



# The National Aviation Operations Monitoring Service

## PROJECT OVERVIEW

Background, Approach, Development  
and Current Status

Mary Connors and Linda Connell

# Purpose of Meeting

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- Introduce NAOMS project
- Describe project in sufficient detail that potential benefits are understood
- Solicit advice on future FAA briefings and activities

# Agenda

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- **NAOMS Briefing**
  - NAOMS introduction and overview
  - Survey methodology; NAOMS design decisions
  - Survey instrument
  - NAOMS survey initial results
  - Future directions
  
- **Discussion**



# The NAOMS Team

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- **The NAOMS team is highly experienced and qualified in...**
  - *Survey methodology*
  - *Statistics*
  - *Survey application*
  - *Aviation operations and safety*

# Expressed Need for Event Data



*There have been multiple and consistent recommendations for improvement in aviation data systems . . .*

- **White House Commission on Aviation Safety and Security (“Gore Report” 1998) --**
  - “Most effective way to identify incidents and problems in aviation is for the people who operate the system (pilots, mechanics, controllers, dispatchers, etc) to self-disclose the information.” (Page 13)
- **GAO Evaluation (Safer Skies Review, June 2000) --**
  - Additional performance measures required
  - Use precursors associated with past accidents to track safety baseline and improvements from interventions
- **NTSB (Safety Report on Transportation Safety Databases, 2002) --**
  - Over 19 recommendations for improvements in safety event reporting (1968-2001)
  - Need to address problem of under-reporting in current aviation safety data systems
- **FAA (Internal Studies, 2004 Strategic Plan draft)**
  - Identify risks before they lead to accidents

# The Unmet Data Need

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- **Reliable, stable numbers with system-wide scope**
  - To inform policy decisions
  - And, investment decisions
  
- **Providing better and more rapid feedback on system change, both technological and procedural**
  
- **Facilitating a truly data-driven basis for safety decisions**
  - An escape from the accident *du jour* policy-making syndrome

# Available Data



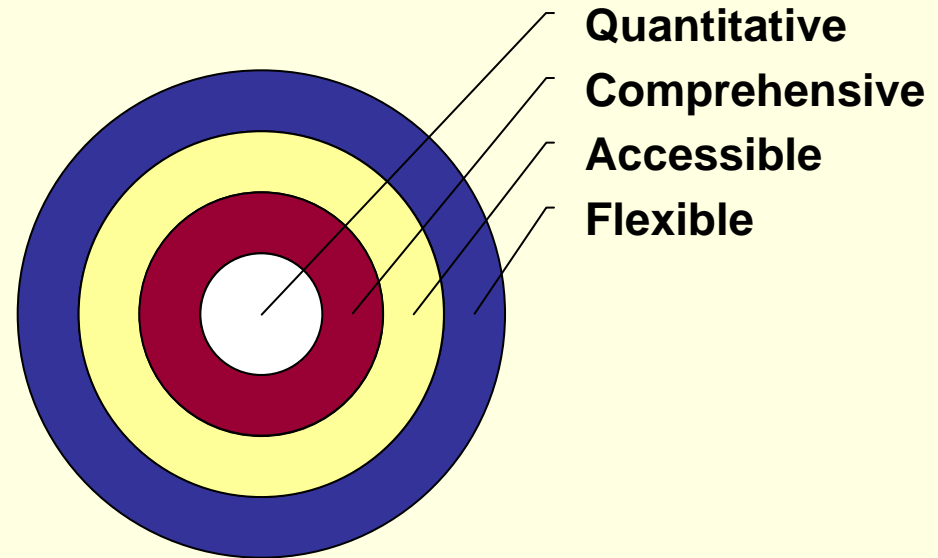
- **A number of databases attempt to capture safety-related information concerning the National Airspace System (NAS)**
  - NTSB Accident/Incident Database
  - FAA Data System (NAIMS)
  - Aviation Safety Reporting System (ASRS)
  
- **A number of databases attempt to capture safety-related information concerning specific parts of the NAS**
  - FOQA
  - PDARS
  - ASAP
  
- **No existing database addresses the health and safety of the NASA as a whole in a quantitatively defensible fashion**

# Goals



*To create a new national capability that will :*

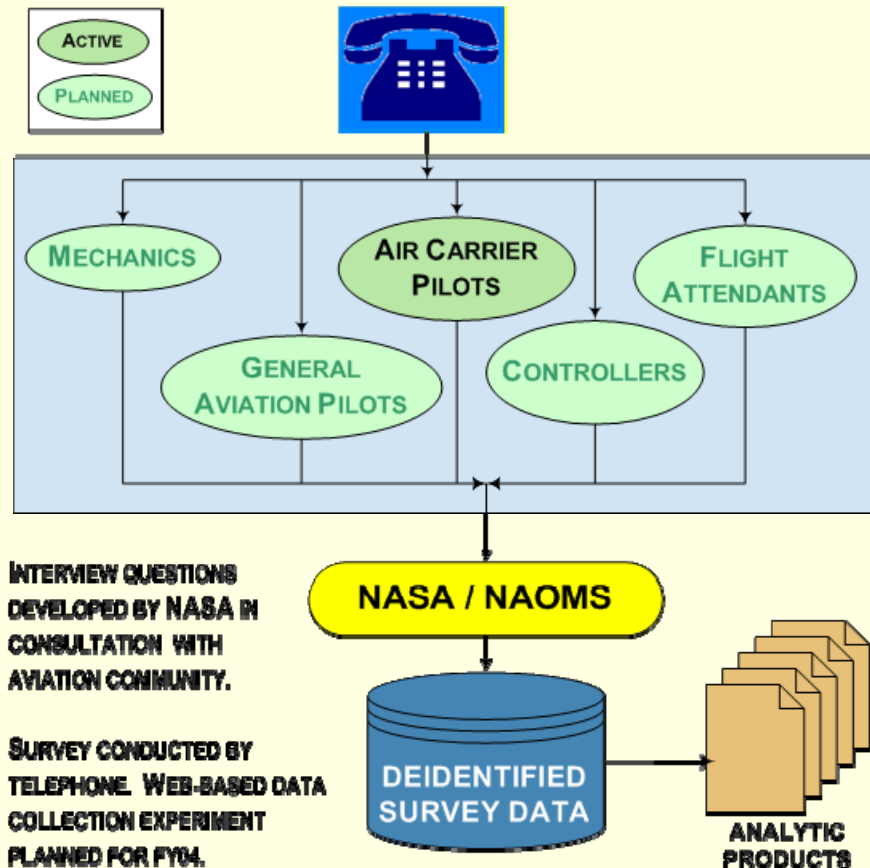
1. Track long-term aviation safety **trends** and patterns.
2. Monitor the impacts of technological and procedural change on the system.
3. Make substantial contributions to data-driven aviation safety decision making.



**Features sought  
in NAOMS**

***NAOMS measures event occurrences, not causes.  
(Notable findings require **additional**  
investigation.)***

# NAOMS Survey Approach



- **Regularly survey those who operate the National Aviation System (NAS)**
  - View the NAS through their eyes
  - Include all types of operations (air carrier, regional, corporate, GA)
- **Collect data on respondents' events (as operationally experienced)**
- **Guarantee confidentiality of data**
- **Achieve scientific integrity by**
  - Using well crafted survey instruments
  - And, rigorous analytic methods.

# Questionnaire Structure



- **Section A: Operational Exposure**
  - Measures operational activity levels (risk exposure)
  
- **Section B: Safety Event Experiences (Core Questions)**
  - Counts standard event frequencies with long-term trends in mind
  
- **Section C: Focus Topics**
  - Provides a moving “searchlight” that can be redirected as needed to topics of interest
  
- **Section D: Participant Feedback**
  - Seeks continuing feedback on the validity of the NAOMS survey process and survey questions

# NAOMS Development: Initial Stages

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- **Initial program planning started in FY1997**
- **Part of NASA's AvSP program**
  - Method for evaluating impact of AvSP interventions
- **Extensive workshops and briefings to FAA and industry through all phases**
- **Development process and OMB approvals were comprehensive, rigorous, and labor-intensive**
  - Required Federal Register Notices (FRN)
- **Routine data collection began with air carrier pilots in April 2001**

# Government & Industry Groups Briefed



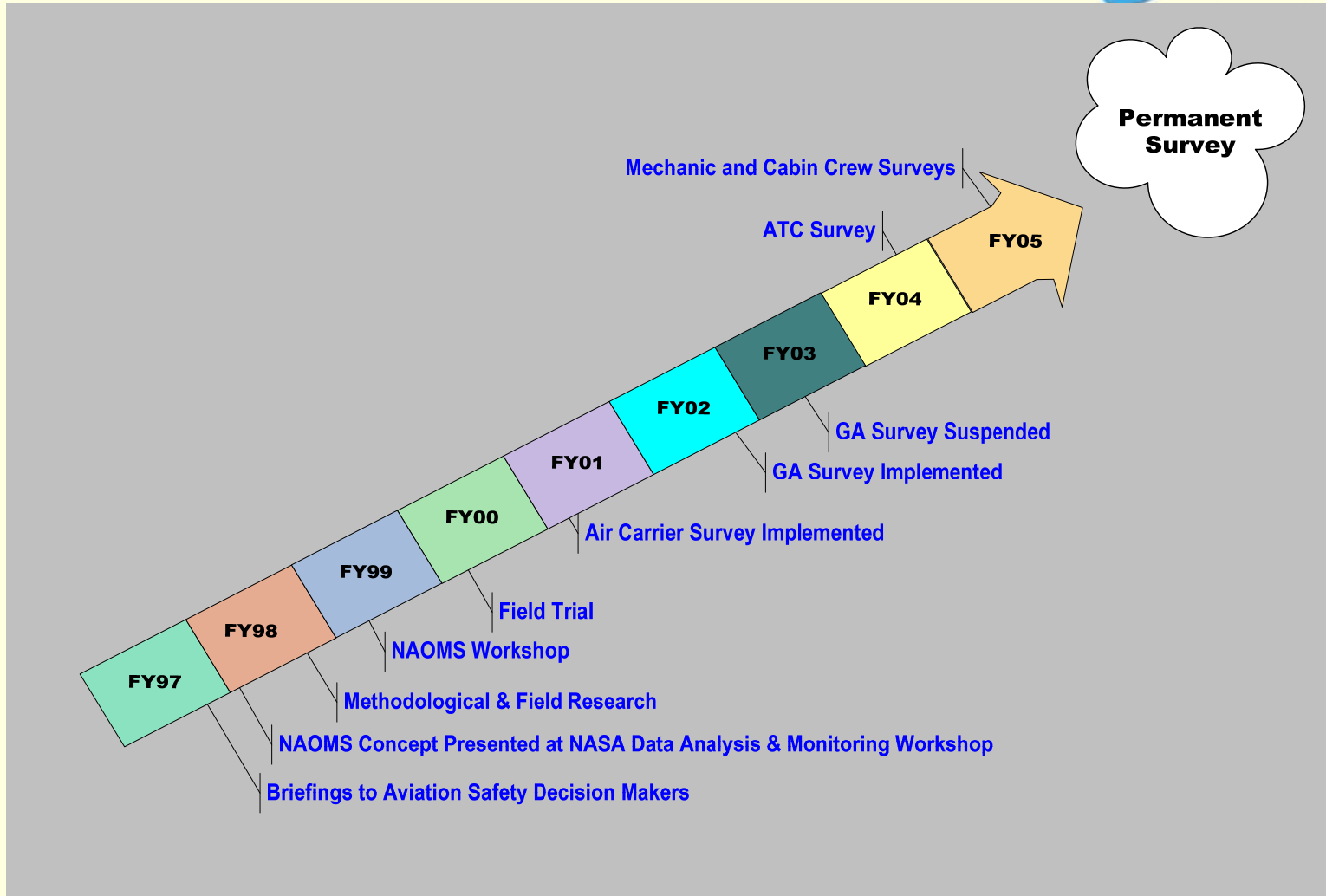
- FAA
- HAI
- GAMA
- AOPA
- ALPA
- CAST-JIMDAT
- NTSB
- NATCA
- NATA
- Boeing
- NBAA
- SWAPA
- ASRS Advisory Subcommittee
- ATA

## *Workshops*

*Preliminary NAOMS workshop, 5/11/99, Alexandria, VA, 60 attendees*

*NAOMS field study briefing 3/1/00, D.C., 75 attendees*

# NAOMS Development Timeline



# FAA Participation



- **Elements of the FAA have been involved in the NAOMS process from the beginning and at various stages in its development**
  - **Office of System Safety**
  - **Flight Standards - GA**
  - **Lines of Business**
  - **ATO - Office of Performance Analysis**
- **NASA has invited FAA representatives to serve on the NAOMS Working Group**
- **Encourage others within their organization to provide feedback through the NAOMS Working Group**
- **Will need support for the NAOMS ATC survey effort**
- **Determine how the NAOMS results can best be used to support the FAA safety mission**

# Overview Summary

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- **NAOMS follows best survey practices**
- **NAOMS measures the occurrence of events, not causes**
- **It is intended to serve the aviation industry as a whole**
- **The NAOMS survey is designed to expose areas that need further investigation**
- **NAOMS questionnaires development is (excrutiatingly) deliberate and thorough**
- **Numerous briefings and workshops have been conducted with the aviation community**

# Overview Summary (cont'd)

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- **NAOMS statistical methods are robust**
- **NAOMS meets the goal of a quantitative statistically defensible, system-wide safety assessment tool, complementing other databases and assessment tools.**



# The National Aviation Operations Monitoring Service

**Survey Methodology/Design Decisions**

**Jon Krosnick Stanford University**

# Surveys Can Measure



- Attitudes
- Preferences
- Beliefs about the state of the world
- Predictions about the future
- Past behavioral experiences or events

**NAOMS will be almost exclusively concerned with measuring events**

# You Can Learn

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- Frequency of occurrences
- Changes over time
- Similarities and differences among groups

# The Survey Approach to Data Gathering

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- Human-centered
- Quantitative
- Flexible (versatile, topical)
- Comprehensive
- Well-developed methods
- Statistically accurate
- Stable

# Survey Benefits

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- Surveys have been used to shape national policy for many decades
- This use is extensive in areas such as public health policy and economics
- Aviation safety is a natural topic for survey data collection
- Survey methods are mature and well understood

# Examples of Federal Surveys



- **Survey of Income and Program Participation (Census Bureau) 1984 -**
- **Consumer Expenditure Surveys (Census Bureau) 1968 -**
- **Annual Housing Surveys (Census Bureau) 1973 -**
- **Survey of Consumer Attitudes (NSF) 1953 –**
- **Health and Nutrition Examination Surveys (NCHS) 1959 -**
- **National Health Interview Surveys (NCHS) 1970 -**
- **American National Election Studies (NSF) 1948 -**
- **Panel Study of Income Dynamics (NSF) 1968 –**
- **National Longitudinal Surveys (BLS) 1964 -**
- **Behavioral Risk Factor Surveillance System (CDC) 1984 –**
- **Monitoring the Future (NIDA) 1975 -**

# Federal Surveys that Measure Event Rates



- National Crime Victimization Survey  
(crimes)
- Behavioral Risk Factor Surveillance System  
(e.g., substance use, immunization, seat belt use)
- National Health Interview Survey  
(e.g., injuries, disability, health insurance coverage)
- National Health and Nutrition Examination Survey  
(food consumption)
- National Survey of Distracted and Drowsy Driving
- National Survey of Drinking and Driving

# Validity of Event Rate Measurements



- National Crime Victimization Survey (NCVS)
  - Survey reports higher crime rates than FBI reported rates
  - “Did you experience this?” vs. Events reported to the police
  - Trends over time are very highly correlated (.91)
  
- Monitoring the Future (MTF) Survey
  - Rates of drunk driving higher than that found in NHTSA Fatality Analysis Reporting System (FARS)
  - Driving drunk vs. fatal accidents with drunk drivers
  - Trends over time are very highly correlated (.94)

# Features of These Surveys

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- Federally-funded via contracts or grants
- Long-term tracking studies
- Large number of constituencies use the data
- Important policy decisions are based on the data
- Conducted by knowledgeable and respected research organizations

# Features of These Surveys (Cont'd.)




- Design done by collaborative teams of investigators
- Principal Investigators remain stable over time
- Advisory Oversight Boards oversee the entire project and make suggestions about project direction
- Methodological experts serve on advisory boards

# Features of These Surveys (Cont'd.)



- Questionnaires have core items that remain constant from wave to wave
- Topical questions are rotated into and out of the questionnaire to reflect current interests
- Press releases and press conferences mark the release of new data (e.g., once a year)
- Publications by the project staff summarize a simple set of core trend findings
- De-identified and aggregated Information is released to the public
- Information forms basis for follow-up studies



# The National Aviation Operations Monitoring Service

**Survey Methodology-Part 2**

**Jon Krosnick Stanford University**

# Design Decisions

# NAOMS Design Decisions

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- What events to address?
- What order of questions?
- How long of a recall period?
- What mode?

# Building Lists of Events



## Content Sources

- **Consultation with Industry/Gov't Safety Group, e.g.**
  - FAA
  - ASRS Analysts
  - Workshops
  
- **Review of Aviation Databases, e.g.**
  - ASRS
  - NTSB
  - NAIMS
  - BTS
  
- **Focus Groups with Active Professional Participants**

# Questionnaire Structure and Organization

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- **Conducted ALPA-supported experimental research with active line pilots to determine**
  - How well pilots remember (period of recall)
  - How pilots organized memory of safety events (questionnaire organization)
  - Survey “talk-aloud” tests (individual pilots provide real time criticism of questionnaire content and structure)

# Question Ordering

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## Question Ordering Relates to Memory Organization:

- Records of experiences are organized systematically and thematically in memory
- Understanding respondent memory organization is crucial to optimizing accuracy
- Asking questions in clusters that match a person's memory organization improves measurement precision
- Various hypotheses about how pilots might organize their memories discussed, but no hard data.

# Memory Organizations

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- Severity
- Causes
- Phase of Flight

# Identifying Memory Organization



- Experiments
- Participants: Air carrier pilots
- Various tasks
  - Order of Recall
  - Labeling of Clusters
  - Sorting of Events into Categories
- Decision: A “hybrid” organization emerged: mostly event categories with some phases
  - ATC, mechanical failure, weather, etc.
  - Takeoff, cruise, etc.

# Recall Period



## Recall Period - The optimal time between event occurrence and survey

- Respondent recall period is crucial to survey validity
- Needs to maximize recall and balance survey logistics
- Memories fade over time
- Participants should not be asked to recall things from too far in the past
- Literature Review: A literature review resulted in data that we felt to be insufficient for our purposes
- Our own study of pilots' recall of mundane flight events: 7 days maximum
- We needed to determine how long more significant events can be remembered

# Field Trial



- **Evaluate methods and survey questionnaire**
  - Response rates
  - Data quality and completeness
  - Data reliability and validity
  - Collection modes
  - Question wording
  - Respondent feedback on survey
  
- **Estimate scale of a fully operational system**
  - Costs
  - Required sample sizes

# Field Trial Approach



- **Assessment of the survey instrument and procedures**
  - 630 air carrier pilots
  - Various versions were tested
  - Last section of survey asked participants for feedback on survey and process
  
- **Variations**
  - Mode (telephone, mail, face-to-face)
  - Recall period
  - Section order
  - Topical foci

# Draft Questionnaire



- **Developed a draft questionnaire that was**
  - Extensively edited and corrected for non-technical wording by survey method experts
  - Edited and corrected for technical accuracy by aviation subject matter experts

**Extensive and detailed up-front effort was devoted to questionnaire development.**

# Recall Period: Validity Analysis

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- Association of hours flown with number of events witnessed
- Association of days in the recall period with number of events witnessed
- Strongest relationships for one month and two months
- Decision: 60 days chosen as recall period

# Mode: Selection and Validation



## ■ Validation results:

- More hours flown should be associated with more events witnessed
- More days in the recall period should be associated with more events witnessed
- Stronger relationships indicate more accurate reporting

## ■ Mode selection:

- 30% stronger relationships for telephone than mail

## ■ Decision: Perform telephone interviewing (Computer Assisted Telephone Interview - CATI)

# Summary of Design Conclusions



- Address as many safety events identified during preliminary investigations as practical
- Order questions to match hybrid clustering
- Use 60-day recall period to maximize documentation of rare events
- Use telephone interviewing to maximize measurement accuracy
- Sample size of approximately 8,000 interviews per year will provide sufficient sensitivity.



# The National Aviation Operations Monitoring Service

## Questionnaire Description

Robert Dodd

Dodd and Associates

# Air Carrier Questionnaire: Structure



- **Section A: Aviation Activity Data**
  - Hours and Legs by make-model and by crew position
  - Previous 60 days and Life-time (total hours only)
  
- **Section B: Safety Related Events**
  - Consistent data set over time
  - Airborne conflicts, spatial deviations, ground events, weather encounters, equipment problems, pilot-ATC interaction issues, turbulence, passenger issues, aircraft handling
  
- **Section C: Focus Questions**
  - Topics driven by government/industry priorities
  
- **Section D: Survey Feedback**
  - Confidence in recall ability
  - Relevance of questions
  - Any problems with specific questions

# Air Carrier Questionnaire: General Characteristics



- Questions are closed and specific
  - Asking number of times events occurred
  - Opinion not included
- Interview is constructed to minimize time required for completion
  - Average time for completion is 18 minutes
- Many questions follow “skip-pattern”
  - Designed to capture more information if a response to a question is affirmative
  - Transparent to the interview subject
  - Reduces time burden
- Many questions are “menu-driven”
  - Helps standardize response values
- Scripted responses provided for interviewers for most common questions for clarification

# Air Carrier Questionnaire: Section A “Demographics”



- Initial questions designed to screen the respondent to ensure they are eligible to complete interview
  - Flew in last 60 days as air carrier pilot
- Balance of questions designed to gain insight into pilot's experience and type of flying
  - Information used for analytical categorization (i.e. aircraft size) and for denominator data for other calculations
  - Extent of flying during last 60 days used as denominator for rate calculations
- Specific data elements include (Questions A1-A8):
  - Total career hours, hours and legs flown in last 60 days
  - Make model of aircraft flown, type operation flown (pax/cargo)
  - Domestic/international experience in last 60 days, size of airline (three size categories)
  - Position in cockpit i.e. captain, first-officer, flight-engineer, relief pilot or other position

# Air Carrier Questionnaire: Section B “Safety Events”

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- Covers operational events that the pilot may have experienced
- There are 50 main questions included in Section B covering 9 topic areas
- These are questions designed to be asked over time. Results are being used for trend generation
- The vast majority of responses are 0 or 1

# Air Carrier Questionnaire: Section B “Safety Events” Cont:



Questions in Section B are contained in 9 main groupings

- |   |   |
|---|---|
| <ul style="list-style-type: none"><li>■ <b>Aircraft mechanical and equipment (ER1-ER7) pgs 5-7</b><ul style="list-style-type: none"><li>■ Maintenance, equipment failures, fire, smoke</li></ul></li><li>■ <b>Turbulence: Wake and enroute (TU1-TU2): Pg 8</b></li><li>■ <b>Weather (WE1-WE6) pgs 8-9</b><ul style="list-style-type: none"><li>■ Icing, diversions, ATC Wx issues, windshear</li></ul></li><li>■ <b>Passenger Related Events (CP1-CP3) pg 9</b><ul style="list-style-type: none"><li>■ Disruption, medical emergency</li></ul></li><li>■ <b>Airborne Conflicts (AC1-AC3) pg 10</b><ul style="list-style-type: none"><li>■ Bird strikes, NMACs</li></ul></li></ul> | <ul style="list-style-type: none"><li>■ <b>Ground Events (GE1-GE10) pgs 10-11</b><ul style="list-style-type: none"><li>■ Near collisions, hydroplaning, off runway events</li></ul></li><li>■ <b>Aircraft handling (AH1-AH15) pgs 12-15</b><ul style="list-style-type: none"><li>■ Variety of pilot related issues: Overweight, stalls, unusual attitudes, tail strikes etc</li></ul></li><li>■ <b>Altitude Deviations (AD1-AD2) Pg 13</b><ul style="list-style-type: none"><li>■ Descend below MSA, deviation from assigned altitude</li></ul></li><li>■ <b>Air Traffic Control Interactions (AT1-AT2) Pg 13</b><ul style="list-style-type: none"><li>■ Difficulty in contacting ATC, “high and fast” clearances</li></ul></li></ul> |
|---|---|

# Air Carrier Questionnaire: Section C “Topical Questions”

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- Section C designed to be changeable and flexible
  - Revision and implementation would take several months
    - Development, editing, testing
  
- Focus of Section C is not trending
  - Focus on specific issues as needs
    - Exploration of new technologies
    - Exploration of specific areas of interest
  
- Section C provides a “quick-response” capability to explore emerging safety issues

# Air Carrier Questionnaire: Section C, “In-Close Approach Changes”



- Current Section C Deals with “In-Close Approach Changes” (ICAC) and Associated Events
- Sixteen main questions (IC1-IC16) pgs 17-20
  - Extensive use of “drill-down” questions to account for
    - Number of ICACs,
    - Type of airplane
      - (“steam-gauge” or “glass”)
      - Type of automation
    - Type of approach
    - Location of airport
    - Type of clearance change
    - Reason for change
    - Type of problem, if any, associated with change

# Air Carrier Questionnaire: Section D, “Feedback”

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- Last section of the questionnaire designed to obtain feedback from interview subjects
- Five questions (D1-D5) Pgs 21-22 provide NAOMS team with information about the survey
  - Confidence that questions were answered correctly
  - Identification of confusing questions
  - Issues that should be addressed that are not currently addressed in the questionnaire (open-ended responses)
  - Internet usage at home (to determine feasibility of web-based surveys)
  - Other comments as appropriate

# Data Collection



- CPHRE (Center for Public Health Research and Evaluation)
  - CATI
  - Sample Selection (without replacement for one year)
  - Locating pilots
  - Mailing Letter (NASA letterhead)
  - Interview process
  - Report of response rates
  
- Response Rates
  - Not located = 18% to 25%
  - Not eligible = 19%
  - Located and eligible = 85% completion rate
  - Over 23,000 interviews completed to date



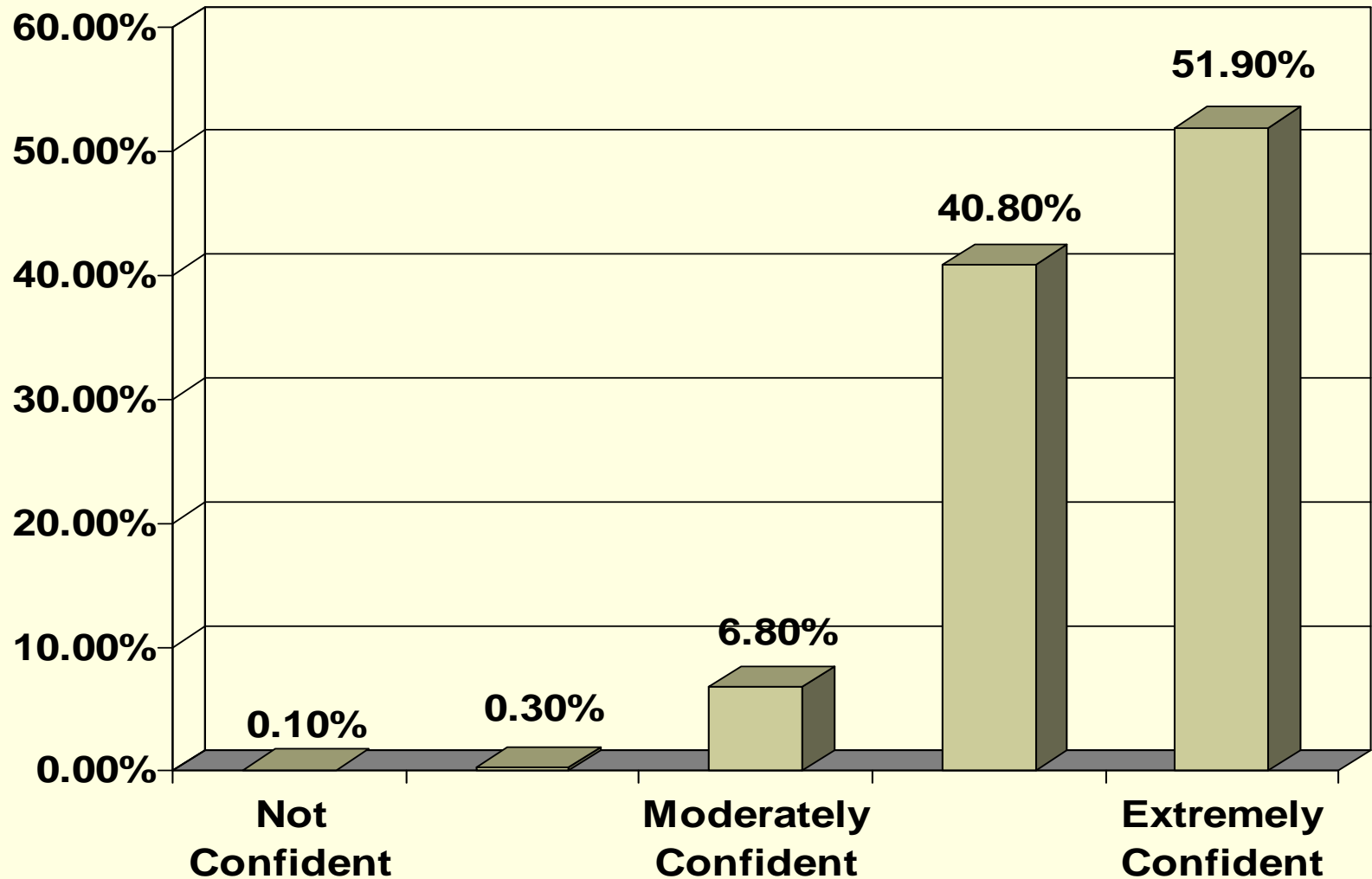
# The National Aviation Operations Monitoring Service

## Preliminary Results

Robert Dodd and Loren Rosenthal,

Battelle

# Section D: Confidence In Accuracy of Answers (Question D1)



# Section D: Confusing or Ambiguous Questions (Question D2)

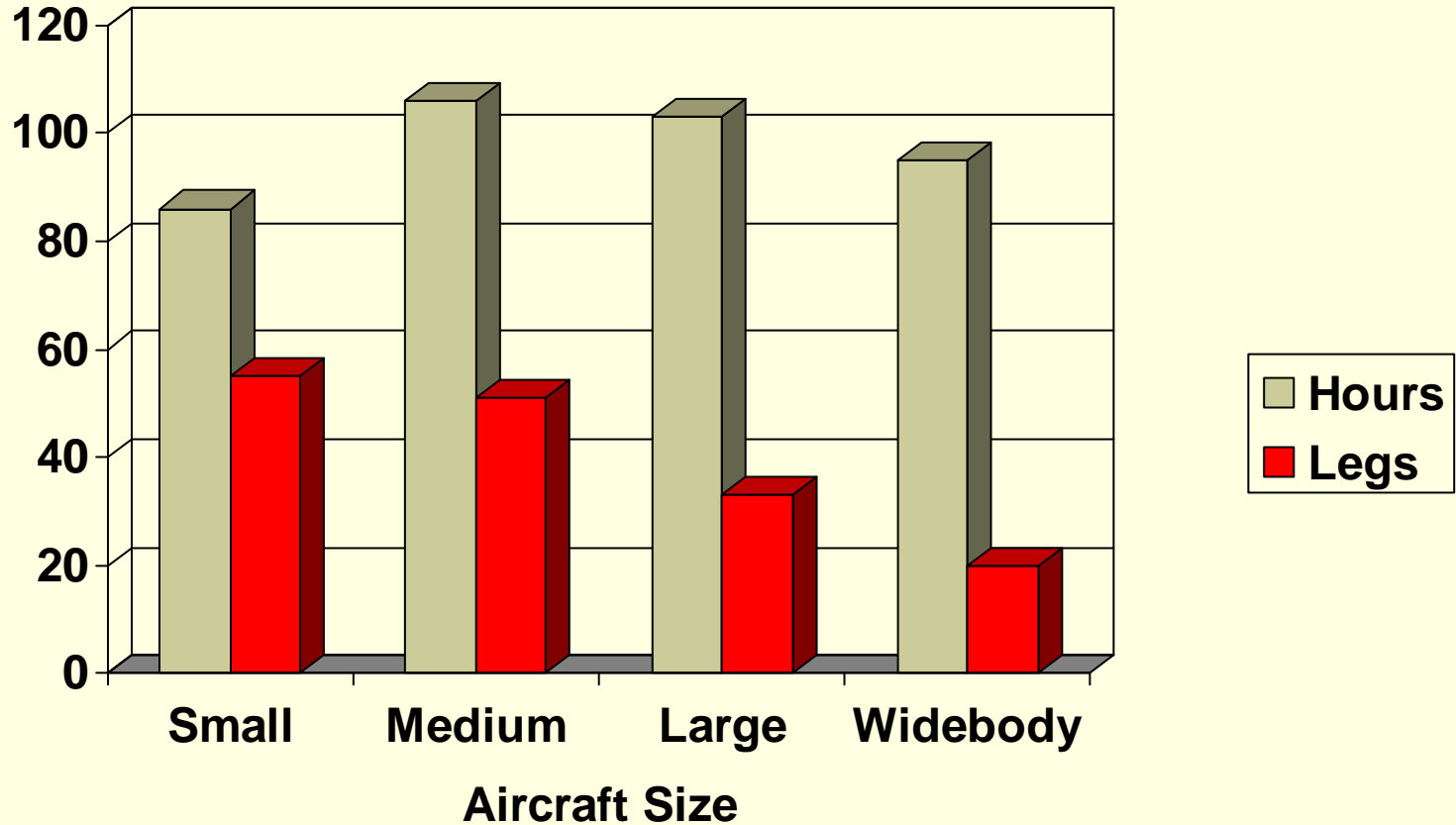
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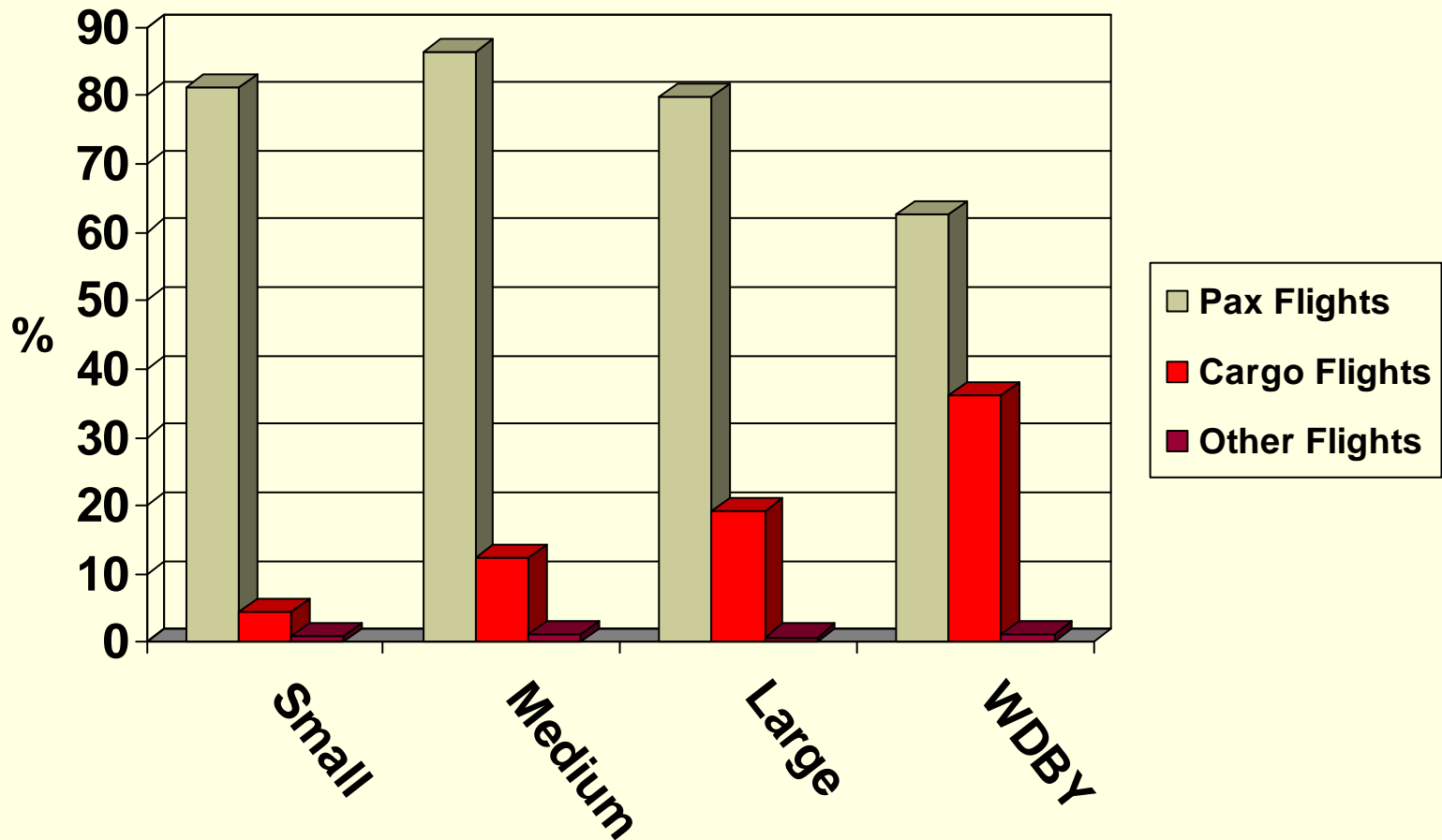
- No 91.1%
- Yes for one or more questions 8.7%

Values based on responses from 12,783 pilots

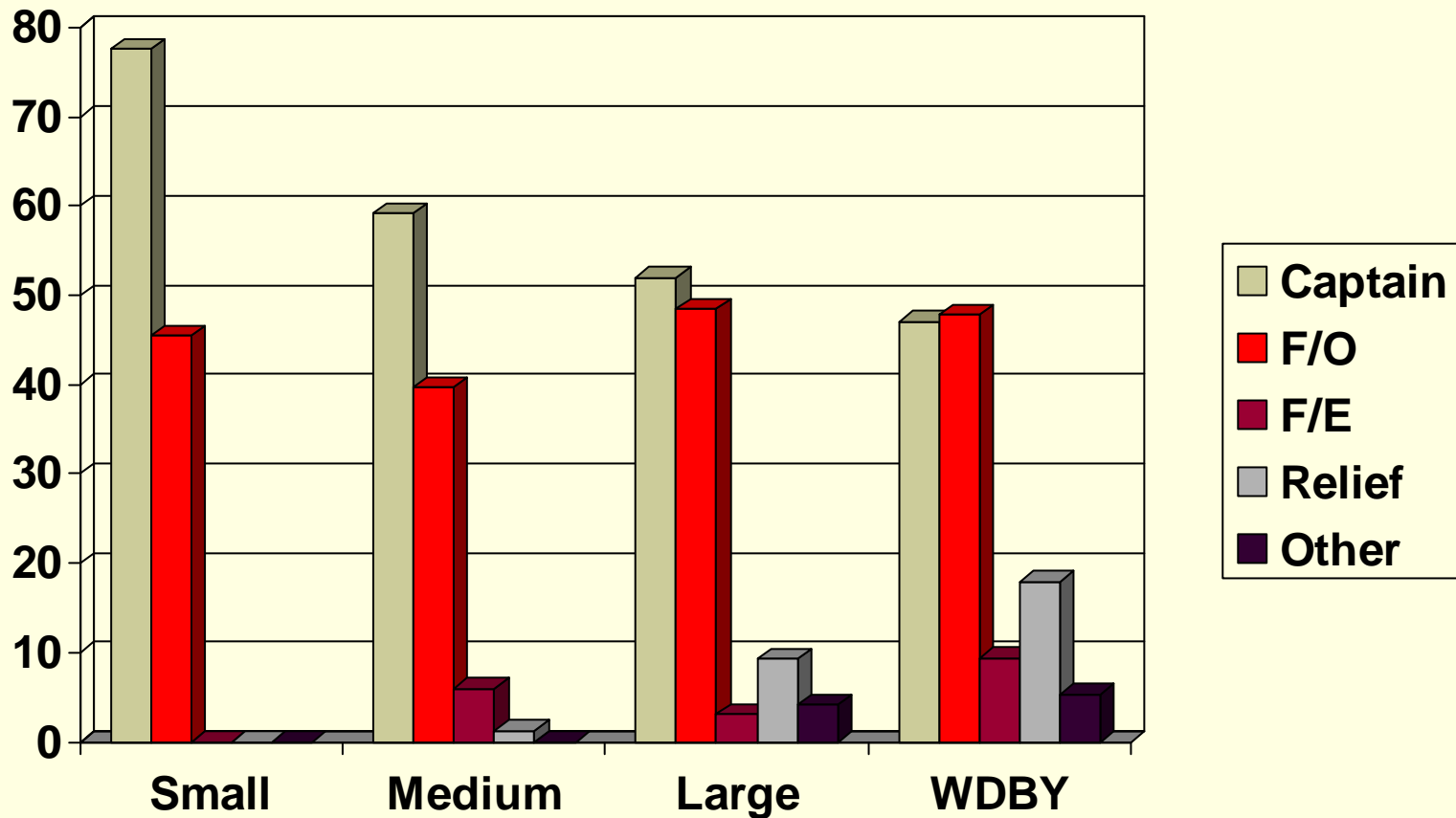
# Section A: Hours and Legs Last 60 Days by Aircraft Size (Questions A1 and A2)



# Section A: Type of Flights (Questions A4-A6)



# Section A: Pilot Reporter Cockpit Position (Question A7)



# Section C: Special Topic – In-Close Approach Changes

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- Dynamics of approach clearance changes requested by ATC within ten miles of a destination airport
- Sixteen questions relating to:
  - Pilot execution of requested changes
  - Consequences
- Questions focus on number of in-close approach change (ICAC) events
- Followed by additional questions concerning the last ICAC experienced by pilot

# Number of In-Close Approach Changes Requested by ATC



	<b>Approaches Flown in Sample Set</b>	<b>Percentage of Approaches Flown</b>
<b>Total Legs Flown</b>	600,410	100%
<b>Total Number of ICAC Requested by ATC</b>	34,291	5.7%
<b>Total Number Accepted by Pilots</b>	32,054	5.3%
<b>Total Number of ICAC Approaches Followed by Unwanted Events</b>	2,076	0.34%

# Issues Associates with In-Close Approach Changes



Type of ICAC Issue	Percentage of Approaches with Unwanted Events
Unstabilized Approach	71.8%
Long/Fast Landing	60.4%
Wake Turbulence Encounter	21.9%
Missed Approach	22.4%
Ground Conflict	4.5%
Airborne Conflict	6.4%
Out of Limit Winds	3.1%
Landing without Clearance	0.5%
Other	37.9%

# Section B Results

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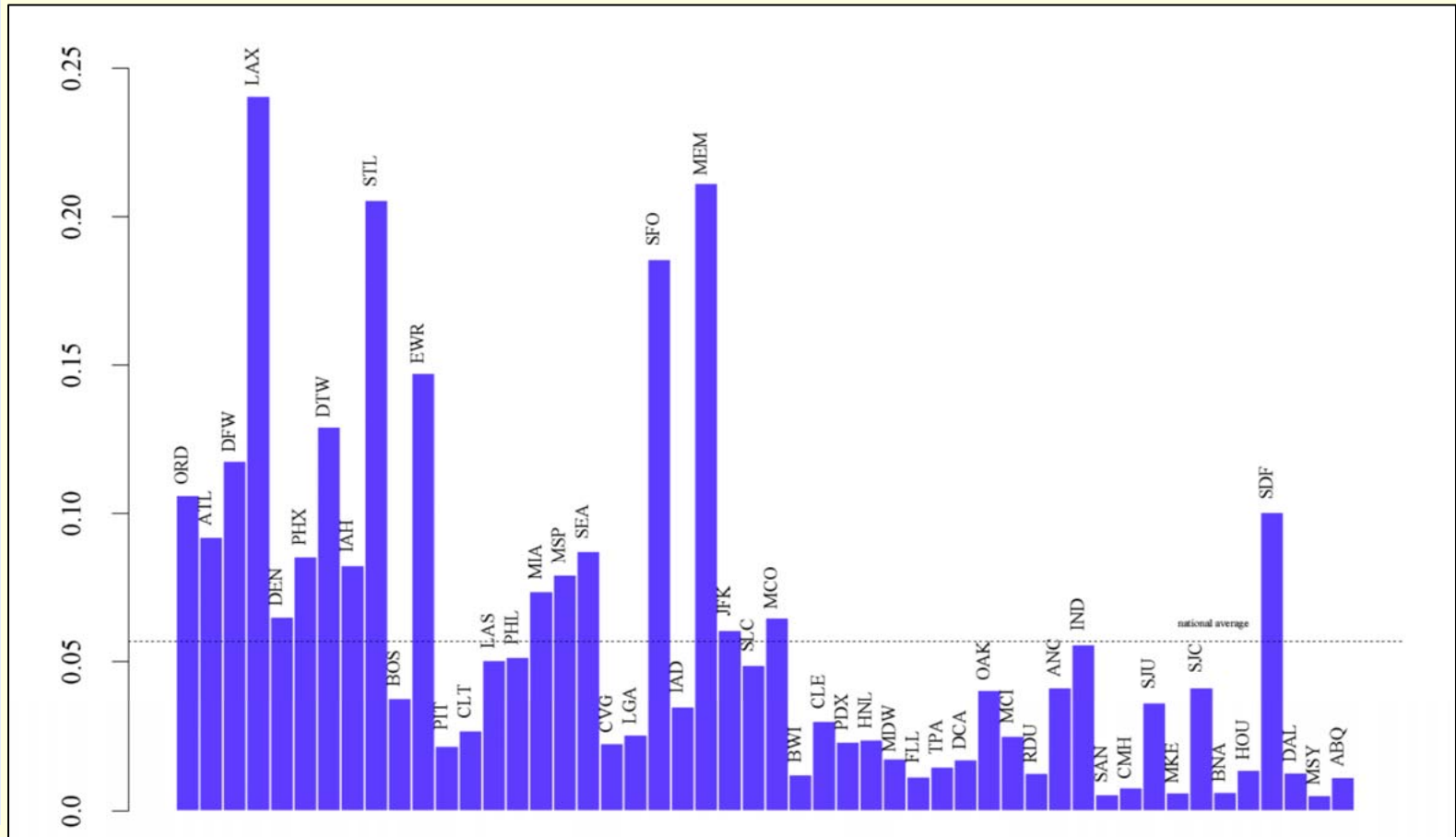


- Adobe Slides

# In-Close Approach Change Probability for the 50 Busiest US Airports



## Probability of An In Close Approach Change

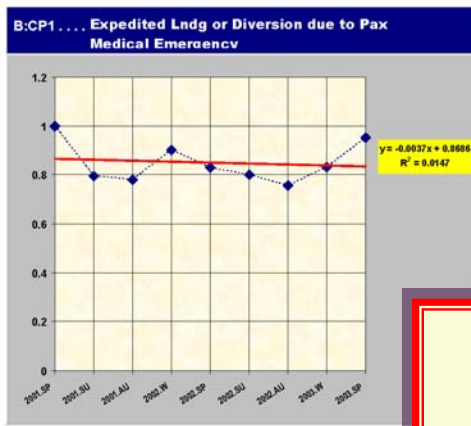


Highest Number of Airport Operations

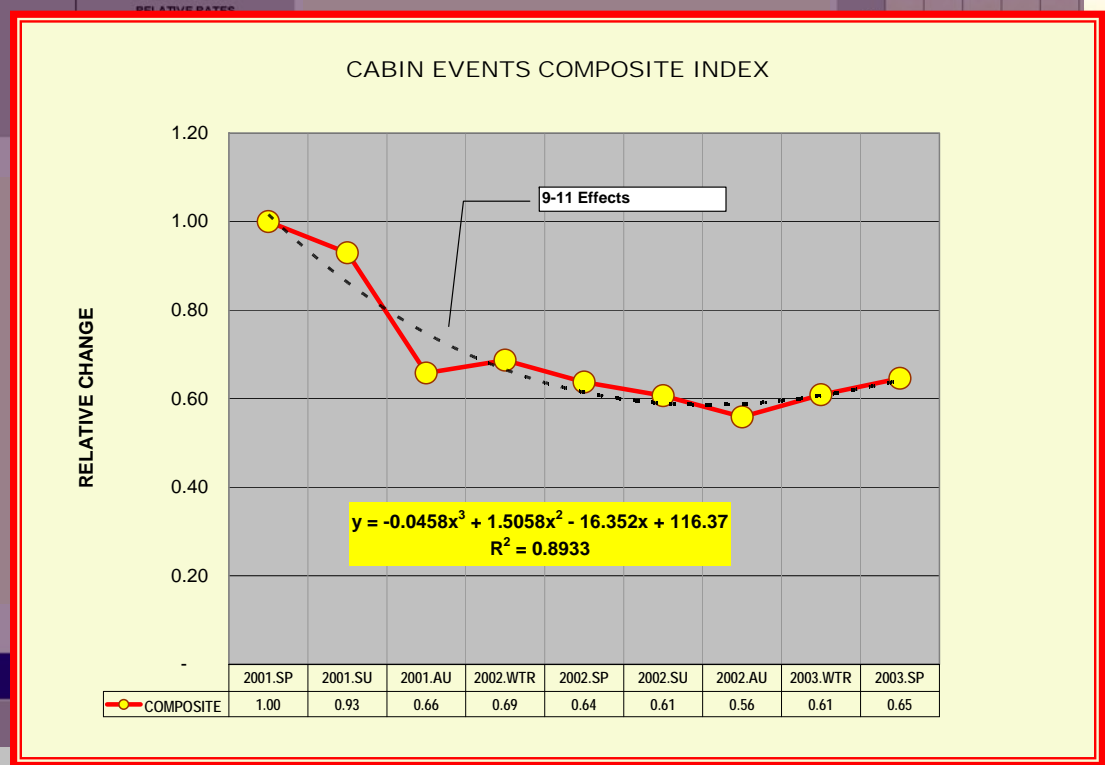
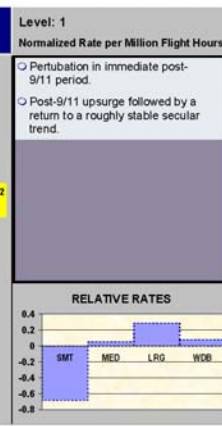
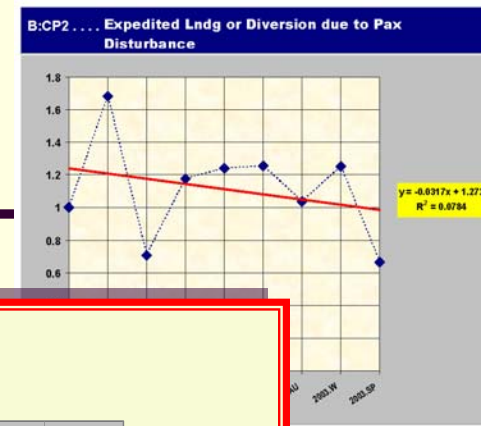
Lowest Number of Airport Operations

# Advanced Analyses

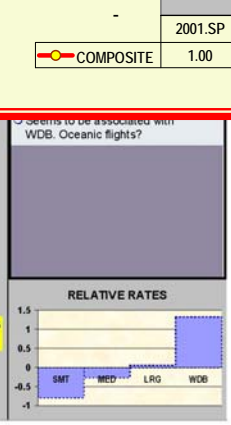
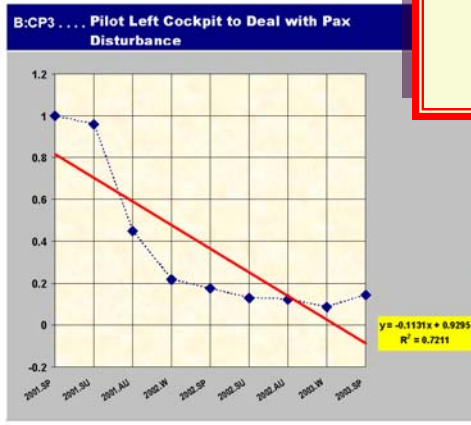
### NAOMS EVENT RATE TRENDS



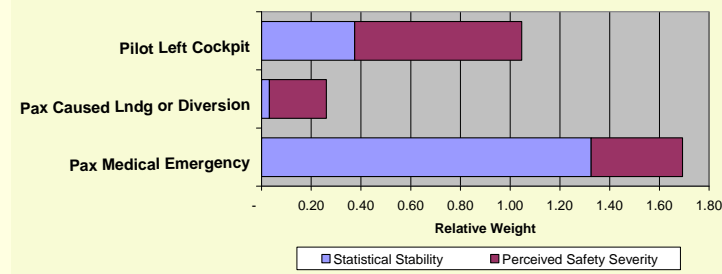
### NAOMS EVENT RATE TRENDS



### NAOMS EVENT RATE TRENDS



### WEIGHTING OF COMPOSITE INDEX COMPONENTS



Bird Strike Modeling Slides Here



# The National Aviation Operations Monitoring Service

**NAOMS Working Group**

Mary Connors

NASA

# The National Aviation Operations Monitoring Service

## **Conclusion and Future Directions**

Mary Connors and Linda Connell

# Conclusion

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- NAOMS data do not stand by themselves; they need to be used in conjunction with other stakeholder data/research
- Ultimate value of NAOMS data depends on government/industry acceptance and use by stakeholders

# CAST/JIMDAT Participation

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## ■ Chairpersons

- Jay Pardee (FAA/ANE-100)
- Paul Russell (Boeing Commercial Airplane)

## ■ Meetings: Several NAOMS briefings over last 18 months

- Feb 03 – San Diego
- Jul 03 – Newport, RI
- Dec 03 – Presentation in Seattle
- Jun 04 - San Francisco

## ■ Activities

- Analysis of 25 completed safety and 21 committed JIMDAT safety enhancements
- At June meeting in San Francisco made suggestions for inclusions of Section B; suggested topics for Section C (Aircraft automation, MELs); procedures; training; cargo versus passenger operations

# CAST/JIMDAT Participation, cont.



- JIMDAT selected Section C “Procedures and Training”
  - Established subgroup including representatives from Allied Pilot Association, Boeing Commercial Airplane and FAA Seattle Aircraft Evaluation Group
  
- Status
  - Initial draft completed
  - Talk alouds completed
  - Questions reworked
  
- Implementation
  - CATI programming complete 9-15-2004
  - Interviews 9/30 through 11/30
  - Results to JIMDAT Dec 04

# Proposed NAOMS Working Group



## ■ Purpose

- Ensure that results are validly interpreted
- Gain agreement on content, level, and timing of information release
- Recommend new directions
- Build community support for NAOMS



## ■ Industry and Government group

- Recruited from all major industry/labor segments
- Individuals selected for their personal knowledge & skills

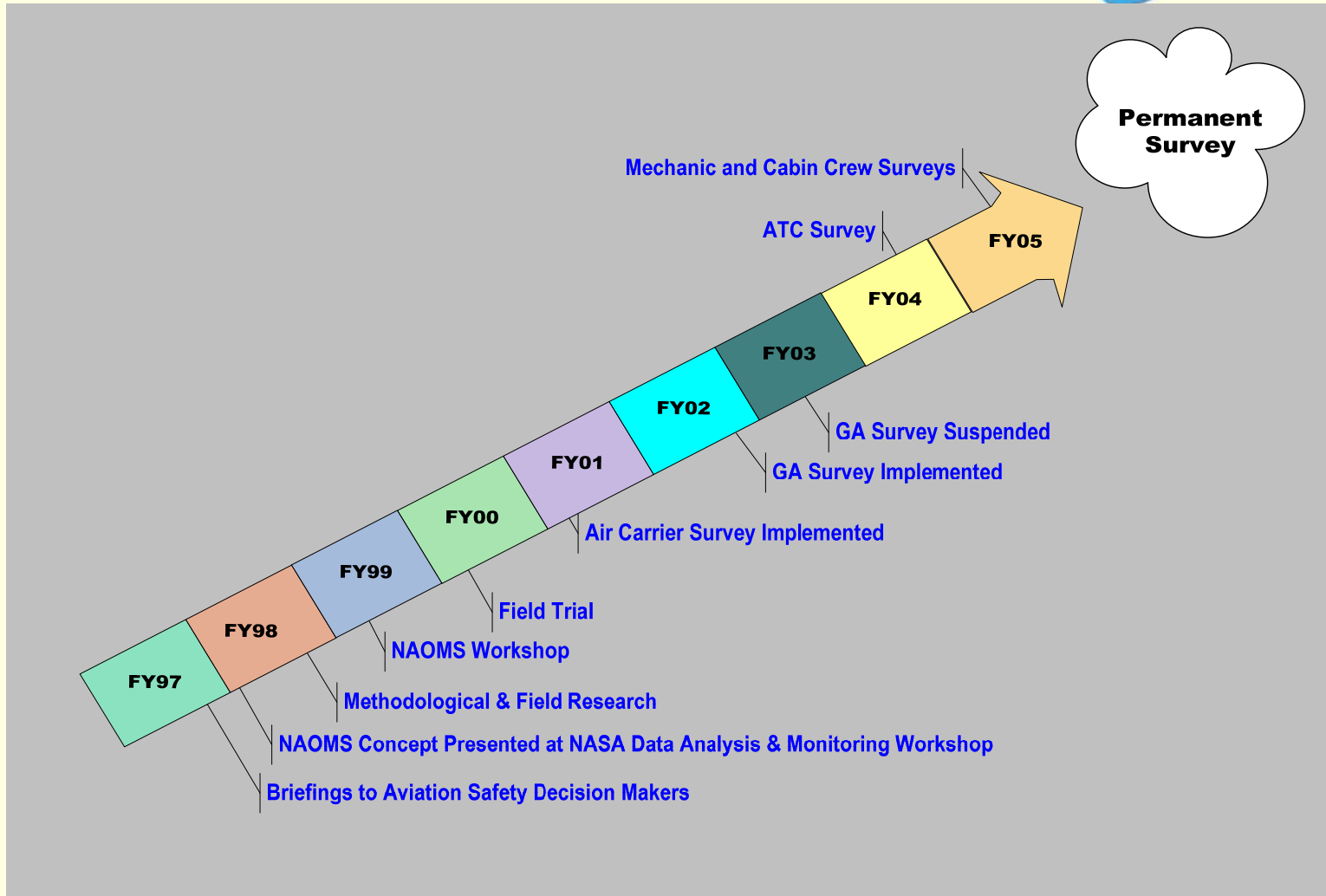
## ■ Non-Disclosure/Confidentiality agreement asked of industry participants

- (Base on pre-decisional exemption from public information requirements)

## ■ Industry Participation through Ames Associates Program

- (No government compensation; no intellectual property rights; participants are covered by Workmen's Compensation by NASA Ames Research Center)
- Status; Two working group formation meetings held

# NAOMS Development Timeline



# Plans/Decisions for FY 05

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- Air carrier pilot telephone surveys continue
- ATC survey developed and tested
- Web-based survey options
- Sampling modified as appropriate
- High-level analytical protocols implemented

**ATO, Especially the Office of  
Performance Analysis,  
may be very important to  
NAOMS' future**