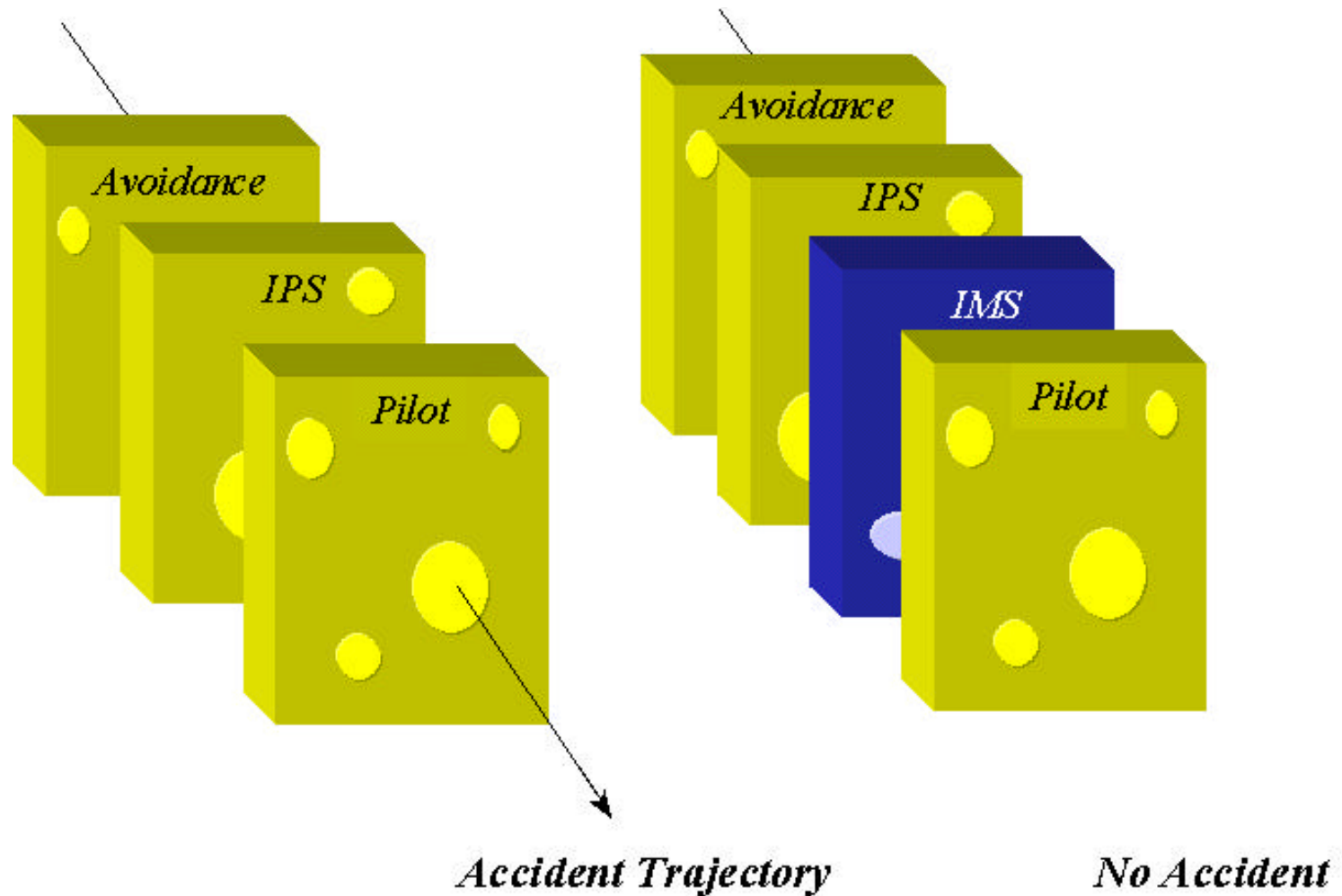
Approach

- An interdisciplinary, systems approach is used to conduct the research in aerodynamics, flight mechanics, controls and human factors. Flight simulation and flight testing are used to develop the concept and validate the methods.

Defenses in Depth



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The diagram illustrates the functional architecture of an aircraft icing protection system, showing the interactions between various components:

- Ice Accretion** (Input) feeds into **Ice Accretion Sensors** and **Ice Protection System (IPS)**.
- Ice Accretion Sensors** provide data to **Pilot / Automation**.
- Pilot / Automation** interacts with **Ice Protection System (IPS)** via **Advisory** signals and receives **Information** from the **Ice Management System (IMS)**.
- Ice Protection System (IPS)** outputs **Ice Effects** to **Aircraft Dynamics**.
- Aircraft Dynamics** interacts with **Pilot / Automation** and provides **Control Adaptation** feedback to the **Ice Management System (IMS)**.
- Ice Management System (IMS)** provides **Envelope Protection** to **Pilot / Automation** and **Primary IPS Operation** to the **Ice Protection System (IPS)**.
- Pilot / Automation** provides **Pilot Input** to the **Ice Management System (IMS)**.

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graph LR; IA[Ice Accretion] --> IAS[Ice Accretion Sensors]; IA --> IPS[Ice Protection System IPS]; IAS --> PA[Pilot / Automation]; PA -- Advisory --> IPS; IPS -- Ice Effects --> AD[Aircraft Dynamics]; AD --> PA; IMS[Ice Management System IMS] -- Information --> PA; PA -- Pilot Input --> IMS; IMS -- Envelope Protection --> PA; IMS -- Control Adaptation --> AD; AD -- Primary IPS Operation --> IPS;
```



SIS Development Strategy



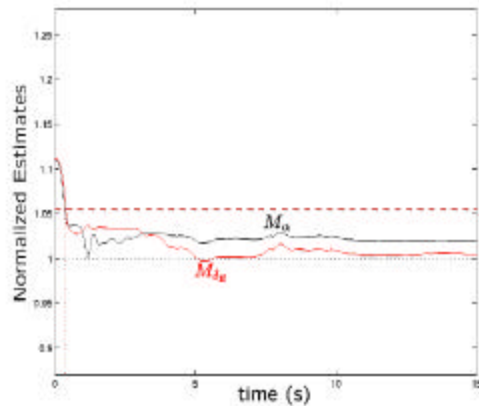
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- Incorporate Human Factors input throughout process
- Focus on technology and tools, not specifics of the IMS for a given aircraft
- Focus on icing effect characterization years 1 and 2
- Use flight simulator as system integrator with emphasis in later years of project
- Conduct envelope protection research in years 3 and 4

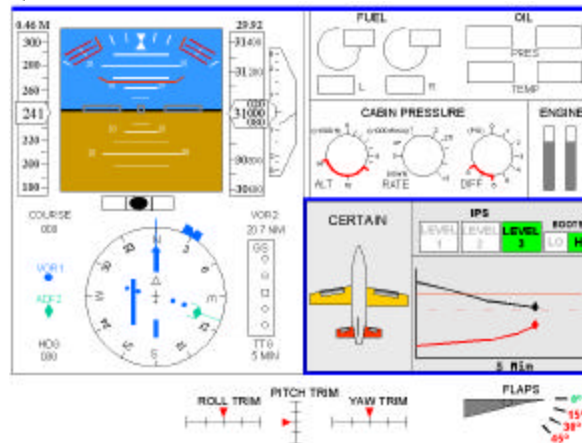
NASA/University of Illinois Smart Icing Systems Program

Technology Development

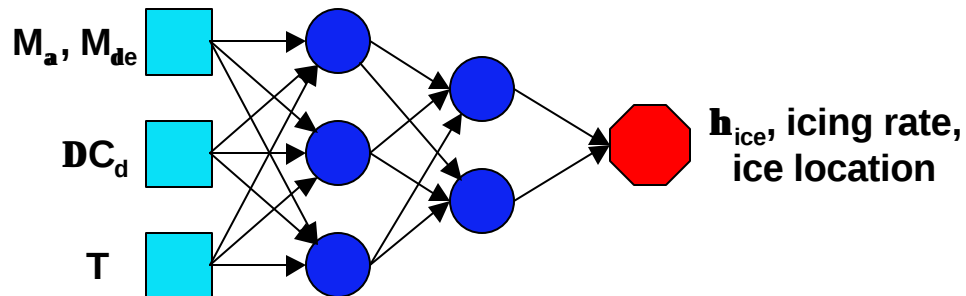
Systems Identification



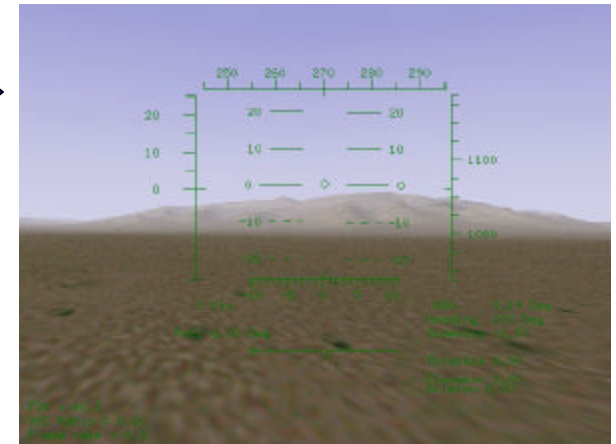
Human Factors



IMS Decision Making



Piloted Flight Simulator Systems Integration



Flight Test

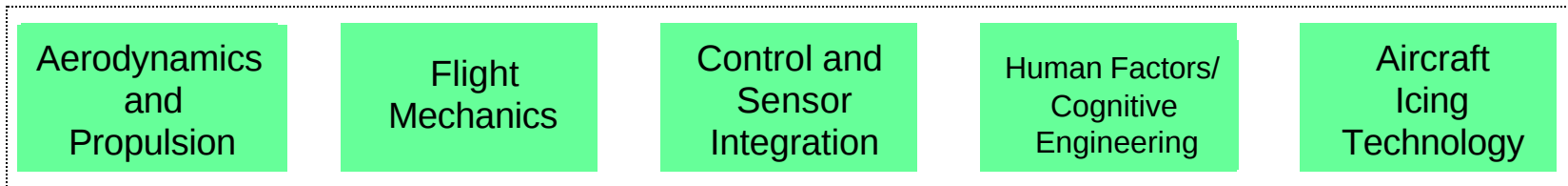


SMART ICING SYSTEMS Research Organization



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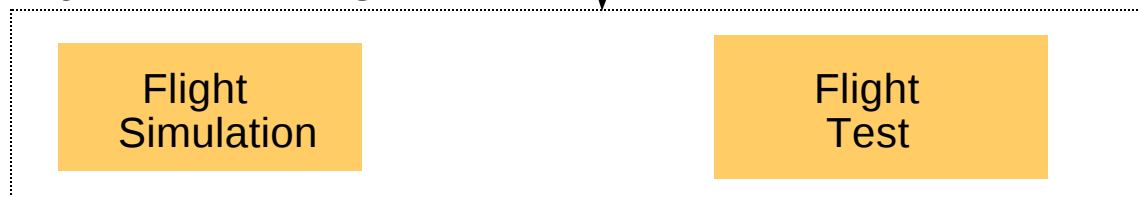
Core Technologies



IMS Functions



Systems Integration



Faculty and Students



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- **Aerodynamics, Propulsion and Flight Mechanics**
 - Profs. Mike Bragg (AAE) and Eric Loth (AAE)
 - Sam Lee, Jason Merret, Kishwar Hossain, Ed Whalen (AAE)
 - Leia Blumenthal (AAE)
- **Control and Sensor Integration**
 - Profs. Tamer Basar (ECE/CSL), Bill Perkins (ECE/CSL), Petros Voulgaris (AAE/CSL)
 - James Melody (ECE/CSL), Vikrant Sharma (AAE/CSL)
- **Human Factors:**
 - Profs. Nadine Sarter (OSU)
 - John McGuirl (OSU)
- **Flight Simulation:**
 - Prof. Michael Selig (AAE)
 - Rob Deters, Glen Dimock (AAE)

SIS Schedule



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Federal Fiscal Year

98

99

00

01

02

03

Concept Development

CRI Funding

Oct. 2002

SIS Core Technologies / IMS research

Icing Encounter Flight Simulator

Systems Study

Flight test

◆ Preliminary IMS Methods
IMS Demo

◆
Final report

Major Program Changes



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- Added
 - Analysis of the effect of atmospheric effects
 - Flight test
- Delayed
 - Envelope protection research
 - Nonlinear aircraft model
- Eliminated
 - Construction of wind tunnel models and testing
 - CFD analysis of iced aircraft
 - Full-control adaptation research

Meeting Schedule



Smart Icing Systems Review, September 30 – October 1, 2002

Monday September 30:

8:30 am – 9:00 am

8:30 am – 8:35 am

8:35 am – 9:00 am

9:00 am – 9:45 am

9:00 am – 9:30 am

9:30 am – 9:45 am

9:45 am – 10:00 am

10:00 am – 11:45 am

10:00-10:30

10:30-11:00

11:00-11:45

11:45 noon – 1:00 pm

1:00 pm – 2:00 pm

1:00-1:20

1:20-1:40

1:40 -2:00

2:00 pm – 3:15 pm

2:00 pm – 2:45 pm

2:45 pm – 3:15 pm

3:15 pm – 3:30 pm

3:30 pm – 4:30 pm

3:30 pm – 4:00 pm

4:00 pm – 4:30 pm

4:30 pm – 5:00 pm

6:30 pm – 8:30 pm

Introductions

Welcome

Smart Icing Systems Overview

Aerodynamics and Flight Mechanics

Aerodynamics and Flight Mechanics Overview

Nonlinear aircraft model

Break

Characterization

Characterization Overview

Flight Test

Real-Time Parameter ID

Lunch

Autopilot and Envelope Protection

Autopilot/Envelope Protection Overview

Open Loop Envelope Protection

Autopilot in Icing/ Closed Loop EP

Flight Deck Displays/Human Factors

Fight Deck Displays/ Human Factors Overview

Supporting Trust Calibration

Break

Flight Simulation

Flight Simulator Overview

Simulator Demo

Wrap-Up Session

Reception

B02 CSRL

Bond

Bragg

B02 CSRL

Bragg

Hossain

Basar

Whalen

Melody

301 CSRL

B02 CSRL

Voulgaris

Hossain

Sharma

B02 CSRL

Sarter

McGuirl

B02 CSRL

Selig

Deters and Dimock

Bragg Residence

Schedule (cont.)



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Tuesday October 1:

8:30 am – 10:00 am	Government Meeting	(NASA/FAA only)	469A CSRL
10:00 am – 10:15 am	Break		
10:15 am – 11:30 pm	Review of SIS Research	(NASA/FAA/UIUC/OSU)	469A CSRL
11:45 am – 1:00 pm	Lunch		Union
1:00 pm	Adjourn		

Future Plans from 2001 Review



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- Do not incorporate gravity wave simulations into neural net
- Obtain/formulate a nonlinear force and moment model
- Formulate initial model of envelope protection and implement into FDC
- Extend ID to full nonlinear dynamics
- Investigate control adaptation and envelope protection
- Develop and test trend display and envelope protection display concept
- Add latest characterization scheme, autopilot and display to simulator
- Support future flight test development
- Study effect of turbulence, sensor noise, IPS operation, icing onset detection, dynamic excitation, etc.
- Apply old and new neural nets to flight data
- Prepare for the second phase of the flight test