Summary of FAA Research Accomplishments 1993-2002

James T. Luxhøj, Ph.D.
Principal Investigator (1997-2002)
Co-Principal Investigator (1993-1996)

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December 2002

Executive Summary

For the past nine years, Professor Jim Luxhøj and his research team from the Department of Industrial and Systems Engineering at Rutgers University have been funded through AAR-490 Risk Analysis Branch (formerly AAR-424) to develop analytical methods and prototype tools for aviation safety risk analysis. These grants led to the development of the following research products:

> - **The Intelligent Safety Performance, Evaluation and Control (InSPEC) System**
> - **Engine Risk Intelligence System (ERIS)**
> - **Performance Measure (PM) Reduction Tool**
> - **ClusterGroup Decision Support System**
> - **Aviation System Risk Model (ASRM)**

These prototype software tools present Artificial Intelligence and statistical methods for Service Difficulty Report (SDR) forecasting, inspection diagnostics, assessing the relative marginal information content from performance measures, collaborative prioritizing of aviation safety risks, and modeling of accident/incident causal factors, among others. Currently, the Aviation System Risk Model (ASRM) is 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 (NAS).

Professor Luxhøj and his team published 9 journal articles, 20 conference proceedings, and 3 electronic publications during this 9-year period. 12 undergraduate students, 8 Masters students and 6 Ph.D. students participated in this joint government/industry/academia research during this period. Professor Luxhoj served as the Co-Chair of the 1st and 2nd FAA/NASA Risk Analysis and Safety Performance Measurements in Aviation Workshops and is a former Co-Chair of GAIN Working Group B: Analytical Methods and Tools. Mr. John Lapointe leads AAR-490 and Professor Luxhøj's technical monitors through the years have included Mr. Michael Vu, Ms. Kathy Fazen, and Ms. Rosanne Weiss.

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1993-2002

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Sponsored by AAR-490, Risk Analysis Branch

Technical Monitors:
Mr. Michael Vu (1993-1996) Ms. Kathy Fazen (1996-1999) Ms. Rosanne Weiss (1999-2003)

Grants

Development of Analytical Methods for Aviation Safety Risk Modeling, Assessment, and Management, $588,672, Principal Investigator, January 2000 – January 2003 (Grant # 00-G-006).

Development of an Intelligent Decision Support System (IDSS) for Aviation Safety Analysis, $511,600, Principal Investigator, January 1997 – December 1999 (Grant # 97-G-005).

Development of Expert Systems and Neural Networks for Analysis of Maintenance Databases, approx. $275,000, FAA Center for Computational Modeling of Aircraft Structures, Co-Principal Investigator: T. Williams, January 1993 – December 1996.

Decision Support Software Prototypes

The Intelligent Safety Performance, Evaluation, and Control (InSPEC) System

This software prototype of an intelligent decision support system for aviation safety analysis comprises modules containing neural network and statistical models for Service Difficulty Report (SDR) forecasting, expert systems for inspection diagnostics, univariate and multivariate data analysis techniques for control charting, and an Intelligent Referencing System for hypertext links to inspection regulations, handbooks, etc., and risk analysis models for event rate forecasting; component reliability prediction; and accident causation assessment.

Engine Risk Intelligence System (ERIS)

The ERIS system is a software prototype that uses the probabilistic approach of Bayesian Belief Networks (BBNs) and the HUGIN information technology tool to assess casual factors impacting risk modeling for the gas path of a "representative" aircraft engine. Various scenarios may be evaluated that consider design and operational factors as well as component interactions.

## Performance Measure Reduction Tool

The PM Reduction tool is a software prototype that applies an analytical methodology for evaluating the relative marginal information content gained from the addition of safety performance measures. The tool may assist in prioritizing the "value-added" of new performance measures and provide a systematic method for approaching the possible reduction in the number of PMs.

ClusterGroup

ClusterGroup is a software prototype that uses cluster analysis techniques to facilitate the priorization of the importance of aviation safety risk factors by groups of experts. The underlying methodology eliminates the necessity of performing numerous pairwise comparisons and initial results with both synthetic and real world data sets are promising. Preliminary results show up to an 80% reduction in the number of computations, yet results compare favorably with more traditional methods, such as the Analytic Hierarchy Process.

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Aviation System Risk Model (ASRM)
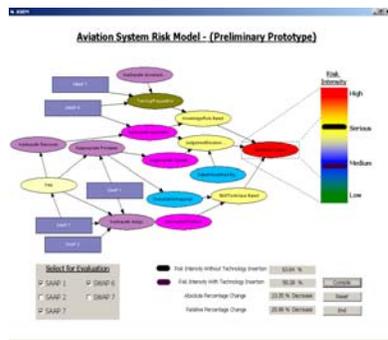
The Aviation System Risk Model (ASRM) is a software prototype that uses the flexible, probabilistic approach of Bayesian Belief Networks (BBNs) and influence diagrams to model the *complex interactions* of aviation system risk factors. The ASRM is currently being enhanced and further developed by the 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.

Refereed Journal Publications (Total = 9)

1. Nordmann, Lars H., and James T. Luxhøj, "Application of a Performance Measure Reduction Technique to Categorical Safety Data," <u>Reliability Engineering and System Safety</u>, Vol. 75, No. 1 (2002), pp. 59-71.

2. Luxhøj, James T., Apichart Choopavang, and Donald N. Arendt, "Risk Assessment of Organizational Factors in Aviation Systems," <u>Air Traffic Control Quarterly</u>, Vol. 9, No. 3 (2001), pp. 135-174. *(Special Issue on Flight Safety)*

3. Nordmann, Lars and James T. Luxhøj, "Neural Network Forecasting of Service Problems for Aircraft Structural Component Groupings," <u>AIAA Journal of Aircraft</u>, Vol. 37, No. 2 (2000), pp. 332-338.

4. Cheng, Andrew Y., Regina Y. Liu, and James T. Luxhøj, "Monitoring Multivariate Aviation Safety Data By Data Depth: Control Charts and Threshold Systems," <u>IIE Transactions on Operations Engineering</u>, Vol. 32, No. 9 (2000), pp. 861-872 *(Special Issue on* Probabilistic *Models for Design, Planning, and Control of Production and Service Systems).* ***Best Paper Award for Feature Applications for 2000-2001.***

5. Cheng, Andrew Y., Regina Y. Liu, and James T. Luxhøj, "Thresholds for Safety Inspection Measurements Based on Control Charts," <u>International Journal of Reliability, Quality, and Safety Engineering</u>, Vol. 4, No. 2 (1997), pp. 205-226.

6. Luxhøj, James T., Trefor P. Williams, and Huan-Jyh Shyur, "Comparison of Regression and Neural Network Models for Prediction of Inspection Profiles for Aging Aircraft," <u>IIE Transactions on Scheduling and Logistics</u>, Vol. 29, No. 2 (1997), pp. 91-101.

7. Luxhøj, James T., and Trefor P. Williams, "Integrated Decision Support for Aviation Safety Inspectors," <u>International Journal of Applied Finite Elements and Computer Aided Engineering</u>, Vol. 23 (1996), pp. 381-403 (*Special Issue on Finite Elements in Analysis and Design).*

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8. Shyur, Huan-Jyh, James T. Luxhøj, and Trefor P. Williams, "Using Neural Networks to Predict Component Inspection Requirements for Aging Aircraft," Computers and Industrial Engineering, Vol. 30, No. 2 (1996), pp. 257-267 (*Special Issue on Computer-Aided Maintenance*).

9. Luxhøj, James T., and Huan-Jyh Shyur, "Reliability Curve Fitting for Aging Helicopter Components," Reliability Engineering and System Safety, Vol. 46 (1995), pp. 229-234.

Conference Proceedings (Total = 20)

10. Ammarapala, Veeris, and James T. Luxhøj, "A Clustering Algorithm for Facilitating Group Decision Making in Risk Intensive Situations," Industrial Engineering Research Conference, Hilton Walt Disney World Village, Orlando, Florida, May 19-22, 2002.

11. Luxhøj, James T., "Risk Analysis of Human Performance in Aviation Maintenance," Proceedings of the 16th Symposium on Human Factors in Aviation Maintenance, San Francisco, CA, April 2-4, 2002.

12. Ammarapala, Veeris and James T. Luxhøj, "A Clustering Approach for Multiattribute Aviation Risk Evaluation," Proceedings of the 2002 International Conference on Industry, Engineering, and Management Systems, Cocoa Beach, Florida, March 11-13, 2002.

13. Luxhøj, James T. and Chakradhar Agava, "An Integrated Approach to Aircraft Engine Risk Assessment," Proceedings of the 11th Annual Flexible Automation and Intelligent Manufacturing (FAIM) Conference, Dublin, Ireland, July 16-18, 2001, pp. 633-642.

14. Luxhøj, James T., "An Intelligent Decision Support System (IDSS) Prototype for Aviation Safety Analysis," SAE Advances in Aviation Safety Conference, Daytona Beach, Florida, April 11-13, 2000, pp. 135-146.

15. Luxhøj, James T. and Atul R. Deshmukh, "Forecasting of a Safety Risk Metric for an Aircraft Operator," The 2000 International Conference on Industry, Engineering, and Management Systems, Cocoa Beach, Florida, March 13-15, 2000.

16. Luxhøj, James T., Bansal, Kapil, Choopavang, Apichart, Horton, Theodore G., and Donald N. Arendt, "An Aviation System Safety Model for Improved Risk Management," Proceedings of the European Safety and Reliability Conference ESREL'99, Munich, Germany, September 13-17, 1999, pp. 1285-1290.

17. Nordmann, Lars, and James T. Luxhøj, "Applying Hilbert-Space Methods to Multivariate Data Reduction,"Proceedings of the 8th Industrial Engineering Research Conference, Phoenix, Arizona, May 23-25, 1999.

18. Nordmann, Lars, and James T. Luxhøj, "An Artificial Intelligence Approach to Trending of Service Difficulties for Aircraft Component Groupings," Proceedings of the International Conference on Industry, Engineering, and Management Systems, Cocoa Beach, Florida, March 8-10, 1999.

19. Cheng, Andrew Y., Regina Y. Liu, and James T. Luxhøj, "A Data Depth Monitoring Scheme for Quality Control," Proceedings of the Ergonomics for Global Quality and Productivity International Conference, Hong Kong, July 5-11, 1998, pp. 177-180.

20. Luxhøj, James T., Donald N. Arendt, and Theodore G. Horton, "An Intelligent Computer-Based Tool for Evaluating Aircraft Accident Causation," Proceedings of European Safety and Reliability International Conference ESREL '98, Trondheim, Norway, June 17-19, 1998, pp. 839-846.

21. Luxhøj, James T., and Jiangfeng Cheng, "Neural Network Modeling of Aviation Safety Field Studies," Proceedings of the 7th Annual Industrial Engineering Research Conference, Banff, Alberta, Canada, May 9-10, 1998.

22. Luxhøj, James T., and Trefor P. Williams, "A Bayesian Belief Network for Aircraft Tire Condition Assessment," Proceedings of the Advances in Aviation Safety Conference, Daytona Beach, Florida, April 6-8, 1998, pp. 95-101.

23. Cheng, Andrew Y., Liu, Regina Y., and James T. Luxhøj, "A Data Depth Monitoring Scheme for Aviation Safety Data," 2nd Annual International Conference on Industrial Engineering, San Diego, CA, November 12 - 15, 1997, pp. 299-304.

24. Luxhøj, James T., Donald Arendt, Trefor P. Williams, and Theodore G. Horton, "An Application of Advanced Information Technology for Assessing Aircraft Accident Causation," Proceedings of International Society of Air Safety Investigators, Anchorage, Alaska, September 29 - October 3, 1997.

25. Luxhøj, James T., Cheng, Andrew Y., and Trefor P. Williams, "A Bayesian Approach to Aircraft Safety Diagnostics," Proceedings of the 6th Industrial Engineering Research Conference, Miami Beach, FL, May 17-18, 1997, pp. 54-59.

26. Shyur, Huan-Jyh, Luxhøj, James T., and Trefor P. Williams, "Use of Neural Networks for Aviation Safety Risk Assessment," Proceedings of the FAA-NASA Symposium on Continued Airworthiness of Aircraft Structures, Atlanta, GA, August 28-30, 1996, pp. 655-664.

27. Cheng, Andrew Y., Luxhøj, James T., and Regina Y. Liu, "Analysis of Safety Performance Thresholds for Air Carriers by Using Control Charting Techniques," <u>Proceedings of the FAA-NASA Symposium on Continued Airworthiness of Aircraft Structures</u>, Atlanta, GA, August 28-30, 1996, pp. 25-36.

28. Shyur, Huan-Jyh, and James T. Luxhøj, "Nonparametric Models for Analyzing Failure Time Data of Aging Aircraft with Multiple Stresses," <u>Proceedings of the 5th Industrial Engineering Research Conference</u>, Minneapolis, MN, May 18-22, 1996, pp. 453-458.

29. Luxhøj, James T., "Development of an Intelligent Decision System for Aircraft Safety Inspections," <u>Proceedings of the 10th Integrated Production Systems (IPS) Research Seminar</u>, Fuglsø, Denmark, April 3-5, 1995, pp. 225-248.

Electronic Publications (Total = 3)

30. Maurino, Michele and James T. Luxhøj, "Analysis of a Group Decision Support System (GDSS) for Aviation Safety Risk Evaluation," *The Rutgers Scholar*, Vol. 4 (2002), http://rutgersscholar.rutgers.edu.

31. Luxhøj, James T. and Michele Maurino, "An Aviation System Risk Model (ASRM) Case Study: Air Ontario 1363," *The Rutgers Scholar*, Vol. 3 (2001), http://rutgersscholar.rutgers.edu.

32. Kenneth Wang and James T. Luxhøj, "Neural Network Forecasting of Equipment Inoperability for an Aircraft Operator," *The Rutgers Scholar*, Vol. 1 (1999), http://rutgersscholar.rutgers.edu.

National Aviation Safety and Risk Analysis Workshops

Dr. Luxhøj served as one of the leaders for a national workshop on *Risk Analysis and Safety Performance Measurement in Commercial Air Transportation* held at Rutgers University during July 20-22, 1999. The leads on the workshop were Rutgers, the FAA, and Sandia National Laboratories. Approximately 100 aviation safety professionals from North America and Europe attended the workshop.

The 2nd Risk Analysis and Safety Performance Measurement in Aviation Workshop was held during August 22-24, 2000 at William J. Hughes FAA Technical Center in Atlantic City, NJ. The co-hosts were the Federal Aviation Administration and Rutgers University. Dr. Luxhøj served as a co-organizer. Approximately 180 aviation safety professionals from 13 different countries attended the workshop.

Invited to be a participant in Safety Forum 2000 that was sponsored by the United Stated Marine Corps held during August 15-16, 2000 at the Center for Naval Analyses in Alexandria, VA. The purpose of the Forum was to offer innovative ideas to enhance the overall Marine Corps Safety Program *(unable to travel)*.

International Aviation Safety and Risk Analysis Working Groups

Dr. Luxhøj is serving as the Chair of a Federal Aviation Administration Working Group on *Organizational Factors in Aviation*. Meetings have been held at the FAA Headquarters in Washington, DC on December 1, 2000, February 20, 2001, and May 23, 2001. He attended the 15th Symposium on Human Factors in Aviation Maintenance and participated in the Interactive Session on Organizational Factors held during March 27-29, 2001 at The Brewery Conference Center, in London, United Kingdom. This Symposium was co-sponsored by the Federal Aviation Administration, the Civil Aviation Authority, and Transport Canada.

GAIN

Dr. Luxhøj served as the Co-Chair on the *Global Aviation Information Network (GAIN) Working Group B: Analytical Methods and Tools* from March 1999 to June 2000. The first meeting of the workshop was held at the Lockheed-Martin Energy Systems office in Washington, DC on March 23-34, 1999. This group will identify and increase awareness of existing analytical methods and tools by collecting, cataloging, and distributing resource materials. The group will also solicit requirements for additional analytical methods and tools from the aviation community and promote development and validation of these methods and tools. Meetings have been hosted by TWA (St. Louis), Transport Canada (Ottawa), Air Line Pilots Association (Herndon, VA), and Air France/Airbus and the BEA/DGCA (Paris). Dr. Luxhøj made a co-presentation on behalf of Working Group B at the Fourth Gain World Conference in Paris during June 14-15, 2000.

Dr. Luxhøj participated with members from the European Safety and Reliability Association (ESRA) on a working group to investigate *"Computer Aided Risk Assessment"*. Working group members were from Germany, The Netherlands, France, Italy, Portugal, and Norway. Dr. Luxhøj contributed to the discussion involving investigation into risk assessment methods for the aviation industry.

National Aviation Safety Data Analysis Working Group

Dr. Luxhøj was invited to serve on the User Group for the FAA's National Aviation Safety Data Analysis Center (NASDAC). Managed by the FAA's Office of System Safety, NASDAC offers access to over 25 databases and a suite of analytical tools. The User Group will gather user needs and concerns and provide input to plan future NASDAC services and technologies. Dr. Trefor P. Williams and Mr. Apichart

Choopavang from the Rutgers research team attended the NASDAC User Group Meeting at FAA Headquarters on March 30-31, 1999.

Presentations

"Analytical Methods for Aviation Safety Risk Management"
- presented at the Civil Aviation Authority (CAA) – The Netherlands, hosted by the National Aerospace Laboratory (NLR), Hooffdorp, The Netherlands, November 16, 2001

"Decision Support for Aviation Safety Risk Management"
- presented at Aer Lingus, Dublin, Ireland, July 16, 2001 *(Invited Presentation)*
- presented at City Jet, Dublin, Ireland, July 18, 2001 *(Invited Presentation)*
- presented at FAA Office of System Safety, June 13, 2001
- presented at the FAA's Civil Aeromedical Institute (CAMI), July 26, 2001

"Decision Support for Aviation System Risk Modeling"
- presented at Cathay Pacific Airways, Hong Kong, January 2001 *(Invited Presentation)*

"Aviation Safety Risk Measurement"
- presented at DFS2000: Design for Safety Workshop, October 10-12, 2000, Moffett Training and Conference Center, NASA Ames Research Center, Mountain View, CA *(Invited Presentation)*

"Aviation Risk Management: Analytical Methods & Tools"
- presented at the 2000 EVA Safety Workshop and Conference, October 18-19, 2000, Taoyuan, Taiwan *(Invited Presentation)*

"Monitoring Multiple Aviation Safety Data by Data Depth: Control Charts and Threshold Systems"
- presented by Dr. Regina Liu at The Institute for Operations Research and Management Science (INFORMS) Meeting, Philadelphia, PA, Nov. 7, 1999 (co-authors: Dr. Andrew Cheng and Dr. James T. Luxhøj) *(Invited Presentation)*

"Applying Hilbert-Space Methods to Multivariate Quality Control & Risk Monitoring"
- presented by Mr. Lars Nordmann at The Institute for Operations Research and Management Science (INFORMS) Meeting, Philadelphia, PA, Nov. 7, 1999 (co-author: Dr. James T. Luxhøj) *(Invited Presentation)*

"A Bayesian Approach to Aircraft Safety Diagnostics"
- Industrial Engineering Research Conference, Miami Beach, May 17, 1997
- New Jersey Department of Transportation, Trenton, NJ, June 2, 1997

"Statistical Modeling of Aviation Safety Field Studies"
- Institute of Mathematical Statistics, Park City, Utah, July 28-30, 1997 (*Invited Presentation*)

"An Intelligent Decision Support System (IDSS) for Aviation Safety Analysis"
- FAA Office of System Safety, Dulles Airport, VA, October 21, 1998
- Department of Industrial and Manufacturing Systems Engineering, Lehigh University, October 16, 1998 (*Invited Seminar*)
- Joint Aviation Authorities (JAA), Mr. Jean-Marc Cluzeau, Ops Maintenance Coordinator, Flight Standards Safety Analysis Information Center (FSAIC), Dulles Airport, VA, July 9, 1998
- Flight Standards Certification Program Office, AFS-900, Dulles Airport, October 28, 1997
- Transportation Safety Board of Canada, Mr. John Maxwell, Director, Air Investigation Branch, Annual Meeting of the International Society of Air Safety Investigators, Anchorage, Alaska, September 29 - October 3, 1997.
- 6th Industrial Engineering Research Conference, Miami Beach, FL, May 17-18, 1997
- Rutgers Undergraduate Education Advisory Council, Rutgers University, April 15, 1998
- Rutgers Board of Governors Sub-committee on Student Affairs, April 20, 1998
- Department of Industrial & Systems Engineering, Virginia Polytechnic Institute and State University, April 22, 1998
- SAS Airlines, Copenhagen, Denmark, May 15, 1996
- Federal Aviation Administration (FAA) Headquarters, Washington, DC, July 30, 1996
- National Transportation Safety Board (NTSB), FAA Technical Center, Atlantic City, NJ, August 23, 1996

"An Application of Advanced Information Technology for Assessing Aircraft Accident Causation"
- Dr. Rita Colwell, Director of the National Science Foundation, Rutgers University, November 2, 1998
- National Transportation Safety Board (NTSB), FAA Technical Center, June 19, 1998
- Rutgers Board of Governors Sub-committee on Student Affairs, April 20, 1998
- Department of Industrial & Systems Engineering, Virginia Polytechnic Institute and State University, April 22, 1998
- Flight Standards Certification Program Office, AFS-900, Dulles Airport, September 12, 1997
- Civilian Aviation Authority (CAA), Ms. Sarah Doherty, Safety Analyst, Rutgers University, October 30, 1997
- Transportation Safety Board of Canada, Mr. John Maxwell, Director, Air Investigation Branch, Annual Meeting of the International Society of Air Safety Investigators, Anchorage, Alaska, September 29 - October 3, 1997.

"Time Dependent Multivariate Analysis for Aviation Safety Monitoring"
- <u>6th Industrial Engineering Research Conference</u>, Miami Beach, FL, May 17-18, 1997 (with A. Cheng and R. Liu).

"Analysis of Maintenance Databases Using Expert Systems and Neural Networks"
- SAS Airlines, Copenhagen, Denmark, March 7, 1995

Undergraduate Research Students

James Britton, Industrial and Systems Engineering
Laura Pfeifer, Industrial and Systems Engineering
Theodore G. Horton, FAA/Rutgers Undergraduate Research Fellow, 1997-99
Daniel Horowitz (Honors Candidacy, 1997)
Kenneth Wang, FAA/Rutgers Undergraduate Research Fellow, 1998-2000
Rishi Hinduja, FAA/Rutgers Undergraduate Research Fellow, 2000
Michele Maurino, FAA/Rutgers Undergraduate Research Fellow, 2000-2002
Kimberlee E. Kauffeld, FAA/NASA/Rutgers Undergraduate Research Fellow, 2002-2003
Victor Izmaylov, Computer Science
Adam Stasiak, Computer Science
Zack Halbrecht, Computer Science
Ryan Dickey, Industrial and Systems Engineering

Master's Engineering Project Reports

Jiangfeng Cheng (Engineering Project Report), 1997
    <u>Publication</u>: Luxhøj, James T., and Jiangfeng Cheng, "Neural Network Modeling of Aviation Safety Field Studies", <u>Proceedings of the 7th Annual Industrial Engineering Research Conference</u>, Banff, Alberta, Canada, May 9-10, 1998.
Kapil S. Bansal (Engineering Project Report), 1998
    <u>Publication</u>: Luxøj, James T., Donald N. Arendt, Choopavang, Apichart, Kapil Bansal, and Theodore G. Horton, "An Aviation System Safety Model for Improved Risk Management", <u>Proceedings of the European Safety and Reliability Conference ESREL'99</u>, Munich, Germany, September 13-17, 1999, pp. 1285-1290.
Atul Deshmukh (Engineering Project Report), 2000
    <u>Publication</u>: Luxøj, James T. and Atul R. Deshmukh, "Forecasting of a Safety Risk Metric for an Aircraft Operator," <u>The 2000 International Conference on Industry, Engineering, and Management Systems</u>, Cocoa Beach, Florida, March 13-15, 2000.

Master's Theses

Apichart Choopavang, *A Bayesian Approach to Causal Modeling of Organizational Factors in Aircraft Accidents*, August 2000
(Ph.D. student, Department of Systems Engineering and Engineering Management, Stevens Institute of Technology)
Chakradhar Agava, *A Decision-Analytic Framework for Creating Risk Intelligence in the Gas Path of an Aircraft Engine,* July 2001
(Aviation Research Analyst, Hi-Tec Systems, FAA William J. Hughes Technical Center, Atlantic City, NJ)
Muhammad Naiman Jalil, *A Probabilistic Decision Support System for Evaluating the Impact of Technology Insertion on Aviation Safety Risk* (degree expected August 2003)
Erim Kardes, *The Use of Hierarchical Bayesian Belief Networks for Advanced Safety Risk Modeling* (degree expected August 2003)
Ahmet Emre Oztekin, *A Case-Based Reasoning (CBR) Approach to Accident Scenario Knowledge Acquisition* (degree expected August 2004)

Ph.D. Dissertations

Huan-Jyh Shyur, *A General Nonparametric Model for Accelerated Life Testing With Time-Dependent Covariates*, October 1996 (co-advisor with E.A. Elsayed)
(Assistant Professor, Department of Information Management, Tamkang University, Taipei, Taiwan)
Yuxien (Andrew) Cheng, *Statistical Process Control for Complex Settings and the Establishment of Threshold Systems,* January 1999
(co-advisor with R. Liu)
(Aviation Research Analyst, Hi-Tec Systems, FAA William J. Hughes Technical Center, Atlantic City, NJ)
Lars Nordmann, *Diagnostic and Reduction Techniques for Assessing the Relative Information Content of Performance Measures,* May 2001
(Systems Analyst, AT&T Research Labs, NJ)
Veeris Ammarapala, *A ClusterGroup Decision Support System for Multiple Criteria Risk Assessment,* August 2002
(Office of Small and Medium Enterprises Promotion (OSMEP), Bangkok, Thailand)
Ram Kuturu, *Economic Models of Safety Risk Investment Portfolios,* degree expected 2005
Songwut Apirakkhit, degree expected 2006