Summary of NASA Research Accomplishments
2001-2005

James T. Luxhøj, Ph.D.
Principal Investigator

*Director, Center for Advanced Risk and Decision Analysis (CARDA)*
Department of Industrial and Systems Engineering, Rutgers University
(http://www.rci.rutgers.edu/~carda)

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Executive Summary

For the past four years, Professor Jim Luxhøj and his research team from the Center for Advanced Risk and Decision Analysis (CARDA) in the Department of Industrial and Systems Engineering at Rutgers University have been funded through the Aviation Safety and Security Program (AvSSP) from NASA to develop analytical methods and prototype tools for aviation safety risk analysis. This contract led to the development of the following research products:

- Aviation System Risk Model (ASRM)
- Post-Consequence Model (PCoM)
- Composite Program Assessment Score (CPAS)
- Bayesian Network—Uncertainty and Sensitivity Analyses (BN-USA)
- Case-Based Reasoner (CBR)
- Executive Information System (EIS)

These prototype software tools present Artificial Intelligence and statistical methods for causal modeling, inferencing and prioritizing of aviation safety risks. The NASA research builds upon 10 years of aviation safety research with the Federal Aviation Administration (FAA). In particular, the Aviation System Risk Model (ASRM), initially developed under an FAA grant, was enhanced and further developed under the NASA contract to evaluate the projected impact upon system risk reduction of multiple new technology insertions/interventions into the National Airspace System (NAS).

Professor Luxhøj and his team published 3 journal articles and 14 conference proceedings during this 4-year period. 8 undergraduate students, 9 Masters students and 2 Ph.D. students participated in this joint government/industry/academia research during this period.

Professor Luxhøj may be contacted at: jluxhoj@rci.rutgers.edu

The web site for the CARDA is: http://www.rci.rutgers.edu/~carda
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Technical Monitors:
Ms. Sharon Monica Jones

Mr. Del Green
(2003-2005)

Contract NAS1-03057

**Decision Support Software Prototypes**

**Aviation System Risk Model (ASRM)**

The Aviation System Risk Model (ASRM) is a software prototype that uses the flexible, probabilistic approach of Bayesian Belief Networks (BBNs) and influence diagrams to model the complex interactions of aviation system risk factors. The ASRM is currently being enhanced and further developed by the NASA Aviation Safety Program Office to evaluate the projected impact upon system risk reduction of multiple new technology insertions/interventions into the National Airspace System.

**Post-Consequence Model (PCoM)**

The Post-Consequence Model (PCOM) is a software prototype that uses the probabilistic approach of Bayesian Belief Networks (BBNs) and the HUGIN information technology tool to provide a severity distribution on the consequences associated with aircraft accidents, such as post-crash fire, injuries and loss of life. New technologies aimed at severity reduction can be easily evaluated.

**Composite Program Assessment Score (CPAS)**

The Composite Program Assessment Score (CPAS) software prototype supports the evaluation of multiple metrics, such as Technical Development Risk, Implementation Risk, Safety Risk, Accident Rate and Cost/Benefit. The scores from the five metrics may be weighted by decision makers and combined into an aggregate score. The software contains “filters” to provide analyses by Part 121/135 and by product “suite”. A portfolio prioritization graph is displayed.
Bayesian Network-Uncertainty and Sensitivity Analysis (BN-USA)

The Bayesian Network-Uncertainty and Sensitivity Analyses (BN-USA) software prototype facilitates the exploration of structural and response uncertainty in the ASRM models. The software facilitates the computation of pairwise importance measures that results in a rank ordering of the most important precursors. In addition, the BN-USA software also supports sensitivity analyses of the impact of precursors upon consequence probability. The BN-USA also has the capability to assist with new technology exploration.

Case-Based Reasoner (CBR)

The Case Based Reasoner (CBR) is constructed using the 17 ASRMs dealing with Loss of Control, Engine Failure, Runway Incursion, Controlled Flight Into Terrain and Maintenance-related accidents. Through a series of dialog boxes, the user answers questions regarding the causal factors involved in an aircraft accident. The CBR then searches the case base for the most closely matching cases and reports a rank ordering. These cases may be retrieved as offered as “solution possibilities” with suggested technology and procedural mitigations.

Executive Information System (EIS)

The Executive Information System (EIS) is the repository for the software prototypes of the ASRM, PCoM, CPAS and BN-USA. In addition, the EIS also offers a number of varied executive displays of ASRM output.

Refereed Journal Publications (Total = 3)


**Conference Proceedings (Total = 14 )**


Submitted Papers


Presentations


Luxhøj, James T., “Probabilistic Decision Support for Evaluating Aviation Safety Program (AvSP) Technologies” - presented to the Rutgers Undergraduate Education Advisory Council, March 26, 2003 (with Kimberlee Kauffeld)

Luxhøj, James T., “Human Error Modeling and Safety Risk Management for Commercial Aviation”  
- presented at the Global Aviation Information Network (GAIN) Asia-Pacific Regional Conference, Tokyo, Japan, November 14-15, 2002 (with Scott Shappell)

Luxhøj, James T., “Aviation Safety Risk Management Schemes in the US and their Future Perspectives”  
- presented at Waseda University, Department of Industrial and Management Systems Engineering, Tokyo, Japan, November 13, 2002 (Invited Presentation)

Luxhøj, James T., “Probabilistic Decision Support to Evaluate Technology Insertion”  

M.S. Theses


Erim Kardes, Hierarchical Bayesian Belief Networks for Advanced Safety Risk Modeling (May 2004) (Ph.D. student, ISE, University of Southern California)

Ahmet Emre Oztekin, A Case-Based Reasoning (CBR) Approach to Accident Scenario Knowledge Acquisition (May 2005)


Nathan Greenhut, An Executive Information System (EIS) for Complex Aviation System Risk Modeling (May 2005)  
NASA Graduate Student Researchers Program (GSRP) ($24,000), NASA Langley Research Center, Hampton, VA, July 1, 2004 – June 30, 2005

Denise Andres, Development of a Post-Consequence Model for Aircraft Accident Severity Assessment (May 2005) (Supply Chain Analyst, Johnson & Johnson, NJ)

Chad Bareither, Uncertainty Resolution and Advanced Technology Concept Exploration in Binary-Node Bayesian Belief Networks (degree expected January 2006)

Varun Sharma, Development of a Composite Program Assessment Score for an Advanced Technology Portfolio Prioritization (degree expected May 2006)

Katherine Lechner, Systematic Creation of Bayesian Belief Networks: Relationship with Logic-Evolved Decision Models (degree expected May 2007)