行政院及所屬各機關出國報告
（出國類別：會議）

參加國際航空心理學第十二屆雙年會

出國報告

服務機關：行政院飛航安全委員會
出 國 人 職　　稱：飛航安全官
姓　　名：王興中
出國地區：美國
出國期間：民國九十二年四月十二日至四月二十日
報告日期：民國九十二年五月十九日

行政院及所屬各機關出國報告提要　　系統識別號 C09201918

出國報告名稱：參加國際航空心理學第十二屆雙年會出國報告

頁數：56　　頁含附件：是

出國計畫主辦機關：行政院飛航安全委員會
聯絡人：黃佩蒂　　　　　　　電　話：(02) 2547-5200 分機 154

出國人員姓名：王興中
服務機關：行政院飛航安全委員會
單位：飛航安全組
職稱：飛航安全官　　　　　　電　話：(02) 2547-5200

出國類別：□1 考察□2 進修□3 研究□4 實習■5 其他
出國期間：民國九十二年四月十二日至四月二十日
出國地區：美國

報告日期：民國九十二年五月十九日

分類號/目

關鍵詞：航空心理學，人為因素，出國報告。

內容摘要：

第十二屆國際航空心理學年會(The 12th International Symposium on Aviation Psychology)於民國 92 年 4 月 14 日至 17 日於美國俄亥俄州的但頓國際會議廳舉行。

航空心理學是一門有關於研究人類在航空領域中所扮演角色的學科。因此，國際航空心理學年會自 1981 年起即開始探討及研究航空科技及環境的改變對人類行為表現的影響，及如何結合學術研究和航空業界以提升飛航安全及效率。

今年會議的主題為「飛行百週年」。自 1903 年萊特兄弟設計第一架動力飛機後，至今已一百年了。雖然飛行的原理並未改變，但百年來飛航環境、科技、及人類在飛航系統中扮演的角色已是大大的不同。此次會議的重點之一就是探討人類應如何因應快速變化的飛航環境。

本文電子檔已上傳至出國報告資訊網

行政院及所屬各機關出國報告審核表

出國報告名稱: 參加國際航空心理學第十二屆雙年會出國報告
出國計畫主辦機關名稱: 行政院飛航安全委員會

出國人姓名：王興中
職稱：飛航安全官
服務單位:行政院飛航安全委員會

出國計畫主辦機關審核意見:

- □1.依限繳交出報告
- □2.格式完整
- □3.內容充實完備
- □4.建議具參考價值
- □5.送本機關參考或研辦
- □6.送上級機關參考
- □7.退回補正,原因:
  - □(1)不符原核定出國計畫
  - □(2)以外文撰寫或僅以所蒐集外文資料為內容
  - □(3)內容空洞簡略
  - □(4)未依行政院所屬各機關出國報告規格辦理
  - □(5)未於資訊網登錄提要資料及傳送出國報告電子檔
- □8.其他處理意見：

層轉機關審核意見:

- □同意主辦機關審核意見
  - □全部 □部份_________(填寫審核意見編號)
- □退回補正,原因:_________(填寫審核意見編號)
- □其他處理意見:

目錄

前言

第十二屆國際航空心理學年會 (The 12th International Symposium on Aviation Psychology) 於民國 92 年 4 月 14 日至 17 日於美國俄亥俄州的但頓國際會議廳舉行。

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會前研討會

四日十四日 **8:30 - 11:30**

1. Workshop on Air Traffic Control Human Factors Research Methods — Dr. Esa M. Rantanen, Institute of Aviation, Aviation Human Factors Division, University of Illinois at Urbana-Champaign
2. A Human Factors Approach to Accident Analysis and Prevention — Dr. Scott A. Shappell, Civil Aerospace Medical Institute and Dr. Douglas A. Wiegmann, University of Illinois at Urbana-Champaign
3. Usability is More than Skin Deep: The Changing Face of User Interface Design — Dr. Victor Riley, User Interaction Research and Design, Inc.
4. Process Facilitation in Aviation Environments — Mr. Cameron Fraser, RANA International Inc.; Mr. Philip Wildey, European Organization for the Safety of Air Navigation; and, Mr. Jeff Wearn, Transport Canada
5. Guide for Selecting Situational Awareness and Workload Measures — Dr. Valerie Gawron, Veridian, Inc.
6. Critical Incident Stress Management (CISM) for Aviation — Mr. Gregory Janelle, President, Janelle & Associates

四日十四日 **13:00 – 16:00**

7. The Importance of Aircrew Fatigue Management and the Effects of Various Fatigue Countermeasures — Dr. John A. Caldwell and
8. Dr. J. Lynn Caldwell; Air Force Research Laboratory
9. The Development of an Air Safety Management Program — Lt. Col. Gary T. Hook, 1 Canadian Air Division Headquarters
10. Tools and Approaches for Working with NTSB Accident Data — Dr. Deborah Bruce and Dr. Jana Price, National Transportation Safety Board
11. Preventing Error in Civil and Military Operations — Dr. Alan E.Diehl, Albuquerque, NM
12. Pulp Fiction for the Airline Pilot: How to Transform Human Factors Theories into Useful Training Concepts for Commercial Airline Crews — Capt. Steve Swauger, Southwest Airlines Pilots' Association (SWAPA)

會議流程

SCHEDULE OF ISAP PAPER SESSIONS

MONDAY	SESSION 1/ROOM 306	SESSION 2/ROOM 307/308	SESSION 3/ROOM 310/311	SESSION 4/ROOM 303/304	SESSION 5/ROOM 302	SESSION 6/ROOM 309
1900-2100	Opening reception Poster session					
TUESDAY						
0830-0930	Opening Plenary Session Tom Crouch Theatre Room 312					
1000-1130	2. Interfaces 1: Ecological Perspective Dr. Max Mulder	21. CRM 1: Evaluation Dr. Eduardo Salas	37. Training 1: PC-based Dr. Henry Taylor	31. Working with Culture Dr. Ashleigh Merritt	40. Workload 1: Mental Factors Dr. Wayne Shebilske	16. ATC 1: Flow Management Dr. Esa M. Rantanen
1230-1400	3. Interfaces 2: Landing Displays Dr. Dennis Beringer	22. CRM 2: Teaching Dr. Barry Strauch	38. Training 2: Skill Decay Dr. Thomas Wetzel	32. Panel: Culture and Aviation Dr. Ashleigh Merritt	41. Workload 2: Attention Management Dr. Michael Vidulich	17. ATC 2: Communication Dr. James M. Hitt
1430-1600	4. Interfaces 3: Primary Flight Displays Dr. Gerald P. Chubb	23. CRM 3: Cultures Capt. Dan Maurino	39. Training 4: Airline Training Dr. Valerie Gawron	1. Cognitive Systems Engineering Dr. Gavan Lintern	42. Concurrent Task Management Dr. Key Dismukes and Ken Funk	62. History Dr. John Hassoun
1600-1800	5. Interfaces 4: Advanced Displays Dr. John Reising	24. Aviation Safety Action Program Dr. Robert Helmreich	46. Decision Making 1: Teams Dr. Phil Smith	69. Cognitive Aging in Piloting Dr. Pamela S. Tsang	43. Workload 3: General Sandy Hart	19. ATC 4: General Dr. Larry Bailey
WEDNESDAY						
0830-1000	6. Interfaces 5: Control Display Advances Dr. John Flach	25. CRM Training in C-130 Dr. Robert T. Nullmeyer	47. Decision Making 2: Free Flight Dr. Amy Pritchett	58. Data Link Dr. Vic Riley	44. Workload 4: Situation Awareness Dr. Chris Wickens	20. ATC 5: Personnel Selection Dr. Bill Marshak
1030-1200	7. Interfaces 6: Alarm Warning Systems Dr. Nadine Sarter	26. UT HF Research Project Dr. Robert Helmreich	48. Decision Making 3: General Capt. Janeen Kochan	59. GLOC Dr. Kristen Liggett	28. Safety 1: Human Error and Risk Dr. Maxine Lubner	55. Assessment of Aircrew Performance L. D. Alford
1300-1430	8. Interfaces 7: CDTI Dr. Sherry Chappell	10. Panel: Safe Flight 21 Dr. Roni Prinzo V. Battiste	49. Decision Making 4: Aging Dr. Beth Lyall	60. Ground Operations Dr. James M. Hitt	29. Panel: Error Reporting Dr. Jeffery Beaubien	57. Communication Dr. Ray King
1500-1630	9. Interfaces 8: CDTI Self Separation Dr. Anthony Andre	27. Synthetic Task Environments Dr. David C. Foyle	50. Decision Making 5: General Aviation Dr. Kathy Mosier	61. Surface Management Charles Billings Deborah Walton	30. Safety 2: Safety Culture Capt. Neil Johnston	18. ATC 3: Decision Making Dr. Victor Ingurgio
1900-2100	Banquet at USAF Museum					
THURSDAY						
0830-1000	11. Interfaces 9: Preventing Error Dr. Kevin Williams	15. Display of SA Information Dr. Walter W. Johnson	51. Identifying ADM Safety Initiatives David Hunter	63. Maintenance Dr. William Krebs	33. Safety 3: Risk Perception Dr. Richard Adams Booz Allen	67. Recent Work on Spatial Disorientation William Albery
1030-1200	12. Interfaces 10: Control Languages Dr. Torbjorn Alm	53. Cancelled	66. Perception Claes von Hofsten Warren?	64. Identifying Human Error Risks in Maintenance Dr. Barbara Kanki	34. Safety 4: Human Error Dr. Al Diehl	68. Physiology/Fitness Dr. Stan Mohler
1230-1400	13. Interfaces 11: Electronic Checklists Dr. Thomas L. Seamster	54. Hijacking and Terrorism Dr. Malcolm Cook	45. Memory Factors Sidney Dekker	65. Managing Human Error Risks in Maintenance Dr. Barbara Kanki	36. Cancelled	71. Stress Dr. Doug Wiegmann
1430-1600	14. UAV HF Research Dr. Mark Draper	56. Crew Factors Dr. Hans-Jürgen Hörmann	70. Selection of Air Crews David Hunter	52. Risk Assessment and Risk Management Dr. Judith Orasanu	35. Safety 5: Abnormal Procedures Dr. Barbara Burian	72. CART project Dr. Chris Hale
1600-1700	Closing Plenary Session Boll					

會議摘要

本次會議共有來自全球二十五個國家約三百六十位學者發表研究論文，發表方式為以七十二個討論單元，分三日完成，每個單元約 90 分鐘，同一時間有六個單元同時進行。論文的題目及發表者資料詳如附件一。

會議討論主題包括認知系統工程學、人機界面、無人載具人為因素、駕艙狀況警覺、航管系統人為因素、維修系統人為因素、組員資源管理、安全文化、訓練、工作負荷、記憶力與注意力、決策下達、風險評估與管理、溝通、組員表現評估、與地面安全等。由於討論的議題非常的廣泛，且同時間有六個不同的議題在不同的地點同時進行，因此本報告只針對和本會調查任務相關，並實際參與討論之議題作一摘要報告。

文化與航空

在與文化相關的討論中，Donald Davis 提出 National Culture, Team Behavior and Error Management in US and Chinese Simulated Flightcrews 論文，他認為人為的失誤是造成許多意外事件的主因，而這些人為的失誤可歸究於組員之間合作的間隙。而組員間合作的間隙又可能是因為國家文化的不同而造成的。Davis 認為文化上的差異會影響團隊合作，尤其是在溝通、領導、決策下達、及角色扮演等，進而影響了組員的表現及飛航安全。

為了證明他的假設，Davis 對 196 位華人和美國學生作組員合作模擬實驗，實驗中將學生兩兩配對並分成華人學生配華人學生，或美國學生配美

國學生的同文化組，及華人學生配美國學生的不同文化組，以量測不同分組間組員合作上的差異。

初步的實驗結果顯示，不同文化的組員組合的確在組員表現上會有所不同。美國學生組有較高的狀況警覺，較多的決策下達次數。同文化的組員間交談的次數頻率頻繁，且較少出錯。詳細結果請參考附錄二中所列的原文。

Honeywell International 的 Zhao Chen 和 Danni Bayn 則針對華人使用的飛機上是否應使用華文的人機界面提出討論，論文題目為：Is an English or Chinese Language Interface Better For Chinese Speaking Pilot? 論文中討論到，由於目前絕大多數的飛機都是由西方國家所製造，其設計理念及人機界面是否適合東方的駕駛員是值得探討的，Chen 和 Bayn 因此針對華人駕駛員對華文及英文的航管指示及人機界面展開研究。

實驗中以華文及英文發布航管指示給華人駕駛員，駕駛員則需用華文或英文界面去操控飛機，以評量華人駕駛員在何種語言的操控界面下會有最短的反應時間。實驗結果顯示不論使用華文或英文的航管指示，華人駕駛員使用華文的操控界面能有最短的反應時間。

但是，若需將英文航管指示翻譯成華文再操作華文界面時，則更易產生錯誤，因此，Chen 和 Byan 認為若不使用華文航管指示配合華文操控界面，則寧可全部使用英文系統。Chen 和 Byan 同時也發現，雖然華人駕駛員在

使用英文操控界面時較容易發生錯誤，也需較長的反應時間，但華人駕駛員大多還是寧可使用英文的界面，Chen和Byan認為可能是因為駕駛員們希望能增進他們的英文能力，並提昇日後飛航國際航線的競爭力。詳細資料請參考附件三中之原文。

飛航安全執行計劃

繼CRM、LOFT、LOSA等飛航安全計劃在全球航空界普遍的推廣並執行後，本次年會中又有學者提出不同的飛安計劃。

美國德州大學的Harper和Helmreich自2002年年初開始在美國的數個主要的航空公司推動一個名為Aviation Safety Action Program (ASAP)的計畫。ASAP為一個飛安自願報告系統，和美國NASA的ASRS及台灣的TACARE飛安自願報告系統類似。該系統接獲飛航組員的通報後，由該系統的委員會解讀、分析該報告，並尋求解決之道。由於ASAP計畫同時得到了美國FAA及飛行員協會(ALPA)的支持，因此通報者的身分都將保密而不會被有關單位追究責任。

基本上ASAP的設立精神及運作方式都和本會設立的TACARE飛安自願報告系統類似，亦和美國ASRS系統有許多重複之處，但因ASAP系統是在不同的航空公司內自行運作，若發現飛安上的隱憂，亦直接在該航空公司內尋求解決。因此相較於其他類似的自願報告系統，ASAP能較迅速及較直接的針對飛安議題尋求改進。但由於該系統會保留通報資料中的航空

公司名稱，因而保密性不若其他類似的飛安報告系統。詳細資料請參考附件四中之原文。

失事及風險調查工具

加拿大 Defense R&D Canada Toronto 的 Hendy 發表一個正在發展的 Systematic Error and Risk Analysis (SERA)系統。SERA 可以幫助調查員從事人為因素失事調查以深入瞭解為何會有不安全的行為發生。

SERA 的理論基礎是建立在 Information Processing (IP)和 Perceptual Control Theory (PCT)模組上，並結合 James Reason 和 Human Factors Accident Classification System (HFACS)的理論。在實際運用上，SERA 先判定出事故中所發生的不安全行為(Active failures)，並找出 Pre-condition，Organizational influences，及 Command, Control and Supervision failures。並將這些因素間之關聯加以分析，以釐清事件發生的因果關係，找出事故發生的原因以避免事故的再次發生。詳細資料請參考附件五中之原文。

結語

百年來，航空科技的發展改變了人類生活的型態，亦擴展了人類活動的能力與極限，而航空心理學的研究在航空科技的發展中佔了不可或缺的地位。

航空事故的可能肇因大部分為飛航組員的因素，因此航空心理學針對駕駛艙設計、自動化系統、及組織因素等方面加以研究，以降低飛航組員發生錯誤的機會。另外，航空心理學亦對航空人員訓練，人格分析，以及如何設計出更能容許人類錯誤的飛航操作系統從事深入的研究以提昇飛航安全。

本次會議中除了瞭解全球目前各地區的航空心理學相關研究及現況外，並能有機會和來自世界各國航空心理學的研究人員交換心得，建立聯絡網路，以使日後在從事飛安工作時可相互支援。尤其本次會議參加的學者及專家非常的多，更有許多航空心理學不同領域的大師級人物，以往在教課書及專業期刊上所讀到的知名學者，如研究 Decision Making 的 Neil Johnston，Situation Awareness 的 Chris Wickens 和 Mica Endsley，工作文化的 Robert Helmreich 和 Ashleigh Merritt 等，都能夠有機會當面與他/她們討論航空心理學方面的各種問題，實屬難得的機會，亦對於我國因非國際民航組織會員國所造成之交流受阻礙情形可有所舒緩，不僅能獲取新知，亦可以瞭解當代各國航空心理學研究現況，進而掌握未來趨勢，參加國際會

議應屬可取。

附錄一

Paper and Panel Sessions

1. Cognitive Systems Engineering

Extending the Abstraction HierarchyFor the Aircraft Manual Approach to Landing Control Task, M.H.J. Amelink, M.M. Van Paassen, M. Mulder, Delft University of Technology, The Netherlands, and J. M. Flach, Wright State University

Dimensionality of the Information-Action Workspace in the Modern Commercial Cockpit, Iya Solodilova, HCI Group, University of Bath, UK, Gavan Lintern, Aptima Inc., Neil Johnston, Trinity College Dublin

Cognitive Systems Engineering (CSE) Framework for Evaluating Cockpit Interfaces, Kamilla Run Johannsdottir, Jo-Anne LeFevre, Chris M. Herdman, Aviation and Cognitive Engineering (ACE) Lab, Carleton University

Design Approach for Decision Support Tools in a Flexible Route Environment: Design Approach and Operational Requirements, L. Bestit, N. Boudes, C. Capsié, and P. Trouslard

2. Interfaces 1: Ecological Perspective

Towards an Ecological Interface Design for the Presentation of Spatio-Temporal Affordances in Airspace, A.L.M. Abeloos, M.M. van Paassen, M.Mulder, A.R. Pritchett, J.A. Mulder

Total Energy-Based Perspective Flight Path Display For Aircraft Guidance Along Complex Approach Trajectories, M.H.J. Amelink, M.M. (René) Van Paassen, M. Mulder, Delft University of Technology, Faculty of Aerospace Engineering, Delft, The Netherlands J.M. Flach, Wright State University

GPS Use in General Aviation: An Overview of Studies in New Zealand, Australia and the United States, Michael Nendick, Civil Aviation Safety Authority, Australia, Ross St. George, Civil Aviation Authority, New Zealand, Jeanne Bevitt University of Newcastle, Australia, Kevin W. Williams; FAA Civil Aerospace Medical Institute, USA, Kurt M. Joseph; SBC Technology Resources, Inc., USA

Visual Constraints in Nap-of-the-Earth Helicopter Night Flights, Sylvain Hourlier, Corinne Roumes Institut de Médecine Aérospatiale du Service de Santé des Armées, France

3. Interfaces 2: Landing Displays

Evaluating a Configural Attitude Display: Wright CAD, Paul F. Jacques, John M. Flach [1], Darby L. Patrick, and Randy Green Wright State University

Design and Experimental Evaluation of Four-Dimensional Tunnel-in-the-Sky Displays, F.J. Vormer, J. Otten, M. Mulder, M.M. van Paassen, J.A. Mulder, P.J. Stappers, and C.J.

Overbeeke Delft University of Technology

Advanced Trajectory Design For Tunnel-in-the-Sky Displays: The Use of Clothoids, J. Brandse, M. Mulder, and M. M. van Paassen, Delft University of Technology, Faculty of Aerospace Engineering, Delft, The Netherlands

Experimental Study on the Information Display for Enhancing Situation Awareness in Autopilot Systems, Daisuke Karikawa, Makoto Takahashi, Akira Ishibashi, and Masaharu Kitamura, Tohoku University Japan

4. Interfaces 3: Primary Flight Displays

Advancing the Primary Flight Display, Patricia M. Ververs, Christopher Misiak, Thea L. Feyereisen, Trent Reusser, and Jeff Rye, Honeywell AES Center of Excellence, Minneapolis, Minnesota

Comparisons Among Three PFD Display Formats With Synthetic Terrain Background, Gerald P. Chubb and Chang Liu, The Ohio State University

Primary Flight Displays in the T-38c: When Do Differences Among Displays Become Inconsistencies?, Michael P. Snow and Guy A. French, Air Force Research Laboratory, Thomas A. Hitzeman, USAF Flight Training Systems Program Office

Instinctive Attitude Display and its Applications Potential, Robert H. Wright, Dothan, AL

5. Interfaces 4: Advanced Displays

Development and Evaluation of Prototyped New and Advanced Head-Down Displays: For the CF188 Fighter: Part I, Ed Campbell, CMC Electronics Inc. Ottawa, Canada and Chris M. Herdman, Carleton University, Ottawa, Canada

Development and Evaluation of Prototyped New and Advanced Head-Down Displays For the CF188 Fighter: Part II, Chris M. Herdman, Ed Campbell, Jo-Anne Lefevre Carleton University, Ottawa, Canada

Direct Manipulation In Aircraft Four-Dimensional Trajectory Planning Interfaces, R.Winterberg, M. Mulder, and M.M. (René) Van Paassen, Delft University of Technology, Delft, The Netherlands

Evaluation of Monocular Depth Cues in 3D Aircraft Displays, Torbjörn Alm, Linköping Institute of Technology Patrik Lif, Swedish Defence Research Agency Martin Öberg, Virtual Technology, Linköping, Sweden

6. Interfaces 5: Control/Display Advances

Depth Perception in Flight from Hyperstereroscopic Images, Corinne Roumes, Justin Plantier, Sylvain Hourlier, Martine Godfroy, Institut de Médecine Aérospatiale du Service de Santé des Armées – France Alain Leger Département Sciences Cognitives Thomson CSF – France

Conceptual Design of a GNC Supervisory Display for a Lifting Body Re-entry Vehicle, T. Verborgh and M.M. (René) Van Paassen, and M. Mulder, Delft University of Technology, Delft, The Netherlands

Aircraft Task-Oriented Control/Display Interfaces, A.R. Veldhuijzen, M. Mulder and S. Bennani, Delft University of Technology, Delft, The Netherlands

An Evaluation of Human Error in U.S. Army Rotary-wing Accidents and the Impact of Cockpit Displays, CPT Gina E. Adam, and LTC Robert Noback, U.S. Army Aeromedical Research Laboratory

7. Interfaces 6: Alarm/Warning Systems

Mistrust of Multiple Alarm Systems, James P. Bliss and Gary Capobianco, Old Dominion University

Designing the Alerting Function For Aviation Safety Detection Systems, Raja Parasuraman, Catholic University of America

Evaluating an Adaptive, Intelligent Flight Deck Interface For Aircraft Warning Systems, A.L.M. Abeloos, Delft University of Technology, J.J. Egging, Delft University of Technology, A.R. Pritchett, Georgia Tech, M.Mulder, Delft University of Technology, M.M. van Paassen, Delft University of Technology

Computer-Based and Web-Based Training Solutions for Meeting Cockpit Avionics Training Needs, Sam Sheller and John W. Ruffner, DCS Corporation, Alexandria, VA

8. Interfaces 7: CDTI

The Effects of Spatial Awareness Biases on Maneuver Choice in a Cockpit Display of Traffic Information, Amy L. Alexander and Christopher D. Wickens, University of Illinois, Aviation Research Lab

Sensitivity and Bias in Searches of Cockpit Display of Traffic Information Utilizing Highlighting/Lowlighting, Walter W. Johnson, NASA Ames Research Center Kevin Jordan, Min-Ju Liao and Stacy Granada, San Jose State University

Potential Causes and Solutions for Symbol Confusion Errors Among Airway Facilities (AF) Specialists, Robert Muldoon, Northrop Grumman Information Technology and Vicki Ahlstrom, ACB-220 Human Factors Group, Atlantic City International Airport

9. Interfaces 8: CDTI Self-Separation

Cockpit Display of Traffic Information (CDTI) Enhanced Flight Rules (CEFR): An Initial Study of Flight Crew Acceptability and Spacing Behavior During a Self- determined Instrument Approach Spacing Task While Using a Traffic Display, Randall Bone, David Domino, and John Helleberg - MITRE CAASD

Aircraft Localization Using Electronic Maps, Pamela Maas and Doug A. Peterson, The

University of South Dakota

Pilot Support for Self-Separation During Decelerating Approaches, A.C. in ‘t Veld and J-P Clarke, Massachusetts Institute of Technology and M. Mulder and M.M. (René) van Paassen, Delft University of Technology, Delft, The Netherlands

Modeling Pilot Behavior at Self-Spacing Tasks, M. Mulder, A.R. Pritchett, V.V. Kalambi, Z.C. Roza, and M.M. van Paassen Technical University of Delft, and Georgia Tech

10. Panel: Safe Flight 21 Ohio River Valley Project: Human Factors Considerations for the In-flight use of a Cockpit Display of Traffic Information

Presentation 1: “An Overview to the Safe Flight 21 Ohio River Valley Project: Human Factors Considerations for the In-flight use of a Cockpit Display of Traffic Information.”, V. Battiste, NASA Ames Research Center, Moffett Field, CA

Presentation 2: “Flight Crew Mediated Spacing for Departure, En route, and Approach Using a Cockpit Display of Traffic Information: Experiences from OpEval-2.”, R. Bone and D. Domino, MITRE CAASD, McLean, VA

Presentation 3: “Flight Crew Use of a Surface Moving Map Display During Final Approach, Landing, and Airport Surface Operations: OpEval-2 Lessons Learned.”, V. Battiste and N. Johnson, NASA Ames Research Center, Moffett Field, CA

Presentation 4: “Pilot and Controller Operational Communication: Lessons Learned from OpEval-2.”, O. V. Prinzo, FAA Civil Aerospace Medical Institute, Oklahoma City, OK

11. Interfaces 9: Preventing Error

Towards a Model of Error Management on Highly Automated Glass Cockpit Aircraft, Mark I. Nikolic And Nadine B. Sarter, The Ohio State University

General Aviation Pilot Use of ADS-B Displays: Human Factors Issues, Kevin W. Williams, FAA Civil Aerospace Medical Institute

Misperception of Cardinal Compass Directions on Electronic Maps, Doug A. Peterson and Pamela Maas, The University of South Dakota

Relationship Between Age, Flight Strip Usage Preferences, and Strip Marking, C. A. Manning, FAA Civil Aerospace Medical Institute, F. T. Durso, Texas Tech University, P. Batsakes, The Boeing Company, T Truitt, FAA William J. Hughes Technical Center, and J. Crutchfield, The Boeing Company

12. Interfaces 10: Control Languages

Tactile Cues for Monitoring Tasks in Complex Systems, John Fontejon, Air Force Research Laboratory Kimberly Murphy, Gloria Calhoun, Heath Ruff & Mark Draper, WPAFB

Spatial Intercoms for Air Battle Managers: Visually Cueing Talker Locations Improves Speech Intelligibility, Robert S. Bolia, Air Force Research Laboratory, WPAFB

The Cockpit Control Language: An Update, Victor Riley, User Interaction Research and Design, Inc. Bob DeMers, Chris Misiak, and Hazel Shackleton, Honeywell International

Operational Evolution Plan: Simulation of a "Day in the National Airspace System", Paul Krois and Jacqueline Rehmann, Federal Aviation Administration

13. Interfaces 11: Electronic Checklists

Cognitive and Human Factors Checklist Performance on the Commercial Flightdeck, Melanie Diez, Deborah A. Boehm-Davis and Robert W. Holt, George Mason University

Electronic Flight Bags (EFBs) With Small Screens Significantly Increase Information Retrieval Times, Chris Hamblin, Cessna Aircraft Company

Use of "Personal Computers" in the Military Cockpit, Jennifer L. Farrell, WPAFB, OH

Structured Information for Flight operations and the Flight Deck, Thomas L. Seamster, Cognitive and Human Factors and Barbara G. Kanki, NASA Ames Research Center

14. Unmanned Air Vehicle Human Factors Research Within AFRL/HEC

Multi-Sensory-interface Concepts for Unmanned Air Vehicle (UAV) Systems, Mark H. Draper, Gloria L. Calhoun, The Operator Vehicle Interface Laboratory Greg Barbato

Operator Functional State Assessment for UCAV Adaptive Automation, Glenn Wilson

The Role of Operatiors in Unmanned Military Vehicles: A NATO Perspective, John Reising

15. The Display of Situational Awareness Information on the Flight Deck: What is it and What is it for? Panel Discussion

Dr. Walter W. Johnson, NASA Ames Research Center and Dr. Vernol Battiste NASA Ames Research Center

Panelists: David A. Domino, MITRE Corporation Center for Advanced Aviation System Development, Mica R. Endsley, SA Technologies in Marietta, Richard F. Shay, former Naval Aviator who retired from the Naval Reserves in 1999 with the rank of Commander Todd R. Truitt, Federal Aviation Administration's NASA Human Factors Group Christopher D. Wickens, Institute of Aviation at the University of Illinois at Urbana-Champaign

16. ATC 1: Flow Management

Design and Evaluation of Tools to Support the Reroute Advisory System to Support Distributed Work in the Traffic Flow Management System, Philip Smith, The Ohio State University, Keith Campbell, MITRE/CAASD, Michael Murphy, Federal Aviation Administration, Roger Beatty, American Airlines, Tahereh Behbehani, Embry Riddle University

Human Factors Implications of Air Traffic Management Procedures and Algorithms, Esa M.

Rantanen and Wayne J. Davis, University of Illinois at Urbana-Champaign

Indicators of Airspace Complexity for Traffic Flow Management Decision Support Anthony, J. Masalonis, Michael B. Callaham, Yesenia Figueroa, Craig R. Wanke, the MITRE Corp., McLean, VA

"Dynastrip": A Time-line Approach for Improving ATCos' Air Traffic Picture Jean-Yves Grau, Jean Nobel, Laurent Guichard, and Gilles Gawinowski Eurocontrol, France

17. ATC 2: Communication

The Impact of Communications Mode on Asynchronous Collaboration in the NAS, Roger J. Chapman and Philip J. Smith, Cognitive Systems Engineering Lab, The Ohio State University

When Language Becomes a Barrier Instead of a Bridge: Communication Failures Between Pilots and Air Traffic Controllers, Jeannie Davison, SJSU/NASA Ames Research Center Ute Fischer, Georgia Institute of Technology and Judith Orasanu, NASA Ames Research Center

Communication and Coordination Between Airway Facilities Sites: Implications For Operations Control Centers, Victor Ingurgio, Northrop Grumman Corporation

Cognitive Processes in Reading Back ATC Clearances, Amy Lynn, Alice F. Healy, Immanuel Barshi, Jon Holbrook, Vivian I. Schneider NASA Ames Research Center

18. ATC 3: Decision Making

Use of Structure as a Basis for Abstraction in Air Traffic Control, Drs. Hayley J. Davison & R. John Hansman

A Field Survey of Complexity in Air Traffic Control Towers, Anton Koros, Northrop Grumman Gulshan Panjwani, Titan Systems Corporation Victor Ingurgio, Northrop Grumman Pamela S. Della Rocco, Federal Aviation Administration Jean-François D'Arcy, Titan Systems Corporation

Collaborative Distributed Problem Solving in the NAS: Building Shared Knowledge Between the Partners Who Know and Those Who Make Decisions, Jodi Heintz Obradovich and Philip J. Smith, The Ohio State University

High Fidelity Simulation Test of New Air Traffic Control Concepts, Todd R. Truitt and D. Michael McAnulty, FAA William J. Hughes Technical Center

19. ATC 4: General

Are ATC Subject Matter Experts Created Equal?, L. L. Bailey and A. L. Scarborough Federal Aviation Administration Civil Aerospace Medical Institute

Resting EEG Predicts Performance in a Simulated Air Traffic Control Task, Richard W. Backs, Sergio P. Da Silva, and Xidong Xu Central Michigan University

A Task Analysis, a Literature Review, and a Need for Further Research, Xidong Xu and Esa Rantenan, University of Illinois at Urbana-Champaign, Aviation Research Lab

Safety Assessment for Validating New Concepts in Air Traffic Control, Jean-Yves Grau, Laurent Guichard, Fabrice Drogoul, Sandrine Guibert and Gilles Gawinowski, Eurocontrol, France

20. ATC 5: Personnel Selection

A Work Sample Test in a Lerntest Design – 10 Years with The Dynamic Air Traffic Control Test -Dac-, Hinnerk EiBfeldt, Deutsche Forschungsanstalt Für Luft- Und Raumfahrt DLR

Taxonomies of Measures in Air Traffic Control Research, Esa M. Rantanen and Ashley Nunes, University of Illinois at Urbana-Champaign

Development of an Empirically-Based Index of Aircraft Mix, Elaine M. Pfleiderer FAA Civil Aerospace Medical Institute

Safety-Efficiency-Workload Balance in ATC: A Tool to Assess Sector Capacity from a Human Factors Perspective, K. W. Kallus, University of Graz, Austria, P. Hoffmann, Austro Control GesmbH, Austria, B. Ehgartner, Chr. Kuhn, A. Pichler, and R. Schuen-Medwed, University of Graz, Austria

21. CRM 1: Evaluation

Integration of Interpersonal Skills Into a Pilot's Proficiency Reporting SystemFirst Results of a Usability Study at Lufthansa, Hans-Jürgen Hörmann, GermanAerospace Center (DLR), Institute of Aerospace Medicine Cpt. Karl-Heinz Burger, Lufthansa German Airlines, Cpt. Harry Neb, Lufthansa German Airlines

Basic Performance of Flight Crew: A New Concept of Competence Based Markers for Defining Pilots Performance Profile, Cpt. Karl-Heinz Burger, Lufthansa German Airlines, Cpt. Harry Neb, Lufthansa German Airlines, Hans-Jürgen Hörmann, German Aerospace Center (DLR), Institute of Aerospace Medicine

Lufthansa's New Concept of Evaluating Pilots' Performance, Cpt. Harry Neb and Cpt. K.H. Burger, Lufthansa German Airlines, and Dr. J. Hoermann, German Aerospace Center (DLR)

ESSAI: Training of Situation Awareness and Threat Management Techniques: Results of an Evaluation Study, Hans-Juergen Hoermann and Henning Soll German Aerospace Center (DLR), Institute of Aerospace Medicine, Hamburg, Germany Helen Dud field, Farnborough, Hants, UK Simon Banbury, Cardiff University, School of Aviation, Cardiff, UK

22. CRM 2: Teaching

Tools to Teach Effective Human Factors Concepts to Airline Flight Crews, Ted N. Beneigh, Wayne S. Cook, Ron E. Clark, Embry-Riddle Aeronautical University

Single Pilot CRM: An Ethnographic Study of Student Pilot Behaviors, Manoj S. Patankar and Gary J Northam, Saint Louis University

Complementing CRM Training and Error Management with Applied Behavior Analysis, William G. Rantz, Western Michigan University

A Transition From Aviation Crew Resource Management to Hospital Emergency Medical Departments: The Medteams Story, John Morey and Robert Simon, Dynamics Research Corp

23. CRM 3: Cultures

The Effective Introduction of Changes to the Flight Crew's Aviation Safety Culture, Through CRM Training Program, by the Air Carrier's Top Management. The case study of Olympic Airways. John S. Lainos, Air Transport. University of Thessaly-Greece Elias Nikolaidis, Olympic Airways

Enhancement of the U.S. Aircrew Coordination Training (ACT) Program, Gary Grubb, DRC, Center for Team Performance

Army CRM Training: Demonstration of a Prototype Computer-Based Program, Larry Katz, Ft. Rucker AL Errors, Mistakes, Cultures Giorgio Sacco, Ente Nazionale Aviazione Civile, France

24. Development and Implementation of an Aviation Safety Action Program

The Value and Application of ASAP Data in Training, Captain Don Gunther, Continental Airlines

The "Everyday" Safety Change Process – Captain Bruce Tesmer, Continental Airlines, Capt. Bruce Tesmer, Continental Airlines ASAP/LOSA Manager

Development and Design of an Aviation Safety Action Program, Michelle L. Harper, University of Texas

CRM in the C-130, Robert Nulmeyer, USAF Research Laboratory

25. CRM And Mission Performance During C-130 Mission-Oriented Simulator Training

Using Air Force Aviation Mishap Data to Improve C-130 CRM Training, Robert Nullmeyer, Air Force Research Laboratory, Lt. Col. Donald White, Kirtland AFB, New Mexico, John Flournoy, Albuquerque, New Mexico

CRM and Mission Performance During C-130 Mission-Oriented Simulator Training, V. Alan Spiker, Anacapa Sciences, Robert T. Nullmeyer, Air Force Research Laboratory, Mesa AZ, Gregory C. Deen, C-130 Aircrew Training System, Little Rock AFB, AR, David D. Wilson, C-130 Aircrew Training System

Using Multiple Sources to Upgrade a Successful CRM Program, Gregory C. Deen, C-130 Aircrew Training System, Little Rock AFB, Arkansas, David D. Wilson, C-130 Aircrew Training System, Dyess AFB, Texas

26. UT Human Factors Research Project: LOSA and ASAP

The LOSA Archive: Threat and Error Analyses from Seven Airlines, James Klinect, University of Texas

Fatigue and Pilot Error: Observations from Line Operations, Dave Musson and James Klinect

Event Reporting in Aviation and Medicine, Michele Harper, University of Texas

LOSA Data Analysis: Boeing's View, Diego J. Castaño and Curt Graeber, The Boeing Company

27. Synthetic Task Environments

Question: Improving System Design and Evaluation through the use of Off-Nominal Testing: A Methodology for Scenario Development, David C. Foyle, NASA Ames Research Center and Becky L. Hooey, Monterey Technologies, Inc.

Testing Tunnel-in-the-sky Displays and Flight Control Systems With and Without Simulator Motion, M.M. van Paassen, M. Roeden, M. Mulder, Technical University of Delft, A.R. Pritchett, J. Chiecchio and S.A. Kalaver, Georgia Tech

Cognitive Performance Assessment in a Complex Space-System Micro-World: On the Use of Generalizability Theory, Bernd Lorenz, and Raja Parasuraman Catholic University of America, Francesco Di Nocera, University of Rome "La Sapienza", Rome, Italy

Audio-Visual Interactions for 3D-perception in Helmet-Mounted Displays, Corinne Roumes, Martine Godfroy, Sylvain Hourlier Institut de Médecine Aérospatiale du Service de Santé des Armées France

28. Safety 1: Human Error and Risk

Systematic Error and Risk Analysis (SERA): a Tool for Accident and Risk Investigation, Analysis and Classification, Keith C. Hendy, Defence R&D Canada Toronto, Toronto, Ontario, Canada

Understanding Human Error in Context: Approaches to Support Interaction Design Using Air Accident Reports, Anne Bruseberg, University of Bath, Bath, BA2 7AY, England

Reshaping the Way We Look at General Aviation Accidents Using the Human Factors Analysis and Classification System, Scott A. Shappell, FAA Civil Aerospace Medical Institute, and Douglas A. Wiegmann, University of Illinois at Urbana-Champaign

Beyond Error Reporting Toward Risk Assessment, Irving C. Statler, NASA Ames Research

Center, Loren J. Rosenthal, Battelle, and Rowena Morrison, Battelle

29. Panel: Error Reporting, Classification, and Analysis as Part of a Comprehensive Risk Management Strategy

Framework Assessing Notorious Contributing Influences for Error (FRANCIE): Perspectives on Taxonomy Development to Support Error Reporting and Analysis, Lon Haney, Idaho National Engineering and Environmental Laboratory, David I. Gertman, Idaho National Engineering and Environmental Laboratory (INEEL)

A Comparison of U.S. Military and Civilian Aviation Accidents Using the Human Factors Analysis and Classification System (HFACS), Scott Shappell, FAA Civil Aeromedical Institute, Douglas A. Wiegmann, University of Illinois at Urbana-Champaign, James R. Fraser, U.S. Naval Safety Center, Norfolk, VA

Toward a Generalized Human Factors Taxonomy for Classifying ASAP Incident Reports, AQP Performance Ratings, and FOQA Output, Jeffrey M. Beaubien and David P. Baker, American Institutes for Research

Understanding Normal, Abnormal, and Atypical Operations through Analysis of Flight Data, Thomas R. Chidester, NASA-Ames Research Center

Beyond Error Reporting Toward Risk Assessment, Irving C. Statler, NASA Ames Research Center, Loren J. Rosenthal, Battelle, Rowena Morrison, Battelle

30. Safety 2: Safety Culture

The Paradox of Rules — Procedural Drift In Commercial Aviation, Capt. Neil Johnston, Trinity College Dublin, Ireland

Measuring Safety Culture in a Regional Airline: Results from a Commercial Aviation Safety Survey, Terry L. von Thaden, Douglas A. Wiegmann, Alyssa A. Mitchell, Gunjan Sharma, Hui Zhang, University of Illinois at Urbana-Champaign

An Examination of the Success and Failures in Developing Safety Cultures, Catherine A. Adams, Research Psychologist, Crew Vehicle Integration Branch NASA/Langley Research Center

Pilot Weather Knowledge – A Dismal State of Affairs, Barbara Burian, SJSUF/NASA Ames Research Center

31. Working with Culture: Current Research and Industry Efforts

National Culture, Team Behavior and Error Management in US and Chinese Simulated Flightcrews, Donald D. Davis, Janet Bryant, Ying Liu, Lara Tedrow, and Rebecca Say Old Dominion University

Training Airline Cadets From Over 35 Cultures: Some Lessons Learned, Barrie Hocking, BAE Systems Flight Training — Adelaide, Adelaide, South Australia

The Cultural Lens Model: Understanding Cognitive Differences and Aviation Safety, Helen Altman Klein, Wright State University

Is an English or Chinese Language Interface Better For Chinese Speaking Pilots? Zhao Chen and Danni Bayn Honeywell International, Victor Riley, User Interaction Research and Design, Inc.

Aviation Safety: Dominant And Minority Culture Obligations, Ashleigh C. Merritt, The University of Texas Human Factors Research Project

32. Panel: Culture and Aviation: Perspectives, Problems and Products

Dr. Ashleigh Merritt, University of Texas

Presenters: Helen Klein, Vic Riley, Don Davis, Ashleigh Merritt, and Barrie Hocking

Addition Presenters: Allen Batteau, Wayne State University, Robert Helmreich, University of Texas, Florian Jentsch, University of Central Florida, Captain Daniel Maurino, ICAO, Montreal, Paul C. Schutte, NASA Langley Research Center

33. Safety 3: Risk Perception

Tyranny in Rules, Autonomy in Fields: Closing the Safety Management Loop, Gavan Lintern, Aptima Inc.

Risks for Aviation Accidents or Incidents Among U.S. Pilots by Pilot Training, Experience and Exposure, Maxine Lubner, Richard Adams, Booz Allen, Dave Hunter, FAA, Bob Sindoni, Fredric Hellman, College of Aeronautics, New York

Human Factors Accident/Incident Classified Standard and the Classified Statistical: Report on China Civil Aaviation Accident/Incident During 1990-2001, Luo XiaoLi, China Civil Aviation Flying College, GuangHan SiChuan China

Investigating Crew Perception of Risks Following Aircraft Accidents: Models, Methods and Experiences, Joel Morley, Transportation Safety Board of Canada

34. Safety 4: Human Error

When Does Human Error Become a Crime? Sidney Dekker, Linköping Institute of Technology, Sweden

The Effectiveness of Human Factors Training in Error Investigation, Colin Drury, University at Buffalo, Jiao Ma, University at Buffalo, Ina Richards, Parxair Inc., and A. Sarac, Curbell Inc.

Defining Darkness — Visual and Environmental Factors, Bartholomew Elias, National Transportation Safety Board

The Death-Notch: Compensation in Test and Evaluation, Lieutenant Colonel L. D. Alford, WPAFB, OH

35. Safety 5: Abnormal Situations

Crisis in the Cockpit — Problems with Emergency and Abnormal Procedures Barbara Burian, SJSUF/NASA Ames Research Center and Immanuel Barshi, NASA Ames Research Center

Declaring an Emergency: Fact and Fiction, Immanuel Barshi, NASA Ames Research Center

In an Emergency Old Habits Can Be Deadly, William E. Scott, Consultant, Gaborone, Botswana and Rudolf G. Mortimer, Consultant, Urbana, IL

Studying Information Behavior Among Part 121 CFIT Accident Flightcrews Through Transcript Analysis, Terry L. von Thaden, University of Illinois at Urbana-Champaign

36. Cancelled

37. Training 1: PC-based

Comparison of the Effectiveness of a Personal Computer Aviation Training Device, a Flight Training Device, and an Airplane in Conducting Instrument Proficiency Check, Tom W. Emanuel, Jr. Henry L. Taylor, Donald A. Talleur, and Esa M. Rantanen, University of Illinois at Urbana-Champaign

Transfer of Manual Flying Skills From PC-based Simulation to Actual Flight, Jan Joris Roessingh, National Aerospace Laboratory, Amsterdam, The Netherlands

Incremental Training Effectiveness of Personal Computers Used for Instrument Training, Henry L. Taylor, Donald A. Talleur,Tom W. Emanuel, Jr., Esa M. Rantanen, Gary L. Bradshaw, and Sybil I. Phillips, University of Illinois at Urbana-Champaign

The Effectiveness of GBTD for Initial CFI Training: A Pilot Study, Donna Forsyth Wilt and Mark Gibbs, Florida Institute of Technology

38. Training 2: Skill Decay

Test Scenarios for Rare Events, Richard Newman, Embry-Riddle Aeronautical University, Prescott, Arizona and Dave Foyle, NASA Ames Research Center

Accurately Assessing Pilot Knowledge: Bridging the Gap Between Paper-and-Pencil and Oral Exams, William Evans, III, Janeen A. Kochan, & Florian G. Jentsch, University of Central Florida

Evaluating the Effectiveness Flight Crew CRM Training: Results of a UK Survey, P. O'Connor, R. Flin, and G. Fletcher, University of Aberdeen, Scotland

Conceptual Design of an Intelligent Certified Flight Instructor Training System (ICFITS), John E. Deaton and Donna Forsyth Wilt, Florida Institute of Technology and Brian Glucroft, CHI Systems, Inc.

39. Training 4: Airline Training

Learning to Fly in the Modern Automated Cockpit: From Piston-Training Airplanes To the Jet Fleet, Stephen M. Casner, NASA Ames Research Center

The Cold Shoulder of Icing Recovery Training, Valerie Gawron, Veridian

Simulator Fidelity Requirements for Airline Pilot Training and Evaluation Continued: An Update on Motion Requirements Research, Judith Bürki-Cohen, USDOT-RSPA-Volpe Center Tiauw H. Go, William Chung, Jeff Schroeder, Thomas Longridge

Validation of a Modern Aviation Psychology Test Battery: First Results of Two Studies, Markus Sommer & Michael Benesch

40. Workload 1: Mental Factors

ERP Indices of Mental Workload for Traditional and Text-based ATC Commands During Simulated Flight, Joseph T. Coyne and Carryl L. Baldwin, Old Dominion University

Transcranial Doppler and Oximetry as Potential Measures of Cognitive Demand, Glenn F. Wilson and Justin Estepp AFRL/HECP, WPAFB, OH, Victor Finomore, Sytronics, Inc. Dayton, OH

On a Computer Based Prediction of Pilot Scanning Workload and Control Workload, M.M. Heiligers, Th. Van Holten, Th. Boersema, Delft University of Technology, The Netherlands

Pilot Mental Workload: Lessons Learned from Subjective and Physiological Measures, J.A. Veltman, TNO Human Factors, Soesterberg, The Netherlands

41. Workload 2: Attention Management

Supporting Attention Management in Complex Event-Driven Domains Through Informative Interruption Cueing, Chih-Yuan Ho, Mark I. Nikolic, Molly J. Waters, and Nadine B. Sarter, The Ohio State University

Hidden Markov Models as a Tool to Quantify Pilot Attention Switching During Simulated ILS Approaches, Miwa Hayashi and Dr. Charles M. Oman, Massachusetts Institute of Technology, Michael Zuschlag, Volpe National Transportation Systems Center

Workload In Flight Cockpit: An Approach for Searching a Methodological Evaluation, Selma Leal de Oliveira Ribeiro, Carlos Gomes de Oliveira, Physical Activity Science Institute of Aeronautic (NUICAF), Rio de Janeiro, Brazil

Evaluating an Integrated Performance Measure for Simulated Control of Unmanned Combat Aerial Vehicles (UCAVs), Michael Vidulich, Air Force Research Laboratory, Edward Fix, Sytronics

42. Concurrent Task Management

Pilots' Monitoring and Task Management Strategies and Performance on Glass Cockpit Aircraft: Beyond Anecdotal Evidence, Chris Wickens, Randy Mumaw, University of

Illinois, Savoy and Nadine Sarter, The Ohio State University

The Cockpit is Not Sterile! Concurrent Demands for Attention and Performance on the Flightdeck, Loukia D. Loukopoulos, R. Key Dismukes, and Immanuel Barshi, NASA Ames Research Center

Scanning for Visual Traffic: An Eye-tracking Study, Kurt Colvin , Key Dismukes, Sean Belcher & Rahul Dodhia, California Polytechnic State University

Can Concurrent Task Management be Trained? Ken Funk, Saher Bishara, Javier Nicolalde, & Kevin Molskness, Oregon State University

43. Workload 3: General

Validation of AutoPACE as an Index of Controller Workload. Paul Stager and Ghee W. Ho, York University, Toronto, Ontario and John M. Garbutt, NAV Canada, Ottawa, Ontario

The Effect of Pilot Visual Scanning Strategies on Traffic Detection Accuracy and Aircraft Control, Donald A. Talleur and Christopher D. Wickens, University of Illinois at Urbana-Champaign

Factors that Mediate Flight Plan Monitoring and Errors in Plan Revision: An Examination of Planning Under Automated and High Workload Conditions, Emily K. Muthard And Christopher D. Wickens, University of Illinois At Urbana-Champaign

The Application of a Qualitative Model of Human-Interaction with Automation in a Complex and Dynamic Combat Flight Task, Scott Galster, AFRL/Human Effectiveness Directorate, WPAFB, OH and Raja Parasuraman, The Catholic University of America

44. Workload 4: Situation Awareness

Performance and Situation Awareness Effects of Levels of Automation in an Advanced Commercial Aircraft Flight Simulation, Melanie C. Wright and Mica R. Endsley, SA Technologies Inc., Marietta, GA, David B. Kaber, North Carolina State University, Raleigh, NC

The Effect of Time-Sharing Training on Pilot Situation Awareness Cheryl A. Bolstad SA Technologies, Inc and Cass Howell, Embry-Riddle Aeronautical University, Mica R. Endsley, SA Technologies, and Anthony M. Costello

Controlling Multiple UAVs: A Workload Analysis, Christopher D. Wickens and Stephen R. Dixon. University of Illinois

The Effects of Preparatory Information on Pilots' Reactions to Unexpected Events, Katherine A. Wilson, Janeen A. Kochan, Florian Jentsch, and Eduardo Salas, University of Central Florida

45. Memory Factors

Human Memory and Cockpit Operations, Jessica Lang Nowinski, Jon Holbrook (presenter), and Key Dismukes, NASA Ames Research Center

Overconfidence, Transactive Memory, and Collective Efficacy in Student Transport Pilot Crews, Daryl R. Smith, Lt. Col, USAF Academy and Mitchell

The Role of Technology and Transactive Memory on Fighter Performance and Situational Awareness. Daryl R. Smith, Lt. Col, USAF Academy, Wells, Hoffman, Mitchell

Waypoint: A New Cognitive Aptitude Test for Aviators, Michael B. Cantor and Eugene Galanter, Waypoint Research, Inc. and Columbia University

46. Decision Making 1: Teams

A Case-Based Discussion of Team Decision— Making in a Corporate Aviation Facility, Manoj S. Patankar, Saint Louis University; James C. Taylor, Santa Clara University; and Robert L. Thomas, III, Santa Clara University

Aircrew Adaptive Decision Making: A Cross-Case Analysis, Constance Gillan, Sea Control Wing, U.S. Pacific Fleet, Naval Air Station North Island

Losing Shared Situation Awareness: The First Symptoms, Jan-Jonis Roessingh, G.D.R. Zon & B.G. Hilburn Delft, The Netherlands

Usability Methodology Applied to On-Board Graphical Weather Displays, Kimberly Raddatz, John Uhlarik, and Peter Elgin, Kansas State University

47. Decision Making 2: Free Flight

A Lens Model Analysis of Pilot and Controller Decision Making Under Free Flight, Pratik D Jha, and Ann M Bisantz, University at Buffalo, and Raja Parasuraman, Cognitive Science Laboratory

The Effects of Mixed Equipage and Decision Support Automation on ATC Performance, Mental Workload, and Attention Allocation in Distributed Air-Ground Traffic Management, Ulla Metzger, Ericka Rovira, and Raja Parasuraman, The Catholic University of America

Predictive Aids and Mental Models Under Free Flight: Proceed with Caution Ashley Nunes, University Of Illinois and Olivier St-Cyr, University of Toronto

48. Decision Making 3: General

Applying Stewart's 1990 Decomposition of Human Forecasting Performance to a Simulated Conflict Prediction Task, Ellen J. Bass and Martin Radzio, University of Virginia

Pilot Subjective Perceptions of the Current NOTAM System: Implications and Suggestions for Improvement, Raegan M. Hoeft, Janeen A. Kochan, and Florian G. Jentsch, University Of Central Florida

The Investigation of Aeronautical Decision Making During Tactical Flight Training, Wen-Chin Li, Cranfield University, Bedfordshire, U.K. Tony Head, Cranfield University, Chung-San Yu, Air Force Academy, Fuh-Eau Wu, Cheng Shiu Institute of Technology, Kaohsiung, R.O.C

An Intelligent Agent for Mixed-Initiative Aiding in the Future Tactical Cockpit, Derek A. Wischusen, Michael A. Szczepkowski, James H. Hicinbothom, Chi, Systems Norman W. Warner, Naval Air Warfare Center

49. Decision Making 4: Aiding

Aiding Pilots in Detecting Faults in the Flight Control Loop, J. Chiecchio, A.R. Pritchett and S.A. Kalavergeorgia Tech, Schools of Industrial and Systems Engineering and Aerospace Engineering, M. Roeden, M. Mulder, and M.M. Van Paassen Delft University of Technology

Supporting Trust Calibration in Automated Decision Aids Through the Presentation of Dynamic Reliability Information, John M. Mcguirl and Nadine B. Sarter, The Ohio State University

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65. Assessing and Managing Human Error Risks in Maintenance and Inspection

An Industry Overview of MRM Interventions for Risk Management, J. Taylor, Santa Clara Univ and M. Patankar, St. Louis University

A Method for Determining an Airline's Probability of Crack Detection Lee Ostrom and Cheryl Wilhelmsen, University of Idaho

Integrated Safety and Training Approaches to Risk Management, J. Schmidt, Navy Safety Center and R. Figlock, Naval Post Graduate School

Reporting Discrepancies: Informational Needs of Maintenance and Flight Crews in Logbook Write-ups, P. Munro, NASA ARC

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Ambiguities in Global Optical Flow: Tuning in to Speed and Altitude Changes, Darby L. Patrick, John M. Flach, and Paul F. Jacques, Wright State University

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Electroneurophysiologic Diagnosis of Pilot Spatial Disorientation, Michael Stephens, Wright State University (WSU), Jennie J. Gallimore, (WSU) and William Albery (AFRL)

The Use of Helmet-Mounted Display Attitude Symbology and Auditory Attitude Information Cues for Unusual Attitude Recoveries, Kristen K Liggett, (AFRL), Tammy Chelette, (AFRL), Richard Mckinely, (AFRL)

Symbology Conceptual Research and Integration Prototyping Tool — SCRIPT Development and Applications, Joseph C. Jenkins, 1Lt USAF, AFRL, Paul R. Havig, AFRL, Eric Heft, Northrop Grumman Information Technology, and Eric Geiselman, Geiselman Consulting

In Flight Training, Col. David L. Brown, (USAFSAM) and Capt. Chris Borchardt, (USAF)

SD Countermeasures Website Update, Todd Heinle (AFRL) and William Ercoline

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Changes in Performance, Mood State and Workload Due to Energy Drinks in Pilots, K.W. Kallus and D. Deixelberger-Fritz, Karl-Franzens-University Graz, Austria

Effectiveness of Advice to Airline Pilots to Prevent Excessive Fatigue, Hans de Ree, KLM Royal Dutch Airlines

69. The Mediating Role of Aviation Expertise in Cognitive Aging

Aging and Expertise in Pilot Time-Sharing, Pamela S. Tsang, Wright State University

Age-Related Group and Individual Differences in Aircraft Pilot Cognition, David J. Hardy, University of California, Los Angeles, CA

Age and Experience Interactions in Air Traffic Controller Performance, James T. Becker, University of Pittsburgh and Dana Broach, Federal Aviation Administration

Assessments of Expertise and Working Memory Factors In Predicting Older Pilots' Performance of a Simulated ATC Communication Task, Joy L. Taylor, Allyson Rosen, Ruth O'Hara, Martin Mumenthaler, and Jerome A. Yesavage, Stanford University and VA Palo Alto Health Care System Discussant: Raja Parasuraman, Catholic University of America

70. Selection of Air Crews

Should FAA Test Questions and Answers Be Published? An Empirical Inquiry, Karen M. Jones and Stephen M. Casner, NASA Ames Research Center

Selection and Performance Assessment of Ab-initio Pilots: Trials and Tribulations, Bernhard F. Frey, Calvin R. S. Hart, Moana D. Kingi, Peter J. Wheeler, Massey University School of Aviation, New Zealand

Distinction Between Static and Dynamic Spatial Abilities: Predictive Value and Implications for Personnel Selection, Teresa C. D'Oliveira, Instituto Superior de Psicologia Aplicada, Lisboa, Portugal

71. Stress

Pilots Under Stress: A Psychosocial Analysis, Richard J. Adams, Booz Allen Hamilton, David R. Hunter, Federal Aviation Administration, Maxine Lubner, College of

Aeronautics, New York, NY

Relating Personality with Stress Coping Strategies Among Student Pilots in a Collegiate Flight Training Program, Tracy G. Dillinger, Douglas A. Wiegmann, and Narinder Taneja, University of Illinois

Psychosocial Support in Disasters as Part of Crisis Intervention Maria-Helena Pereira Franco, Sao Paulo, Brazil

Work Engagement and Psychological Burnout Among Air Traffic Controllers Monica Martinussen and Astrid M. Richardsen, University of Tromso, Norway

72. Combining Task and Cognitive Modeling in Simulation-based Acquisition: Lessons Learned from the CART Project, Dr. Chris Hale, Science Applications International Corporation

Introduction to the Purpose and Scope of the Cockpit Automation Requirements Testbed (CART), Bryan E. Brett and Christopher R. Hale, Science Applications International Corporation

CART Case Studies Progress Report, Jeffrey A. Doyal, Science Applications International Corporation

HPMI: Integrating Systems Engineering and Human Performance Models, Karen Gery, Science Applications International Corporation

Technology Trade Space Development in Crew-systems Integration for Long-range Strike, Christopher R. Hale, Science Applications International Corporation, Edward Martin and Richard Moss, AFRL/HECI

An Analysis System Relating Individual Human Performance Measures to Overall Mission Effectiveness, Bryan E. Brett, Jeffrey Doyal, Science Applications International Corporation

附錄二

NATIONAL CULTURE, TEAM BEHAVIOR AND ERROR MANAGEMENT IN US AND CHINESE SIMULATED FLIGHTCREWS

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Human error is responsible for most aircraft accidents. Many of these errors can be traced to ineffective flightcrew team behavior. Culture influences team behaviors, attitudes toward teamwork and error detection and management. We describe a research study that discovered cultural differences in team behaviors and error management using Chinese and American participants. We discuss the implications of cultural differences for flightcrew performance, crew resource management and aviation safety.

Introduction

Human error causes over 70% of aircraft accidents (Helmreich & Foushee, 1993). Team communication and team coordination are the primary causes of human error in aircraft accidents (Helmreich & Foushee, 1993). Improvements in team performance enhance flight safety by reducing human error.

Crew resource management (CRM) is defined as "using all available resources—information, equipment, and people—to achieve safe and efficient flight operations" (Lauber, 1984). It includes training in group dynamics, leadership, communication, and decision-making (Helmreich & Merritt, 1998). The purpose of CRM is to enhance teamwork behaviors of flying and nonflying pilots. Helmreich, Wilhelm, Gregorich, and Chidester (1990) report that CRM training increases the percentage of crews with above average ratings in performance and decreases the percentage of crews with below average ratings. CRM increases airline safety and efficiency and is accepted and valued throughout most of the aviation community (Helmreich & Merritt, 1998).

The model of CRM developed and demonstrated to be effective in the United States may not generalize successfully to other, especially nonwestern, cultures (Davis & Kuang, 2000). Cultural differences related to teamwork are the chief reason for this uncertain generalizability.

Culture affects many aspects of teamwork (Granrose & Oskamp, 1997), especially communication (Orasanu, Fischer & Davison, 1997), leadership (Dorfman, in press), decision-making (Ilgen, LePine, & Hollenbeck, 1997), influence processes (House, Wright, & Aditya, 1997), and role relationships (Earley & Gibson, 2002). National culture may be more influential in temporary teams, such as flightcrews, than in collocated teams, although this impact may be moderated by organizational and professional culture (Davis & Bryant, in press; Helmreich & Merritt, 1998).

Teamwork mediates the relationship between culture and the likelihood of aviation accidents (Davis & Kuang, 2000). Culture and teamwork may also exert an influence on other mediating characteristics, such as error management, that then influence the likelihood of aircraft accidents (Helmreich, Wilhelm, Klinect, & Merritt, 2001).

Culture may be operationalized in different ways. Measurement of cultural values is one of the most common methods used to operationalize culture (Smith & Schwartz, 1997). Collectivism, power distance and uncertainty avoidance—commonly studied cultural values—have been shown to influence cockpit communication and decision-making (Redding & Ogilvie, 1984). These values are also related to pilots' attitudes concerning CRM characteristics, such as independence, command, preferences for automation, and rules—attitudes that may influence flightcrew performance and the probability of aviation accidents (Helmreich, Foushee, Benson, & Russini, 1986; Helmreich & Merritt, 1998).

Cultural values also affect attitudes toward flightcrew performance (Merritt & Helmreich, 1996). For example, crews from Asian nations tend to emphasize group solidarity and harmony (collectivism) and differences in authority (high power distance). Crews from the US emphasize individualism and egalitarianism (low power distance) (Davis & Kuang, 2000). Cultural values may also impact flightcrew performance through their influence on personality traits and cognitive processes. Culture shapes development of personality traits, such as locus of control, which is influenced as well by occupational status and gender, factors that are also important in the cockpit (Smith, Dugan, & Trompenaars, 1997). Cultural differences influence cognitive processes, such as how individuals perceive, encode, store, and process information (Matsumoto, 2000), as well as cognitive style, such as field dependence (Triandis, 1997). Finally, culture affects nature and frequency of teamwork behaviors, such as communication and feedback as well as frequency of errors (Davis & Kuang, 2000).

There is ample evidence to show that national culture influences team behaviors that are essential to effective flightcrew performance and aviation safety. Team behaviors are related to team performance, error management and flight outcomes. The research we report here examines the influence of national culture on flightcrew team behaviors and error management.

Method

Participants

One hundred ninety-six Chinese and American graduate and undergraduate students participated in this study. Only males were used because too few female Chinese students were available. The average age was 26.39 years. Virtually all participants (184) reported having previous team experience. Only twenty-eight participants reported having previous simulator experience. Twenty-seven participants reported having previous or current military experience.

American participants were significantly younger (mean American age = 24.94, mean Chinese age = 27.87) and reported having significantly more experience with personal computer-based simulations (22 Americans, 6 Chinese).

Design and Procedure

Subjects were paired in a same culture condition and a mixed culture condition, for a total of one hundred fifty, two-person teams operating as flightcrews. There were three experimental groups in total—same culture American teams, same culture Chinese teams and mixed culture Chinese-American teams. The flying pilot role was counterbalanced in mixed culture teams. Culture, as represented by national origin, was the independent variable in our design. Team behaviors and error management behaviors served as dependent variables. Their measurement is described below.

Prior to training, participants completed measures of demographic, personality and cultural characteristics. Upon completion of these measures, participants were trained to fly a Cessna 182S using Microsoft Flight Simulator 2000 Professional. Training focused on take-off, landing, simple navigation using GPS, use of a flight computer to calculate fuel levels, flying in bad weather, ATC communications, and flying and nonflying pilot roles and responsibilities. Participants typically completed training within eight hours. Participants who successfully passed the Microsoft Flight Simulator 2000 proficiency check ride moved to the experimental phase of the study.

Each pair of subjects flew two scenarios created for this study. Each scenario contained anomalies that required participants to demonstrate team behaviors. The first scenario contained adverse weather conditions; the second scenario presented low fuel and conflicting directions. Subjects were randomly assigned the role of pilot in one scenario and the role of copilot in the other scenario. Each scenario lasted approximately 45 minutes. Teams were videotaped while flying these scenarios. After the team completed its scenario, team members individually completed measures of situational awareness, shared mental model and cognitive workload.

Measures

We reviewed videotapes for presence of the following team behaviors taken from Davis (1999): assertiveness, decision-making, monitoring, feedback, backup, coordination, situational awareness, leadership, and communication. We also coded the presence of the following errors taken from Helmreich, Klinect and Wilhelm (1999) and Klinect, Wilhelm and Helmreich (1999): noncompliance, communication, proficiency, and operational.

Raters were trained to interpret team behaviors similarly. Two trained observers independently scored six tapes to determine inter-rater reliability. Correlations ranged from 0.42 for

Feedback to 0.99 for Monitoring. The average inter-rater reliability across all teamwork ratings was 0.88.

Results

We report here preliminary results from our analysis of the data. We focus on simple cultural differences in teamwork and error management.

We found cultural differences in team behaviors. American teams had significantly higher situational awareness than Chinese teams or mixed culture teams. American teams displayed more decision-making than Chinese teams and mixed culture teams. Same culture teams (American and Chinese teams) communicated more frequently than mixed culture teams. Coordination of team members was higher in American teams than in Chinese or mixed culture teams. Finally, American teams committed fewer communication errors than Chinese or mixed culture teams. There were no significant differences in other team behaviors. Significant differences between experimental groups are summarized in Table 1.

Table 1

Summary of Cultural Effects on Team Behaviors

Team Behavior	Finding
Situational Awareness	American teams had higher situational awareness
Decision-making	American teams made more decisions
Communication	Same culture teams communicated more frequently
Coordination	American teams displayed more coordination
Communication Errors	American teams had fewer communication errors

Discussion

Results from this study demonstrate that national culture influences teamwork in simulated flightcrews. In contrast to previous research, which has relied on use of survey research designs, we used an experimental design to manipulate culture and look at its effects. Our results are consistent with other research studies that have employed different research methods: culture influences team performance and error management (e.g. Helmreich & Merritt, 1996; Helmreich et al, 2001).

Our results also demonstrate that same culture and mixed culture teams perform differently. Same culture crews performed better teamwork and communicated more frequently than mixed culture teams. American teams made more decisions, displayed more team coordination, and had fewer communication errors than Chinese or mixed culture teams. Differences in cultural values such as power distance among Americans and Chinese may explain these findings. It is also possible that Americans, due to their greater experience with simulations, may have had an advantage over their Chinese counterparts.

Our manipulation of culture was crude. We cannot, at this time, explain the manner in which national culture influences teamwork and error management. For example, cultural differences may generate perceptions of differences in ability to verbally express and receive information, which may reduce communication in mixed culture teams. That is, one may fear misunderstanding or being misunderstood by a member of another culture and, as a result, communicate less frequently. Cultural differences in communication may also be due to explicitness: Chinese are more implicit in their communication, whereas Americans are more explicit (Gao, Ting-Toomey, & Gudykunst, 1996). The finding that American teams were higher in situational awareness may indicate cultural differences in the way Americans and Chinese attend to and perceive their environments. Cultural differences in environmental perceptions are widespread (Berry, Poortinga, Segall, & Dasen, 1992). Differences in decision-making and coordination may result from differences in cultural values such collectivism and power distance.

The purpose of this study was to examine cultural differences in team behaviors. We used national identity to represent culture. This procedure is commonly used in cross-cultural research (van de Vijver & Leung, 1997). Nevertheless, we recognize that national identity and culture are not synonymous; cultural differences may exist within national identity. We have also collected data on nearly forty cultural and other individual characteristics. In future analyses, we will use these measures to tease out the manner in which culture exerts its influence on simulated flightcrews. These analyses will allow us to describe more clearly fully the precise role that culture plays in shaping teamwork, error management and flight outcomes.

In sum, teams in our study demonstrated different levels of team behaviors. Teams that were able to display effective team behaviors had fewer errors. These differences varied with the cultural makeup of the experimental groups. We believe these findings provide encouragement for further examination of cultural differences in flightcrew performance.

Practical constraints forced us to use students as participants in our research. We do not know the extent to which the same results would be obtained with professional flightcrews flying high fidelity simulators or real aircraft. This is a ripe subject for future research and deserves attention.

Acknowledgements

This research was supported by a grant from NASA-Langley Research Center (NAG-1-2303). We have benefited from the contributions of Paul Schutte, Kari Strobel and Katherine Selgrade.

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附錄三

IS AN ENGLISH OR CHINESE LANGUAGE INTERFACE BETTER FOR CHINESE SPEAKING PILOTS?

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In developing a pilot-centered interface for autoflight systems based on air traffic control syntax (see Riley, DeMers, Misiak, and Shackleton, 2002), we confronted the question of whether an anglo-centric interface would be usable by pilots from other cultures. To address this, we performed an experiment to see how Chinese speaking pilots would understand and process air traffic control clearances. We gave the clearances in English and Chinese, and asked the pilots to sort elements of the clearance into sensible statements in English and Chinese. The intent was to reproduce the thought process they would go through in interaction with an autoflight system interface that requires them to enter in clearance elements that are contained in the clearance. The results show that the Chinese language interface produces the shortest response times regardless of whether the clearance is given in English or Chinese. However, any translation introduced errors; therefore, even though the combination of an English language clearance and a Chinese language interface produced a faster response than an English language clearance with an English language interface, the latter produced fewer errors. Differences were also found in how Chinese and English speaking pilots represented clearances to themselves in shorthand form and in what parts of the clearance each chose to represent. Finally, we found that Chinese speaking pilots preferred English language interfaces, even though they produced more errors when the clearance was given in Chinese and longer overall response times. These preferences were due largely to the desire to improve English language skills and to operate effectively outside of Chinese domestic airspace.

Introduction

Commercial air traffic is rapidly increasing around the globe. English is the official language of commercial aviation. But for non-English pilots, language is probably one of the most fundamental sources of problems on the flight deck. Honeywell designed a Cockpit Control Language, which is a user interface metaphor that integrates a variety of flight deck functions into a consistent framework based on what pilots already know about flying. When we applied the concept to flight path management and developed a pilot-centered interface for autoflight systems based on air traffic control syntax, we confronted the question of whether an anglo-centric interface would be usable by pilots from other cultures. One of the basic questions for non-English speakers is: if the clearance is given in English, do they try to mentally translate it into their own language in order to understand it conceptually? Or would it be easier for non-English pilots to enter the clearance into the Flight Management System (FMS) in the order they hear them in the clearance, and can they understand it conceptually without having to linguistically translate it? And if the clearances were given in a mixture of English and native languages, would an English language interface be easier overall because it supports direct entry in the unfamiliar language, reducing the translation requirement? Or would a native language interface be better because they have to understand the intent of the clearance conceptually, and they program the system based on their intent rather than on the clearance?

To address this, we performed an experiment to see how Chinese speaking pilots would understand and process air traffic control clearances. We gave the clearances in English and Chinese, and asked the pilots to sort elements of the clearance into sensible statements in English and Chinese. The intent was to reproduce the thought process they would go through in interacting with an autoflight system interface that requires them to enter in clearance elements as they are contained in the clearance.

Card Sorting Experiment

The purpose of the Card Sorting Experiment was to determine how Chinese speaking pilots would understand and process air traffic control clearances. The four distinct interaction possibilities between the flight deck and Air Traffic Control (ATC) were contrasted. Linguistically, there are clearances given in English with an English language interface, English clearances with non-English interface, non-English clearances with English interface, and non-English clearances with non-English interface. The clearances were given by audio recordings in English and Chinese, and the pilots were asked to sort elements of the clearances into sensible statements in English and Chinese.

Method

Participants

The subjects for this study were 20 Chinese pilots from three Chinese airlines: Air China, China Eastern and Xinhua Airline. The range of their Pilot In Command (PIC) time was from 182 hours to 9500 hours. Among the twenty pilots, three were captains, eleven were flight officers, and six were student pilots. The range of ages was between 26 and 34 years old. The base city of 13 participants was Beijing. The base city of the remaining seven pilots was Shanghai. Participation was voluntary and a gift was given to each subject for his participation in the study.

Apparatus

The experiment program was written in Perl V5.6.1. A Dell Latitude C600 Laptop with a fourteen-inch screen was used to conduct this experiment.

Procedure

The experiment extended over a forty-minute period. Participants received both written and oral instructions describing the simulation and the tasks. In the experimental session, the participants completed four blocks of trials (one for each combination the flight deck interface and ATC clearances). The four blocks were randomly balanced within participants. There were five trials in every block. The experiment was preceded by a practice session of three trials. The pilots were told that they should perform the task as they would during the flying. The pilots were asked to listen to the clearances which were played by the Windows Media Player on a laptop and order the clearance items which were displayed on the screen according to their understanding. The study was conducted in quiet rooms at Air China Airlines Building at Beijing International Airport, Xinhua Airlines Building, Beijing and China Eastern Airlines Building, Shang Hai.

The clearances were recorded using the Windows Sound Recorder. The clearances in English were read by a native male English speaker and the clearances in Chinese were read by a native male Chinese speaker. The clearance items were displayed vertically in a random order in either English or Chinese (see Figure 1). Items in the clearances were presented out of order to prevent participants from performing the task as an English listening test in which they would merely order the items according to their memory for how they heard the clearance read to them. There were twenty clearances in the experiment. All of the clearances were selected from "Radiotelephony Communication Course, English for Flight Crew" (Wu Tuxing, 1996). _For example, in the English language card shown in Figure 1, the clearance is, "Climb and maintain FL 170, cross Bao Ding at or above FL 130." The subject is asked to click on the card items to put them in the correct order for the language of the card.

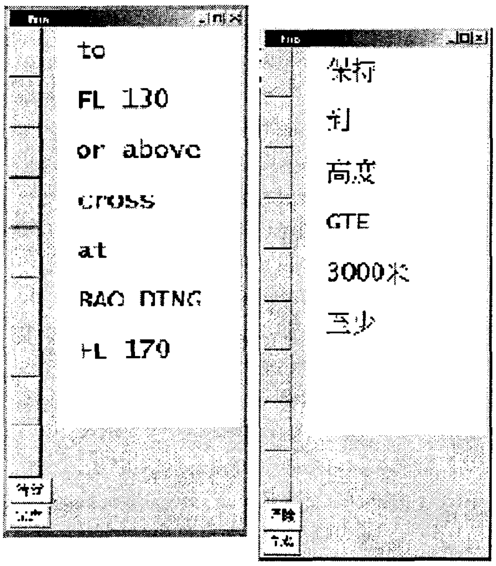


Figure 1. The display of the clearance items; subjects put the items in the proper order for the clearance by clicking on the items in that order

Design

Table 1 displays the experimental design used in this experiment. A within-subjects design was used. The independent variable was the linguistic interaction mode between the flight deck and ATC. The four modes tested were English Clearance -- English Items (EE), English Clearance -- Chinese Items (EC), Chinese Clearance - English Items (CE), and Chinese Clearance--English Items (CE). The dependent measures were task completion time and error rate.

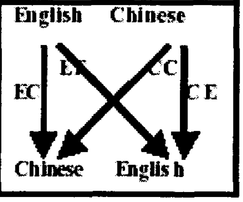
Experimental Conditions	The languages used by ATC (clearance)
The languages used in the cockpit	

Table 1. The four distinct interaction possibilities between the cockpit and Air Traffic Control.

Results

The data were examined to determine the effect of different linguistic interaction modes between the flight deck and ATC. Data analyses were conducted through ANOVA and a series of t-tests to determine whether relevant conditions differed from each other in task completion time and error rate measures.

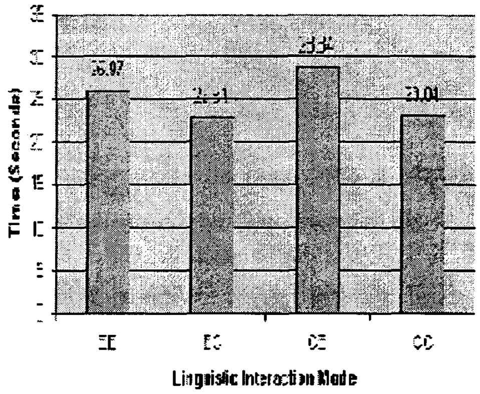


Figure 2. Task complete times under different linguistic interaction modes between the clearance and the card items.

For task time, outliers (data points +/- 2 standard deviations from the mean) were removed, resulting in the elimination of approximately 6.7% of the data points. The main effect of task time of the independent variable - the linguistic interaction mode between the flight deck and ATC, was significant, F (3, 19) = 4.06, p = 0.011. To test the significance of the difference of task time between every two modes, a series of t – tests were conducted. When comparing the English Clearances – Chinese Items (EC) with the Chinese Clearances – English Items (CE), we found a significant (5.93 sec) increase in task time for the CE condition (t(19) = 2.80, p = 0.011). Pilots took almost 6 seconds longer to complete the task when they heard the clearance in Chinese and had to work with an English word list than hearing the clearance in English and working with a Chinese word list. When comparing the Chinese Clearance – Chinese Items (CC) with the Chinese Clearance – English Items (CE) condition, there was a significant difference found in task time (5.8 sec) (t(19) = 2.99, p = 0.008). Pilots were 5.8 seconds faster at completing the task when they did not have to change linguistic modes (Chinese to Chinese) as compared to when they heard the clearance in Chinese and needed to translate it into English. (Note that Chinese-English is the current mode of operation while flying in mainland China). For the error rate, Chinese pilots made the fewest errors on the CC mode, then EE mode, EC mode, and the most errors on the CE mode. Not surprisingly, fewer errors are made when the clearance does not have to be translated into another language in order to complete the task. However, the main effect of the linguistic interaction mode between the flight deck and ATC on error rate didn't reach statistical significance (F(3)=0.081).

Figure 2 indicates that Chinese pilots had the shortest task completion time under the English Clearance – Chinese Items (EC) mode. Under the Chinese Clearance – English Items (CE) mode, pilots took the longest time to finish the task. It is noteworthy to mention that the CE mode is the current circumstance in China — the language used by most Chinese pilots and Air Traffic Controllers is Chinese and the displays on the flight deck are English. Statistically, the results show that under the Chinese language interface conditions, the task times were shorter regardless whether the clearance was given in English or Chinese.

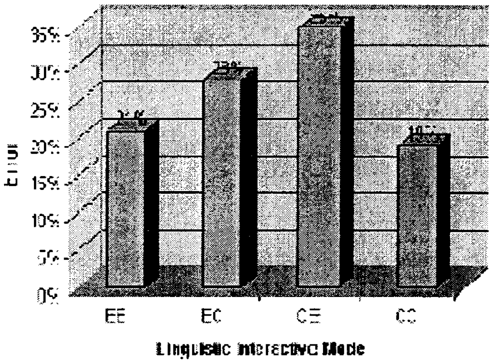


Figure 3. Error rate under different linguistic interaction modes between the clearance and the card items.

Discussion

From the results of the experiment, it appears that a Chinese interface would be preferable. However, the Chinese interface was not advocated by Chinese pilots. In a debriefing interview conducted after the experiment, the pilots said that they didn't prefer the Chinese interface. Four reasons were given to explain their preference for English interface: 1) English is not a big deal for young pilots who are gradually taking more active and important roles in airline companies 2) new CAAC (Civil Aviation Administration of China) mandate requires the use of English to conduct air traffic control in 2003. It is noteworthy to mention that most all ATC voice traffic is conducted in English throughout the world. However, this is not the case in China, a country where non-Chinese airlines can not fly. Most Chinese pilots speak Chinese with air traffic controllers when they fly in China. In 1996, the CAAC instituted a requirement for English use by Chinese controllers and pilots. However, many of the more experienced (i.e., older) Chinese pilots, who are the main power at airline companies, have difficulty with English, so the requirement has not been strictly enforced. Now there are more and more young pilots joining the airlines. Through training, the younger generation pilots tend to have a good understanding of the English language. Nevertheless, it's natural to speak the native language with the same native language people. With the CAAC's requirement, the pilots who were interviewed believe that English will replace Chinese in air traffic control in China in the future. 3) International development trends: the pilots think that English is an emerging international standard and the Chinese interface deters them from learning English; 4) When aircraft operate outside of China, the Chinese interface will cause problems if the aircraft needs be examined and repaired. There is also the problem that if the aircraft is flown outside of China, the pilot will again have the problem of having to translate the clearances from English into Chinese.

We also looked at differences between how Chinese and English speaking pilots represented clearances in their own shorthand when copying down the clearance. Differences were found in what parts of the clearance each chose to represent. Chinese pilots' notes would include the flight number, airspeed, heading, and altitude of a clearance in the shorthand form. English speaking pilots typically omitted the flight number.

In conclusion, the Chinese language interface produced the shortest response times regardless of whether the clearance was given in English or Chinese. However, the Chinese speaking pilots preferred English language interfaces, even though they produced more errors when clearances were given in Chinese and resulted in longer response times overall. These preferences were due largely to the desire to improve English language skills and to operate effectively outside of domestic airspace.

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附錄四

APPLYING THE THREAT AND ERROR MANAGEMENT MODEL TO AN AVIATION SAFETY ACTION PROGRAM

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This paper describes the work that has been completed in the last 18 months on the development of a data collection process and analytic framework that can be applied to information collected through an Aviation Safety Action Program (ASAP). The project consisted of a systematic review of a new ASAP program being run by a major commercial airline and the development of a set of data collection tools to be used to categorize and archive ASAP data. These tools were developed based on the theory and taxonomies derived from the University of Texas Threat and Error Management Model. This paper describes a critique of the ASAP data collection process that was being used by the airline, and the data collection tools and analytic strategies that were developed through the application of the Threat and Error Management Model.

Review of an Aviation Safety Action Program

At the request of a major commercial airline we completed a review of their ASAP data collection and event review process. This review included an analysis of the current data collection process, monthly reviews of the pilot submitted ASAP reports, and the data archiving and analysis procedures used to support the program. This paper outlines the information gathered from this review, and describes an alternative method for handling ASAP data, including a review of the theoretical basis for applying the Threat and Error Management Model to an ASAP and the tools that were developed to support data collection and analysis procedures. The statistics reported in the paper include pilot submitted ASAP reports collected beginning January 2002 at a major commercial airline.

Objectives of ASAP

The Aviation Safety Action Program is a voluntary, non-jeopardy reporting program developed through a joint agreement between the FAA, the Airline Pilots Association (ALPA) and the participating commercial airline. Through this program pilots are encouraged to submit reports of safety events, including reports of Federal Aviation Regulation violations. These reports are then reviewed by a committee consisting of representatives from ALPA, the FAA and the airline. It is the task of this group to determine appropriate corrective action in response to the reported event.

There are two main objectives of an ASAP. These objectives are supported not only by the airline we reviewed but describe the basic goals outlined in the FAA memorandum of understanding which must be agreed to by all carriers who begin an ASAP (Federal Aviation Administration, 2002).

1) Collect voluntarily reported safety information that would not have been known through conventional means and provide protection to the reporter.
2) Use this information to develop corrective actions to reduce the potential for reoccurrence of accidents, incidents or safety-related problems.

The first objective; to collect voluntary reports and provide protection to the reporter, was observed to be upheld by the program we reviewed. Currently this program receives between 1 to 3 reports per day. This rate was slightly higher before the events of September 11th at which point the report rate dropped off slightly, but has since returned to the previously retained rate.

A review of the types of reports that were being submitted demonstrated that 88% of the reports described events that were not known by the FAA or airline management. The submission of these types of reports, commonly referred to as sole source, suggests that the program has established a level of trust with the pilot community. This statistic also demonstrates the unique perspective ASAP data may bring to a fairly comprehensive safety industry.

ASAP Data

Based on our review there are two main sources of ASAP information, one source is the report submitted directly from the pilot, 85% of all reported events included both a Captain and a First Officer report. The other source of information is derived from the FAA, ALPA and airline committee members who are tasked with reviewing reports. This group is commonly referred to as the Event Review Committee (ERC). As part of the FAA Memorandum of Understanding these three representatives are required to meet on a regular basis to review reports and develop corrective action recommendations to address the reported problem. Typically these recommendations are directed toward the reporting pilot(s) and any other external group involved in the event. Other sources of incoming information may include documents from other groups involved, including ATC tapes, maintenance reports, and airport charts.

Narrative based ASAP model

An overview of the types of pilot reports used by most ASAPs (there are currently 13 airlines that have submitted proposals to the FAA to start an ASAP) demonstrated that the most common way for a pilot to submit an ASAP report is a narrative based model. Based on our review of the participating airline, this type of report contains a large section for pilots to complete a written description of the event. These types of forms also have limited number of categorizations used for labeling the type of event and currently a small number of carriers are attempting to expand the form to include error categorizations. The range of information contained in the narratives varies greatly from pilot to pilot and one option used to attain completeness of these reports is a pilot interview. According to our review, 15% of the pilots submitting reports were interviewed for more complete information. Information gathered by the interview was normally verbally reported to the ERC when the event was reviewed at the monthly meeting. This information was not documented or archived in a database with the original reports.

The Event Review Committee

It is the job of the ERC members to read the pilot's narrative and any other acquired information and deduce the relevant information needed to make a formal recommendation of corrective action. From our review the main pieces of information that the ERC derives from the report were identified as the following: 1) Whether or not the report is appropriate for acceptance in to the program, 2) What type of event occurred, 3) What the crew did wrong, and 4) What actions were recommended to keep the crew from making the mistake again.

The FAA memorandum of understanding states that ERC must decide as a group if the report should be submitted into the program. If there is agreement from all three members then the pilots are granted protection against FAA corrective action based on their completing of any recommended actions resulting from the ERC's review of the event. If the ERC members can not come to a joint agreement on corrective actions then the report will not be accepted into the program and the pilots are informed of the decision.

From our review the following tasks were completed by the ERC following the submission of a report into the program. The ERC members determine what type of corrective action to recommend based primarily on the pilot's narrative. The ASAP manager completes a basic labeling of type of report so that narratives can be sorted into smaller groups. Selected reports, along with corrective action recommendations, are then sent to relevant departments to be re-read and re-evaluated by department or fleet managers. Following the closure of the report a limited amount of information stemming from the ERC's review of the event is entered into a database with the pilots report.

ERC Corrective Action Recommendations

From our review it was found that corrective action recommendations were less punitive in nature than what may have occurred if the pilot had not submitted the report to the ERC. Corrective action recommendations ranged in level of severity from a template letter thanking the pilot for reporting the event to the most punitive action of pilot dismissal based on the pilot's inability to be trained to proficiency. Other types of corrective actions included having pilots write a summary of their experience regarding the event for a quarterly publication of ASAP events, to the more severe action of placing a letter of correction in the pilot's record.

Deficiencies of Narrative Based ASAP Data Collection Programs

The primary deficiency we observed with the use of a narrative based ASAP data collection program is that critical information that would be needed to keep the event from reoccurring was not identified or retained in the database. Instead there was a narrowed focus by the ERC to develop corrective actions based on the report they were currently reviewing. The narrative based data collection process appeared to make it difficult for the ERC to identify and categorize causal information contained within the reports, and instead made them focus on developing actions to handle the individual pilots who had submitted the report. Our conclusion upon finishing the review of the program was that due to the amount of work needed to review each written narrative and due to a lack of categorization of causal factors either by the pilots or the ERC members, the program was not proactive in addressing causal issues. Instead, the program had taken a reactionary approach to handling one pilot at a time and one error at a time.

Recommendations

Upon completing the program review, our objective for this project was to develop a set of tools that would help the airline to be more efficient in using ASAP data to make corrective action decisions that focused on decreasing the impact of causal factors. The next section of this paper will describe the data collection tools we developed and the use of the Threat and Error Management model as the theoretical basis for the development of these tools.

The Threat and Error Management (TEM) model is both a theoretical model depicting the relationship between factors that contribute to the occurrence of events as well as a working model that can be used to categorize these factors. The theoretical model is used to test hypotheses of relationships between threats, errors, and how pilots manage these issues. Threat and Error Management when applied as a working model, can be used to categorize factors contributing to a wide range of safety events, from normal operations to accident investigations (ICAO, 2002). This is not a model based purely on assessing pilot error but focuses on a wider spectrum of factors that contribute to mistakes and how pilots manage unpredicted, non standard situations.

With the two objectives of ASAP in mind, we have developed a set of standardized tools that can be applied to an ASAP data collection and ERC review process. This application of the Threat and Error Management model enables ASAP data to be categorized, identified and analyzed for key factors that cause events and how pilots manage or mismanage these events.

Why the Threat and Error Management Model can be applied to ASAP

The Threat and Error Management model and its supporting taxonomies can be applied to the collection of ASAP data because the model was developed through the collection of observations made from the cockpit during normal line operations, and this is the same environment that pilots are describing when completing an ASAP report. Formally referred to as line operation safety audits (LOSA), these observations are completed by trained line pilots who observe crews from the jump seat under voluntary agreement by all parties involved. The Threat and Error Management model and its supporting taxonomies have been empirically derived from the information gathered by these observations. The methodology used to develop the model is considered empirically based because it was not developed through simulator assessments or from a cognitive modeling approach, commonly used in human factor error research, but through the collection and analysis of pilot-derived terminology and pilot-identified issues. Through the use of pilot experts, identification of the formal and informal process that crews use to manage various types of distractions from external sources to crew errors has been completed. As a result the database supporting the development of the model is composed of both superior and inferior crew performance that pilots use to counteract adverse situations. From this database of over 3000 flight segments we have developed a set of taxonomies of pilot observed/pilot labeled errors, threats and countermeasures.

The ASAP Threat and Error Management Model

The Threat and Error Management Model as it applies to ASAP can be divided into 2 separate parts. The model starts with a categorization of the type of event that occurred and the associated crew errors and threats that contributed to the occurrence of the event. Threats are defined as any issue that takes the crew out of the normal work load and must be managed. These categorizations of type of event, threats and errors are completed by the crew reporting the event. The second part of the model includes an assessment of the severity of the event and a categorization of how each error and threat were managed by the crew. This section of the model includes a categorization of pilot performance markers. Performance markers are defined as skills assigned to pilot's management or mismanagement of threats and errors. These are not crew committed errors but crew factors that can be used to describe how the crew managed or mismanaged the event. The last component of the model is the corrective action recommendation. See Figure 1.

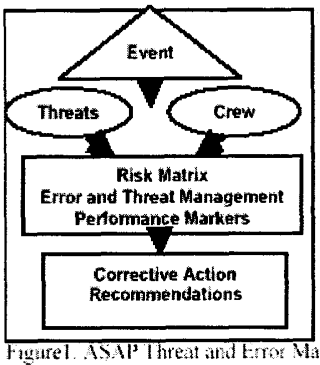

Figure1. ASAP Threat and Error Management Model

ASAP data collection tools

The tools we have developed enable the pilot and the ERC to quickly categorize the information outlined in the model so that it can be archived for future reference and analysis. There are two main reporting forms used to collect ASAP data, the pilot report and the ERC incident review.

Pilot Reporting Form. The ASAP pilot reporting form prompts pilots to categorize the event outcome, any threats contributing to the event and crew errors. Event demographics and an event narrative are also reported by pilots. Each section of the pilot reporting form contains lists of varying types of events, errors and threats that the pilot can choose as factors describing the reported event. As previously mentioned these taxonomies were derived from observations conducted in the cockpit during normal line operations and the terminology that pilot observers used to label these factors has been retained and is easily recognizable to pilots completing the form.

ERC Incident Review Form. The main objectives of the ERC incident review form are to assess severity of the event, proficiency level of the crew and make recommendations for reducing the likelihood of the reoccurrence of the event. The ERC is privy to a different set of information then the crew, in that they can evaluate both crew members report of the event, and they can interview external groups as well as crew members. The ERC incident review form is divided into three parts: 1) a risk matrix, 2) an assessment of performance markers to evaluate the crew's management of the event and 3) corrective action recommendations. The information submitted by the ERC is used to assess the crew's accuracy of reporting the event, their proficiency in managing the threats and errors contributing to the event, and recommended actions to correct these issues. The ERC incident review form serves several purposes; it gives the members a manner by which to organize information contained within the pilot report, it enables them to identify and categorize contributing factors directly relating to the event, and it allows information from each member to be archived into a database for future use. See Figure 2 for a flow chart of ASAP data by the Pilot Reporting Form and ERC Incident Review Form.

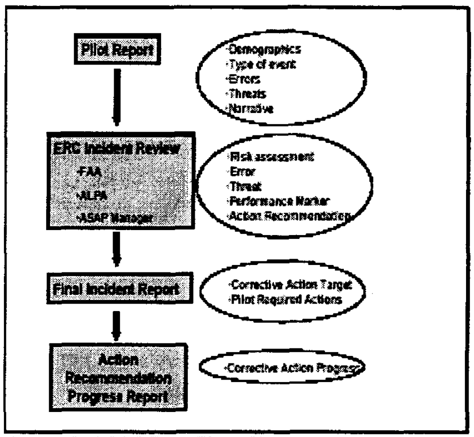

Figure 2. ASAP Data Flow Chart.

Utility of the ASAP Threat and Error Management Database

The tools we have developed provide a systematic framework that can used to collect, categorize and analyze incoming data. By using the Threat and Error Management model and supporting taxonomies derived from normal line operations we developed a set of tools that enable both the pilot and the ERC to identify critical factors contributing to the occurrence of events. A database containing these categorizations can be easily used to answer a wide range of questions.

Trend analyses. The utility of The Threat and Error Model extends beyond the ability to calculate frequencies of event descriptors. Due to the input of both pilots and the ERC members, a database based on the Threat and Error Management taxonomies contains information about the connections between threats and errors, including how the crew responded, what the outcome of the response was, and what specific skills or lack of skills the crews used to address the event. Analysis assessing trends between these variables and across time enables the identification of critical contributing factors. This information can then be used to aid the ERC or any other interested group in making corrective action decisions.

Identification of system factors. The key to the model and set of tools we have developed is that it allows ASAP managers as well as other interested parties to proactively make corrective actions based on the demonstrated relationships contained within the database. Identification of the error that the crew made is not the sole focus of the program; instead errors are used as indicators of contributing system factors. In this way crew errors do not become the focus point of the ERC review process but can be used as a starting point for the ERC to develop corrective actions that focus on developing solutions to system problems. This process can be easily completed by looking at other factors associated with this error, including how the error was managed and what threats contributed to the error. The result of this type of analysis process enables identification of causal factors existing in the system. Targeting these factors for corrective action will help ensure that the next crew encountering a similar situation will not be as likely to make the same error. The value of this type of intervention is that Safety departments, ASAP managers , and ERC members can be more effective in proactively addressing problems rather than focusing on correcting problems one crew at a time.

Using the database to make corrective actions. By using a database to derive correct action recommendations the reliability of the program does not become dependent on individual ERC members opinions or what can be immediately addressed by the ERC. Instead the ERC can make corrective action recommendations using a range of categorizations, including risk factor ratings, pilot management assessments, crew performance markers, threats, errors and type of event categorizations. They can also review previous reports with similar contributing factors and make recommendations that match those previously made. This function lends to both the internal stability of the database and the external credibility of the program.

Conclusion

The development of ASAP as an industry safety initiative was based on premise that pilots are privy to a large amount of information that is not discoverable by other regulatory means. And, based on the growing number of new programs being started (as previously mentioned there are at least 13 airlines currently implementing an ASAP), pilots appear to be willing to submit reports detailing this previously unknown information.

From our review we concluded that the current process for collecting and reviewing ASAP data creates a narrowed focus on addressing one report at a time and one individual pilot error at a time. Although this process may keep that single pilot from making a similar mistake in the future it is not addressing larger system problems that contributed to the occurrence of the event and, most importantly, will not help the next pilot who encounters a similar situation.

Although ASAP as a growing safety program holds tremendous potential, airlines developing these programs must be careful that they organize their data collection and analysis process so that the information contained in reports can be used to identify and proactively address critical safety issues. Upon completing our review of an ASAP one question remains. What are the legal ramifications of collecting event reports and not proactively addressing the contributing system problems contained within the reports? Although not within our scope of research, we believe this question should be seriously considered by any airline currently running an ASAP or contemplating the development of a new ASAP. The Threat and Error Model as applied to ASAP data will not tell airlines how to make changes once these critical system problems have been identified but the tools we have developed will suggest to them where to focus their limited resources.

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附件五

SYSTEMATIC ERROR AND RISK ANALYSIS (SERA): A TOOL FOR ACCIDENT AND RISK INVESTIGATION, ANALYSIS AND CLASSIFICATION

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As technology has become increasingly reliable, accidents due to equipment and material failure have become rare. Now days, cause factors are more likely to be attributed to the human elements in the system than to the hardware. Obviously the ability to investigate, classify and track human factors causes of accident and incidents is central to preventing their recurrence or for putting in place traps to stop these 'human errors' from propagating. A tool for human factors accident investigation and classification must provide insight into why a particular pattern of behavior was observed. Generally one is concerned with the behavior that led directly to the accident or incident. Understanding why this pattern of behavior emerged is the key to explaining the human factors issues associated with the occurrence. The Systematic Error and Risk Assessment (SERA) process sets out to do this.

Introduction

A tool for human factors accident investigation and classification must provide insight into why a particular pattern of behavior was observed. Generally one is concerned with the behavior that led directly to the accident or incident. Understanding why this pattern of behavior emerged is the key to explaining the human factors issues associated with the occurrence. Using the theoretical constructs of the Information Processing (IP) and Perceptual Control Theory (PCT) models (Hendy, East, and Farrell, 2001; Hendy and Farrell, 1997; Powers, 1973), the Systematic Error and Risk Analysis (SERA) process sets out to do this.

A system for investigating and classifying the behavioral components of accidents and incidents should be:

Exhaustive — it should capture all the potential points of failure that lead to unsafe acts.

Orthogonal — each point of failure should capture a specific and unique breakdown in the system.

Valid — interventions made as a result of the analysis should reduce the probability that the occurrence of the same set of circumstances will result in the commission of an unsafe act.

The IP/PCT model is used to establish a consistent theoretical framework for linking cause to effect. SERA attempts both to be exhaustive and establish an orthogonal set of failure descriptors from which points of intervention might be proposed. SERA also draws on the influential work of James Reason (Reason, 1990) as manifested in Shappell and Weigmann's (Shappell and Wiegmann, 2000) Human Factors Accident Classification System (HFACS). It is the attempt to establish an orthogonal and exhaustive system, based on the theoretical framework of the IP/PCT model, that distinguishes SERA from HFACS.

The IP/PCT Model

The essence of the IP model is that all factors that impact on cognitive workload can be reduced to their effects on the amount of information to be processed and the amount of time available. Time pressure is defined as proportional to:

(Could not display picture)

which at a constant rate of processing reduces to:

(Could not display picture).

The IP model is about Time and Information processed (knowledge).

It is argued, in Perceptual Control Theory, that humans behave as multi-layer closed loop control systems (see Figure 1). The set points for these control loops are our perceptual goals (how we want to perceive the state of the world). According to PCT we sense the world state, transform that sensation into a perception of that state which we then compare with our goal. If there is a difference between our perceived and desired states, we formulate and implement an action (another transformation process) in order to operate on the world so as to drive the perceived state of the variables of interest towards the goal. The perceptual and decision processes draw on internal knowledge states that transform sensation into perception, and difference into action. Our attentional mechanism shifts our focus from loop to loop to loop. The PCT model is therefore about Goals, Attention, Knowledge and Feedback. The IP model is embedded within the PCT loop and applies

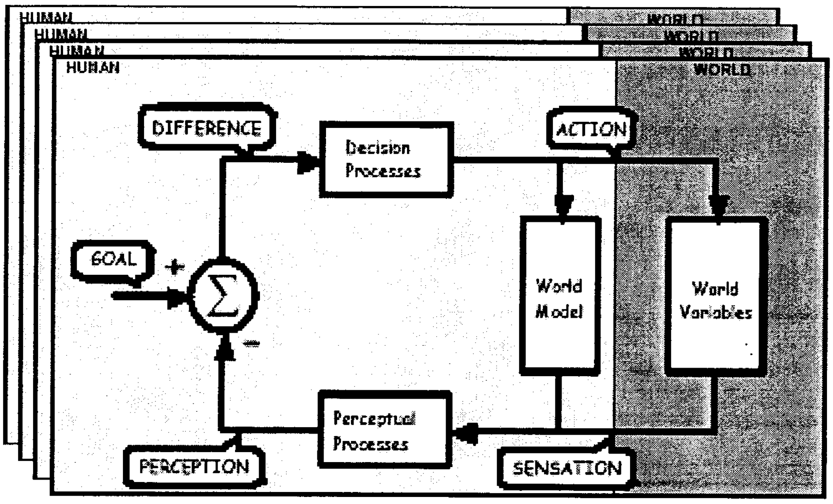


Figure 1. The multi-layered Perceptual Control loop for a human operator interacting with the world.

anywhere where information is being processed.

Systematic Error and Risk Analysis

The starting point for a SERA analysis is the identification of the unsafe act or incident. If there has been an accident or incident there must have been some departure from safe operation at some point in the timeline. Some world state must have gone outside acceptable limits (e.g., clearance from terrain, separation from another aircraft, the installation of the wrong part, the torque on a fastener). An observable unsafe act or unsafe condition will mark this point. A particular unsafe act or unsafe condition is on the accident or incident trajectory, if its removal or modification would have prevented the accident or incident from occurring. The most critical unsafe act or condition is that from which there is only one trajectory…the one that led directly to the accident or incident. Up until that critical act or condition, there are always options, but once the critical decision has been made there is no way back. So now the issue is why did that pattern of behavior emerge?

From PCT one can predict that the answer to the question "…why did they do that?" is generally resolvable once you know: what a person's goal is; how they perceived the world; and how they were trying to achieve the goal. From these three basic questions one can use the structure of the PCT loop of Figure 1, along with the time dependency of the IP model, to trace the potential information processing breakdowns that led to the unsafe act or condition. The decision ladders for tracing these dependencies are shown in Figure 2. The decision ladders of Figure 2 lead to twelve basic types of active failure, as follows.

1. Intent Failure;
2. Attention Failure;
3. Sensory Failure;
4. Knowledge (Perception) Failure;
5. Perception Failure;
6. Communication/Information Failure;
7. Time Management Failure;
8. Knowledge (Decision) Failure;
9. Ability to Respond Failure;
10. Action Selection Failure;
11. Slips, Lapses and Mode Errors;
12. Feedback Failure.

Reason's *Latent Failures Model* provides two points of focus, the active failures themselves and the pre-conditions that make the active failures more likely. The explicit representation of latent or dormant pathogens in the system is perhaps the greatest contribution of Reason's work to error management.

In SERA the four levels of Reason' *Latent Failures Model* are expressed as follows (see Figure 3):

1. **Active failures:** the twelve points of breakdown in the human information processing system.
2. **Pre-conditions:** these are factors that are directly and immediately connected to the unsafe act or

condition. They are defined in terms of:

- the condition of the personnel,
- the condition of the task (time pressure and objectives), and
- the working conditions (equipment, workspace and environment).

The three categories of immediate pre-conditions describe the condition of WHO was involved in the unsafe act, in the service of WHAT task, WHY the task is taking place, and WHERE it is performed (in other words, the environment, including the equipment and workspace; cf. the SHEL model of Edwards, 1988). Time of day (WHEN) effects will be reflected in both the physiological condition of the personnel (e.g., circadian effects) and in the environmental conditions (e.g. ambient light levels).

3. **Organizational influences:** these are remote factors that establish the purpose of the activities to be performed, control the resources, define the climate within which the activities are to be performed, set constraints that bound behavior though procedures, rules and regulations, and provide oversight.
4. **Command, Control and Supervision failures:** these are defined in terms of forming strategic goals, the communication of those goals, and the provision of error correcting feedback. The Command, Control and Supervisory process is the conduit whereby the organizational layer affects the immediate pre-conditions.

Figure 3 retains the basic form of HFACS (Shappell and Wiegmann, 2000) but differs in detail. Within the framework of Figure 3, the activities of the personnel can be traced back to strategic goals, shaped by organizational constraints, that flow from the Mission, down through the Command, Control and Supervisory processes, and emerge as task objectives. Figure 3 is consistent with the PCT view that all human systems are purposeful goal driven systems. Organizational influences determine the factors that constrain this purposeful goal driven system, and shape the goals that are actually serviced as distinct from those that should be pursued in the achievement of the mission objectives (of course in a healthy and effective system these will be identical).

It is intended that SERA is sufficiently complete as a classification system to capture most human factors failures and all reasonable points of intervention. While the active failure layer in SERA is directly traceable to IP/PCT, the pre-conditions shown in Figure 3 are less bounded by theory. The taxonomies investigated by Wiegmann and Shappell (1997) apply only to active failures, which are already comprehensively covered by IP/PCT, and therefore provide no further guidance. HFACS draws obscurely on several descriptive models through its linkage with *The Taxonomy of Unsafe Operations* (Shappell and Wiegmann, 1997), but again there is no clear guidance. Although one might be guided by concepts of hierarchical systems decompositions such as Hierarchical Goal Analysis (see Hendy, Beevis, Lichacz, *et al.*, 2001), the arguments for the remaining layers in Figure 3 are constrained to be somewhat qualitative.

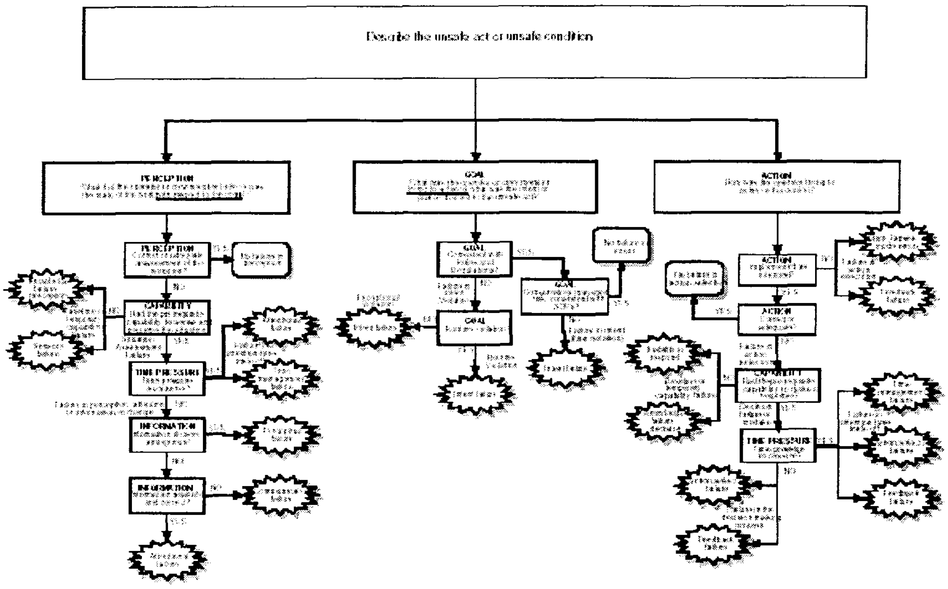
Linking Pre-conditions to Active Failures

With the hierarchical breakdown of Figure 3 it is possible to link each active failure with a set of most likely pre-conditions (e.g., see Hendy, 2003, for a description of this process). Active failures represent 'what happened'...and they can be traced to fundamental limitations in the human sensory, response or information processing systems. These are things that are unlikely to change, they are part of human capabilities and limitations. There is relatively little point in telling a person to attend and be more vigilant in a sustained attention task. What you have to change is the nature of the task, in others words the pre-conditions that set up the scenario for a sustained attention task (e.g., increase the number of events, limit exposure to about 20 minutes at a time, provide other stimuli to increase activation and arousal levels; see also Wickens and Hollands, 1999, p40-43).

The pre-conditions mark the points of intervention for the safety system. Interventions are intended to reduce the probability that the same set of active failures will occur given similar circumstances. The pre-conditions, both immediate and remote, represent 'why' the active failure existed. These are the things that have to change to prevent a recurrence because they define, either directly or indirectly, the condition of the personnel, the task and the working environment.

Discussion

At the start of this paper it was claimed that a tool such as SERA should be exhaustive, orthogonal and valid. The underlying theoretical basis for SERA gives some hope that the 12 active failures are a complete and independent list. The use of the IP/PCT model also gives some face validity to the taxonomy as potential failures at all points of the PCT loop are included. The taxonomy is complete and orthogonal in this sense.



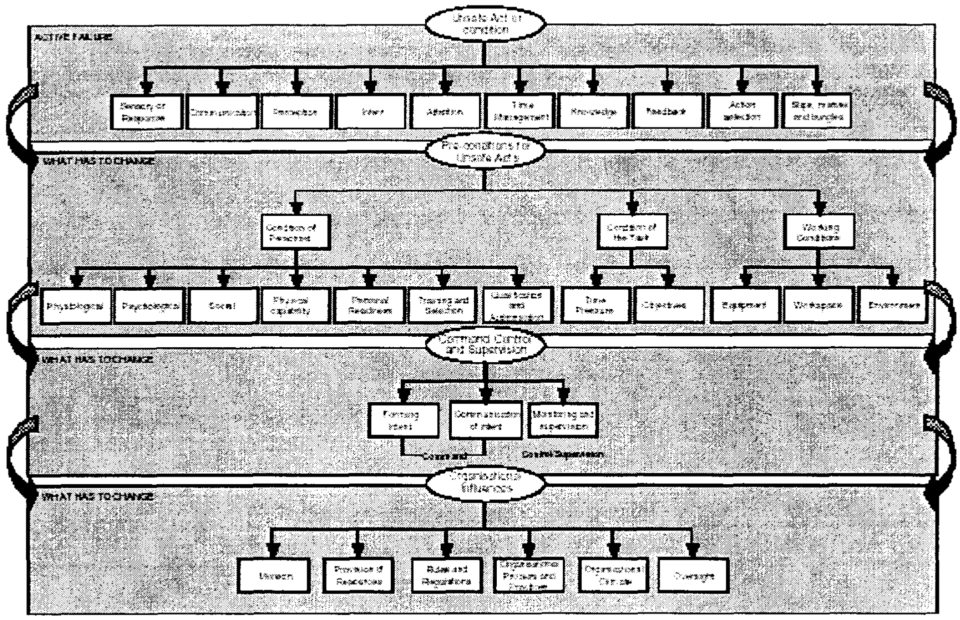


Figure 3. Active failures and three layers of pre-conditions.

However, the issue of predictive validity and reliability is yet to be established. It is intended to start by establishing the test-retest reliability of SERA. It is planned to have a number of investigators apply the tool to the same set of accidents and incidents. Twenty cases have been selected from the NTSB data base for this purpose. Participants from the US, Australia and Canada will be involved through the auspices of The Technical Cooperation Program (TTCP), HUM Group, Technical Panel 7.

The SERA tool has been coded in Java to run on a variety of platforms. Currently SERA runs on Windows® and Macintosh® operating systems. It is being ported to the Windows CE® environment for hand held computing devices to encourage use of SERA in the field. The SERA software guides the analyst through the complete investigation process from the identification of the unsafe act or condition through to the assignment of the pre-conditions that were identified as being present. The SERA framework aids in ensuring that appropriate questions are asked by the investigator (these are the questions one must answer in navigating the decision ladders of Figure 2). Finally SERA assembles all of the information gathered into a first cut at the accident or incident report. The software also includes a mechanism that identifies the HFACS categories that are the closet fit with the SERA classification scheme.

The SERA framework has been extended to provide both tactical and strategic risk analysis tools (reference) based on the observation that the 12 immediate pre-conditions, and the six organizational factors are the factors that must be controlled to reduce the occurrence of unsafe acts and hence mitigate risk (see Hendy, 2003).

Conclusions

This paper has provided a glimpse of a tool for systematically connecting unsafe acts or conditions to breakdowns in the human information processing system and thence to the underlying pre-conditions that caused these acts or conditions to emerge. SERA's reliance on the theoretical models of human information processing distinguishes it from similar efforts to establish error taxonomies for accident and incident investigation.

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