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NLR-TP-2016-100 | June 2018

Are Pilots in Control?

How do Pilots React to Unexpected Situations

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Netherlands Aerospace Centre

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EXECUTIVE SUMMARY

UNCLASSIFIED

Are Pilots in Control?

How do Pilots React to Unexpected Situations

REPORT NUMBER
NLR-TP-2016-100

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KNOWLEDGE AREA(S)
Training, Missiesimulatie en Operator Performance

DESCRIPTOR(S)
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Pilot Performance
Cockpit Technology
Experiments
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Problem area

Modern airliners are extremely safe, and automation clearly plays a very positive role in enhancing aviation safety and preventing accidents. However, there has recently been a steady rise in the number of incidents and accidents where the manual handling skills played a role. During the chain of events that leads to these accidents, the flight crew may be unable to sufficiently maintain control of the aircraft by not managing the aircraft systems effectively or applying appropriate manual operation skills. There is a question as to whether flight crew are sufficiently able to recognise a developing threat and respond effectively.

Description of work

The Man4Gen research project was initiated in 2012 under the European 7th Framework Program with the aim to investigate the processes used by flight crew to respond to an unexpected event. The Man4Gen team performed experiments to examine flight crew reactions to unexpected conditions that may contribute to the loss of control and Situation Awareness. These experiments concluded that improvements needed to take place in procedures, training and technology. A series of recommendations were developed in these three areas focusing on mitigation strategies and techniques to better manage unusual situations, training to prepare pilots for keeping or regaining control during unexpected events and cockpit modifications to increase SA. A second series of experiments were set up in two research simulators and two training simulators examining the effect of the developed recommendations.

Results and conclusions

The aim of the technique that was developed in the Man4Gen project was to support flight crews in handling unexpected situations. The form that this technique took in our experiment was a procedure that was briefly trained in the simulator, and provided to the crews in the form of a one page procedure card during the experiment. The analysis of how the flight crew applied the procedure demonstrates that a structured strategy is beneficial when faced with an unexpected situation in the flight. The flight crew that applied the technique that was given to them, and that followed the philosophy behind the procedure that was developed in the project, demonstrated better performance in handling the engine issues, and in assessing the route management related issues in the scenario.

Applicability

The experiments were carried out to investigate how flight crew can be prepared to respond to unexpected situations and what strategies were effective. The results of these experiments are being used to develop recommendations on the training for crews to handle abnormal and unexpected situations.

GENERAL NOTE
This report is based on a presentation held at the AIAA SciTech, San Diego, USA, January 2016.

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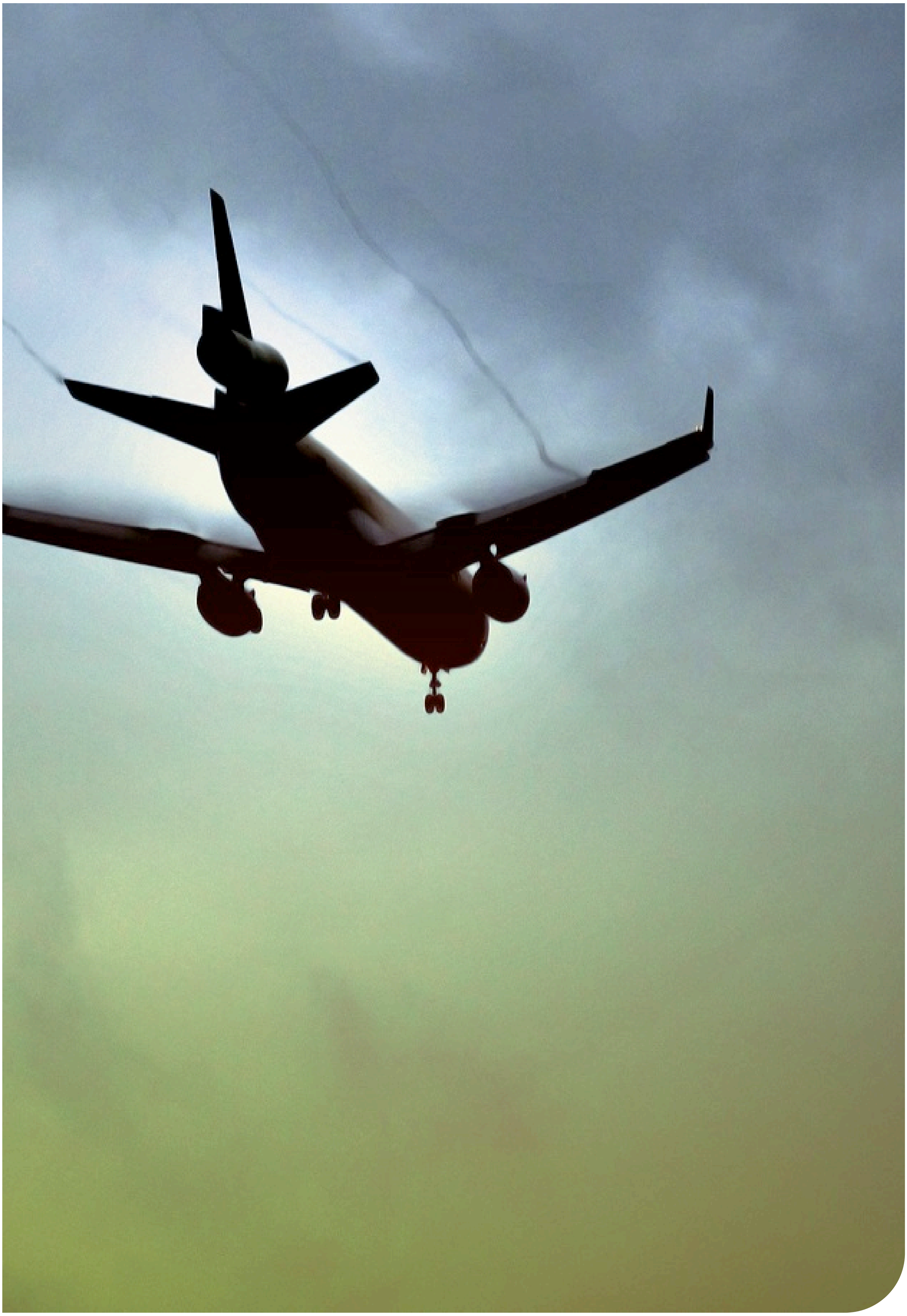
Summary

How flight crew respond to unexpected situations is an area of intense study at the moment. The European Man4Gen research project – Manual Operations for 4th Generation Airliners - has been investigating the strategies that pilots apply in unexpected situations and examining methods that might improve the pilots' ability to respond to these events. The aim of the project is to investigate the processes used by flight crew to respond to an unexpected or surprising event in modern airliners. This includes the decision making processes that are used, as well as the methods to assess the aircraft state in such an event.

The Man4Gen team performed experiments to examine flight crew reactions to unexpected and challenging conditions that may contribute to the loss of control and SA. The intention behind the experiment was to study the flight crew's decision making and risk assessment in response to a situation that they were unlikely to have encountered during routine training. This initial simulator study was used to identify the competencies that were desirable when the crew was faced with an unexpected situation. Researchers concluded that improvements needed to take place in procedures, training and technology after the experiments revealed several flaws in existing operations. A series of recommendations were developed in these three areas focusing on mitigation strategies and techniques to better manage unusual situations, training to prepare pilots for keeping or regaining control during unexpected events, and cockpit modifications to increase SA.

A second series of experiments were set up in two research simulators (the NLR GRACE, and the DLR AVES) and two training simulators (at two different Airline training centres in Europe and the Middle East) examining the effect of recommendations that arose from the conclusions of the initial study. The simulator experiments were focused on evaluating the application of training, procedures and system design solutions to improve the resilience of flight crew to unexpected situations. The two simulator experiments at training centres focused on the application of competency based training principles in simulator sessions. The NLR experiment and DLR experiments focused on the investigation of adjustments to procedures for abnormal situations, and improvements to cockpit displays, to assist flight crew in handling unexpected situations.

This paper discusses the outcome of these experiments at different simulator centres testing a procedural technique for abnormal situations that was developed in the project to provide flight crew with a structured response to an unexpected event.



Contents

Abbreviations

ACRONYM	DESCRIPTION
AIAA	American Institute of Aeronautics and Astronautics
ATC	Air Traffic Control
AVES	Air Vehicle Simulator
CSE	Cognitive Systems Engineering
DESIDE	Detect, Estimate, Set safety objectives, Identify, Do, Evaluate
DH	Decision Height
DLR	German Aerospace Centre
DNW	German-Dutch Wind tunnels
ECAM	Electronic Centralized Aircraft Monitor
DODAR	Diagnose, Options, Decide, Act, Review
ECOM	Extended Control Model
EICAS	Enigne Indications and Crew Alerting System
ENG	Engine
FMA	Flight Mode Annunciator
fMRI	Functional Magnetic Resonance Imaging
GRACE	Generic Research Aircraft Cockpit Environment
G/A	Go Around
HDG	Heading
IDT	International Development of Technology engineering
ILS	Instrument Landing System
Man4Gen	Manual Operations of 4th Generation Airliners
ND	Navigation Display
NLR	Netherlands Aerospace Centre
RW	Runway
R&D	Research and Development
SA	Situation(al) Awareness
SHOR	Stimuli, Hypothesis, Options, Response
SPD	Speed
THR	Thrust
TOGA	Take Off Go Around

1 Introduction

The modern aviation system has evolved into one of the safest modes of transportation, and the accident rates have been reduced to historically low levels, particularly for the latest generation of civil airliners. The most modern “4th generation” of airliners integrates highly reliable automated systems in the aircraft, including envelope protection and advanced flight controls. Highly automated 4th generation aircraft are increasingly common in civil aviation operations. However, there are still times when the flight crew are faced with an unexpected event, and must respond appropriately, including taking control of the aircraft manually. There is a question as to whether flight crew are sufficiently able to recognise a developing threat and respond effectively.

In 2012 the Man4Gen research project – Manual Operations for 4th Generation Airliners – was initiated and funded under the European 7th Framework Program. The Man4Gen project delivered its results at the end of 2015. The aim of the project was to investigate the processes used by flight crew to respond to an unexpected or surprising event in modern airliners. This includes the decision making processes that are used, as well as the methods to assess the aircraft state in such an event. One of the specific aspects that was also examined was the decision process associated with the transition from automated to manual control (Field & Lemmers, 2014). The research aim of the project is summarized in the following problem statement:

Despite the substantial and proven safety benefits of automation systems in 3rd and 4th generation aircraft, evidence indicates that when faced with unexpected and challenging situations, pilots sometimes have difficulties in quickly responding to situations which require a rapid transition in their activity from monitors of very reliable systems, to active and authoritative decision-makers exercising manual control of the aircraft.

The Man4Gen team performed experiments to examine flight crew reactions to unexpected and challenging conditions that may contribute to the loss of control and Situation Awareness (SA). The experiments took place in high-fidelity research flight simulators and in an fMRI setting to gain deeper understanding of the decision making processes of pilots. Within Man4Gen the crew’s actions and behaviour were investigated using Cognitive Systems Engineering (CSE) methods. The research focus was on understanding the ‘sensemaking’ processes taking place after an unexpected event. It used Hollnagel’s Extended Control Model (ECOM) to analyse crew-automation behaviour, and trace the sensemaking and perception-action processes taking place in the context of the cockpit (Field, Woltjer, Rankin & Mulder, 2015). The intention behind the experiment was to study the flight crew’s decision making and risk assessment in response to a situation that they were unlikely to have encountered during routine training.

An initial simulator study carried out in the project was used to identify the competencies that were desirable when the crew was faced with an unexpected situation (further explained in chapter 2). The desirable competencies identified by the analysis of crew responses to this scenario are: leadership & teamwork, communication and problem solving & decision making. We also found that high-performing crews used these competencies to recover most effectively from unexpected and challenging situations. Poor-performing crews, on the other hand, lacked these competencies and also showed some weaknesses in the application of procedures during low-workload situations.

Researchers concluded that improvements needed to take place in procedures, training and technology after the experiments revealed several flaws in existing operations. A series of recommendations were developed in these three areas focusing on mitigation strategies and techniques to better manage unusual situations, training to prepare pilots for keeping or regaining control during unexpected events, and cockpit modifications to increase SA. This is explained in more detail further in this report.

A second series of experiments were set up in two research simulators (the NLR GRACE, and the DLR AVES) and two training simulators (at two different airline training centres) examining the effect of the recommendations that arose from the conclusions of the initial study. The simulator experiments were focused on evaluating the application of training, procedures and system design solutions to improve the resilience of flight crew to unexpected situations. The two simulator experiments at training centres focused on the application of competency based training principles in simulator sessions. The NLR experiment and DLR experiments focused on the investigation of adjustments to procedures for abnormal situations, and improvements to cockpit displays, to assist flight crew in handling unexpected situations. The experiments and the final findings from the experiments are fully described in the final deliverables of the Man4Gen project (Man4Gen, 2016a; 2016b)[1]. This paper presents the findings from the procedural experiments carried out at the NLR simulator centre. The experiments were carried out to investigate how flight crew can be prepared to respond to unexpected situations, and what strategies were effective. The results of these experiments are being used to develop recommendations on the training for crews to handle abnormal and unexpected situations.

[1] The final project reports are available on the project consortium website: http://man4gen.eu/ or through contacting the authors.

2 Initial Exploratory Experiment

The initial experiments carried out in the project at NLR and DLR in 2014 were designed to create an operationally relevant situation for line pilots on the Boeing 747-400 (at NLR) and Airbus A320 (at DLR) that would include an unexpected event. The intention behind the experiment was to study the flight crew's decision making and risk assessment in response to a situation that they were unlikely to have encountered during routine training. The scenario was designed to include a number of events to address the specific aspects of the project problem statement including: reversion to manual control, a challenging, ambiguous situation and active and authoritative decision making. These scenario design principles were carried over into the recent final simulator study of the Man4Gen procedure.

2.1 Experimental Method

Two initial experiments were carried out, one at NLR, and one at DLR. The NLR "GRACE" research simulator was used for the experiment; the flight deck was set-up in a Boeing 747-400 configuration. The DLR "AVES" research simulator, with an Airbus A320 cockpit and simulation, was used for the DLR experiment.

The experiment at NLR was carried out with a total of 12 crews of line pilots, both captains and first officers – a total of 24 pilots. The experiment at DLR was carried out with a total of 8 crews of line pilots – a total of 16 pilots. All crew members were active line pilots or recently retired. Crews were unaware of the events in the scenario, and were instructed to treat the scenario as a normal operational flight.

The research simulators were set up to record data for the analysis of the flight crew's actions, decisions and behaviour, including simulator log data, audio and video recordings. At the end of the experimental scenario, the flight crew were debriefed by the project researchers. Recordings of the debriefings were transcribed, and contributed to the analysis. The crew's communication and actions were captured during the analysis by transcribing the video and audio recordings.

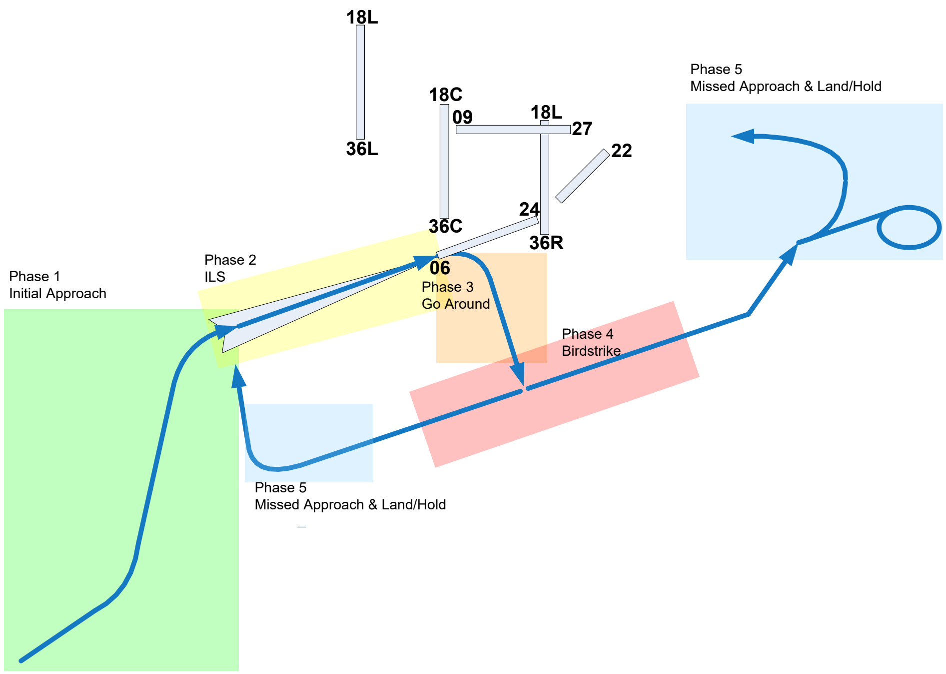
During the initial operational analysis of the experiments the instructor observer ratings were used to identify causes for the different crew behaviour. The idea behind this analysis is to look for patterns in the crews' decision making processes that explain the differences in their performance when compared against each other. Hence, the Airbus Pilot Assessment and Grading System was applied for which the instructor observers got special standardization training. This was done for ensuring a consistent rating between the individual observers of the DLR and NLR experiments. The rating system considers the following 9 core competencies:

- Application of Procedures
- Communication
- Aircraft Flight Path Management, Automation
- Aircraft Flight Path Management, Manual control
- Knowledge
- Leadership and Teamwork
- Problem Solving and Decision Making

- Situation Awareness
- Workload Management

2.2 Experimental Scenario

Except for the aircraft type and airports (Amsterdam and Frankfurt) the NLR and DLR scenarios were the same. The NLR scenario is described in five phases, illustrated in the Figure below.



1. *Initial Approach*

The weather conditions at Schiphol are acceptable – visibility is marginal Cat II conditions, due to a rain shower in the area of the active Runway 06.

2. *Instrument Landing System (ILS) Approach*

Once established on the ILS, the aircraft continues descent down the glideslope. As the aircraft descends, the visibility decreases, due to heavy rain. There is a change in the wind direction and strength during the descent, from 15 knots cross to almost a straight tail wind with 30 knots. The effect of the wind change is to destabilise the aircraft speed, and destabilise the approach. The destabilisation is not major but might lead to some crews deciding on a Go-Around (G/A). If the aircraft descends further, visibility decreases such that at the Decision Height (DH) of 200 ft, the Runway (RW) is not visible. Since the RW is not visible at the DH, a G/A is executed.

3. *Go-Around*

The G/A is executed following the standard missed approach procedure. Shortly after calling G/A to Air Traffic Control (ATC), ATC informs of a non-standard missed approach, and command a heading of 150 (90 off the RW Heading HDG). If the mode control panel HDG is used to command the change in HDG, on autopilot, the autopilot HDG select mode fails (without warning annunciation), such that the aircraft maintains the current (RW) HDG. The HDG can be selected, the HDG bug on the Navigation Display (ND) turns, only the Flight Mode Annunciator (FMA) does not change from Take Off Go Around (TOGA) to HDG select. This is the only (minor) cue that the autopilot will not respond to HDG select commands from the mode control panel.

4. *Birdstrike*
After approximately one minute on HDG 150 ATC commands a HDG (approximately) north. During or just after this turn a flock of large birds is encountered resulting in a bird strike. Engines 1, 3 and 4 are affected. The resulting state of the engines is such that engine 1 has to be shut down or flames out, and engines 3 and 4 cause multiple vibrations if operated at full power. At 40-50% thrust on engines 3 and 4, the vibrations cease. There are no further direct control difficulties due to the birdstrike, and with engine 2 operating normally the thrust is still relatively symmetrical. This leads to a situation in which the (future) reliability of the aircraft is questionable but the aircraft is under control.

5. *Missed Approach & Landing/Hold*
After the birdstrike, the crew are able to assess options for the flight and either elect to land immediately (visibility is good, wind is favourable for multiple RWs, or proceed to hold and perform checks and/procedures. The visibility is improving, and was located at the southern end of Schiphol, around the 06 threshold. The wind is returning to the original strength and direction as the aircraft climbs above the inversion. The visibility is such that other Schiphol RWs are visible. If the information is requested (or if that is a standard procedure when an aircraft calls a mayday (which we expect most crews to do) ATC informs RWs 18R, 18C and 27 are available for approach and landing.

2.3 Results of initial experiment

During the scenarios, one the most poignant observations was that many crews considered landing as soon as possible as their highest priority almost immediately. Although all crews managed to get the aircraft on the ground, some crews exposed themselves to unnecessary risks or exceeded safety margins during the second approach and landing. For example, more than half of the crews returned to the original RW 06, even though they performed a G/A due to weather difficulties on that RW two minutes before. While some crews did show limited consideration of possible threats, not a single crew performed a sufficiently thorough threat assessment. The poor quality of subsequent decisions and actions is a direct result of this limited level of awareness that crews experience in such unexpected situations. Specifically, there were several cases in which crews applied the incorrect procedure when responding to the engine problems and other times when they missed particular preparation steps for their second approach. Indirect issues pertain more to the overall behaviour and cognitive state of the crew. There were crews which exhibited much higher stress states and were more task saturated resulting in rushed solutions and reduced diligence in their assessment. On the other hand there were crews which created time to diagnose their situation and prepare their second approach. Lastly, these two effects – a higher stress state and taking the time to develop an approach plan – interrelate and also contribute to crews locking into a particular course of action (for example a poor plan for a rushed second approach) and fail to step back and gain a different perspective on their plan.

3 Development of Procedure

In light of the above observations, it would seem that there are three main problem aspects that may be captured by providing flight crew with a technique for unexpected situations. This technique could be applied in unexpected situations, where the situation is ambiguous and there is no clear existing procedure or action. The first problem is a lack of threat assessment. Crews, often experiencing a high level of temporal stress, expedite decisions and actions without preceding these with a sufficient analysis of the situation at hand, especially with respect to understanding the critical short term and long term threats. The second problem is a lack of process review. Crews apparently seem to lock in on a plan (often the checklist or the procedure on the crew information display (e.g. ECAM, EICAS), which in some cases is insufficient) and fail to check if their plan should actually follow from the information cues available (especially if these cues are changing). The third problem aspect is the failure to comprehend what they intend to achieve with their choice of action. Essentially, this boils down to missing a step in clarifying the intended goal of a procedure or series of actions. Admittedly all three problems are intertwined to some extent, and may share a common solution.

To assist crews a procedure has been designed to manage those unexpected, complex and diffuse/ambiguous situations where conventional training and published procedures may be insufficient by the project team at NLR and IDT. The procedure serves as a decision making tool or a strategy assisting crews in these situations. The term strategy is used explicitly, as the procedure must not allude to a strict checklist or do-list. Rather it must support a crew's cognitive flexibility, judgement and airmanship to properly assess and manage a complex and ambiguous situation. It must not, however, be so high-level that it becomes too unclear what is meant (this is the risk that a basic mnemonic design has, e.g. DESIDE[2], DODAR [3]or SHOR[4]).

This procedure is designed to limit the cognitive load on crews at the start (in consideration of stress and emotional responses), but increase cognitive demands as cognitive capacity becomes available by reducing the sense of criticality and temporal (time) pressure. In other words, it aims for the right balance between cognitive workload and cognitive capacity. The strategy encompasses three philosophy concepts:

1) **Manage time criticality**, to ensure an accurate assessment of available time
2) **Manage (un)certainty**, to focus on those factors that have consequences for flight safety and those factors that might mitigate those
3) **Plan for contingencies and changes**, to …

Similar to the purposeful order of the above concepts, the procedure itself is structured into six phases, mentioned below. These phases are designed to be performed in order but, as mentioned before, the procedure is a strategy, and not a strict do-list: deviation is permitted as crews deem fit. In addition, subsequent changes in the situation (e.g. the emergence of a new event, or the effects of some actions) may warrant re-initiating (part of) the procedure. Depending on the nature of the changes, crews may

[2] DESIDE – Detect, Estimate, Set safety objectives, Identify, Do, Evaluate
[3] DODAR – Diagnose, Options, Decide, Act, Review
[4] Stimuli, Hypothesis, Options, Response

for example require re-stabilisation with Phases 1 or 2, or may only re-consider planning at Phase 3, or only restart troubleshooting at Phases 4 or 5.

Phase 1: Stabilise Flightpath
Phase 2: Manage Immediate Threats
Phase 3: Short Term Planning
Phase 4: Identify Situation
Phase 5: Perform Appropriate Actions
Phase 6: Long Term Planning

Each phase consists of three to five action points. Phase four is presented as an example. This phase has been selected because it involves two of the philosophy concepts: manage (un)certainty and plan for contingencies.

IDENTIFY SITUATION

- **ACKNOWLEDGE CERTAINTIES, UNCERTAINTIES AND CONCERNS**
  Issues to consider: fuel or time limit? Structure integrity? Controllability/performance? Information reliability? Secondary failures? External complication factors such as weather, traffic and routing/destination?
- **CROSS-CHECK SUSPECTED SITUATION**
- **IF SEVERAL POSSIBILITIES: PREPARE FOR WORST CASE**

In Phase 4 the crew is tasked with ensuring a sufficient awareness of the nature of the situation (both failures and context), before proceeding to verify and perform appropriate actions in Phase 5. Usually in basic, single failure cases, the failure or situation may be non-complex and the process of problem identification is concise and intuitive. However, in the context of complex and ambiguous situations, familiar and rapid responses may be less effective or even detrimental, and may contribute to undesirable states and a (further) loss of SA. In these situations it is particularly important to be aware whether the situation may be different than initially assumed or expected, and in which ways. In unclear situations, this phase may assist crews with steps geared to setting up a mental model of the situation at hand, which will support Phase 5 in determining what actions and procedures are most likely to be suitable/effective/safe given the situation.

4 Simulator Experiment

In order to test the application of the procedure, a simulator experiment was set up at the NLR centre in Amsterdam using the GRACE simulator in an Airbus A330 configuration. The experiment was designed to put crews in an unexpected situation where risk assessment and decision making were required. The aim was to observe if the new developed procedure helped the crew to deal with the unexpected situation.

4.1 Experimental Method

The participants in the experiment were qualified, type rated airline pilots, and each experiment session used a complete crew of two pilots – a Captain and First Officer. The flight crews were volunteers, with current experience on the A330. A total of nine crews participated in the experiment, 18 participants. The crews were all taken from one airline. The crews were split into two groups: a baseline group that simply carried out the flights and responded to the scenarios using their standard training and procedures, and an experimental group that were trained in the procedure, and encouraged to use the procedure in the experimental scenario. All the crews were provided with the normal operations checklists for the aircraft that applied to the scenario (descent, approach and landing). Crew members brought their own (electronic) checklists for non-normal scenarios for use in the cockpit. Crews were asked to conduct the pre-flight briefing using their company procedures. The briefing materials included weather forecasts for the Schiphol area. The crews were unaware of the forthcoming events in the scenario, and were instructed to treat the scenario as a normal operational flight.

Pilots in the experimental group were prepared for the use of the procedure by a short training program. The procedure training consisted of three segments. First, the pilots received information about the procedure including an explanation of the philosophy behind the procedure. Second, the pilots applied the procedure to a case study, in a semi-guided discussion. Third, the pilots applied the procedure independently in a training scenario in the simulator. The training flight including the briefing took place after the simulator familiarization flight. The pilots in the baseline group only carried out the familiarization flight.

The performance of the crew in handling the situation was evaluated using a performance checklist method. The actions that the crew undertook were evaluated relative to the associated risk, relative to the expected actions that would be taken by an operational crew. The expected performance was defined by a pool of experts, including test pilots and pilots from the airline taking part in the experiment. In the examination of the results, the analysis focused in on the actions that pilots took to manage the failure of engine 1 (ENG1), and in the decisions and actions carried out in relation to the route management after the decision to divert.

4.2 Experimental Scenario

The experimental scenario started with a departure from the crew's home base. After eight minutes from TO the oil temperature rises. Some minutes later an Electronic Centralized Aircraft Monitor (ECAM) advisory arises about the oil temperature, shortly thereafter the warning 'ENG2 OIL HI TEMP' pops-up. Two minutes after the advisory the plane is hit by a lightning strike, which gives a big bang. Due to the lightning strike, a problem arises with the control of engine 1. Auto thrust disengages and the ECAM warning 'THRUST LOCK' and 'ENG 1 THR LEVER FAULT' will appear. As a result of this failure, auto thrust only works in thrust mode (disables in speed/Mach mode). If crews simply re-engage auto thrust, they will not detect the engine 1 thrust lever fault. However, this failure will occur later at level off when the crews will reduce thrust manually.

The aircraft has thrust asymmetry during manual flight, as the engine 1 throttle lever is inoperative. However, with auto thrust on, symmetric thrust management is available. Engine 2 is made unreliable by a near-threshold oil temperature. Thrust variations affect the temperature, which may trigger a more serious OIL HI TEMP warning, but unloading the GEN2 and IDG2 has a very positive effect on the oil temp. Because engine 2 is unreliable, and N-1 presents risks in this weather, the crew is challenged in disabling the troublesome engine 1. The auto thrust operates normally in thrust mode, but disengages when SPD/MACH MODE is selected. The alternate airports are more or less equidistant and have a preferable weather situation. However, they are subprime with respect to company considerations.

5 Results

The performance of the crews that were in the baseline group, and the performance of the crews that performed poorly using the experimental procedure was similar. There was a significant difference ($p<.001$) between the crews that performed poorly, and the crews that performed well within the experimental group when examining the within group analysis of the performance in the route management. Similarly, there was a positive trend in the difference between the highly performing crews, and the crews that performed poorly on the engine 1 management, while this was not a significant difference.

Referring to the route management performance measures, the results indicated that better performing crews exhibited more sequenced (e.g. from phase 1, to phase 2, 3, etc.) and looped (e.g. from phase 4 to phase 5, shortly back to 4 and back to 5) procedure patterns. In addition, they exhibited less return to time management (a significant difference). ENG1 management results showed a similar trend, although the differences between good and poor performing crews were nearly negligible (average difference 1%). The combination analysis reinforces the conclusion that better performing crews use the procedure in the intended sequence, and refrain from returning to time management. Apparently good and poor performing crews skip uncertainty management similarly.

The route management performance metric suggested that better performing crews spend less time on phase 1 and more on phase 3. In addition, compared to poorer performing crews they exhibited a significantly smaller proportion of their time on phase 1, and a significantly larger proportion of their time on phase 3. The ENG1 management performance metric showed weaker differences, but also indicated that better performing crews spend less time on time and uncertainty management, and more time on contingency management, both in an absolute and relative sense. The combined metric of route management and ENG1 management reinforces the conclusion that better performing crews spend less time on time management, and more time on contingency management. Crews do not differ in the amount of time spend on uncertainty management. A possible explanation for this result could be that promptly addressing time management issues and spending more time on consciously assessing the effects of the situation and taking action improves performance.

6 Discussion and Conclusions

The aim of the procedure that was developed in the Man4Gen project was to support flight crews in handling unexpected situations, especially those situations for which there was no existing clear procedure or strategy. The concept that was being explored was whether or not the strategy that was applied by the more successful crews in the initial experiments in the project could be captured in such a form that it could be used by other flight crew. The form that this procedure took in the NLR experiment was a procedure that was briefly trained in the simulator, and provided to the crews in the form of a one page procedure card during the experiment.

The analysis of how the flight crew applied the procedure in the simulator experiment demonstrates that a structured strategy is beneficial when faced with an unexpected situation in the flight. The flight crew that applied the technique that was given to them in the form of the Man4Gen procedure demonstrated better performance in handling the engine issues, and in assessing the route management related issues in the scenario.

Both from the perspective of the actual procedure, and in the more general sense of the philosophy that was being applied in the experiment, the outcome of the experiment suggests that a structured, and sequential, strategy enables the crew to stabilise the situation more quickly, and thereby gives them more time to examine contingencies to handle the situation. The key phases of the strategy that most affected the performance of the crews were the actions that related to time management, and the time that was available for contingency management. The “uncertainty management” phase interestingly enough was the challenging phase to examine in the results of the experiment. A potential explanation for this is that the way of assessing the situation – identifying certainties and uncertainties – is less familiar to the crews, and was not addressed sufficiently in the short training program to be able to implement it in the experimental scenario.

It is fair to say that the results of the experiment are but an indication given the limited nature of the experiment. The number of crews, and the limited nature of the experimental scenario, are both factors that should be taken into account. That being said however, the results are an interesting indication of how a successful strategy for handling unexpected situations could be developed and trained. The authors are aware that an additional procedure in an already highly proceduralised cockpit may not be welcome, and the philosophy behind this procedure, or technique, is at a higher level than the many existing failure management procedures. The technique that was examined is designed to be applicable in a variety of different scenarios, and as such simply prompts the crew to “consider…” and to apply a basic decision making strategy to enable a structured response to the event.

When considering how to prepare pilots to react to unexpected situations, it is interesting to examine the role that mental preparation can play. Taking the results of the above described studies in the Man4Gen project there are a number of potentially interesting aspects that could be investigated further. While it was not explicitly measured, it was observed that the crews that created time through applying a structured decision making process, also tended to spend more time on contingency management, thus being able to identify potential risks for the remainder of the flight. It could be argued that by creating a mental plan for the management of potential risks, the level of expectation of the risks or threats occurring is increased. This in turn could decrease the potential of surprise or startle in an unexpected situation.

One of the key questions in the Man4Gen project has been how to assist flight crew in handling unexpected situations, and what would be required to help them to react effectively in an unexpected situation. The procedure that has been developed in the Man4Gen project can play a role in the training of flight crew in a decision making strategy. The steps that are included in the project may already be familiar to pilots, instructors, operators, manufacturers and regulators. There are already several different decision making, or risk assessment, strategies that are applied by airlines in their initial training, in command courses, or in specific recurrent training exercises. The results of our project suggest that training a decision making strategy, for example by using the procedure that was demonstrated in the NLR experiment, would be a beneficial addition to pilot training. This could form the basis for how pilots assess situations, and how they respond; thus helping them to remain in control, and helping them to respond effectively and appropriately to unexpected situations.

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