JUP Quarterly Review – MIT

Agenda

November 4-5 2015

Thursday, Nov. 5 – room 33-206

12:30 - 1:00 PM Sign in

1:00 – 2:30 PM MIT Research Activities - Prof. R. John Hansman

- Implication of Inconsistencies between Flight Crew Mental Model and System State
  Sathya Silva
- Investigating Air Traffic Controller's Management of Unmanned Aircraft
  Brandon Abel
- Analytical Approach for Quantifying Noise from Advanced Operational Procedures
  Jacqueline Thomas

2:30 - 3:00 PM BREAK

3:00 - 4:30 PM MIT Research Activities - Prof. R. John Hansman

- Trajectory Clustering and Classification for Characterization of Air Traffic Flows
  Mayara Condé Rocha Murça
- A Stochastic Runway Capacity Model for Evaluating the Impacts of Future Wake Separation Concepts
  Tamas Kolos-Lakatos

6:30 - 9:00 PM Dinner at Local Restaurant

Friday, Nov. 6 - Room 33-206

8:30 AM - 9:00 AM Coffee and pastries

9:00 - 10:30 AM Ohio University Research Activities - Prof. Chris Bartone

- Bird Strike Mitigation for Aviation
  Christopher Drummond, Anthony Combs
- Single-element Patch Antenna with Pattern Control
  Joel L. Schopis, Levi Moore

10:30 – 12:00 PM Princeton University Research Activities – Prof. Luigi Martinelli

- Continuing progress of high-order accurate simulation tool for cargo hold fires
  Mark Lohry
- Uncertainty Quantification for Airfoil and Wing Icing
  Anthony DeGennaro

12:00 PM Principal Investigators' Meeting

- Joel L. Schopis

10:30 – 12:00 PM Princeton University Research Activities – Prof. Luigi Martinelli

- Uncertainty Quantification for Airfoil and Wing Icing
  Anthony DeGennaro
- Progress on the Numerical Simulation of fire in airplane cargos
  Mark Lohry

12:00 PM Principal Investigators' Meeting

## Abstracts

### Massachusetts Institute of Technology Abstracts

#### Implication of Inconsistencies between Flight Crew Mental Model and System State

Sathya Silva

Pilot error has been named the leading cause of aircraft accidents for decades; in 2010, 73% of the 1243 fixed wing general aviation accidents had pilot related causes (AOPA Air Safety Institute, 2011). It is possible to explain some occurrences of pilot error as inconsistencies between the pilot mental model and actual state of the system. With the increase in automation technology, it is possible that these inconsistencies could become more prevalent depending on the design of human-automation interface. In order to investigate the implications of errors in the pilot mental model of aircraft system, analysis will be conducted to determine how prevalent the problem is and determine effective mitigation strategies. A model will be created to abstract the crew cognition system and quantify the inconsistent cases into a common framework. This research can contribute to improved mode awareness due to the better understanding of human

interpretations of the system. The purpose of this research is to improve the pilot's ability to manage aircraft failures and abnormal situations, the effects of which could resonate throughout worldwide aviation safety.

## Investigating Air Traffic Controller's Management of Unmanned Aircraft

Brandon Abel

The safe expansion of Unmanned Aircraft Systems (UASs) in the National Airspace System (NAS) will require integrated operations between manned aircraft pilots, UAS operators, and Air Traffic Controllers (ATC). However, manned aircraft pilots and UAS operators have different goals, perspectives, informational inputs, and mental models of the system. Understanding how Air Traffic Controllers model unmanned aircraft, what underlies this model, and what strategies they use to manage unmanned aircraft are crucial to ensure the safe expansion of UAS in the NAS. This research will identify key factors influencing Air Traffic Controllers management of unmanned aircraft. Future research will investigate factors Air Traffic Controllers consider in their strategies for maneuvering manned and unmanned aircraft in conflict scenarios.

## Analytical Approach for Quantifying Noise from Advanced Operational Procedures

Jacqueline Thomas

The objective is to expand aircraft noise analysis capabilities such that advanced operational procedures and future aircraft configurations, which may reduce aircraft noise exposure over a given observer population, may be reflected during the environmental review process. Current industry standard models rely on flight test data interpolation and do not fully capture noise impacts from aircraft configuration (aerodynamic noise, shielding, etc.), advanced operational techniques (delayed acceleration approaches, climb thrust scheduling, etc.), or future aircraft designs. Therefore, a new approach integrating the Transport Aircraft System OPTimization (TASOPT) model, physics-based aircraft performance model, with NASA's Aircraft Noise Prediction Program (ANOPP) has been done to capture those impacts. Benefits of this integrated TASOPT-ANOPP model include its demonstrated capability of computing noise contours of aircraft flying user-defined advanced operational procedures. Also, because the aircraft and engine performance inputs into ANOPP are physics-based computed outputs from TASOPT, the user is able to predict the noise of future aircraft configurations. To assess the accuracy of this integrated model, its noise results for two existing aircraft have been compared to FAR Part 31 certification noise data at defined approach, flyover, and sideline observer

locations. Current results show within 1dB EPNL agreement for both aircraft at the approach and flyover locations and up to 5dB EPNL over-prediction for the sideline location. The work moving forward includes improving the sideline noise prediction and further use of the model to evaluate the impact of various metrics on resulting noise exposure over representative observer grids. The outcomes include improved fidelity of noise analysis methods for considering noise during development of advanced operational procedures and noise benefits analyses for next-generation aircraft and approach and departure procedures.

## Trajectory Clustering and Classification for Characterization of Air Traffic Flows

Mayara Condé Rocha Murça

The increasing availability of massive air transport system data along with the pressing requirements for identifying and eliminating inefficiencies of air traffic operations have created opportunities for developing data mining tools that can be useful for post-event analysis, efficiency assessment and predictive modeling for real time decision support. This research aimed to develop a data mining framework for identification of airspace structure and characterization of air traffic flows solely based on recorded radar tracks. As part of the methodology, a density based clustering algorithm is used to learn the typical network of operations and an ensemble based classification algorithm is used to assign traffic flows to the previously identified patterns. The framework is then used to assess the conformance of flight trajectories against typical patterns and to evaluate the dynamics of resource use and operational behavior under various operating conditions. An initial case study was performed for New York Metro operations.

## A Stochastic Runway Capacity Model for Evaluating the Impacts of Future Wake Separation Concepts

Tamas Kolos-Lakatos

Wake vortex turbulence is a critical factor in aircraft separation and it is one of the limiting elements in increasing runway capacity. This project aims to develop a stochastic runway capacity simulation model and a framework to evaluate how new wake separation rules (distance based or time based) will impact arrival and departure throughput under various runway layouts, traffic mixes, and operational procedures. This runway capacity model will also be used to look at the additional benefits that can be gained from moving to static pair-wise or dynamic separation concepts in the future.

Ohio University Abstracts

Introduction: Chris G. Bartone

## Bird Strike Mitigation for Aviation

Christopher Drummond, Anthony Combs

Ohio University has begun to investigate taking avian radar target detections and producing target reports that are suitable for distribution in the National Air Space. This investigation explores formatting the bird detections as avian target reports within the Traffic Information Service-Broadcast (TIS-B). The plan is to format avian radar detections as TIS-B avian target reports, which may be broadcast using 1090 Extended Squitter (1090ES) and UAT. Ohio University will also investigate the appropriate classification of the avian targets/traffic so the information can efficiently be conveyed in the NAS to Air Traffic Controllers and flight crew pertaining to bird activity.

## Single-element Patch Antenna with Pattern Control

Joel L. Schopis, Levi Moore

Patch antenna have widespread use in various aviation applications due to their low profile, small size, and low cost. While the radiation characteristics of a single-element patch antenna can be affected by the antenna design, including ground plane size and shape, the ability to dynamically control the radiation characteristics in azimuth and elevation is limited. This paper presents a single-antenna GNSS patch antenna design that can dynamically control the radiation characteristic, whereby an area of high directivity (i.e., broad beam) can be placed, along with a commensurate area of low directivity that may be useful for interference suppression. Here, a circular four-feed GNSS L5 patch antenna over a circular ground plane with four-probe is illustrated with an amplitude and phase control subsystem for beam control. To control the radiation pattern, a four-feed circular patch antenna was modeled and simulated using a high-fidelity computational electromagnetic model (CEM). This control has a major advantage by controlling the radiation characteristic to allow for isolation of interfering signals.

Princeton University Abstracts

Following presentation was canceled because of extenuating circumstances. Work will be presented at the next meeting.

Continuing progress of high-order accurate simulation tool for cargo hold fires

Mark Lohry

Accurate prediction of heat and particulate transfer in fire-induced flow is necessary for predicting the performance of aircraft cargo hold fire detection systems. Past investigations of cargo hold fires include full-scale experiments and simulations using traditional 2nd order accurate finite volume CFD methods. In previous meetings, we have identified several inadequacies in available simulation tools. As a result, we are continuing development of a new flow solver using the discontinuous Galerkin method for discretization, which allows for arbitrarily high order accuracy and geometric flexibility.

In this talk, we present the current state of development of this new tool. Buoyancy driven flow simulations will be demonstrated in 2D and 3D cargo hold geometries with varying order of accuracy. Standard CFD validation cases confirming the high order accuracy of the schemes will also be presented, in particular the ability to predict the advection of vortical flow.

Uncertainty Quantification for Airfoil and Wing Icing

Anthony DeGennaro

Ice accumulation on the surface of a wing can be detrimental to aircraft performance – it can drastically reduce the lift, increase the drag, lead to stalling at lower angles of attack, and change the control performance of the airplane. Furthermore, there is a wide range of geometric shapes and properties of the ice that are possible, which depends on a large number of physical parameters. This results in a large amount of uncertainty in the ice shape. Hence, our goal is to quantify how simple measures of aerodynamic performance are affected by uncertainty in the icing process.

In this talk, we discuss research aimed at addressing this issue using two approaches. First, we treat the uncertainty in the icing problem as existing only in the form of several ice shape parameters, which are identified using existing data on ice shapes. We review previous

examples demonstrating this approach on various icing datasets. Second, we discuss current efforts to treat the uncertainty in the icing problem from a physical standpoint, as opposed to the data-based approach. This necessitates obtaining a wing icing code and then doing modeling and UQ on it. We review recent and on-going progress to- wards developing, testing, and verifying a 2D icing code, and discuss possible uncertainty quantification studies that can be conducted once this code is completed.