Introduction

Mike Bragg
University of Illinois at Urbana-Champaign

Smart Icing Systems
NASA Review
Sept. 30 – Oct. 1, 2002

Outline

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

Aircraft Icing Accidents

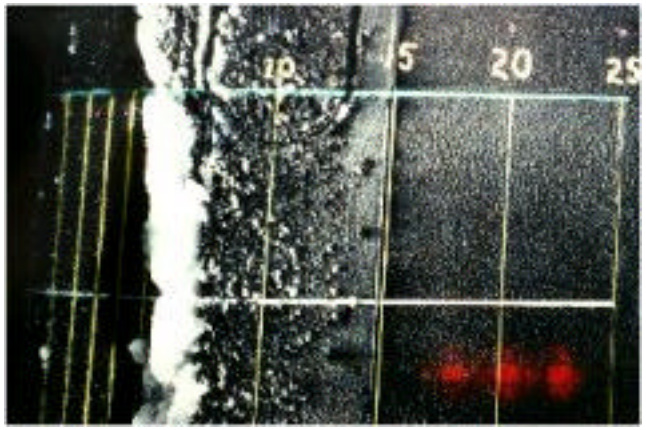
Accidents

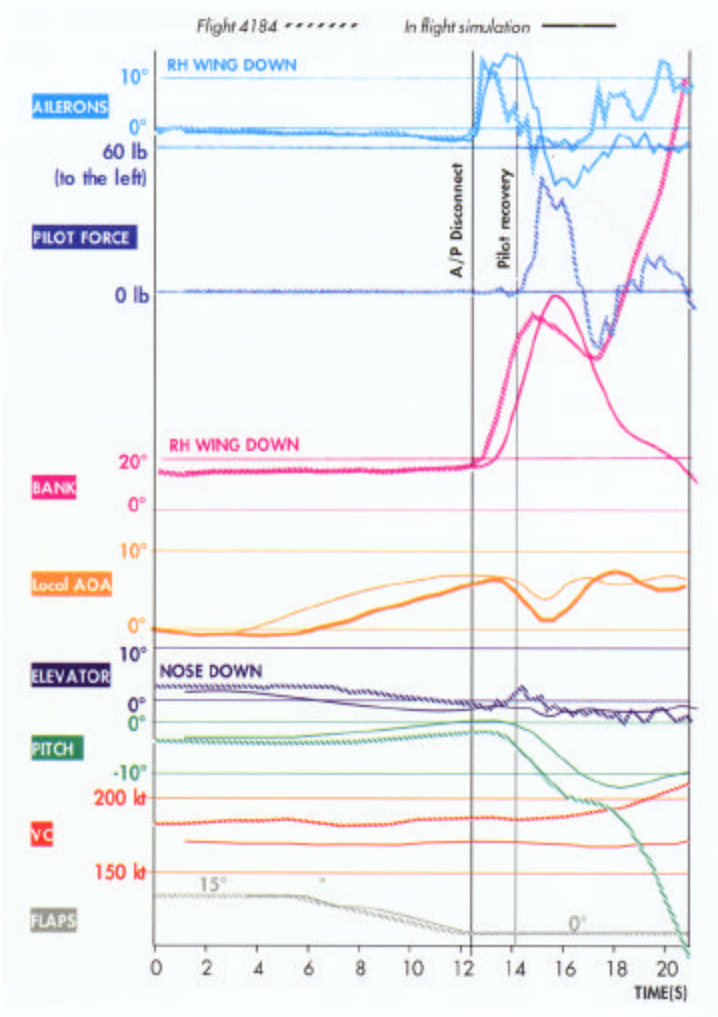
- Air Florida - takeoff accident - performance and S&C.
- United Express Jetstream - tail stall - longitudinal S&C.
- Roselawn ATR - roll upset - lateral S&C.

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





Smart Icing Systems

Goal

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

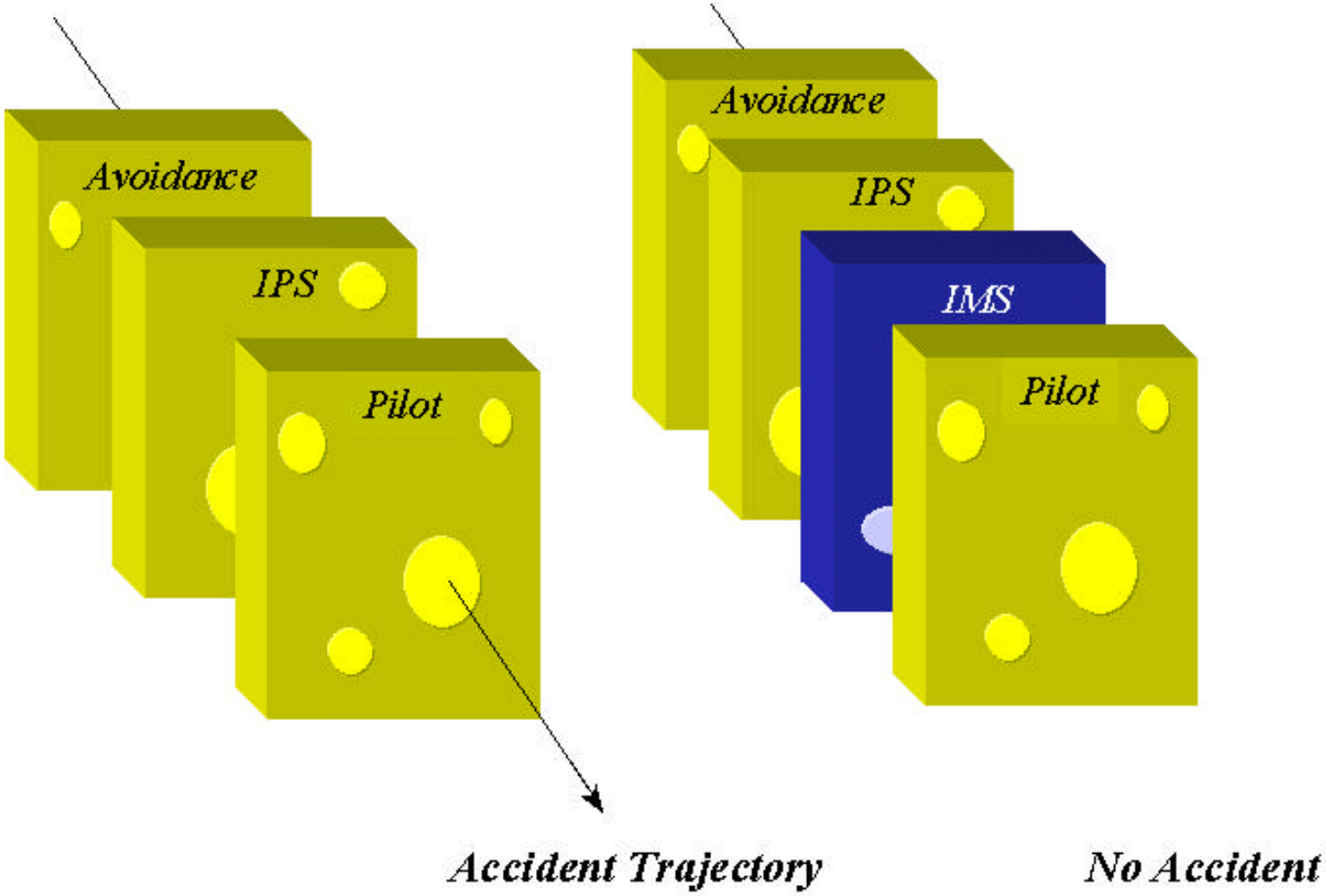
Objective

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

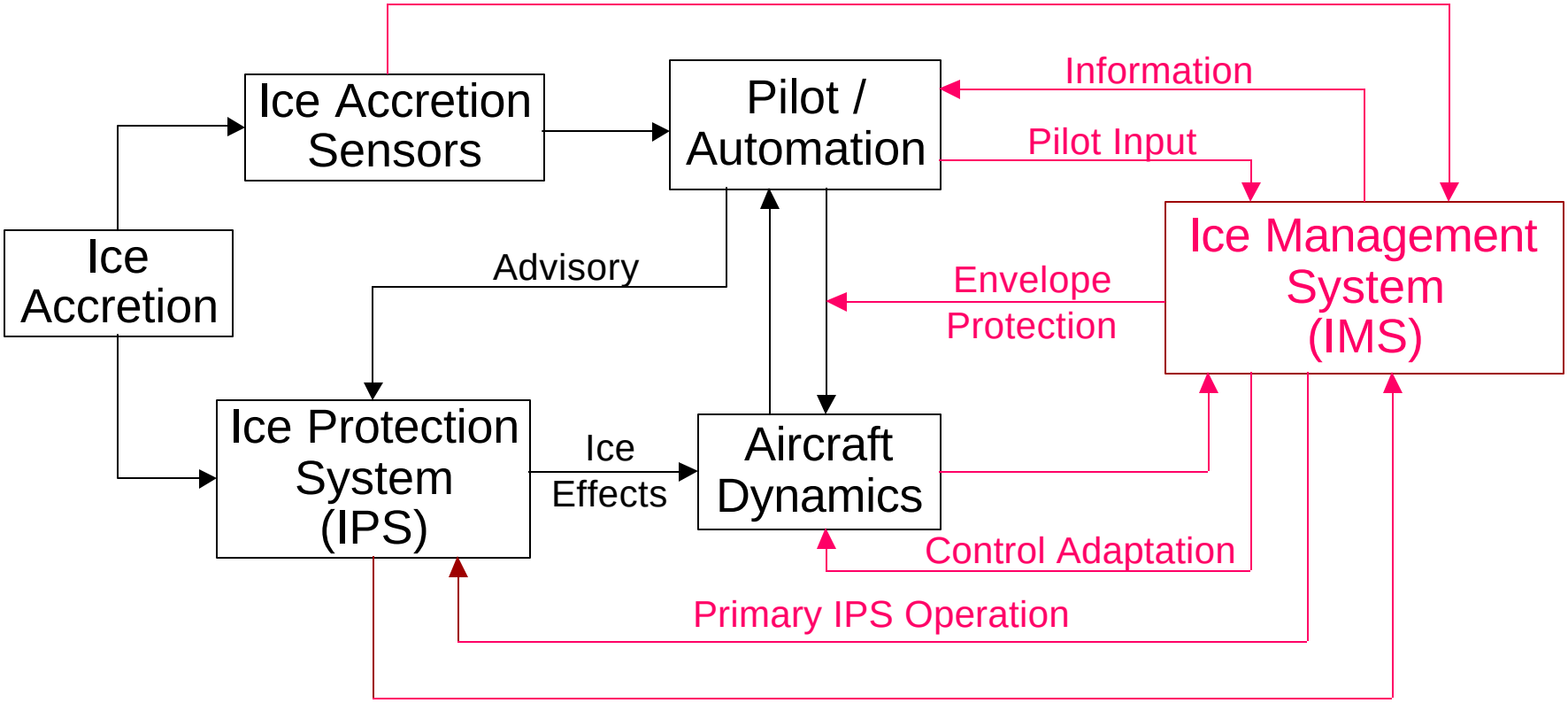
Approach

- 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.

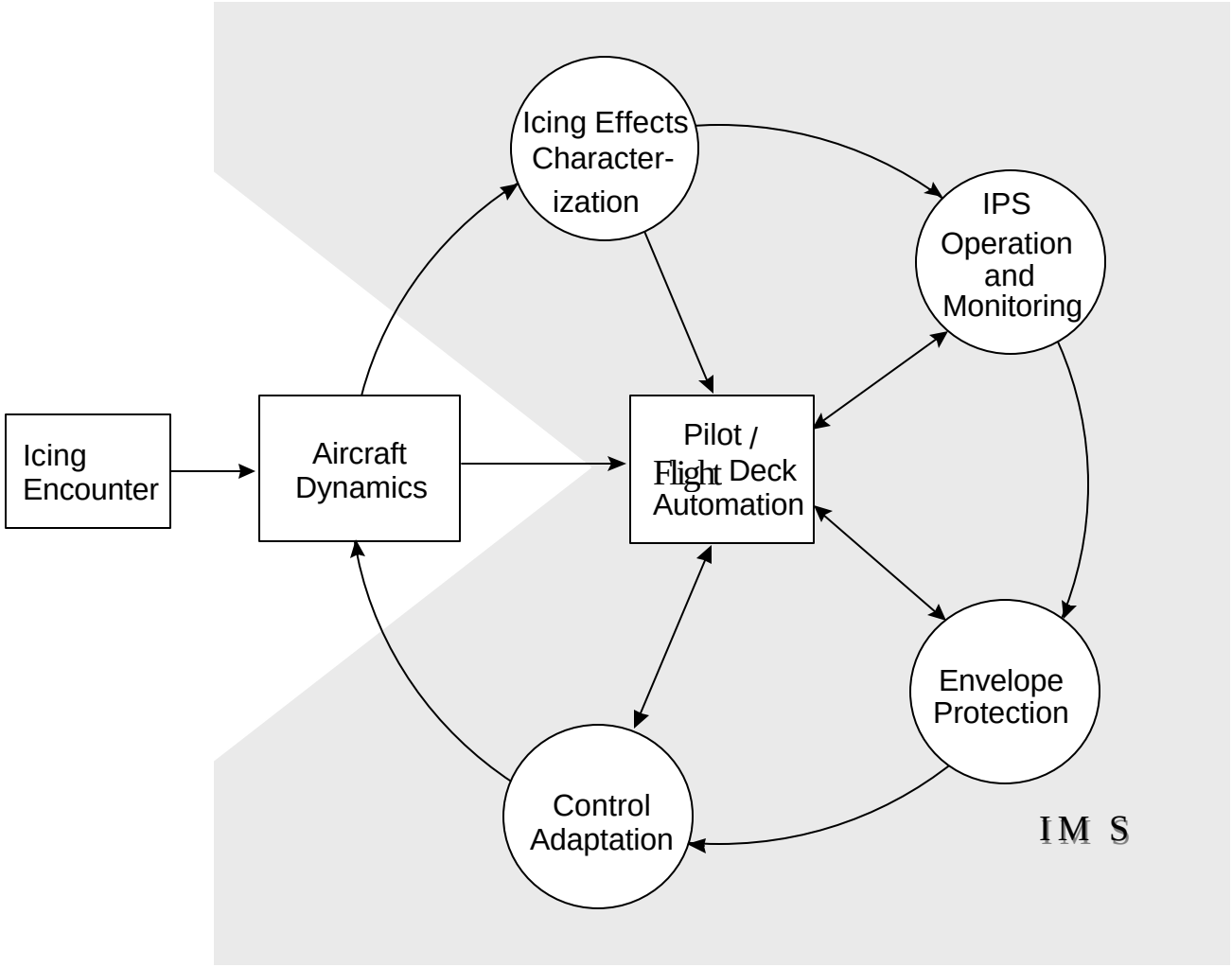
Defenses in Depth



New Aircraft Icing Encounter Model



IMS Functional Model



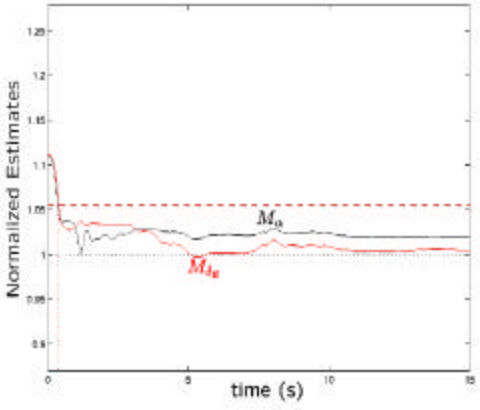
SIS Development Strategy

- 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

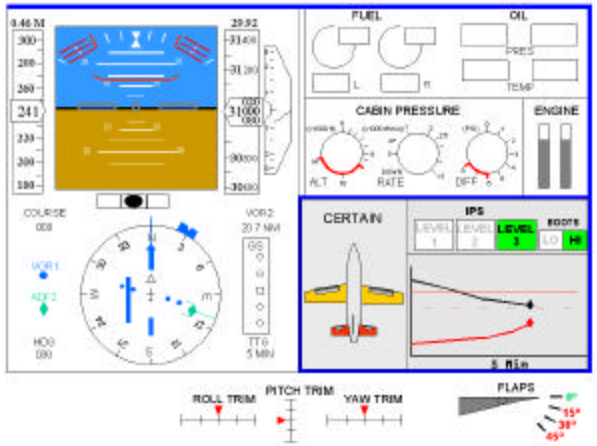
NASA/University of Illinois Smart Icing Systems Program

Technology Development

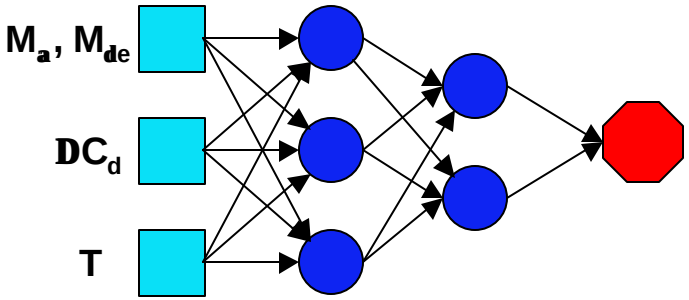
Systems Identification



Human Factors

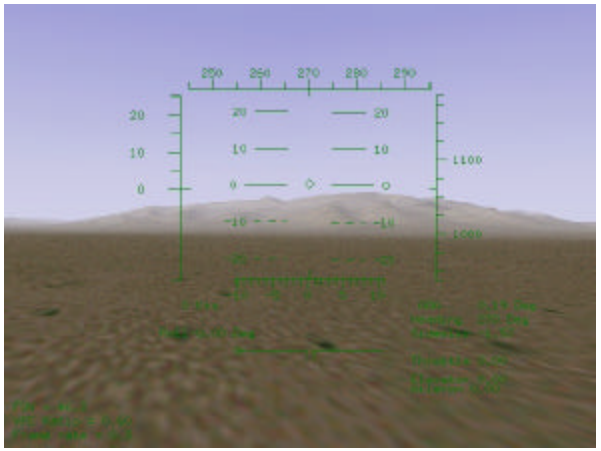


IMS Decision Making



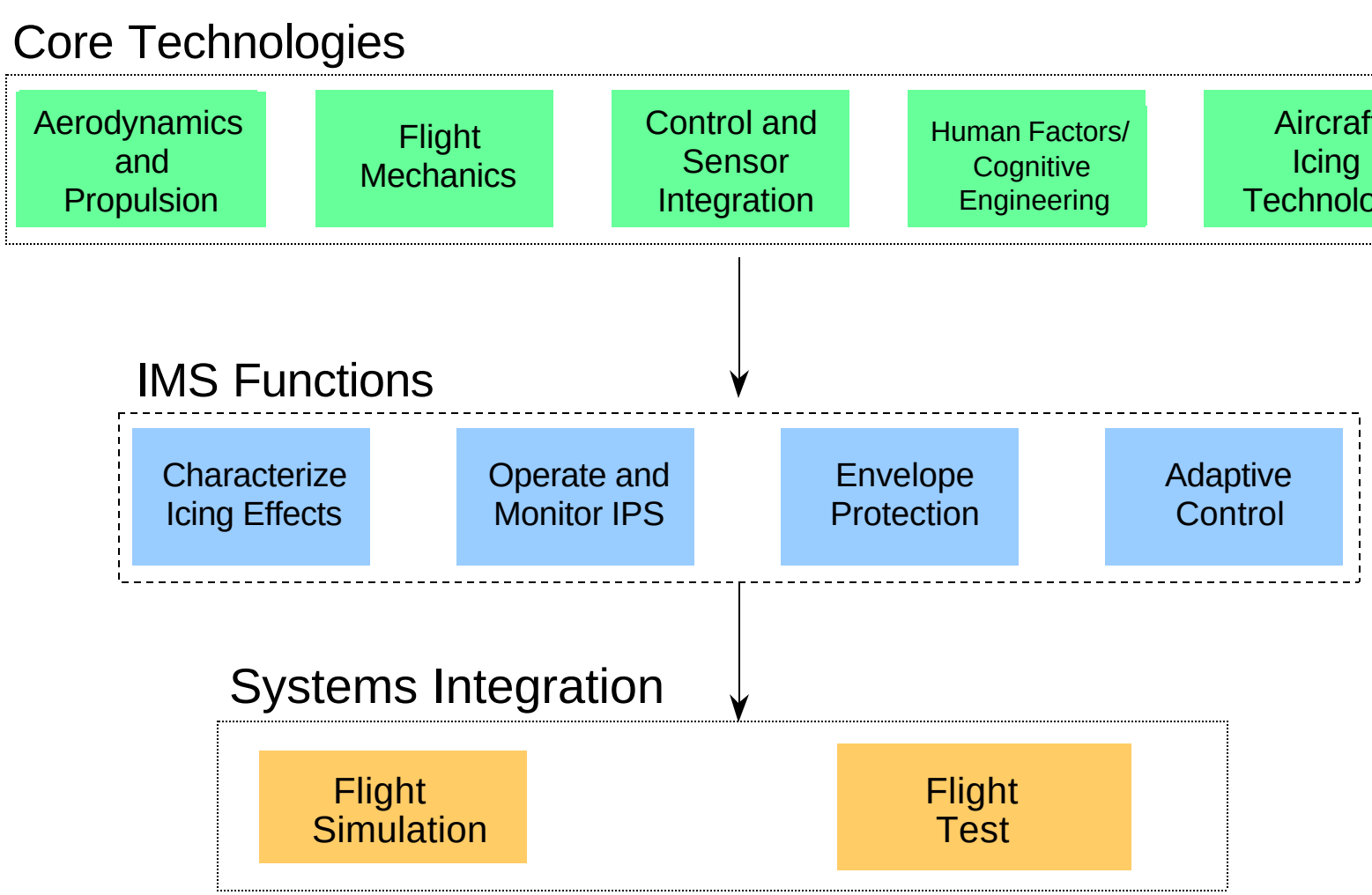
h_{ice}, icing rate, ice location

Piloted Flight Simulator Systems Integration



Flight Test

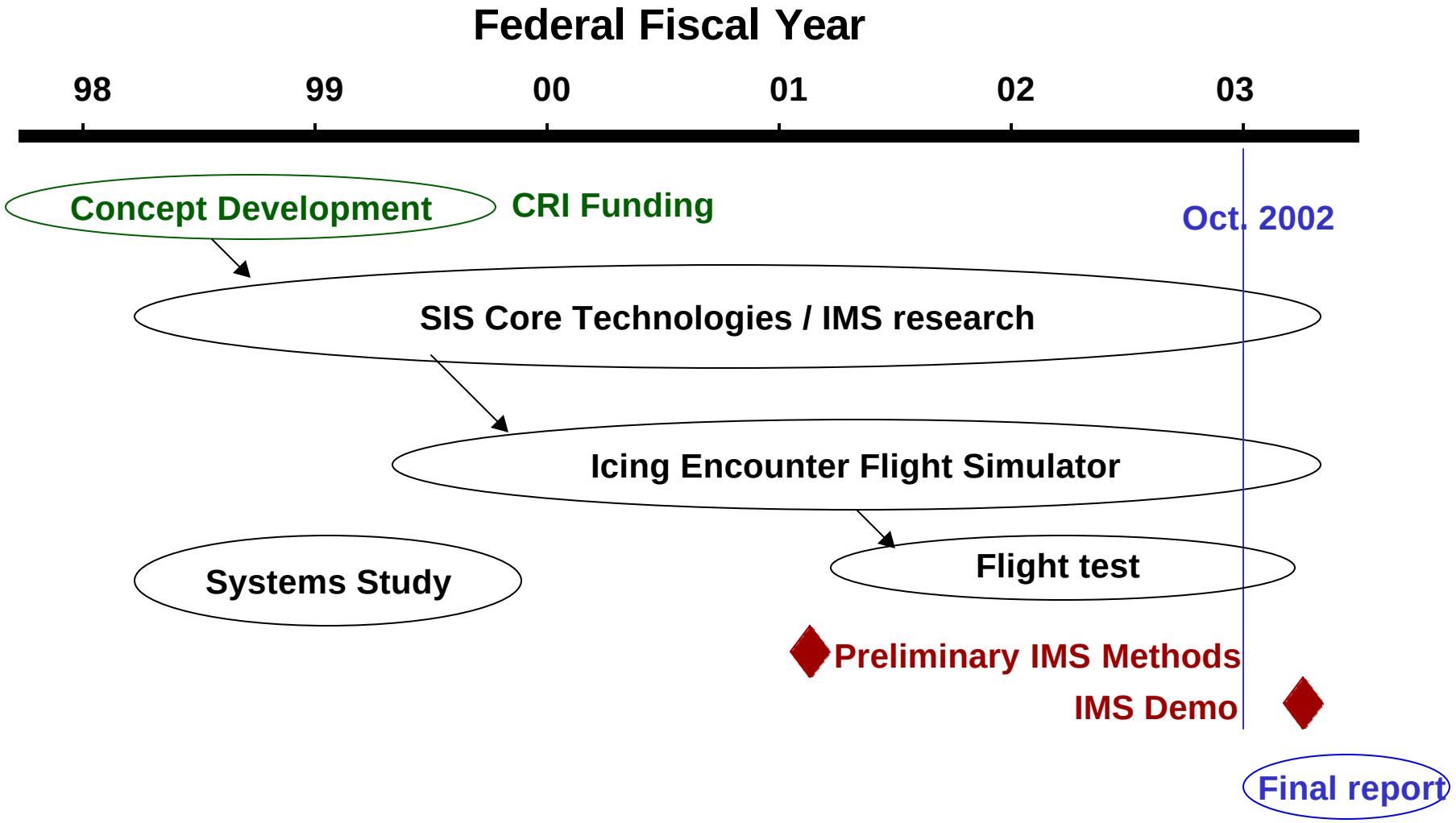
SMART ICING SYSTEMS Research Organization



Faculty and Students

- **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



Major Program Changes

- 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

Monday September 30:

8:30 am – 9:00 am	**Introductions**		**B02 CSRL**
8:30 am – 8:35 am	Welcome	Bond	
8:35 am – 9:00 am	Smart Icing Systems Overview	Bragg	
9:00 am – 9:45 am	**Aerodynamics and Flight Mechanics**		**B02 CSRL**
9:00 am – 9:30 am	Aerodynamics and Flight Mechanics Overview	Bragg	
9:30 am – 9:45 am	Nonlinear aircraft model	Hossain	
9:45 am – 10:00 am	Break		
10:00 am – 11:45 am	**Characterization**		
10:00-10:30	Characterization Overview	Basar	
10:30-11:00	Flight Test	Whalen	
11:00-11:45	Real-Time Parameter ID	Melody	
11:45 noon – 1:00 pm	**Lunch**		**301 CSRL**
1:00 pm – 2:00 pm	**Autopilot and Envelope Protection**		**B02 CSRL**
1:00-1:20	Autopilot/Envelope Protection Overview	Voulgaris	
1:20-1:40	Open Loop Envelope Protection	Hossain	
1:40 -2:00	Autopilot in Icing/ Closed Loop EP	Sharma	
2:00 pm – 3:15 pm	**Flight Deck Displays/Human Factors**		**B02 CSRL**
2:00 pm – 2:45 pm	Fight Deck Displays/ Human Factors Overview	Sarter	
2:45 pm – 3:15 pm	Supporting Trust Calibration	McGuirl	
3:15 pm – 3:30 pm	Break		
3:30 pm – 4:30 pm	**Flight Simulation**		**B02 CSRL**
3:30 pm – 4:00 pm	Flight Simulator Overview	Selig	
4:00 pm – 4:30 pm	Simulator Demo	Deters and Dimock	
4:30 pm – 5:00 pm	**Wrap-Up Session**		
6:30 pm – 8:30 pm	Reception		**Bragg Residence**

Schedule (cont.)

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

- 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