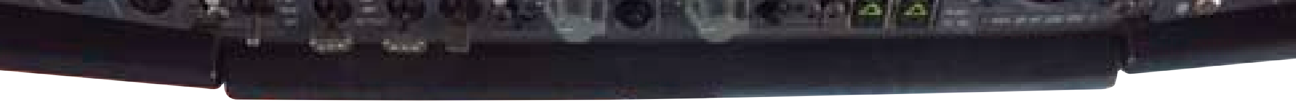

THE CHALLENGE OF THE AUTOMATED FLIGHT DECK

By **Captain Tim Rawlings,** 17 Wing Canadian Forces Air Navigation School

Foreword

The original version of this paper, by Capt Tim Rawlings and (then) Capt Don Barnby, working in Air Force Training and Central Flying School respectively, deserves much of the credit as the catalyst for the Air Force's automation strategy. The Air Division aircraft automation philosophy has now been developed and published, and experienced outside assistance has been engaged and has already started visiting a number selected Wings and units to gain an understanding of our current policies, as well as observe our automation awareness and airmanship. The contractors who have been engaged have done similar work with the United States Marine Corps and United States Coast Guard, and have ensured that those organizations' tactical and operational imperatives have been respected even as they changed themselves to exploit the capabilities of their automated cockpits.

Following the development of appropriate pan-Air Force automation policies and the amendment of our orders, the Air Force's automation strategy will examine type-specific procedures and practices for our specific operations. It is important that the cascading nature of this change strategy be respected to ensure that when new standard operating procedures (SOPs) and checklists are re-published or amended, they reflect and incorporate the overall philosophy and the new orders.

Our Air Force's cascading top-down automation strategy has been described as a world-leading project to synthesize best practices, effective automation procedures, new equipment, an already effective operational culture, and modern crew resource management (CRM). It will involve effort, and it will demand change from all of us; but it will bring us out the other end operating as a safer and more capable Air Force.

Introduction

Automated flight deck technology, on both fixed- and rotary-wing aircraft, has recently been introduced to the Air Force. The training approach and operating philosophies necessary to operate these types of aircraft safely differ from the traditional legacy-pattern aircraft that have until recently dominated the Air Force inventory.

Changing Air Force training and operating practices to incorporate the maximum use of automation within a well-developed set of SOPs that effectively employ automation skill sets and exploit sound CRM practices will not only enhance flight safety, but increase operational effectiveness.

Why Change Is Required

To be sure, the automated flight deck is driving change on many levels. The most obvious and easiest change to witness is how technological advancement has altered the look of the modern flight deck. Gone are the many dial-type trend instruments and electro-mechanical avionics that supplied the pilot with control and performance information. These instruments have been consolidated and integrated into a few flat-panel type computer screens and the information presented to the pilot has increased exponentially. For example, a primary flying display (PFD) can incorporate an artificial horizon, airspeed indicator (ASI), altimeter, heading indicator, turn and slip indicator, vertical speed indicator, angle-of-bank indicator, flight director command bars, a flight-mode annunciator (FMA), as well as approach-track and glide path information for both precision and non-precision approaches. Embedded within the basic information presented on the PFD are all possible warnings, cautions, alerts, and advisories that a pilot will need to know. Examples include traffic alert and collision avoidance system (TCAS) resolution advisories (RAs), wind-shear alerts, radio-altimeter callouts complete with a change in font size below certain altitudes, flight mode changes (for example, to alert the pilot that the altitude capture mode is armed), stall speed depiction, and an up-to-date L/D MAX indicated on the ASI portion of the PFD. It is possible for a PFD-type presentation to have the capability of providing upwards of 250 separate pieces of information to the pilot. To manage and integrate this information in a safe and effective manner within a crew concept in all operational environments, requires training and operational practices to be expanded and re-focussed with emphasis in areas previously unknown (i.e. automation skill set) or poorly understood or employed (i.e. CRM and SOP development).

To date, the Air Force, in conducting the training and operation of multi-crew aircraft (fixed- and rotary-wing), has largely relied on principles developed during WW II. Early military and civilian airplanes had rudimentary flight control and navigation systems. Limited redundancy meant that even a minor problem could create a significant situation. Because of these design shortcomings, when an airborne emergency developed, the aircraft commander was expected to use their experience and skill, which was acquired through time-on-type, to create a knowledge-based solution to address the problem.

The Air Force still employs this knowledge-based approach as evidenced by the lengthy aircraft operating instructions (AOI) components in many of our operational training unit / flight training ground schools. This approach works in a legacy aircraft because these airplanes lack a high degree of information exchange between the aircraft and pilot. In legacy aircraft, aircrew are presented with symptoms that they are expected to synthesize with their extensive AOI knowledge to determine the exact nature of the problem and then produce a solution to recover the aircraft. This fact serves as the philosophical foundation for all legacy-pattern-aircraft training programs and operating methodologies.

However, flight crew in an automated aircraft are overloaded with information and can become distracted to such a degree that flight safety is compromised. The objective for crews operating advanced-technology aircraft is to prioritize the relevant information to effect a safe operation with as little distraction as possible while maximizing the exchange of information between the aircraft and the flight crew so that a shared mental model is developed and maintained. This information exchange is accomplished through a detailed, well-constructed set of SOPs. Modern aircraft internally monitor, assess, and provide solutions to the flight crew. As a result, training and operating methodologies must take on a rule-based method of operation where the analysis process resembles an IF/THEN sequence. Considering the degree of integration in today's flight deck, troubleshooting under a legacy context could exacerbate a problem. Clearly, this is not desirable.

With the modern airplane, understanding and operating the automation in an effective, efficient manner as well as learning and employing the SOPs combine to become the 'new' AOIs.

The Air Force has operated a limited number of automated, integrated technology aircraft platforms such as the CT142 Dash-8, CC144 Challenger, and the CC150 Polaris. As the training on these aircraft is contracted out to civilian agencies, the Air Force, until now, has not had the responsibility to develop and introduce pilot training programs that employ this level of technology. These civilian agencies are continually evolving their training practices to meet operator needs and satisfy regulatory requirements. This means that industry best-practices and lessons-learned are continually implemented. Unfortunately, only the CT142, CC144, and CC150 communities have benefited from this training evolution while the remaining Air Force communities have not had to develop new, more applicable philosophies or modify current training and operating practices because they continue to operate hybrid or legacy-pattern aircraft.

While the Air Force has significant, well respected experience conducting ab initio and post-wings flight training dating back to the British Commonwealth Air Training Plan, this experience falls short when developing and conducting advanced, integrated-technology flight training. Methodologies and philosophies that are effective on analog or legacy-type aircraft are not appropriate in the training and operating of advanced-technology aircraft. In fact, there is ample evidence to indicate that using legacy practices in the automated flight deck is inappropriate and unsafe. The "integration of the human with modern technology in the cockpit remains a significant problem that will continue to appear prominently in accident reports…."[1] Of equal importance is the understanding that with new technology comes the requirement to develop, train, and utilize new skill sets.

What Is Different About the Automated Integrated Flight Deck

The automated, integrated flight deck of today's modern aircraft reduces the crewing requirements to what is commonly referred to as a two-man flight deck. This reference is a

1 Don Spruston, "A Number of Safety Issues Related to Flight Deck Technology Require Our Urgent Attention," ICAO Journal 53(3) (1998): 9-10.

misnomer. By design, the automated aircraft performs as a third crewmember in that the auto-flight technology is so complete that it expertly performs most piloting tasks. As noted earlier, modern aircraft internally monitor, assess, and provide solutions to the flight crew. Out of necessity, the aircraft continually communicates, in discrete fashion, its intentions to the human crew. As a result, the requirement for the human crew to interact with each other, as well as the aircraft, in an efficient, effective manner must be the objective of all advanced-technology aircraft training and operating philosophies and practices. The importance of this requirement cannot be overstated. This interaction is achieved through a well-designed, comprehensive set of SOPs.

Although many advanced-technology aircraft have silent or automatic flight mode changes, the pilot commands the majority of the mode changes. Accordingly, the aircraft only does what it is told to do by the pilot. Needless to say, incomplete or ineffective training can and has resulted in automation surprises at inopportune times. Unfortunately, these surprises have sometimes led to aircraft crashes. Understandably, the maintenance of mode awareness is necessary for the flight crew to operate the aircraft safely in accordance with aircraft operating limitations and air traffic control (ATC) direction. Mode awareness is analogous to situational awareness and the loss of mode awareness can have catastrophic results. For example, the autopilot is considered an automated mode of flight. If training and SOP coverage governing the use of the autopilot is incomplete, there is the potential for the flight crew to become unaware as to the whether or not the autopilot is controlling the airplane. In a situation where the crew becomes distracted (emergency, unplanned manoeuvre or any tactical change) and the mode is active (on), the result could be an internal 'fight' between aircraft and pilot for control of the aircraft if the pilot tries to manually control the aircraft without first disconnecting the autopilot. Recall that the aircraft will do exactly what it is told to do. So if the autopilot is engaged and a situation develops where the pilot tries to manually control the aircraft without turning the autopilot off (i.e. overpower the autopilot), the autopilot will react to maintain the programmed flight parameters. This 'fight' can result in extreme aircraft attitudes resulting in crew disorientation and potential loss of aircraft. A well defined SOP that is trained and properly adhered to will avoid this situation.

Within the context of incomplete training and SOP coverage there is one consideration that must be addressed. That is, how will the autopilot be used? Will its use be mandated at all times, save certain scenarios such as some configuration or engine malfunctions, or will it be used solely at the discretion of the crew? Once this policy is defined the training program can be developed and the SOPs developed to reflect these basic operating policies.

Automated flight decks require a high degree of monitoring by the pilots and unfortunately human beings are poor monitors. Of specific concern with current glass-type aircraft is the requirement for aircrew to monitor the FMA. Monitoring the FMA is crucial because it indicates to the human crew the specific (current and planned) autoflight configuration (mode) of the airplane. Research has classified mode changes into three groups:

- **Manual – those selected by the pilot;**
- **Automatic Expected – automation-initiated mode changes expected by the pilot; and,**
- **Automatic Unexpected – automation-initiated mode changes that are not expected by the pilot.**

While the first two groups are intuitive, the automated unexpected mode change would manifest itself where the automation is commanding a change to the performance of the aircraft (i.e. pilot input is required) yet no change to the aircraft performance occurs. For example, following a take off / go-around (full power) departure, the automation will command a thrust reduction via the FMA at a pre-determined altitude, say 1500' AGL. The command can be annunciated by the font changing colour, the command font blinking, a box forming around the command font or a combination of these annunciations. If the pilot does not reduce the power levers to the appropriate position, their mode awareness would be classified as automatic unexpected. This is not the required terminal behaviour and indicates an insufficient shared-mental-model fidelity between man and machine. Pilots must be aware of these mode transitions and their timing to safely and effectively operate automated aircraft.

Even the traditional "T" pattern of monitoring flight deck indications has changed. Take the PFD–type presentation found on most modern automated aircraft. As specified earlier, the amount of information that can be presented via the PFD to the pilot is staggering. Now multiply that information quantity by six and include the other information panels such as the flight control unit, the flight management system (FMS), and the multi-purpose communication panel and you have a large and very diverse amount of information that must be continually monitored. Monitoring strategies must be developed and trained so that the crew has the tools to effectively monitor the proper information at the appropriate time.

The auto-flight capability of modern aircraft has had a powerful impact on all phases of flight. Specific functions/components within the auto-flight context include the autopilot, flight director, auto-thrust, FMA, flight control unit, and FMS. These systems are fully integrated and can, when engaged, guide the aircraft from a height of 100' on take-off to a full-stop post-landing in adverse weather conditions. While auto-flight capability eases the pilot's active monitoring and physical interaction of flying the aircraft, the technology also increases the pilot workload and requires sound task-management strategies and practices. Traditionally, the enroute/pre-descent phase of flight was a low-workload phase with the largest cognitive effort devoted to timing the top-of-descent point accurately. The approach phase—with navaid tuning, ATC instruction, and flying the approach—was traditionally very busy. With autoflight technology and FMS available, the approach phase now focuses on monitoring duties with the possibility of ATC-directed tactical changes to the planned flightpath in the terminal area. These 'new' crew duties are the result of a purposeful redistribution of task and workload management. Many of the traditional as well as new automation skill-set approach phase tasks such as approach set-up/programming (data entry), approach briefing, approach call-outs, crew communication, automation usage for the approach, as well as landing and go-around considerations have to be re-distributed to the enroute/pre-descent phase in order to ensure a high-level of safety and awareness by the crew during the approach phase. The risk of not recognizing the additional workload and skill sets and the necessity to redistribute these tasks can lead to a loss of mode and situational awareness by the flight crew on approach. The objective is to reduce the cognitive effort required by the crew as much as possible during busy phases of flight (to avoid task saturation), in order to have them ready to effectively handle the inevitable tactical changes or abnormal situations that can occur during a busy phase of flight.

How Do We Adjust

Automated aircraft are relatively new to the Air Force inventory. The good news is automated aircraft have been in use elsewhere. Their associated training programs and operating philosophies have been developed and refined, over the last few decades, in part due to corrective post-accident analysis and research. These same philosophies that guide training and operating practices in industry must be adopted by the Air Force.

The Air Force would be wise to recognize the wealth of experience and adopt the best practices that exist in other aviation organizations. The new automation and crew skills required to manage and exploit aircraft automated systems are generic to all flight operations regardless of the organization or the specific unit mission. By adopting best practices of industry, the Air Force can learn, tailor, and accelerate these training and operating philosophies to meet its specific needs.

The biggest challenge facing the Air Force is in identifying exactly what must be trained, identifying the required resources, and then determining the training methodology.

Recognizing that operating an automated flight deck requires a completely new skill set and understanding that this automation skill set must be trained is crucial. Once the skill sets have been identified, the appropriate training aids must be chosen. The training and operating philosophies that provide the organizational automation guidance must be considered. This consideration is key if the training program to meet its objectives. For example, the design intent of FMS-equipped aircraft, such as the C130J Hercules II, is for the FMS to control the entire operation. This means that the FMS is the main interface for both pilot and aircraft. As a result, FMS knowledge and proficiency must be high and its integration into the operation of the aircraft must be seamless.

Accordingly, FMS training is central to the development and training of the C130J. The question then is one of how to accomplish this training effectively and efficiently. Using a desktop emulator that is identical (in terms of software, tactile interface, and performance) to the FMS found in the aircraft is required. Having a stand-alone FMS trainer, along with a structured FMS training syllabus with defined objectives, allows for focused training and enhances transferability of the FMS skill-sets that will be required in the next level of training.

The follow-on phase of training would integrate the FMS skills into the SOPs in normal and non-normal operations. Again this phase will introduce and train additional automation-skill sets and CRM practices that are embedded into the SOP. Because of the volume of information to learn and the precision required from the SOPs, the actual task of flying the aircraft in this phase of training is not the objective. The objective is to prevent information overload and task saturation of the trainee and maximize the development of basic automation skills. With this objective in mind, it becomes easy to see that a full-flight-simulator (FFS) at this stage is not the preferred training enabler. A fixed-based, fully operational, tactile-accurate part-task-trainer (PTT) or cockpit-procedures-trainer (CPT) will better meet this objective of basic automation skill development.

Only after the trainee has demonstrated the required competence will the FFS phase be introduced. Here, the only new work is integrating what has been learned in the early phases with the task of flying the aircraft. Simulation today is of such high fidelity that all training can and should be conducted using this training resource.

This training program is analogous to the layers of an onion. Take what is central to the operation, train it first then build outward continuing to utilize the desired skills sets as new ones are introduced. This process is layered until the training objective has been achieved.

Automation Philosophy

The first step toward developing, training, and utilizing these automation skill-sets is the creation of a

strategically developed, organizationally supported automation philosophy.

For this philosophy to be effective, pilots experienced in glass cockpit operations must develop it. This prerequisite is essential if the automation philosophy is to lead the Air Force beyond legacy policies and procedures. Once this new automation philosophy is published, it will provide organizational guidance and direction for the training and operation of all advanced technology aircraft in the Air Force inventory.

Although the importance of an Air Force automation philosophy cannot be overstated, this philosophy is really just the beginning of the integration of advanced-technology aircraft into the training and operational environments that the Air Force excels in.

Policies

Air Force policies that govern the operation of our aircraft are communicated through our flying orders, regulations, and standard manoeuvre manuals. In order to ensure that these documents reflect the new reality (in terms of training and operations) that an automation philosophy will deliver, the Air Force requires an integrated approach to ensuring that this transition from legacy to glass is done quickly, efficiently, and above all, safely. Accordingly, this integrated approach should not only include organic resources but also the expertise of an external, appropriately qualified organization. As professionals, Air Force pilots can be justifiable proud of their skill-sets and 'can-do' attitude however, there is ample evidence to prove that legacy organizations cannot complete this legacy-to-glass transition without outside expertise. "One of the most common mistakes…observed, especially for an aircraft whose basic design closely resembles its 'steam' ancestor, is the use of legacy pilots, instructors, managers and evaluators to bring the new aircraft on-board, and to develop the SOPs, training, documentation and checklists both normal and abnormal/emergency. Unintentionally on their part, their culture and legacy background can hinder the proper development of a glass cockpit automation philosophy, SOPs, and checklists. In addition, instructors with a legacy background tend to develop training programs and to teach as they did in legacy aircraft."[2] It is essential then that organizations, such as our Air Force, faced with a legacy-to-glass transition select, as a minimum, individuals who have glass cockpit experience. If the Air Force cannot satisfy this requirement organically, consideration must be given to contracting an external agency to review our documentation, make recommendations on required changes to our operating policies, and assist in the transition.[3]

An example of an automation policy would be the use of the autopilot on approach except when operating visual meteorological conditions (VMC) in low-traffic conditions. Another example of an automation policy is the use of the vertical navigation (VNAV) capability (when provided) for all non-precision approaches.

Once these policies are defined, then procedures and practices can be developed and regulated.

Standard Operating Procedures

SOPs represent the integration of sound CRM / human performance military aviation (HPMA) practices and models with the technical aspects of operating modern automation.

Properly constructed, effective, and efficient SOPs are produced with flight safety, operational capability, and human limitations as the guiding principles. In a two-crew flight deck, duties are divided up along the pilot flying (PF) and pilot monitoring (PM) responsibilities. Appropriately designed SOPs integrate automation to: maximize efficiency and operational capability, enhance crew and aircraft interoperability, provide a high degree of crew monitoring, develop input/output cross-verification, implement operation standardization, and increase crew discipline. The by-products of such a set of SOPs are increased safety and enhanced crew situational awareness. Strict adherence to these SOPs must be enforced.

---

2 Christopher J. Lutat et al., "From "Steam to Glass": Essential Elements for Transitioning from Legacy Aircraft Systems to Advanced Technology" (paper presented at the 50th Annual Corporate Aviation Safety Seminar, Orlando, United States, April 26-28, 2005).

3 Ibid.

Effective crew communication is recognized as a critical tool in the successful operation of any flight. Today's flight deck now incorporates the aircraft into this communication loop using verbal, visual, and aural strategies. In addition to human-to-human communication, flight crews must completely understand the methods and meanings by which the aircraft communicates.

Automation use is not a stand-alone tool to be employed discretely when and if the crew desires. Aircraft are designed to use the technology from pre-start to post-shut-down. This means that flight crew must be able to effectively use any and all technology available to meet the challenges posed by the mission or environment. To safely accomplish this requirement, crews must be trained and evaluated in all facets of their respective aircraft's technology.

Ultimately, advanced technology compartmentalizes piloting skill and ability into three elements:

- **the ability to monitor effectively;**
- **the ability to communicate with the aircraft; and**
- **the ability to skilfully operate the available technology in all conditions.**

These elements must be integrated into one guiding operating scheme—a standard operating procedure. An SOP incorporates the elements into a clear, concise, standardized (a crucial attribute), and choreographed interface.

An organization that does not have top-down level support for such initiatives and/or relies on legacy individuals and practices to influence the automation philosophy, SOP development, and implementation process, will fail to meet the fundamental procedural changes necessary to safely and efficiently fly advanced automated aircraft. Holdover legacy flying practices forced onto the automated flight deck will result in unsafe flying situations.

Organizational Behaviour

Within the context of change and change management, understanding organizational behaviour, specifically the resistance to change and strategies to effect the desired change, is crucial to the success of any organization. Technology is one external force that drives change. At the outset of this discussion was the acknowledgement that technology, in terms of automated aircraft, is driving change in the Air Force. The necessity to adapt old training and operating paradigms to meet the challenges posed by modern-day aircraft automation is paramount. Success will come so long as the top command structure is engaged and fully committed to the change process and whole-heartedly endorses the desired goals of the change program.

Perhaps more subtle and insidious is the organizational culture that gives the organization its identity. The Air Force is a 'can-do' organization yet for many years the Air Force has been a 'make-do' organization. While justifiably proud of its accomplishments over the years, the organizational culture that is created can also impede progress. Adapting the Air Force to meet the automation challenge is a long- term commitment. While creative, short-term solutions may initially meet the immediate challenge, the long-term consequences of this approach are often ignored, poorly understood, and create future short-term crisis.

Conclusion

The arrival of additional highly automated aircraft to meet the future operational needs of the Air Force requires a corresponding change from a knowledge-based aircraft training/operating philosophy to a procedural based operating philosophy. The objective of this new operating philosophy is to provide the flight crew with the skill sets required to:

- **effectively and safely manipulate the automation;**
- **communicate with the aircraft; and**
- **vigilantly monitor aircraft automation and its systems.**

These objectives represent the new 'systems knowledge'. Going forward, our training programs must reflect this shift in operating philosophy.

Given that advanced-technology aircraft are designed with the expectation that the automation will be employed to the maximum extent possible, it is necessary that a strong set of SOP's are developed to:

- **provide a safe, effective, efficient, and standardized operational framework for the aircraft and crew;**
- **reflect the philosophy that automation will be used as the baseline operating standard;**
- **embrace the manufacturer's design intent/usage of the automation; and**
- **ensure that, within the bounds of safety and reason, manual-flying skill is preserved.**

The development of an Air Force automation philosophy and the subsequent review and changes to our operating policies will change the way we operate our advanced-technology aircraft. This change is necessary because the aircraft (current and soon to be) in our inventory today do not resemble the legacy aircraft we have flown for so many years. Air Force personnel, in cooperation with an outside consultant, must be tasked to develop new operating practises and SOPs. It will be important that those (within the Air Force) tasked have glass cockpit/automation experience and are ready to challenge our legacy mindsets and practises. Our success with this challenge will be measured in our operational effectiveness, mission accomplishment, and our ability to manage error and risk in our technologically advanced aircraft. ■

List of Abbreviations

AOI	aircraft operating instruction	PF	pilot flying
ASI	airspeed indicator	PFD	primary flying display
CPT	cockpit-procedures-trainer	PM	pilot monitoring
CRM	crew resource management	PTT	part-task-trainer
FFS	full-flight-simulator	RA	aresolution advisory
FMA	flight-mode annunciator	SOP	standard operating procedure
FMS	flight management system	TCAS	traffic alert and collision avoidance system
HPMA	human performance military aviation	VMC	visual meteorological conditions
		VNAV	vertical navigation

Capt Rawlings received his wings in October 1990 and earned his airline transport pilot licence in 1997. He has accumulated over 6,000 hours total time (military and civilian). He has flown the CH136 Kiowa helicopter at 427 and 408 Tactical Helicopter Squadron, and his fixed-wing time includes 2,500 hours on CT114 Tutor at 2 Canadian Forces Flying Training School and 431 (Air Defence) Squadron while 1,800 hours were logged on the Airbus 319/320/321 with Air Canada. Capt Rawlings is currently at 17 Wing Canadian Forces Air Navigation School flying the CT142 Dash-8.

Other achievements and functions held include Deputy Commanding Officer, Flight Commander, Chief Standards Officer, A2 instructional category, and staff officer at Division HQ.

References

European Cockpit Association. ECOTTRIS Project. http://www.eurocockpit.be/content/view/134/283/ (accessed June 21, 2005).

Helmreich, R.L., Merritt, A.C., and Wilhelm, J.A. "The Evolution of Crew Resource Management Training in Commercial Aviation." International Journal of Aviation Psychology, 9(1), (1999): 19-32, http://homepage.psyutexas.edu/homepage/group/HelmreichLAB/ (accessed October 27, 2005).

Kreitner, A., Kinicki, A., and Cole, N. Fundamentals of Organizational Behaviour: Key Concepts, Skills and Best Practices. 1st Canadian edition. Toronto: McGraw-Hill Ryerson, 2003.

Lutat, C., Major J. Petrina, S. Swah, R. Rayhill, C. Stickney, Major K. Brawley, and T. Kern. "From 'Steam to Glass': Essential Elements for Transitioning From Legacy Aircraft Systems to Advanced Technology." Paper presented at the 50th Annual Corporate Aviation Safety Seminar, Orlando, United States, April 26-28, 2005.

Maurino, Capt D. "Threat and Error Management." Paper presented at the Canadian Aviation Safety Seminar 2005 Plenary Sessions, Vancouver, Canada, April 18-20, 2005. http://www.tc.gc.ca/civilaviation/systemsafety/cass/2005/plenary.htm (accessed January 25, 2006).

Mumaw, R.J., Sarter, N.B., and Wickens, C.D. "Analysis of Pilots' Monitoring and Performance on an Automated Flight Deck." Paper presented at the 11th International Symposium on Aviation Psychology, Columbus, United States, March 5-8, 2001. http://www.humanfactors.uiuc.edu/Reports&PapersPDFs/isap01/starter.pdf (accessed February 22, 2006).

Safety Regulation Group. "Flight Crew Reliance on Automation." Civil Aviation Authority Paper 2004/10. (2004), http://www.caa.co.uk/docs/33/2004_10.PDF (accessed March 25, 2005).

Sarter, N.B., D. D. Woods, and C.E. Billings. "Automation Surprises." In Handbook of Human Factors and Ergonomics (2nd edition), edited by G. Salvendy, 1926-1943. New York: Wiley, 1997. http://csel.eng.ohio.state.edu/woods/automation/automation_surprise%2097.pdf

Spruston, D. "A Number of Safety Issues Related to Flight Deck Technology Require Our Urgent Attention." ICAO Journal 53(3) (1998): 9-10.

Sumwalt III, Capt R., Thomas, Capt R., and Dismukes, K. (2002, November 4-7). "Enhancing Flight-Crew Monitoring Skills Can Increase Flight Safety." Paper presented at 55th International Air Safety Seminar, Flight Safety Foundation, Dublin, Ireland, November 4-7, 2002. http://human-factors.arc.nasa.gov/flightcondition/Publications/FSF_Monitoring_FINAL.pdf (accessed February 22, 2006).

Rawlings, T.J., and Barnby, D.S. "Automation and Standard Operating Procedures." Service Paper, Winnipeg, 2006.

Wiener, E.L., and Nagel, D.C. Human Factors in Aviation. San Diego: Academic Press, 1988.

1 Canadian Air Division Automation Philosophy

Modern aircraft rely on a high level of automation and technical integration to create tactical advantage and achieve operational effectiveness. The acquisition of modern aircraft, and the modernization of legacy aircraft, demands new skills, knowledge, and attitudes to effectively and safely achieve mission success. Adherence to legacy operating practices on highly automated aircraft is ineffective and unsafe.

The employment of aircraft automation must be standardized, disciplined, and fully integrated in all phases of flight. Because the aviator retains authority in determining optimal use of automation, the aviator must be proficient in operating the aircraft in all levels of automation and be fully knowledgeable in the selection of the most appropriate level of automation for the situation.

All Flying Orders, flying training programs, assessment and evaluation criterion, standard operating procedures, briefing guides, checklists, flight manuals, and flying operations shall be in accordance with this automation philosophy.

Note: This Automation Philosophy was published June 22, 2007 by Major-General Bouchard Commander 1 Canadian Air Division.