TRAINING FOR AUTOMATION AND THE ASSESSMENT OF MANUAL FLYING SKILLS

A Summary of Research Findings.

Summary of Research into training for highly automated aircraft and the assessment of manual flying skills.

1. Why was this work carried out?
2. What were the Objectives
3. What was done?
4. What was discovered?

5. Suggested actions to encourage implementation and to recommend to EASA for Regulatory Change .

Two Related Projects:

(1) Training for Automation and (2) Manual Flying Skills

Why was this work carried out?

- Anecdotal and accident/incident evidence that crews of highly automated aircraft are overly dependant upon the automation.
- When the automation is in control crews do not always fully monitor the aircraft's performance
- When problems arise crews sometimes respond inappropriately due to an incorrect diagnosis.
- Finally, when in that situation, their manual flying skills appeared to be degraded to the extent they had difficulty coping with the "raw" aircraft.

CAA - Flight Operations Research Centre of Excellence FORCE (2004 - 2008)

What were the Objectives

Training for Automation

- Develop a better training method for commercial pilots moving to highly automated aircraft.
- Apply this to an intake of students.
- Compare their performance with those coming off current courses.

Manual Flying Skills

- Develop a method for deducing the level of manual flying skills.
- Examine how flying skills vary with pilot background, hours and recent manual flying practice.

Training for Automation

Training for Automation
What was done?

A novel Type Rating course syllabus was constructed:

- Using modern teaching methods.
- Focussed on the sequence and type of knowledge required for operating automated aircraft.
- The syllabus was overlaid upon the time footprint of an existing Type Rating Course.

Detailed briefing material

- Was provided for both instructors and students.

A "Use of Automation Assessment" exercise was conducted

- To see if the students better monitored and handled the automation.
- To allow comparisons between products of the new and current courses.

Training for Automation

Standard Airbus Course

Day 1	Day 2	Day 3	Day 4	Day 5
Trainee's welcome (1:00) Welcome briefing (1:30) FCOM LPC (1:00) CRM (3:00) : - Cockpit philosophy - SOP's CBT introduction (1:00)	**CBT** (6:30) **MFTD A** (1:00)	**CBT** (6:30) **MFTD B** (1:00)	**Performances**	**Aircraft Systems** (Self study CBT) Electrical Flights Controls APU **MFTD 1** (4:00)
Day 6	**Day 7**	**Day 8**	**Day 9**	**Day 10**
Aircraft Systems (Self study CBT) Fire Protection Fuel Power Plant **MFTD 2** (4:00)	**Aircraft Systems** (Self study CBT) EIS-ECAM EIS-EFIS Navigation **MFTD 3** (4:00)	**Aircraft Systems** (Self study CBT) Air Conditioning Pressurization Hydraulic Pneumatic **MFTD 4** (4:00)	**Aircraft Systems** (Self study CBT) Communications Ice and Rain Landing Gear Doors **MFTD 5** (4:00)	**Aircraft Systems** (Self study CBT) Cabin presentation Lights Oxygen **MFTD 6** (4:00)
Day 11	**Day 12**	**Day 13**	**Day 14**	**Day 15**
Aircraft Systems (Self study CBT) EIS-ECAM EIS-EFIS Pneumatic APU Power Plant Fuel **MFTD 7** (4:00)	**Aircraft Systems** (Self study CBT) Electrical Hydraulic Flight Controls Navigation Doors **Cabin** (1:00) **MFTD 8** (4:00)	**Aircraft Systems** (Self study CBT) Air Conditioning Pressurization Ventilation Auto Flight Fire Protection Landing Gear **MFTD 9** (4:00)	**Aircraft Systems** (Self study CBT) Communications Cabin presentation Ice and Rain Oxygen Lights **MFTD 10** (4:00)	**Performance Test** **System test**
Day 16	**Day 17**	**Day 18**	**Day 19**	**Day 20**
Training **FFS 1** (4:00)	**Training** **FFS 2** (4:00)	**Training** **FFS 3** (4:00)	**Training** **FFS 4** (4:00)	**Training** **FFS 5** (4:00)
Day 21	**Day 22**	**Day 23**	**Day 24**	**Day 25**
Training **FFS 6** (4:00)	**Training** **FFS 7** (4:00)	**LOFT** **FFS** (4:00)	**Skill Test** **FFS** (4:00)	**Low visibility operations** (optional) **FFS**(3:00 or 4:00)

Third Party Trainer's Course

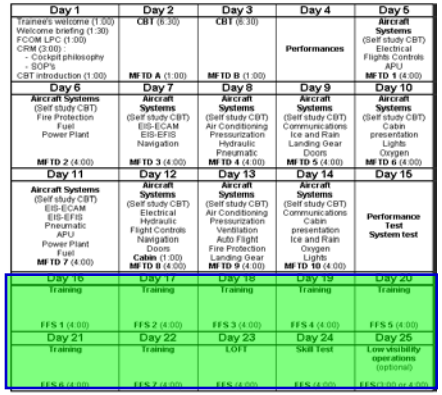
Day 1	Day 2	Day 3	Day 4	Day 5
Ground School	**Ground School**	**Ground School**	**Ground School**	**Ground School**
Welcome A/C Overview CBT: Indicating/ Recording Sys. G/S Time: 6:00 VFD Time 2:00	S.G. Review CBT: Power Plant, Communications Hydraulics G/S Time: 6:00 VFD Time 2:00	S.G. Review CBT: Flight Controls G/S Time: 6:00 VFD Time 2:00	S.G. Review CBT: Landing Gear, Fuel G/S Time: 6:00 VFD Time 2:00	Progress Test CBT: Electrics Pneumatics G/S Time: 6:00 VFD Time 2:00
Day 6	**Day 7**	**Day 8**	**Day 9**	**Day 10**
Ground School	**Ground School**	**Ground School**	**Ground School**	**Ground School**
S.G. Review CBT: Air Conditioning, Fire Prot. G/S Time: 6:00 VFD Time 2:00	S.G. Review CBT: Navigation Ice & Rain Prot. G/S Time: 6:00 VFD Time 2:00	Progress Test CBT: Autoflight G/S Time: 6:00 VFD Time 2:00	S.G. Review CBT: APU, Equipm't, Doors, Lights, Oxy, Water & Waste, G/S Time: 6:00 VFD Time 2:00	S.G. Review MEL CBT: Revision G/S Time: 6:00 VFD Time 2:00
Day 11	**Day 12**	**Day 13**	**Day 14**	**Day 15**
Ground School	**Ground School**	**CRM**	**Fixed Base Sim**	**Fixed Base Sim**
Final Exam: Part A Debrief. LVO's / VFD (1 Hr) CBT: Ground Servicing G/S Time: 8:00	Performance Load & Balance Final Exam. Debrief G/S Time: 8:00	CRM G/S Time: 8:00	Normal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30	Normal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30
Day 16	Day 17	Day 18	Day 19	Day 20
Fixed Base Sim	**Fixed Base Sim**	**Fixed Base Sim**	**Fixed Base Sim**	**Full Flight Sim**
Abnormal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30	Abnormal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30	Abnormal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30	Abnormal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30	Handling Phase Normal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30
Day 21	**Day 22**	**Day 23**	**Day 24**	**Day 25**
Full Flight Sim	**Full Flight Sim**	**Full Flight Sim**	**Full Flight Sim**	**Full Flight Sim**
Handling Phase Abnormal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30	Handling Phase Abnormal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30	Handling Phase Abnormal Operation Briefing; 1:30 Simulator: 4:00 Debrief: 0:30	Skills Test OPC Briefing; 1:30 Simulator: 4:00 Debrief: 0:30	Skills Test OPC LVO's / Pre-Base. Briefing; 1:30 Simulator: 4:00 Debrief: 0:30

Training for Automation

The New Training Course (FORCE)

Day 1	Day 2	Day 3	Day 4	Day 5
Introduction	Normal Procedures	Manual Flying	Manual Flying	Manual Flying
Welcome Brief Aircraft overview Indicating & recording Panel layout, scan patterns (PFD/ND)	Flight controls (Normal laws) Study Guide/Profiles	Flight controls (Degraded laws) Manual flight	Flight controls (Slat/Flap) Manual flight (OEI, Abnormal flight controls)	Manual flight (Abnormal configurations)
VFD 1	VFD 2	FFS 1	FFS 2	FFS 3
Day 6	**Day 7**	**Day 8**	**Day 9**	**Day 10**
Autoflight	Autopilot	FMS	FMS	Systems Training
Autoflight	Flight guidance (Autopilot/Autothrust) Autoflight procedures	Flight management (Introduction to lateral and vertical functions) FMS procedures	Flight management (Managing automation) FMS procedures (Progress check)	Navigation Ice/rain System procedures
VFD 3	FBS 1	FBS 2	FBS 3	VFD 4
Day 11	**Day 12**	**Day 13**	**Day 14**	**Day 15**
Systems Training	Systems Training	Systems Training	Systems Training	Systems Training
Review (Progress Test 1) Power plant Communications Hydraulics System procedures	Review Landing gear Fuel Systems procedures	Review Electrical Pneumatics System procedures	Review (Progress Test 2) Air Conditioning Fire System procedures	Review APU Doors, Equipment Lights, Oxygen Water / Waste MEL System procedures
VFD 5	VFD 6	VFD 7	VFD 8	VFD 9
Day 16	**Day 17**	**Day 18**	**Day 19**	**Day 20**
Ops Procedures	Ops Procs & Exam	Ops Procedures	Ops Procs & Exam	FMS
Revision Final exam Part A Examination Debrief	CRM	Cold weather procedures LVO Procedures	Performance Load & Bal Grnd Serv Final Exam Part B Examination Debrief FOVE	Managing automation
Classroom	Classroom	VFD 10	Classroom	FBS 4
Day 21	**Day 22**	**Day 23**	**Day 24**	**Day 25**
Abnormal Procedures	Abnormal Procedures	LOFT (Progress check)	LST	LST
FBS 5	FBS 6	FFS 4	FFS 5	FFS 6

Standard Airbus Course



Third Party Trainer's Course

Training for Automation

Typical events that were used in the Automation Assessment formed the following groups:

Prepare/Use of Automation To Ease Task

- Direct TO operation. (An ATC clearance to deviate from the airway and go directly to the named point.)

Select Correct Mode or Level of Automation For Task

- ATC gave speed constraint in the descent (280 kts or less) and then once in the descent ATC gave “Increase rate of descent”

Monitor Automation for Correct Mode

- Auto Thrust fails to engage at Thrust Reduction Altitude after Take-off

Monitor Automation for Correct Aircraft Performance

- On Go-around autopilot fails to pitch aircraft, all other indications normal

Training for Automation
What was discovered?

1. By exposing pilots to simulated malfunctions their level of understanding and awareness of automation can be assessed.
2. The new course produced an apparent improvement in the management of automation.
3. The rescheduled syllabus, with major changes in emphasis and limited instructor training time, produced issues in terms of resourcing and quality of presentation.
4. Pilots who had been through a Jet Orientation Course were noticeably more able than those who had not, irrespective of the course used.
5. The content and delivery of the training is driven by the Licence Skill Test drive rather than the need to train for today's operating environment.

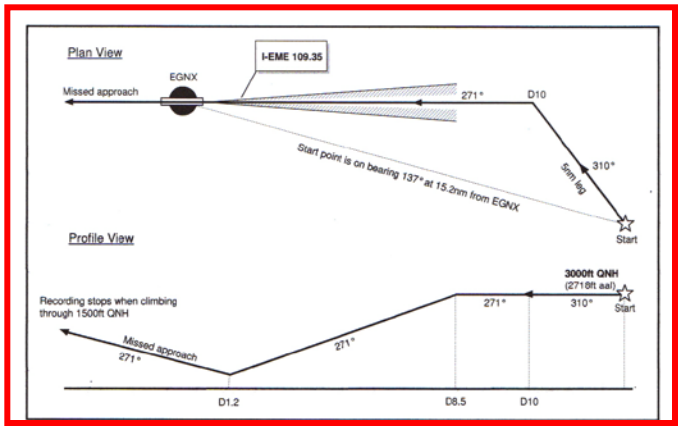
Suggested actions on ***Training for Automation***

1. Students should complete a familiarisation course before undertaking a type rating on their first highly automated aircraft.
2. The effectiveness of the current LST as a measure of readiness for line operations in highly automated aircraft should be reviewed.
3. Crews should be exposed to simulated malfunctions, in both initial and recurrent training, so as to:
    1. Hone their automation management and handling skills and
    2. Provide an assessment of those skills enabling targeted training.

Manual Flying Skills

Manual Flying Skills
What was done?

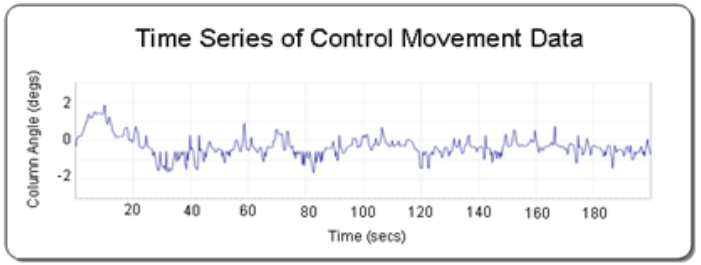
- A cognitive task analysis was conducted to understand the mental models used during manual flying.
- A method for discriminating between good and poor manual flying was developed and tested.
- Test data was obtained from a sample of 66 current airline pilots and used to compare how their manual flying skill measures related to their background and recent experience.

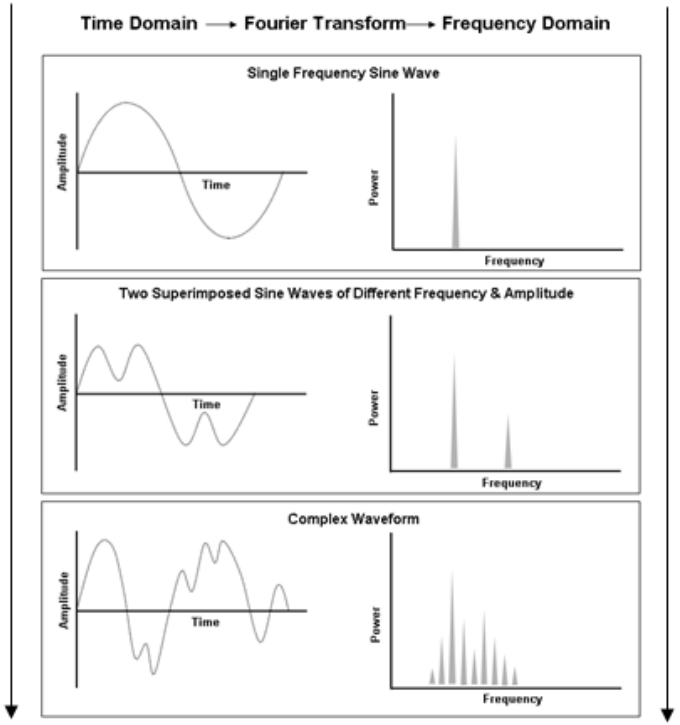


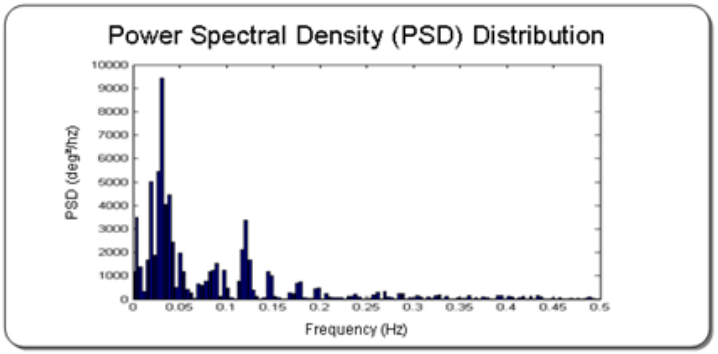
Manual Flying Skills

Methodology:

"The transposition of time series data into the frequency domain using a Fast Fourier Transform algorithm".



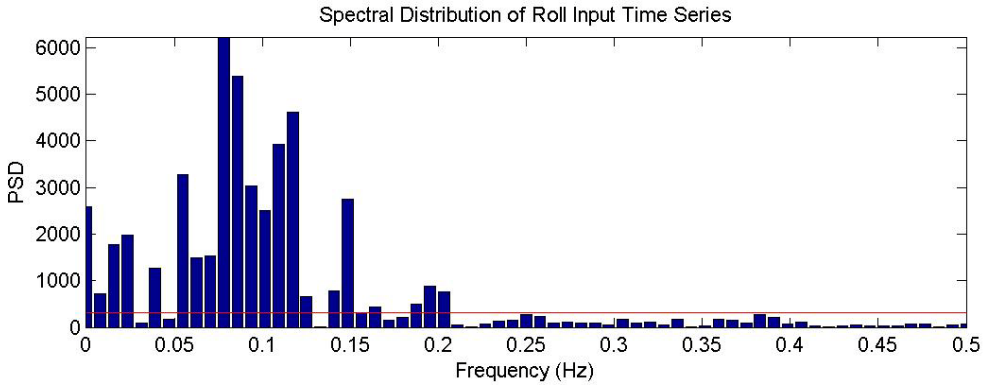




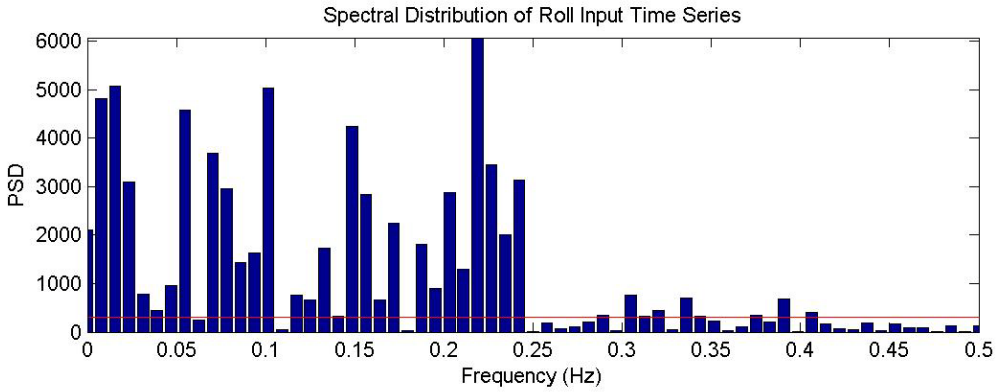
Manual Flying Skills

- The method successfully discriminated the different control input strategies of two performance groups

JOC Student



Instructor



Manual Flying Skills
What was discovered?

1. The cognitive task analysis lead to a better understanding of the mental models used during the manual flying of expert pilots.

2. New performance measures, based upon control input frequency analysis improved upon traditional “outer loop” measures which looked at aircraft displacement vs control inputs.

3. The manual flying skills of commercial pilots during a challenging flying task was evaluated and lead to some initial conclusions.

Manual Flying Skills
What was discovered?

4. A significant proportion were found to exhibit “less than ideal” manual flying performance, as confirmed by the assessment of a TRE.

5. Analysis showed that the performance was significantly influenced by the amount of recent manual flying experience rather than long term experience.

6. Importantly, airspeed tracking ability was strongly influenced and this is known to be a factor in many accidents.

7. The work indicates that manual flying skills may be maintained by recent practice.

Suggested actions on ***Manual Flying Skills***

1. **The underlying drivers of reducing manual flying skills should be studied** by tracking a group of individual pilots over a period of time to determine how environmental factors affect the skill level.

2. **Recommend the best way of obtaining recent manual flying skill experience** (Given substantiation of the initial results) taking into account (a) Low risk , (b) low cost and (c) high effectiveness.

3. **Once this skill enhancement is established the measurement methodology developed should be used** to (a) test the effectiveness of the training and (b) better target the training on weak areas or individuals.

Summary

Training for Automation

1. No one “Silver bullet” solution
2. Training for automation could be improved
3. A tool for assessing the understanding of automation was developed
4. The current testing environment requires review

Manual Flying Skills

1. A method was produced to distinguish between good and bad manual flying technique.
2. Application to current pilots showed a significant correlation between recency and good technique.
3. The methodology should be further developed to understand and then aid the development and maintenance of skill levels.

Points for Consideration

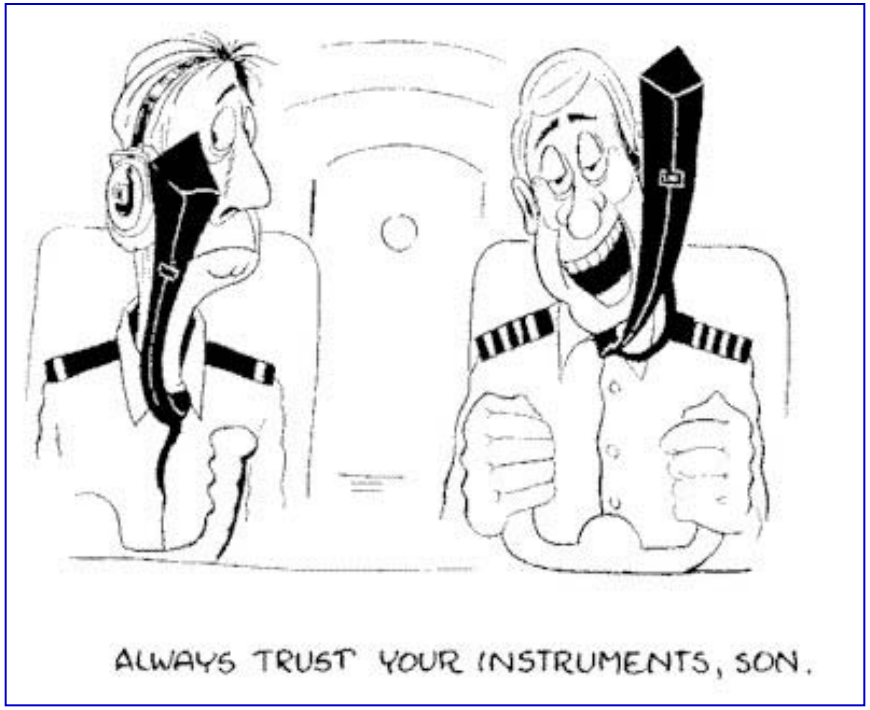
Training for Automation

1. Changes in training automation must not degrade other aspects.
2. Change in the operating environment needs to be paralleled by regulatory change in training.
3. ATQP may help direct training towards particular “hotspots” such as automation.

Manual Flying Skills

1. A risk assessment should be made before any increase in exposure to manual flying.
2. Manual flying skills are highly individual – should the assessment and training also be?

TRAINING FOR AUTOMATION AND THE ASSESSMENT OF MANUAL FLYING SKILLS



Thank you for your attention.

We would welcome your comments and questions