Automation Addiction

Skill losses induced by continuous reliance on Flight Management and Guidance Systems

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Executive Summary

Exclusive use of automation during normal operations can result in degradation of the ability to precisely maneuver the aircraft without automation. Equally important, some pilots lose the ability to recognize and resolve erroneous automation displays during certain automation malfunctions, especially those involving pitot-static systems.

Automation Addiction

During normal flight operations automation provides significant benefits. However, there are brief periods that demand the aircraft be flown without automation or contrary to automation-directed flight paths. Pilots should be trained and, equally important, be provided with recommended operational practices that maintain skill levels required for these automation exceptions.

Automation Exceptions

Examples of automation exceptions include Flight Management and Guidance Computer (FMGC) systems or Flight Management Systems (FMS) that are not operationally stable or require pilots to create work-arounds for system deficiencies, go-arounds that are not flown as programmed, partial or full pitot-static system failures, Traffic Alert and Collision Avoidance System (TCAS) resolution advisories, Precision Radar Monitor (PRM) instrument approach system breakout maneuvers, Ground Proximity Warning System (GPWS) escape maneuvers, "slam dunk" approaches, abbreviated instrument approaches initiated from altitudes considerably above the normal descent profile, rapid decompression descents, and Air Traffic Control (ATC) instructions requiring divergence from planned or assigned flight paths.

An additional category of automation exceptions is associated with pitot-static system errors. Pitot-static systems provide numerous inputs to FMGC or FMS computers. These systems are uniquely exposed to random failures. Insect debris or nests, or undetected ice accumulation occasionally plug pitot probe inlet openings or drains. Failures may also be induced by maintenance errors such as un-removed pitot covers or tape over static ports (commonly applied during aircraft washing activities). The Aero Peru and Bergen Air accidents are two recent examples of such errors.

Suggestions for changes to operational practices and training are provided to address many of the factors identified within numerous industry studies. The conclusions of this study are aligned with many of the concepts found within Federal Aviation Administration (FAA) Human Factors Team report 1996; United Kingdom's Civil Aviation Authority (CAA) Paper 2004/10 Flight Crew Reliance on Automation, Summary table 1; FAA Certification Process (CPS) study report 2003; Airbus Human Factors conference 2003, When Go-Arounds Go Bad. Additional references such as *Aviation Today*, June 1, 2005 issue, Reducing Mode Errors Through Design, and NTSB, CAA or ICAO accident reports are utilized.

The lesson plans appended to this report are specific to the Airbus A320 family of aircraft. Pilots of other fully automated aircraft would benefit from similar changes specific to the flight management and guidance system utilized by that particular aircraft.

Automation Addiction – what is it?

This discussion is based upon four years of personal experience, observations and discussions with several hundred airline pilots and instructors who have transitioned to the A320/319 or B757 aircraft from older aircraft with analog instrument displays. The newer fully automated aircraft with integrated flight management and guidance computers are frequently referred to having "glass cockpits," whereas the older aircraft are considered to have "steam gauges." The author's own experience includes a total of approximately 22,000 hours in transport category aircraft, of which about 2,500 hours are in the A319/320.

During transition training from the DC-9 to the Airbus A320, I was trained to deal with most events while operating with all available automation. Training activities were devoted to establishing proficiency in the use of automation. There was little emphasis on operating the aircraft without all of the automation, unless the specific automation feature was inoperative or specifically denied as part of the training. The automation training was comprehensive and thorough, and I did not view the lack of emphasis on the old art of basic attitude instrument flying to be a major deficiency. Due to my background of many thousands of hours in steam gauge aircraft, I was highly proficient in the art of attitude instrument flying. It is the belief of the author and many of the line pilots that during training, an individual pilot's basic attitude instrument flying skills often aided resolution of automation errors, either pilot-induced or otherwise.

Author's personal experience with automation addiction

During my first year on the Airbus, I found little need or perceived opportunity to practice basic attitude instrument skills; the aircraft generally operated flawlessly. *Many of the automation exceptions I experienced were induced by operator errors or ATC demands rather than equipment malfunctions.* Additionally, I did not perform a single go-around or missed approach during the 12 months between initial aircraft qualification and annual recurrent training.

My experiences during my first year check ride were not what I had expected. When the automation was intentionally failed or was out of sequence with the desired flight path, I found myself scrambling to maintain aircraft control. My cognitive efforts were devoted to the simple task of maintaining airspeed, altitude and heading control while navigating somewhere without the benefit of the flight director and "green line" on the Navigation Display (a solid green line on the Navigation Display indicates the aircraft is on a course programmed in the FMGC). I found myself nearly overwhelmed with these tasks and unable to focus on the training or proper analysis of the other tasks. My instrument scan and management of navigational radios was virtually non-existent. This was an alarming change from my basic attitude instrument proficiency level during initial training. I found my experiences were not unique; many other pilots expressed similar concerns regarding the effects of automation on their flying skills. Discomfort with various levels of reduced automation was a constant refrain. In short, we had become automation addicted.

Changes in pilot behaviors and skill sets

Effects of automation dependency are a continuous subtle degradation of basic attitude instrument skills combined with an increase in confidence in the automation as flight time provides familiarity and apparent mastery of the automated environment. This combination can have serious consequences.

There have been numerous perfectly flyable second or third generation glass aircraft which crashed by being flown into the ground [1]or were nearly lost when the pilots were called upon to fly the aircraft in a manner incompatible with the use of automation.[2, 3] These aircraft and flight crews were experiencing an "Automation Exception." An automation exception occurs whenever there is a significant difference between flight management system (FMS or FMGC) programming and the pilot's desired flight path. Automation exceptions may be due to operational errors, FMS or FMGC software design (see Appendix A, Appendix B), navigation database errors or omissions, Air Traffic Control (ATC) requests, pitot-static system errors, [4, 5] or any of the numerous unforeseen activities that can occur during flight operations.

What every operator, instructor and pilot must understand is that all of the various combinations of "Automation Exceptions" such as go-arounds from other than the preprogrammed MAP, ATC demands, weather, Pitot-Static malfunctions, failures occurring during operations utilizing MEL relief, maintenance errors, etc., cannot be foreseen or trained for as unique events. However, all of these events share a common recovery survival strategy — a strategy that places the pilot in full control of the aircraft flight path. That survival strategy must be the least complicated available. Disregarding or eliminating the automation information during these events often presents the best, if not the only, option available.[6]

Pilot skill degradation due to automation usage

Prior to transitioning to a fully automated aircraft such as the Airbus, I would have suspected deficient flying skills on the part of any pilot who had a flight director, autopilot and auto-thrust activated from shortly after takeoff until just prior to landing during every flight. After I began flying the fully automated aircraft, I seldom saw any pilot hand fly the aircraft, and, if hand flying was performed, it was almost exclusively in combination with a flight director and auto-thrust. Seldom did I observe a pilot hand fly above four or five thousand feet on climb out. Never did I observe any pilot operate the aircraft with all of the automation turned off. Fully automated flight typically continued until between 1,500 feet and 500 feet AGL during approach and landing.

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[1] Gulf Air August 23, 2000: Bahrain VFR night approach (Automation errors)
[2] Indian Airlines February 14,1990: Bangladore, India (Mode mismatch)
[3] Aero Peru Flight October 2,1996: Ancon, Peru (Static port tape by maintenance)
[4] Federal Express October 17,1999: Subic Bay, Philippines (Pitot tube drains blocked insect debris)
[5] Bergen Air Flight February 6,1996
[6] Airbus: Flight Operations Briefing notes; Optimum use of Automation, summary of key points

It is interesting to note the change in pilot behavior and skill as automation proficiency is acquired. During transition to a glass cockpit many steam gauge pilots will turn off the automation at the first sign of confusion or automation difficulty. This instinctive action places the pilot in direct command of the aircraft, and provides the simplest method for solving whatever problem is occurring. Instructors constantly admonish pilots to work out the issues utilizing the automation. As the pilot develops automation proficiency, the urge to disconnect the automation becomes less compelling. Instructors look for resolution of flight path issues using FMGC assets as confirmation the pilot is becoming proficient with the automated systems.

Continuous emphasis of FMGC management results in diminished focus on the art of basic attitude flying. Indeed, a pilot's proficiency in the art of basic attitude instrument flying seems to diminish
proportionately as automation proficiency is acquired. At some point in this process the pilot loses the ability to precisely and accurately fly the aircraft without the use of automation. Equally important, the pilot begins to blindly trust the output of FMGC systems and becomes reluctant or unwilling to doubt, disregard or fly in opposition to Flight Director displayed guidance. That pilot now suffers from ***Automation Addiction***.

Company policies regarding normal operations using reduced automation
Discussions with various Fleet and Training Captains led this author to believe that the reduction of automation in order to maintain proficiency is acceptable. However, there is no flight operations profile or description in the Flight Operations or Aircraft Operating Manuals of flight conditions that are deemed acceptable for automation reduction.

Flights routinely operate in an environment where Standard Operations Procedures and Standard Maneuvers prescribe most procedures. Within these comprehensive instructions there is no description of when it might be appropriate to operate with reduced automation. This lack of guidance leads the line pilot to conclude that the airline management would not condone any reduction in automation unless specifically approved in SOP and/or SM text. For the purpose of comparison the text of an Aircraft Operations Manual (AOM) is quoted in the following discussion.

Aircraft Operations Manual: Describes application of SOP/SM
General section:
"Standard Maneuvers" provides diagrams and descriptions of standard maneuvers. It provides 'How to Fly' information and is intended to be followed in day-to-day line flying and training. SM is the only approved source for this information."

Automation Philosophy: Aircraft Operations Manual
"The effective use of automation enhances safety and improves operational capabilities. Pilots are expected to use the appropriate level of automation for their aircraft to optimize these safety and operational capacities. Regardless of the automation technology available within any specific aircraft type, the appropriate level of automation has been achieved when:

1. *Situational awareness is maintained, and*
2. *Workload is optimally managed.*

"Pilots are expected to maintain proficiency at all appropriate levels of automation. All flight deck crew members are responsible for the safe operation of the flight, notwithstanding the level of automation use."

Application of automation philosophy by line pilots
In air carrier operations the cockpit is an environment where every switch position, pilot callout and interaction is carefully choreographed. Little discretion is allowed for unscripted or non-automated operations. It is hard to imagine that many pilots would attempt to invent strategies for maintaining skills that the Management, Directors of Training or Instructor Captains do not believe are necessary or relevant to modern glass aircraft. Indeed, the very practice of maintaining basic attitude instrument skill is often viewed with doubt and suspicion.

Resistance from instructors to reduction of automation
The strongest condemnation of reducing automation levels during flight operations has come to me directly from some instructors. I gathered the following comments (during the development of this paper) from a few Captain Instructors, Check Airmen and First

Officer Instructors during my own line checks, annual recurrent training events and an extensive trip with an F/O Instructor.

Their comments were quite surprising. Regarding my suggestion that we should practice basic attitude skills during low workload flying, such as turning off the flight directors, autopilot and auto-thrust during a day VFR climb above 10,000 feet when the aircraft was on a heading to intercept a departure airway, one Line Check Pilot's comments during an en-route flight check ride were revealing:

> "I would never condone or recommend any 'Glass' be operated without all the automation engaged."
> "The liabilities are too high. The company lawyers would never condone such a thing."
> "As an ordinary Line Captain you are not authorized to experiment with the aircraft in this fashion."
> "You are just asking for trouble."

These comments came after my briefing on what to expect with regard to the change in instrument displays. Needless to say, the reaction of the check pilot to the demonstration was interesting to observe.

On another occasion during a day VFR flight, with a first officer instructor flying, only after I assumed control of the aircraft did he reluctantly acquiesce to a demonstration of reduced automation. This particular First Officer instructor stated that he was agreeing to a demonstration with the greatest of reservations because he was an Instructor and type-rated in the aircraft. His particular qualifications placed him in a special category that would allow him to resolve any difficulties I created during my demonstration or discussion of non-automated flight operations. After the demonstration, he resumed flying the aircraft without automation inputs. His experience in transitioning to basic attitude instrument flying skills was similar to that of other pilots, as will be discussed below.

One has to question the logic of condemning any reduction of automation when workloads are low, then demanding the elimination of automation during "Automation Exceptions" that are very high workload flight operations such as GPWS recoveries, TCAS avoidance maneuvers or "slam dunk" arrivals, which require flying performance the automation often cannot deliver. When would the Training Department or Lawyers and Regulators propose that we line pilots practice these flight operations requiring reference to basic attitude instruments or raw instrument flying skills?

Discussion within the instructor group regarding needed changes

Many carriers have reduced the training footprint to the minimum possible. The extraordinary task of training a student in the minimum time does not allow instructors any opportunity to attempt major changes in the training curriculum. Although many instructors believe some change is warranted, they are unable to conduct research and development within the restrictive confines of the current training environment.

Numerous instructor pilots believe that during training the overwhelming volume of information is so intense that many subtle nuances of the learning experience are lost. In the past multiple exposures to complex flight training scenarios cemented the subject matter together. Current minimum training curriculums often lead to confusion or misunderstanding of complex relationships between essential flight management resources. Often the student is told "Don't worry, you will get it later on the line."

There is a significant amount of discussion within the ranks of the Instructor group regarding these issues. Many instructors express the need for change in training and operational practices. Unfortunately at this time no simple solution to the phenomenon of Automation Addiction has developed within those discussions. Certainly the economically driven goals of reducing training cost have had a significant effect on the resources available to Instructors and Students. It may be that the goal of reducing training costs and producing pilots who are fully cognizant of the intricacies of automated aircraft has reached a point of diminishing returns.

Discussions and Observations from a 15-year Airbus Instructor and program manager

- Your theory that "steam gauge" pilots are proficient in attitude instrument skills appropriate to flight in the A320 may not consider the influence of the fly by wire flight control system and radical change in flight instrument displays. I note that pilots transitioning from DC-9 type A/C are challenged by the new skills that must be mastered to fly the A320. The lack of feedback from trim systems, the changing modes of the sidestick and the A/THR system make many "intuitive" skills these pilots possess ineffective. Pilots must train to clearly rationalize decisions that were made without thought in older technology aircraft. This is a challenging aspect of the early phases of transition to the A320. It should also be noted that the change in the physical dimensions of the pilot's "scan" as well as the tape style displays (now confined to the PFD) can be an issue for new pilots.

As you can tell from the discussion there is much we still do not understand about how to adapt training and flight operations to complex, fully automated aircraft. If it is the case, as the highly experienced instructor has observed, that "pilots must train to rationalize decisions that were made without thought in older technology aircraft" then a person may easily conclude that current efforts to reduce training time need careful review. Are applications of attitude instrument flying skills something that should be specifically reviewed and re-mastered during training for "Glass" aircraft?

Current practices of line pilots

Pilots report that they most often practice reduced automation levels during the last portion of a visual approach, once the aircraft is lined up and in a position to accomplish a normal landing. This is a relatively high workload environment with little room for error. When an error occurs it is often unnoticed or ignored. Some errors cannot be ignored, such as failure to extend the landing gear, final flap setting, forgetting to stow the flight spoiler panels, etc. The FOQA air safety data-base is populated with many events that occurred during periods of high workload, so the landing approach may not be an ideal place to practice flying without automation.

Typical pilot reaction to NO automation

Elimination of autopilot, auto-thrust and flight directors during VFR climb-out causes most pilots to experience several minutes of intense concentration in order to achieve normal flight profiles. This is followed by a gradual reduction in apprehension as the pilot becomes familiar with the changes in the instrument display and establishes more precise control over the aircraft.

Interestingly, the pilots least apprehensive about loss of automation are often just out of initial training and still are highly skilled in basic attitude instrument flying. Pilots who have been flying fully automated aircraft for several years tend to be very apprehensive, and highly experienced glass pilots typically require a few additional minutes before confidence returns. In my experience, there appears to be little difference in the level of skill demonstrated by most pilots after approximately 10 minutes of flight without automation.

Factors contributing to loss of basic attitude instrument flying proficiency

1. Continuous use of automation in the same repetitive fashion.

   The "green line" is leading you around whenever the flight directors are active. These devices tend to replace the pilot's cognitive thought processes occurring during attitude instrument flying. Those processes are quite robust if they are used constantly. During times of automation the pilot no longer is flying miles ahead of the aircraft but instead spends his or her time insuring the automation is performing as desired. The constant vision of perfectly operating systems, as indicated by flying in the flight director bars, results in pilots accepting these images as confirmation the aircraft is on the desired flight path.

2. Operational practices that do not allow or encourage the pilots to practice, build or maintain basic attitude instrument flying skills. Air carrier pilots are encouraged to use the maximum automation possible.

   Reasons for this include
   - passenger comfort,
   - workload management,
   - impact on safety
   - liability concerns for the operators certificate, and
   - liability concerns for the Pilot's certificate.

3. Pilots being uncomfortable with or unwilling to participate in activities with which they have little or no proficiency.

Pilot proficiency – the required skills

A proficient attitude instrument pilot uses rule-based behaviors for aircraft flight path control and knowledge-based behaviors to determine how to resolve an aircraft flight path or automation issue.[7]

Rule-based behaviors are the result of multiple practice efforts instilling a specific response. The response eventually occurs without a conscious reaction to the stimulus. Training and operational practices must create and maintain the necessary rule-based behaviors, for these are the instinctive responses a pilot will need to promptly resolve an automation exception.

Knowledge-based behaviors occur when the pilot analyzes the information from various cockpit instruments. Based on a rational process, a course of action is chosen. Knowledge-based behaviors require time to gather, analyze and react to specific situations. Knowledge-based behaviors are useful when a pilot has time to work through a complex issue, but in the heat of battle they are frequently not sufficient.

As pilots become accustomed to automation it becomes more difficult for them to deal with the occasional events that demand that automation be disregarded. During an

[7] CAA Paper 2004/10, Flight Crew Reliance on Automation.

automation exception, knowledge-based behaviors are required for recognition of the need to challenge or disregard the automation. These knowledge-based behaviors require a high degree of confidence by the pilot that his choice of action will not result in an undesired outcome. An automation exception requires direct and correct action on the part of the pilot, and this is where proficiency in rule-based behaviors will stand the pilot in good stead.

These behaviors will allow the pilots to perform the basic attitude instrument flying tasks required to respond to the automation exception.

Conclusion

In order to be immediately available during times of automation exception, rule-based behaviors must be developed and maintained during normal flight operations. Successful intervention will require several paradigm changes**.**

1. Practice of basic attitude skills is essential. It matters not whether the aircraft is from an earlier generation or the most modern design.
2. Transport aircraft pilots transitioning from analog aircraft to glass aircraft possess extraordinary skills as attitude instrument pilots. We must cultivate and maintain these skills.
3. Numerous opportunities for attitude instrument skill maintenance exist in a normal flight operations environment. These opportunities must be employed.
4. Flight training and operations departments have an obligation to define the best methods and flight regimes for development and maintenance of attitude instrument skills. Furthermore, pilots must be encouraged to take advantage of these opportunities.
5. Regulators must consider the need for enhancing training opportunities.

Recommendations

A comprehensive solution to automation addiction requires changes to AOMs, training curriculum and operational practices, as specified below.

- The AOM, SOP, SMC and FOM must be amended to clearly support the maintenance of basic attitude instrument skills. Those amendments should contain definitions of low threat environments suitable for this activity.
- Flight operations practices should actively engage skills the pilots already possess. The current practice of "managing automation to fly the jet" should change to "flying the jet and managing the automation."
- Simulator training curriculums must be adjusted to create a comprehensive understanding of FMGC interactions with automation and non-automated flight operations. The demonstration should be part of the first interactions pilots learn. This utilizes the learning concept of placing most important items at the beginning and end of the learning task.

∞ Initial Operational Experience (IOE) demonstration and operational practice of basic skills is the best way to equip the pilots to fly without automation during times of crisis.

- The pilot must demonstrate comprehension, competency and comfort in these operations prior to completion of IOE. The IOE demonstration utilizes the learning concept of placing important items into the actual aircraft operational environment.
- Annual training activities should demonstrate the procedure and practice to pilots who are already operating glass aircraft. The training should be accomplished prior to recommending that an individual pilot adopt a practice of non-automated flight operations.
- All pilots must routinely practice during normal line operations. The purpose of this practice is to create and maintain rule-based behaviors that will provide essential survival skills during times of automation exception.
- Based on personal observations of other pilots, I would estimate that practice of 15 to 30 minutes per month should be sufficient. For the average line pilot schedule this might equate to once or twice monthly during routine airline flight operations
- Improvement of stick and rudder skills should improve control "feel" during takeoff and landing operations. These are operations which require precise inputs without conscious thought to effectively manage a number of variables, including last moment wind gusts or environmental changes.[8]

Lesson Plans

Restoration of Basic Attitude Instrument flying skills

Caution: This demonstration must not be conducted during flight in RVSM airspace
Objective: To restore basic attitude instrument skills. These skills are diminished or lost during numerous hours of routine automated aircraft management.
Problem: Automation addiction.

During fully automated flight operations, pilots function principally as managers or overseers of system operations. In this capacity, the automation systems replace nearly all of the pilot's direct inputs to the flight controls. A subtle and steady loss of basic attitude instrument flight skills occurs with exclusive use of automation. This loss of basic piloting skills results in the addiction of the pilot to automation.

The objective of this lesson is a restoration of basic attitude instrument flight skills. Equally as important is the provision of a methodology that will maintain these skills during normal line flying. Restored skills will be instantly employable during those brief moments the automation is out of phase with the demands of the flight path. Examples of *automation exceptions* are: Go-arounds not flown as programmed, TCAS, GPWS, PRM Breakouts, "Slam Dunks," Rapid Decompression events, etc.

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[8] Dutch NLR report: Safety aspects of aircraft operations in a crosswind. Gerard W.H. van Es, Peter J. Van der Geest, Ton M.H. Nieuwpoort. 11th EASS Amsterdam, Netherlands, March 1999.

Lesson goals: At this lesson's completion, the pilot will be proficient in basic attitude instrument skills. The interrelationship of various FMGC assets will be clearly understood. Equally important, the pilot will demonstrate a high degree of comfort with all levels of automation reduction. This comfort level must be high enough that the pilot will be willing and able to routinely practice these skills during normal line operations in the defined low threat environments.

WARNING: The introduction and practice of these skills should only be attempted in a low workload or low threat environment. This does not include aircraft involved in challenging operations such as actual IFR instrument departure, en-route and/or instrument approaches. Actual IFR conditions are not suitable environments for the reduction or elimination of automation.

Optimum environment:
During a low threat flight operation such as a day VFR climb, above 10,000 feet with the "Climb checklist complete to the transition", on a heading assignment, while climbing to an altitude that will allow several minutes of flight control manipulations prior to level off at assigned altitude. Plan 5 to 8 min for demonstration, practice and comprehension.

Modifying rules of behavior
Operations without the autopilot, auto-thrust and flight directors should be conducted for the duration necessary to allow the student to change from knowledge-based behavior to rule-based behavior.

Basic attitude instrument flying skills are primarily rule-based behavior. It is the application of knowledge-based behavior that allows the pilot to analyze and resolve automation issues. By the act of routine practice of all phases of automation we allow the various iterations of automation to change from knowledge-based behavior to rule-based behavior. Rule-based behavior is what most individuals apply to stressful or new situations. Generally, application of rule-based behavior does not require a significant amount of a pilot's cognitive function. This leaves the pilot in the position of readily being able to fly the aircraft during analysis and application of knowledge to a new or unique flight situation.

The entire demonstration will need to be repeated several times for the student to develop complete understanding of the interrelationships between the various automated systems. The goal of this exercise is to change from knowledge-based behavior to rule-based behavior. Pilots will need these rule-based behaviors available in times the automation is out of sequence with the demands of the aircraft flight path.

A320 Lesson Plans

Restoration of Basic Attitude Instrument flying skills

Lesson Plans: Restoration of Basic Attitude Instrument flying skills

1. **Turning Off Auto Pilot (AP) –**

- Use the instinctive disconnect push button
- Confirm Flight Management Annunciator (FMA) changes in column 5
- AP1 or AP2 should not be illuminated on the top line of FMA column 5
- Demonstrate there are no changes to the flight director (PFD) or Navigation display (ND) will occur.

FMA indications

Column 1	Column 2	Column 3	Column 4	Column 5
SPEED	OPN CLB	HDG		
or		or		1FD2
MACH		NAV		A/THR

2. Turn off Auto Thrust

Preferred method in this lesson is to place the thrust at a fixed output. This will prevent thrust changes resulting from to pitch changes while demonstration is conducted. Subsequent "Slam Dunk" demonstration lessons will train operations with AP and FD off with auto-thrust active.

- Confirm the N1 Thrust Lever (TL) alignment doughnuts are aligned with the Climb Thrust N1 limit arc.
- Use the instinctive disconnect p.b.
- Confirm FMA changes in column 5, line 3

A/THR is not illuminated

Turn off Auto Thrust (cont.)

FMA indications				
Column 1	Column 2	Column 3	Column 4	Column 5
	OPN CLB	HDG or NAV		1FD2

- Demonstrate that no changes to the flight director (PFD) or Navigation display (ND) will occur.
- The magenta managed speed index on the airspeed indicator will remain in the managed speed mode. This is important to demonstrate because it confirms that the presence of a magenta coloration on the index is *not* an indication of autothrust operation. The source for the Magenta or Managed speed display is the Performance Page.
- Reconfirm FMA change in column 5.
- Review the concept that thrust management will now be similar to all other aircraft equipped with devices that maintain a constant thrust regardless of altitude. Climb Power will remain at the appropriate limit regardless of altitude while the TL is in the climb detent. As level off altitude is achieved the TLs must be retarded to an appropriate thrust value. Generally between 85 percent and 90 percent N_1, depending on weight and altitude.

3. Elimination of Flight Directors

Prior to turning off both flight directors:

- Refer to the pitch attitude for present flight condition. It will be similar to every other transport category jet previously flown.
- The student must comprehend that the aircraft will fly like any other non-glass transport jet.
- Prior basic attitude skills are relevant and must be applied.

1 Turn Off both Flight Directors

FMA indications				
Column 1	Column 2	Column 3	Column 4	Column 5

- FMA indication changes – All 5 columns/lines will be blank
- PFD indication changes –
    - Airspeed will revert to the value present at the exact instant the FDs were turned off. The magenta triangle will turn blue.
    - Heading will revert to the value present at the exact instant the FDs were turned off. The Green course indicator will revert to a Blue "lubber line." This change is important to recognize because the blue lubber line will not provide course tracking guidance. A

common error is the student will follow the lubber line and not observe/correct the wind drift.

- ND indication changes –
  - The managed Nav (solid green course) line will change.
  - There will be a solid green Track Line displayed from the yellow aircraft symbol extending to the green track diamond found on the ND heading ring.
  - The original planned flight path will be displayed as a dashed green line beginning at the point the FD was turned off and extending along the flight plan listed in the MCDU.
  - Instructional emphasis must be made to monitor the ND for an off course message. The message will be present to the left or right of the aircraft symbol's nose. Students will often mistake the ND message of .3R or .5L for instructions regarding the degree and direction a course correction must be made.
  - Demonstrate how the Track Line can be flown to match the proposed course line. Once the Track Line matches the proposed course the aircraft will have a wind drift corrected heading. This information is especially useful during non-precision approaches. The practice of this will establish a highly integrated crosscheck during high workload environments.

Instructional technique note:
The actions of the ND are exactly the same when FD or autopilot systems are operated in the HDG mode. However, practice of this integration while operating without any automation will build the fully integrated scan desired for all operations.

Restoration of Automation systems:
This section of the lesson is designed to complete the student's understanding of the all FMGC automation systems. The demonstration sequence is selected to reinforce the points in a very specific way.

1. Can the Auto Pilot be turned on if the autopilot, auto thrust and Flight Directors are off?

Have the student use the Auto Pilot P.B. The Autopilot is now operational. Now refer to the FMA. The student will observe the Auto Pilot is operating in the HDG and Vertical Speed mode (the Vertical speed mode will be exactly the same as the flight path present at the instant the Auto Pilot was activated. It may be + or – or 0)

FMA indications

Column 1	Column 2	Column 3	Column 4	Column 5
	VS + or -	HDG		
	VS 0			
	ALT			

2. Will the Auto Pilot capture an Altitude?

Allow the aircraft to continue to climb to the selected altitude.
Point out the Altitude box displayed on the PFD altimeter. Point out the FMA indication of an ALT message. The ALT message indicates the FMS system will capture an altitude only if the aircraft is proceeding toward the Altitude box.

Instructional technique note:
Remember, these conditions must be discussed. If the aircraft is above the box and climbing there will be no capture. If the aircraft is below the altitude and descending there will be no capture. This is a commonly observed error when restoring the FDs in training. The purpose of this discussion is to reinforce FMA cognizance.

FMA indications

Column 1	Column 2	Column 3	Column 4	Column 5
	VS + or - Or VS 0 ALT	HDG		

Have the student use the FCU Vertical Speed control.
Instructional caution: You must use caution to insure the V/S mode selected will be in the direction the aircraft needs to fly to the altitude displayed on the PFD and FCU window.
When the selected altitude is achieved the FMA message will change from V/S + V/S- or V/S 0 . The ALT * will appear followed by ALT CRZ.

FMA indications

Column 1	Column 2	Column 3	Column 4	Column 5
	ALT *	HDG		

- Can you activate Managed Nav with the Autopilot on, and the FD and AT are off? Have the student use the FCU heading P.B control. The HDG message will change to NAV.

FMA indications

Column 1	Column 2	Column 3	Column 4	Column 5
	ALT * then ALT CRZ	NAV		

Point out the change to the Nav Display. The display will now have a solid green line over the flight plan.

<u>Managed Speed rules of behavior: Restoration of the Auto Thrust system</u>

4. **Can we activate Managed Speed with the AP on, and the AT and FD off?** Have the student activate the Managed Speed P.B. and observe the FMA has not changed.

FMA indications

Column 1	Column 2	Column 3	Column 4	Column 5
	ALT CRZ	NAV		

Now look to the Air Speed index triangle. You will observe the index is Magenta, indicating Managed Speed is active. This is an extraordinarily important point to understand as the magenta Airspeed triangle has nothing to do with Auto Thrust being on or off. The Magenta triangle indicates the Airspeed display is being provided by the Flight Management and Guidance Computer, Performance Page. If there is an Auto Pilot or Flight Director active, the Perf Page will deliver information to the activated system.

The activation of an Auto Pilot or Flight Director will provide a place for the FMGC system to interact with the aircraft. The FMA will always tell you what the FMGC is doing with the aircraft, be it heading or managed nav, open climb, open descent, or altitude capture, cruise.

Auto Pilot rules of behavior with regard to Selected or Managed Speed

Instructional technique note:

Both the Auto Pilot and Flight Director system perform according to very specific rules. These are the same rules of aircraft operation the pilot would employ if hand flying the aircraft using basic attitude instrument flying principles.

During Climb with a fixed climb thrust, Pitch is the only available control. Pitch is used to satisfy Airspeed needs. When you level off at altitude, Pitch is the best control of altitude changes. Power then controls Airspeed. Pitch is used to control altitude or Airspeed or Vertical speed when that is the most important variable.

So what happens with Managed Speed?

The FMGC uses Perf Page information for the phase of flight you are in. Climb, Cruise, Descent, etc. Managed Speed only indicates what the FMGC has calculated for the desired speed. With Managed Speed active the FMGC will calculate whatever thrust value needed to satisfy the resulting airspeed. When the Auto Thrust system is active the FADEC system control thrust output. At that time, the Auto Thrust system will adjust thrust to meet the requirements of a pilot's Selected Speed or the FMGC's Managed Speed function.

Restoration of the Auto Thrust system

3. Can we activate the Auto Thrust System with the autopilot on, and the autothrust and Flight Directors off?

- Have the student activate the Auto Thrust P.B.
- The Auto Thrust system will now become active.
- The thrust Levers must be placed into the Climb detent.

Restoration of Automation systems

Auto Pilot and Auto Thrust ON / Flight Directors OFF Observe the FMA

FMA indications

Column 1	Column 2	Column 3	Column 4	Column 5
MACH	ALT CRZ	NAV		
or				
SPEED				A/THR

Instructional technique note:

Again review the following principles. The FMGC systems are flying the aircraft using the same rules for pitch and power control that any pilot would employ during attitude instrument flying.

The aircraft is now fully automated with no Flight Directors operational.

Routine operation of the aircraft without the Flight Directors is important to develop and maintain the pilot's cognitive processes. With this configuration, conformation that the aircraft is on the desired flight path can only be obtained thru the FMA. We know that this is the "Golden Rule" of automated operations. Additionally, the Flight Director display is not required or desired when building FMA awareness.

Discussion of interrelationships between FCU-FMGC-AUTOPILOT-AUTOTHRUST-Flight Directors

The aircraft is now flying in the fully automatic mode with *no* flight Directors displayed. *This is an important concept. Flight Directors are not required to be operating, yet the autopilot and auto thrust will function if requested.*

- First review the FMA annunciations; the student will see the same indications with the exception of the 1FD2 message.
- The Flight Control Unit sends messages in the form of selected altitudes, headings, speeds, Managed Nav, etc., directly down to the FMGC box. The FMGC device receives its command from the FCU indicating desired commands such as: vertical speed, heading hold, altitude capture or whatever the pilot desires. The FMGC then delivers the pilot's requests.

If you are climbing at a specific airspeed with a fixed thrust like CLB THR, the FMGC will use pitch as the only variable control device to control airspeed. Airspeed is the most important variable in the climb. If commanding a specific rate of climb, the FMGC will now use pitch to control rate of climb and the airspeed becomes a balance between CLB THR and rate of climb. Once you reach cruise altitude the FMGC will now use the most effective control to maintain altitude. The FMGC will vary thrust to control the speed.

Let's look at the FMA. At this point, the instructor will point out how the FMGC is conforming to the demands of the pilot. The following FMA possibilities are presented for illustration but instructional discussion will need to be modified depending on flight path – climb, cruise or descent.

Auto Pilot and Auto Thrust ON / Flight Directors OFF Observe the FMA

FMA indications

Column 1	Column 2	Column 3	Column 4	Column 5
MACH	ALT CRZ	NAV		
or				
SPEED				A/THR

Instructor should discuss the way pilots would control speed and altitude – i.e., thrust output for speed and pitch for altitude. The student must understand that the FMGC will operate exactly as the pilot commands.

This is an example of the simple but effective means of creating a basic understanding of the interrelationships between FCU-FMGC-AUTOPILOT-AUTOTHRUST-Flight Directors.

Sample demonstration of Pilot and FMGC interaction

For this discussion the Instructor is in the left seat and the Student is in the right seat. The demonstration can be accomplished from either seat but the described hand movements have to be adjusted accordingly.

Aircraft is now flying in the fully automatic mode with NO flight Directors displayed.

This is an important concept. Flight Directors are not required to be operating yet the autopilot and auto thrust will function if requested. The aircraft is fully automated and the FMA is the only means of confirming the aircraft trajectory. With no Flight Directors in view there will be no confusion about where a pilot must reference when confirming the aircraft flight path.

Sample demonstration of Pilot and FMGC interaction *(cont.)*
First review the FMA annunciations. The student will see the same indications with the exception of the 1FD2 message.

Now explain the FCU panel is named the Flight Control Unit because that is what it does. It sends messages in the form of selected altitudes, headings, speeds, Managed Nav, etc., directly down to the FMGC box located by your knee. That FMGC device receiving its command from the FCU says, "Hey I have the PILOT wanting me, the FMGC, to do something. Like Vertical Speed, Heading hold, Altitude capture or whatever the PILOT desires. The FMGC then looks for a place or device to deliver the results of the pilot's demands. Those devices are the Autopilot, Flight Directors and Auto-thrust.

"The Finger Wave": Description of Instructor's hand actions in this demonstration

Facing the student, hold up your ***right hand with your palm toward you***. Explain that the right hand replicates the Flight Director functions. Wiggle your thumb to represent heading information, wiggle your various fingers to represent other functions like Altitude capture, etc. Explain that the finger wiggles represent FMGC outputs after the FCU sends an instruction to the FMGC.
Now repeat the process with the ***left hand palm toward the student*** representing the Autopilot. Wiggle your thumb to represent heading information, wiggle your various fingers to represent other functions like Altitude capture, etc. Explain that the finger wiggles represent FMGC outputs after the FCU sends an instruction to the FMGC.

Explain that the FD and Autopilot are "Married" and they are "Equal partners."

1 Separate your hands and place them side by side between you and the student.
2 One does not "Lay on top of the other" and at this point place both hands together palm to palm, *but*, are equal partners in the obeying the demands of the FMGC.
3 Separate your hands and place them side by side between you and the student. Now wiggle both thumbs at the same time and explain that the heading actions are separate *but* mirrored by both in such a way that they react simultaneously. When both are operational they cannot act contrary to the other device.
4 *However*, they can be divorced from each other by the pilot selecting OFF. Close one hand and remove from display. Then close the other hand and remove from display.

Now let's talk about how the FMGC will carry out the pilot's *demands*.
It will fly using the exact same rules of flight behavior as ***you*** *the pilot.*
If you are climbing at a specific airspeed with a fixed thrust like CLB THR the FMGC will use pitch as the only variable control device to control airspeed. Airspeed is the most important variable in the climb. If you tell it you want a specific rate of climb the FMGC will now use pitch to control rate of climb. The result is, airspeed will become whatever the balance between CLB THR and rate of climb create. Once you reach cruise altitude the FMGC will now use the most effective control to maintain Altitude, the most important variable in the flight path. If you the pilot were flying that is *exactly* what you would do. Now the FMGC will vary thrust to control speed *exactly what* you would do.

In short the FMGC looks for instructions from *you* the pilot and will carry out those instructions just as you would.
So now let's look at the FMA. At this point the instructor will point out how the FMGC is conforming to the demands of the *pilot*.

We are now ready to introduce some processes that keep the pilot in control at all times.

Integrating pilot skill components into the automatic aircraft environment
Most pilots transition to "glass aircraft" as highly skilled instrument pilots. That pilot's navigation system is VOR based. Glass aircraft have systems that allow flight without selection of specific VORs. However, both the pilot and ATC systems still function with VOR references. Additionally, all flight operations are required to maintain compliance with assigned ATC procedures such as airport specific departures, or arrivals. En-route navigation generally is from VOR to VOR. Using the RAD NAV selection of VORs will help insure compliance with the demand for operational oversight of INS systems. Current training and operational practices miss the opportunity to fully integrate the aircraft and a pilot's existing and very successful navigation reference system. We need to integrate the actions of pilots and machines at very basic levels. The process described is designed to

1. Reinforce the pilot's command of the aircraft
2. Ensure separation of PF (Pilot Flying)/ PNF (Pilot Not Flying) duties
3. Ensure situational awareness is maintained
4. Prevent inadvertent acceptance of erroneous navigational inputs.

Integrating the Navigational actions of the Pilot's FMGC inputs, and efficient aircraft operations
The aircraft is in NAV mode and ATC re-clears us DIRECT to XYZ interception or VOR. Do not allow the flying pilot to wait passively while the other pilot starts FMGC inputs. While the FMGC is being altered, the pilot will select heading and turn the aircraft toward the new navigation point. This will accomplish several very important objectives.

1. Pilot is in control of aircraft and cognizant of desired heading before any FMGC alterations. It is important to reinforce the concept that the pilot is in control. Simple acts of control prepare the pilot to intervene when "Automation Exception" events occur. This always keeps one pilot flying the aircraft and the PNF working with the FMGC or other systems.
2. Fuel savings
3. Time savings
4. If the pilot is to be successfully prepared to intervene he must have intervention as a normal behavior.

This simple process is creating at a very basic level the modification of behaviors so the pilot will find it normal to question the actions of the FMGC systems and be prepared to interact accordingly.

Modifying rules of behavior

Changing from "Knowledge based behavior" to "Rule based behavior" (CAA Paper 2004/10 - Flight Crew Reliance on Automation Operations without the Auto Pilot, Auto Thrust, and Flight Directors) should be conducted for the duration necessary to allow the pilot to change behaviors. The entire demonstration might need repetition for the student to develop complete understanding of the interrelationships between the various automated systems. Once the transition from knowledge based to rule based behavior is complete it is imperative that opportunities for retention of those skills are clearly defined. Rule based behavior requires practice to instill the behaviors desired. Retention of those rule based behaviors requires practice, practice, practice.

About the many contributors to this research

This project involved several hundred Airline Captains and First Officers who are “Line Pilots” from the Memphis, Tennessee pilot base and the leadership of the NWA-ALPA Air Safety Committee. The Memphis “Line Pilots” who are all highly experienced aviators from a wide range of backgrounds such as US Air Force or US Navy test pilots, aircraft engineers, and many other aviation disciplines have read and offered ideas and edits of each portion of this paper. This research is unique because the intention of the participants is to help aircraft operators, designers, engineers and regulators understand the impact of automation on highly experienced pilots. Many of these participants believe quite strongly that the answers to many aspects of “*Automation Addiction*” and “*Automation Exceptions*” are the simple concepts found within these discussions. They have freely given hundreds of hours of discussion and effort to this research. Additionally these concepts were fully reviewed during flights with A320 Instructor Captain Scott Hammond who, at the time, was Chairman of the NWA flight safety department. Additional demonstration flights also included a three day multiple leg trip with the NWA- FAA Certificate Management Office, A320/330 Principal Operations Inspector.

About the author

Captain Dennis J. Landry (aeronaut@tsixroads.com or Dennis.Landry@alpa.org) is currently flying as a Northwest Airlines DC-10 Captain. During Captain Landry’s 27 year career as a pilot for North Central, Republic Airlines and Northwest Airlines he has flown more than 25,000 hours and well in excess of 26,000 commercial airline takeoff and landing operations.

In 2000 he earned a promotion to Airbus A320 Captain. During the subsequent four years of Airbus operation the concept of “Automation Addiction” and resolutions for those issues were developed.

Captain Landry also has worked on numerous Airline Pilots Association Air Safety committees. He serves as the ALPA National Chairman of the Master Minimum Equipment List committee (MMEL), and Technical Operations Chairman for the Northwest pilots division of ALPA.

His service earned the 2000 Northwest Airlines Air Safety Award. This award is earned only by Air Safety volunteers selected by the Central Air Safety committee. Captain Landry has worked for many years as an Airbus 320/330, DC-9 and DC-10 maintenance and flight operations expert. His expertise has helped formulate several Northwest Airlines flight operations programs and policies. The current Northwest Airlines winter operations review program is one program that Captain Landry helped formulate. Other winter operations team members include numerous organizations such as the FAA Certificate Management Offices, Airport Standards Division, DC-9 and A320 Flight Operations and Policy Boards, Master MEL and ATC.

APENDIX A:

Instructor's homemade "Gouge Sheet" for resolving

Thales-Smith Rev 1 and Rev1+ problems.

THALES – SMITH FMS

1. "**TO STEEP PATH AHEAD**" Not honor the FMS flight plan constraints and descending to the FCU altitude window setting.

2. **36 hours** – of continuous power on the Thales FMS will automatically "Time out" no matter the phase of flight.
   a. **Problem Solved** – requires the A/C to be shut down cold (black) every 36 hours. Think of using the GRD service bus when leaving the A/C?

3. **Direct To with Abeam waypoints**. This function can cause a FMGC time out. Only use the DIRECT TO without abeam waypoints which is not the default setting.
   a. **Remember** – Direct To with Abeam waypoints the "TO Waypoint" displayed on the ND is NOT your TO Waypoint. If an error was made scrolling to the selected Direct To Waypoint it will not be confirmed on the ND display, only the MDCU display. NO check and balances between the MDCU and the ND to waypoint.

4. **Unable to clear the PPOS** on the approach. The APR pb push and has captured on the ILS approach course.
   a. **Problem** – If you capture the approach and miss the IAF waypoint by two or more waypoints
   the MDCU will not allow clearing the PPOS. KDTW 21L, IAF "COUNT" with all the other
   waypoints displayed to the runway. If the PPOS was not cleared and you intercepted the ILS
   approach just outside the OM 'PUKLE', you cannot clear the PPOS and the flight plan will not
   sequence.
   b. **Problem Solved** by going to Heading to clear the PPOS and rearm the APR pb.
   c. **Remember** – Thales FMS as with the Honeywell FMS will not sequence the flight plan with a PPOS.

5. **Stacking** – Changing runways can cause the current STAR to be reinserted into the flight plan.
   a. **Problem** – The STAR transition waypoints that were previously sequenced are reinserted into the flight plan. The same problem with SIDs, less common but engines out SIDs are affected.

6. **Intercepts** – Unable to intercept a course not on the flight plan routing.
   a. **Problem** – Unable to intercept the imaginary line created by two waypoints. Even though the ND will display a cross track error.
   b. **Differences** – The Honewell FMS will intercept a line defined by two waypoints even if the
   heading is outside the defined green rout line. A cross track error will be displayed on the

ND, the same with the Thales FMS but it will not intercept the route.

c. **Problem Solved** – Use the Direct To function with 'Radial in' to intercept the course.

Waypoint-Radial In (recip).

d. **Problem Solved** – Check the FLT PLN in between waypoints for **C**-206 or **T**-206 if a "**C**" is there clearing to the next waypoint will allow an intercept without the DIR function. If it has a "T" it will not intercept and a DIR Radial IN function is required to intercept.

e. **Remember** – Watch the scratch pad for "NO NAV INTERCEPT".

f. A **positive** for the THALES is intercepts for ILS beyond the IAF or FAF use the Direct TO function for radial in and it works and you have a green line to the ISL with intercept.

7. **Pilot creating PBDs** that are inserted into the flight plan route.

a. **Problem**- you can only insert waypoints that define that leg. Waypoints A, B, C, and D are the FMS flight plan route. A PBD is defined from D and placed in between B and C. The Thales FMS will not allow this. Use waypoint B or C to define the PBD. Arrivals into SAN might have problems with this FMS difference

8. **Triple Clicks** for FMA changes / revisions, only on a couple of A/C.

9. **Airspeed control large variations** without FMS corrections. I've had to change from Managed to Selected speed to correct the problem.

10. **Init pg** change of the Lats / Longs after the Align Key has been pushed.

a. **Problem** – Position change at the gate after the Align Key is pushed. No Align prompt to push to change the inaccurate position.

b. **Problem Solved** – If both FMS are wrong quick align the IRs. If only on FMS is wrong consider a FMGC reset.

c. **Problem** – Another version is only the captains MDCU gate position is correct and the first officers MDCU gate position does not have the correct gate coordinates. No warning for gate position error between the two FMS. Checking the Lats / Longs of only one MCDU will not be a valid check of initial gate position for IR alignment.

11. **Data base dates** are different than the Honeywell. Minor problem but it could be missed on preflight.

a. **Remember** – change over is at 0900Z

12. **Non-precision missed approaches** – Back Course and LDA Non-precision missed approaches cannot be entered the same way as the Honeywell FMS.

a. **Problem** – No waypoints can be entered after the 'End of Flight Plan.'

b. **Problem Solved** – Lateral revision from the inserted RWY. LAT REV, NEXT WPT ( ) missed approach waypoint and continue build the missed approach. The lateral revision function is the only way to insert waypoints in between the runway and the "END OF FLIGHT PLAN".

13. **VOR Non-precision approach** – Hard tuning the VOR frequency can cause the FMS scratch pad to display "Tune XXX VOR" which is different than the VOR approach frequency. The DME, DME mix is requesting the frequency change to update the FMS.

14. **A/Cs Clock functions** (ea: hold) can cause the FMS Flight plan arrival time to change from a count down timer.
    a. **Problem Solved** – At the gate reset FMGC #1 to correct. Using the printer time stamp as an aid.

15. **Reserve Fuel Computations** are not what was entered in the INT B page of the MDCU.
    a. **Problem** – The Thales FMS will recalculate the Reserve fuel to 15% of the total flight plan burn and use the greater of the two.
    b. **Problem Solved** – All reserve and alternate fuel enter in the Final time box.

16. **SRS stays on during a Go-around** until a different function is selected from the FCU.
    a. **Problem** – A/C keeps climbing at SRS speed.
    b. **Problem Solved** – Go-arounds will require the crew to PULL selected speed or ALT knob after thrust levers are pulled back to CLB to change from SRS to CLB.

17. **Un-commanded Speed change** – Selected speed changes to managed speed during climb to cruise phase without pilot input on the FCU

18. **ILS frequency & course** is not available until 200 – 300 nm from the runway.
    a. **Problem** – ILS runway selected and inserted in the MDCU no ILS on the displayed on the ND until less than 200 nm or in the descent phase of flight. No ILS frequency in the RAD / NAV page until less than 300 nm. Pushing the ILS pb or LS pb will not display a freq. / ID or course if beyond 200 nm. Approach plate briefing before 300-200 nm will be unable to verify frequency and course.

19. **MORE HEADS DOWN TIME** with the Thales than the Honeywell

20. **Clean up the Flight Plan** –
    a. **Problem** – Clean up the flight plan will cause the FMA to change to the TMPY flight plan in AMBER. It is hard to check how far to CLR to with the AMBER flight plan

to check the change
from GREEN flight plan to the BLUE missed approach procedure after a go-around.

21. **CAT II/III approaches** – If you forget to turn off the A/P after you land and are taxiing in the A/P
will disconnect after 20 degrees of heading change.

22. **Scratch PAD MEMO** – is important to check for these messages.
    a. OWN FMGC IN PROGRESS – WHITE – GOOD
    b. OWN FMGC IN PROGRESS – AMBER – NOT GOOD
    c. CHECK TAKEOFF DATA
    d. NO NAV INTERCEPT

APENDIX B:

Air Safety reports, Operational disruptions due to FMGC system failures

Report 1:

Air Safety report of Thales-Smith FMGC Multiple failures during all phases of a single flight: March 2005

Approximate location of event:

Preflight, Taxi out, climb out, and enroute operations

Aircraft malfunctions: Instruments/Navigation

Other: FMS system and abnormal procedures not well defined

Event description:

During preflight first abnormality was observed. All normal preflight, INS alignment and flight plan loading had been completed. about 5 min after completion of preflight, the FMGC scratch pad presented an amber message RE-ALIGHN IRS. The fast align mode was selected. The FMS preflight was performed a second time. All systems appeared normal. During taxi-out in very congested traffic a GPWS TERR ecam warning appeared. FMS1 fail light was momentarily illuminated. I instructed the FO to disregard the ECAM and we advised ATC of need to park in a remote pad. The COM was consulted. (If I were to tell you how poorly this document is written the words would make a Sailor blush.) The Supplemental section is a piece of crap. A second grade child could create a better document. (Please pass the cheese for my wine). After several min reviewing my own notes and sorting out the applicable Thales sections we were unable to effect a successful reset. Dispatch and MC were consulted. Under the direction of MC the entire FMS1 and 2 systems were reset. Reset required the aircraft be completely depowered. This resulted in almost 20 min of ground time before successful reset and all preflight, taxi, and before takeoff checks had been recompleted. Now we were on our way. The VFR climb out was uneventful until 25,000 ft. At that time the FMS1 fail light came on again. All the associated failure modes were observed. I had the FO (who is also an A320 CA) perform the ECAM and COM. Reset appeared successful. During our coast-out IRS check we observed the #1 FMS had no position listed on the POSITION page. The overhead readout was consulted and the correct position was observed. A second check of the IRS mix and IRS #2, IRS3# was performed. All positions except IRS1 were normal and accuracy was rated as HIGH. Flight continued to CUN with no other FMS#1 irregularities. I am puzzled why the A320 training and flight operations department continues to be allowed to provide pilots confusing or incomplete information in the FAA approved COM. Had the initial FMS event occurred while airborne I would most likely not have continued to CUN. This device presents unreliable performance and disruptive influences to the cockpit operations. Editorial comment to the ERC and FAA I would like to say that the FAA's allowance of flight operations without useable cockpit documentation of Thales systems normal, abnormal, reset, and solutions for known operational abnormalities is difficult to understand. Perhaps the original promise from Thales can explain the approval of train by bulletin. But when the problems became apparent during the initial cutover I expected the FAA in its watchdog safety/regulatory role would ask questions of the JAA and require proper

documentation of any additional changes such as REV1+. Problems that were so bad the aircraft operator halted conversion for a politically brief time. At that time Thales should have provided Government Regulators, Airline operators, and Pilots with a complete explanation of how to operate this REV1 device BEFORE it was allowed to continue to operate in US airspace. How did the FAA ever sign off on a train by bulletin for a complete Flight Management and Guidance System that has significant and substantial differences? Did the FAA ever review the full operational system of REV 1 or REV1+ before allowing passengers and flight crew members to become test pilot and test passengers for the next generation of (FUBAR) Thales equipment. The airline flight operations department told Pilots the problems would be fixed with REV1+. Again no documentation of how to operate the device was provided until long after REV 1+ was installed. The REV1+ problems were significantly worse. By my count there are many significant problems that can combine during almost any phase of flight. Ask the fleet to explain why you do not have to be concerned with a 36 hour DUAL FMGC timeout. The answer will sound like the classic engineering study. A 10x9th power argument. The 36 hour timeout problem is a significant safety hazard. REV1+ added -- Stacking-- which now occurs on both departure and/or arrival runway changes. Some departures would change from Pilot NAV to Managed NAV without any input from pilots. One time it caught me off guard while I was searching for traffic the aircraft began a right turn without any input from me!!. This uncommanded FMGC input resulted in a loss of separation and TCAS event. Other places the legs don't properly cycle and you cannot get the FMS to a managed NAV departure procedure that was loaded. I could go on for a long time. I would suggest you go to COM Supplemental Section 34 FMGC abnormalities, Operating Bulletins, AOM Vol2 section34A, the fleet web site" Thales Tips". Is that the system you the FAA want to defend? This Thales-Smith system is such a pile of junk. Flight Instructors have created private gouge sheets to keep up with the workarounds. Yes I do have a copy, a gift from a pilot in the crew room. I hope proper documentation and training are provided BEFORE any more revisions are installed. If you would like to hear more please feel free to contact me.

Approximate location of event:

Preflight, Taxi out, climb out, and enroute operations

Preventative measures:

FAA oversight of all phases of FMS development OR remove defective Thales FMGC/FMS system, Provide pilots with Cockpit information that is useable, correct, and readable information.

Report 2:

Departure improper built and sequencing during Managed NAV departure Thales- Smith REV1, 1+, and 2 aircraft:

Text from pilot report:
Photo taken while parked at the gate. As you can see the next fix after the runway is DEN, if the crew does not select a heading in the FCU the aircraft will turn back to the airport and the DEN VOR after takeoff with the autopilot on. That is not what ATC wants us to do since the Yellowstone Three is fly assigned heading with radar vectors to later join the radial for the transition. Then there is the problem of not being able to delete the runway after departure to get the correct waypoint as the T/O fix.

Until this gets corrected maybe we could get the Company to issue a NOTAM for DEN to make the crews aware of the problems with this departure and Thales-Smith FMS 2 aircraft.

Report 2: Departure improper built and sequencing during Managed NAV departure


FROM NW572
YELLO3 TIME SPD/ALT
KDEN08 ---- ---/ 5350
YELLO3 BRG159° 3
DEN ---- ---/ -----
HANKI TRK012° 58
YOKES ---- ---/ -----
HANKI 16
COPLA ---- ---/ -----
HANKI 71NM
HANKI ---- ---/ -----
DEST TIME DIST EFOB
KMSP12R ---- 984 -----
DIR
PROG
PERF
INIT
DATA
BRT
F-PLN
RAD NAV
FUEL PRED
SEC F-PLN
ATC COMM
MCDU MENU
DIM
AIR PORT
ECAM

Report 3:

Incorrectly coded departures at MSO. Airport surrounded by high terrain.

Description:
We departed runway 29 MSO on the Northwest Runway 29 Charted Departure Procedure, page 10-7G. When loading the flight plan in the MCDU the departure procedures were listed in the database for MSO runway 29, KONNA2 and MZULA1. KONNA2 gave us the radial and the turn back to the MSO VOR so we selected that procedure. The problem with the KONNA2 is that the fix MSO09 is only 9 miles out, not enough distance from the airport, and the crossing restriction at this fix in the database is at or above 7600 MSL. It should be at or above 9600 MSL as listed on the 10-7G page. The charted runway 29, 10-7G is the MSO 294 radial up to 9600 MSL before turning left turn back to the MSO VOR, not to exceed 14 NM before making the turn back to the VOR. That is not what comes up in the database KONNA2 for runway 29. There are no NOTAMS about this database problem or are they listed in the 10-7 pages for MSO.

Report 4: Arrival Stacking Thales-Smith Rev 1+

FMGC failure triggered by attempting to go Direct to PRINO intersection. Condition prior to attempt to go direct was ILS runway 25L using SHAND as initial point on arrival. Pilot was unable to resolve "Stacking" using a direct SHAND or RNY 25L. All automation disconnected and ILS in visual conditions hand flown. When aircraft passed FAF all stacking cleared without any input from pilot.

Arrival Stacking Problem 4

Report 5:

Dual FMGC timeout or failure during initial flight operational training of First Officer.
Text provided by instructor.
MX found no “Failure and effected no repair.
Freeform_Description: During pre-descent phase, we obtained the KMEM ATIS and determined a visual approach to KMEM27 with ILS backup would be appropriate. As we attempted to select the ILS to runway 27 in the data base there where NO choices for an arrival (STAR) associated with this approach.
(Problem 1)
We determined we would leave the current STAR (Wilder Arrival) with the approach to runway 36R active so we could comply with our ATC clearances. Once we were given radar vectors, we would then select the ILS to 27 as a "stand alone" flight plan.
As predicted Memphis approach approved our request for runway 27 and gave us an initial heading of 210 for radar vectors to the final approach.
I then selected the ILS 27 on the arrivals page of the Thales-Smith FMGC. Upon making the temporary flight plan our active all indications appeared "normal". However, shortly thereafter we received the message "ILS/RWY MISMATCH" in the scratch pad of our MCDU.
(Problem 2)
I selected the RAD/NAV page and sure enough, the freq/ident and course of KMEM36R where depicted in small font. Additionally, the PFD ILS depiction indicated KMEM 36R. We waited several minutes thinking the FMS was slow to change frequencies. But after a sufficient amount of time I then "manually tuned" the ILS frequency for 27.
Upon returning to the FLT PLN page of my (Captains) MCDU I was no longer able to make any inputs to the MCDU it was “LOCKED UP”.
(Problem 3)
The first officer then made an attempt to make changes to his MCDU and it was also LOCKED UP!
(Problem4)
With BOTH MCDUs locked up, I attempted a reset of MCDU 1 since this is the only Circuit Breaker within the reach of my seat, however this reset was unsuccessful. Both MCDU remained locked up.
During all this, ATC assigned an approach speed of 170KTS until SOCIT (final approach fix). As we approached this fix, the F/O (PF) pushed for managed speed, but you guessed it. NO REACTION to his inputs on the FCU speed button. He finally manually selected the appropriate approach speed.
(Problem 5)
With both MCDU's locked up, no control over managed speed and approaching the final approach fix, the Autopilot then decides to disconnect with associated fail indications on the upper ECAM and Calvary charge oral warning.
(Problem 6)
First Officer completed the final approach segment manually and made a normal landing. Upon completing the parking checklist, a writeup was completed in the logbook.

Mx Writeup:
DURING DESCENT, CHANGED RUNWAY ON FMGC FROM 36R TO 27, FMGC WOULD NOT AUTOTUNE ILS RUNWAY. MESSAGE RUNWAY/ILS MISMATCH WAS
DISPLAYED, THEN BOTH MCDU'S LOCKED UP AND WOULD NOT TAKE ANY INPUTS. THE FCU (AIRSPEED) WOULD NOT RETURN TO MANAGE SPEED BY PUSHING IT. THEN AUTOPILOT DISCONNECTED ON ITS ON. ALL ABNORMALS APPEAR TO BE RELATED TO THE THALES-SMITH FMGC.

CORR BY AUG04 ATA 2283
PERFORMED AFS AND AFS LAND TEST AS PER AMM 22-96-00 AND 22-97-00. ALSO RESET FMGC1 AND FDMGC2 BEFORE BEGINNING TEST. - NEEDS LLM QUALIFIED (150525).Â PERFORMED LLM - CK GOOD 104405. A/C OK FOR SERVICE.

REPORT 6:

DEPARTURE STACKING:

No stacking was evident prior to Takeoff.

However, a runway change had occurred during taxi-out for Takeoff.

Report written by A320 Instructor Captain and A320 Captain who was jumpseat observer working on Thales-Smith FMGC issues.

Kanur Conundrum

Flight XXXX YUL-DTW Nov 2004 AC # XXXX REV1+ SOFTWARE

XCM observer and reporter: Dennis Landry A320 Captain

Thales- Smith problem Improper flight plan sequencing/ or cross loading?

Problem name: Departure Stacking- (KANUR intersection – YUL conundrum)

First flight of the day.

Captains additional description of preflight FMGC issues:

This was the first flight of the day. I believe it is important to mention that prior to loading the flight plan we also had the FO's FMGC "timeout" and 1FD1 on the FMA displayed. As per reset on 3.34 pulled and reset Circuit breaker M17. Reset appeared to be normal with 1FD2 on FMA, FO's MCDU able to select his own FMGC, and Map on ND was available.

During "wakeup/ initialization process FAC2 FAULT indicated. FAC2 was reset per the COM supplemental procedure.

Then a FMGC2 fault message appeared. Reset per the COM procedure.

After these resets were accomplished the Aircraft preflight was begun by the Captain. The INIT page alignment was accomplished for the gate location and both FMA's indicated 1FD2 with the ND displayed correctly. All appeared operational normal. The Captain began loading data into the MCDU per SOPA. After he had completed loading his flight information the Captain gave the flight plan to the FO who immediately observed a different flight plan in his MCDU. The Captain then went to the DATA pg and selected Status/Xload. At this point he observed a FM1/FM2 IDENTICAL message.

The Captain then re-loaded the flight plan. It still did not transfer to the FO's MCDU. The FO still had a different flight plan displayed. The FO's INIT page 1 and FLT PLN page were observed to be different.

Captains additional description of preflight FMGC issues:

. I can also add the FO's Flight plan page A on the **primary and secondary** flight plan just had the first fix YUL and then the subsequent fixes up to the start of the Spica arrival with the Aylmer (YQO) transition were missing.

However INIT page 2 was identical. So some communication between the "boxes" appeared to be occurring.

There were no scratch pad warnings or messages present on either Captain or FO's MCDU's.

The FO then entered the correct flight plan on his MCDU. He then loaded the winds for each fix. As the winds were entered the information transferred to the Captains MCDU. A complete review of both MCDU preflight actions was accomplished after the Captain and FO had completed the odd sequence of flight plan entries. All appeared correct.

The corrected active flight plan was recopied by both pilots " Just to be sure we got the right stuff" The secondary flight plan did indicate correctly.
YUL24L - YUL – J579- as filed.

Captains additional description of preflight FMGC issues:
Upon doing some more research on the the crossload/status page, I believe that the FMS1/FMS2 Identical message basically tells us that the part number (software) loaded in both FMGC's is identical . That being said however, one would think you would receive some kind of message such as Independent Operation or OPP FMGC in Process. There were no such messages.
The flight taxis to the exit point of the apron planning a runway 24L departure. The departure indicates a conventional Runway to Centerline fix and a discontinuity between the CL fix and YUL –KANUR intersection and subsequent J579 down line fixes.
Just as the flight approaches the runway 28 parallel taxiway they are issued a new runway for takeoff. Runway 28 is entered and it does appear to load correctly into the FO's MCDU flight plan page and is displayed on the ND correctly with a runway to CL fix and a discontinuity.
Now the fun begins::::::
Flight operations begin with a departure from Runway 28 with an initial climb to 5000 feet on runway heading.
As the aircraft is climbing thru approximately 3000 feet, instructions to contact departure control are received. After the flight checks in with departure control a turn to a heading of 295 degrees and intercept J579 is received. The flight turns to the heading and the proposed intercept appeasers on the ND as an amber dashed line between YUL and KANUR intersection with a discontinuity after KANUR intersection.
After KANUR intersection there is a white arc turn line appears to indicate the next action after KANUR intersection is a right turn back to YUL. For some reason the YUL – KANUR – V526 route has been replaced with YUL – KANUR then a return to YUL.

All of this creates quite a bit of confusion and a flurry of work on the part of the non-flying pilot (Captain) this high workload occurs while in IMC conditions and with traffic all over the place (YUL) is a rather busy airport at 0915 local time.
The solution was the Captain had to reload the flight plan. Cross talk functions appeared to operate normally during this reload.
The subsequent flight operated normally from this point until arrival.

Background information: The Captain was an A320 instructor and this was the first time he had seen this Thales-Smith abnormality.
All resets during the preflight and the MCDU behavior were written up.

PROBLEM 7: Thales-Smith alignment abnormality

This was a fairly quick COS turn. At the gate in COS a rapid align was performed as part of the usual preflight - the coords for Gate 10 were entered - it was only slightly different from where the airplane "thought" it was, so I only had to scroll up a fraction of a degree. About 5 mins prior to pushback the F/O was completing his flow and noticed on Init. page 1 that the airplane present position was off in both Lat and long by a considerable amount. The displayed Longitude was something like 93W instead of 104W and the Latitude was also off by a large margin. We double checked the displayed numbers versus the Gate position and it was literally in a different state.

Now it gets odder. The ND showed the airplane displaced just .7 NM from the departure runway (17L), and that was about what we expected. Stranger yet (at least for me), I decided to do another rapid align, and again entered the correct gate coordinates. The align lights went out almost instantly and the ND still showed the exact same position - .7NM displaced to the west of the departure runway.

It would appear that the airplane knew exactly where it was all the time but the coordinates displayed on the init page were something else entirely.
I didn't think to look at the lat/long for the 3 individual IRUs on the overhead.

Have you seen this before?