EASA Automation Policy: Bridging Design and Training Principles

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1. Introduction

The EASA Automation Policy[1] adopts an innovative approach consisting of mapping crew-automation interaction issues, design and certification and training principles, and respective regulatory provisions to identify top challenges and paths for improvement. It was developed by the EASA Internal Group on Personnel Training (IGPT)[2], set-up by Agency to follow-up the EASA International Conference on Pilot Training of Nov 2009[3].

Modern aircraft are increasingly reliant on automation for safe and efficient operations, whether commercially operated or not. Automation has brought significant advantages for flight safety and operations and is required for certain types of operations and for precision navigation. Automation can however cause problems for instance to senior pilots who may be less comfortable with automation while the new generation of pilots may lack basic flying skills when the automation disconnects or fails or when there is a need to revert to a lower automation level, including hand flying the aircraft.

Development and promotion of an EASA Automation Policy are actions of the European Aviation Safety plan (EASp), Editions 2011-2014 and 2012-2015, Section Next Generation of Aviation Professionals.[4]

The EASA Automation Policy was first presented in the EASA Conference “Staying in Control – Loss of Control (LoC) Prevention and Recovery” of 4-5 Oct 2011 in Cologne, Germany, and subsequently is other international events.

[1] Contact: Dr Michel A. Masson, PhD (michel.masson@easa.europa.eu), Safety Action Coordinator, Safety Analysis Department, Executive Directorate, EASA.

[2] The Internal Group on Personnel Training (IGPT) bridges design, certification, training, and operations aspects in an EASA internal forum focusing on training. The IGPT is composed of experts from all operational Directorates and adopts a total system approach in training based on the three pillars Rulemaking, Oversight and Safety Promotion. The IGPT addresses all types of training and checking for all types of personnel and operations. Regarding pilot training, this includes flight and type rating training, including both ab initio and recurrent elements, all categories of aircraft, all types of operations, and pilots with different backgrounds (e.g. those trained on highly automated glass cockpits aircraft and those pilots trained on older generation conventional aircraft).

[3] http://www.easa.europa.eu/events/

[4] Updated on a yearly basis, the EASp is published at http://www.easa.europa.eu/sms/.

2. Automation Advantages

The following non-exhaustive list[5] summarises the main advantages of automation:

- Progress in flight safety:
    - Overall safety improvement from aircraft generation to generation, usually with poor introduction rate that improves over time.
    - Former generation aircraft are ageing and are operated by smaller companies, in less safety mature regions (e.g. Africa).
    - New generation aircraft fly in better operational environments, with better trained pilots, better ATM, navigation systems, weather services, etc.
    - Envelope protection provides additional safeguards.
    - Certification regulation has evolved: CSs and AMCs 25.1302 and 25.1329.
    - Next revolution with SESAR and NextGen (data link, self-separation, Sense and Avoid, SWIM, Performance Based Navigation, 4D trajectories, etc.) introduce new design and training challenges.
- Technical reliability: computer technology is more reliable than mechanical technology. It is light and cheap and can be used to increase redundancy.
- Advances in engine control technology and improved vertical and lateral navigation accuracy.
- Allows control of unstable aircraft or attitudes (e.g. centre of gravity moved backwards) and is used to improve aerodynamic performance and lower fuel consumption.
- Increases passenger comfort.
- Family concept based on similarity of cockpit design and flight dynamics facilitates type transition.
- Improved flight path control, reduced weather minima, allows decommissioning of land-based navigation aids.
- EFIS and map displays enhance navigation awareness.
- Systems monitoring displays coupled with diagnostic assistance systems (ECAM/EICAS) have enhanced pilots' and maintenance staff's understanding of aircraft system states.
- Automation relieves pilots from repetitive or not rewarding actions and from actions that humans are less suited to.
- Automation globally reduces workload, free attentional resources and reinforces the gratifying parts of pilots' job such as decision making.

Automation however presents a certain number of challenges.

3. Automation Challenges, Assessment and Mitigation

The approach taken to develop this Automation Policy consists of the following steps:

1. Identify and group crew-automation interaction challenges
2. Bridge design and training principles
3. Prioritise issues
4. Assess risk mitigations in regulatory provisions
5. Identify paths for improvement

Step 1 – Identify crew-automation interaction challenges

Crew-automation interaction challenges were identified from expert opinions and from existing sources, including:

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[5] Adapted from Briefings 2000, Dédale and IFSA, Eds. R. Amalberti, M. Masson, A. Merritt and J. Pariès, Chapter 9 Cockpit Automation.

- Billings C.E. (1997). Aviation Automation – The Search for a Human-Centred Approach/. Lawrence Erlbaum Associates, Mahwah, New York.
- Briefings 2000, Dédale and IFSA, R. Amalberti, M. Masson, A. Merritt and J. Pariès Eds, Chapter 9 Cockpit Automation.
- Chidester T. (1999). Introducing FMS aircraft into airline operations. In S. Decker and E. Hollnagel (Eds), Coping with Computers in the Cockpit, Ashgate, Aldershot, UK.
- EASA SIB No 2010-33,Flight Deck Automation Policy - Mode Awareness and Energy State Management, issued 18 Nov 2012.
- FAA HF Team Report The Interfaces Between Flightcrews and Modern Flight Deck Systems, 1996.
- CAST Safety Enhancement 30 Revision-5, August 2008: Mode Awareness and Energy State Management Aspects of Flight Deck Automation, Final Report.
- Flight Safety Digest (special issue): Transition to Glass: Pilot Training for High-technology Transport Aircraft .Advanced-technology Aircraft Safety Survey Report Flight Safety Foundation, 1996.
- Flight Deck Automation Issues website, Accident Evidence and Incident Evidence (up to 1997) www.flightdeckautomation.com.
- ICAO Training Report, Vol. 1, No1 – July/August 2011. The challenges of Continuous Modernization. Addressing looming skilled personnel shortages and the need for industry-wide technology upgrades.

Several references provide analysis and recommendations based on the results of accident or incident investigations, surveys, review of literature, or manufacturer philosophies and policies.

More than 100 flight crew-automation interaction issues were identified and then and grouped into the 17 themes (not prioritised) listed below:

1. Authority and control
2. Monitoring and intent recognition
3. Managing the automation versus flying the aircraft
4. Simplicity of operation
5. Aircraft types, variants, and (lack of) standardisation
6. Special equipment
7. Transformation of pilots' role
8. Flight crew co-ordination and communication
9. Situation Awareness, mode awareness, failure detection and management
10. Complacency, over-reliance on automation, decision making
11. Workload management
12. Error Management
13. Information processing, integration and formatting
14. Diagnostic and troubleshooting
15. Alarm management
16. Programming and related issues (for example of the FMS)
17. Database related issues

Step 2 - Bridge Design and Training Principles

For each issue, the following questions were asked:

- How could this issue be (further) mitigated by design?
- How could it be (further) mitigated by training?

This combined approach allowed identifying Design Principles and Training Principles suitable for improving flight crew-automation interaction.

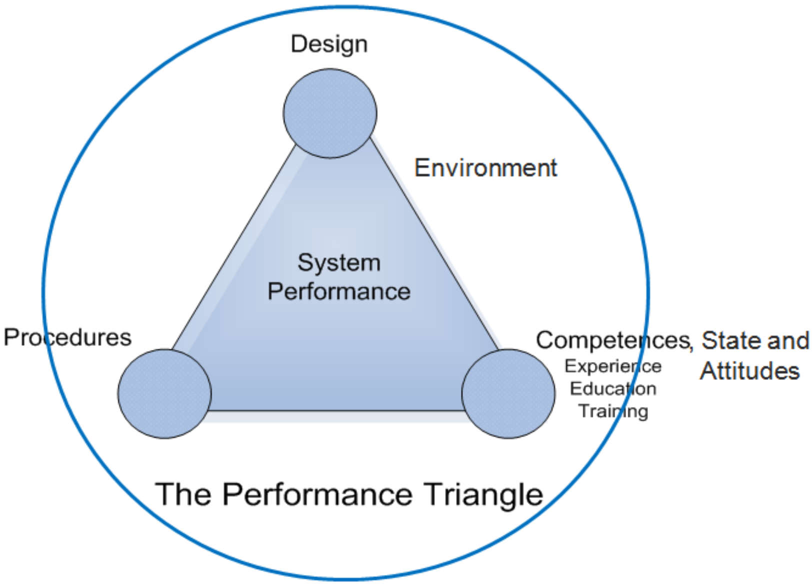
Guidelines on the use of automation developed by the manufacturers[6] provide principles formulated in the form of competences that pilots must have to best use automation, for instance "Select the appropriate automation level for the task and situation at hand". To make the link with training, competences are to be considered as training objectives: "Pilots must be able to select the appropriate level of automation". This competence then needs to be practiced and consolidated operationally.

The corresponding design objective would be "Allow / advise on selection of automation level(s) appropriate for the task and situation at hand". See the table below.

Design and Certification objective *The System should:*	**Training objective** *The Flight Crew should:*
Allow selection of / advise on automation level(s) appropriate for the task and situation at hand.	Select an appropriate automation level for the task and situation at hand.
Provide information on selected automation level.	Check/monitor selected automation level.

The approach also includes *bridging principles* classically addressed by different communities and enshrined in different types of regulations: Certification Specifications (CS) on the design side and Flight Crew licensing (FCL) and Operations (OPS) regulations for the training aspects.

The interrelation between Design and Training is illustrated by the basic Performance Model [7] shown below:



Performance of a Man-Machine System basically depends on Design, Procedures, and Competences, which result from Education, Training, and Experience, and on the Environment. The physiological and psychological state of the actor(s), for instance stress, fatigue, etc., attitudes, interest and involvement in the task also play a role. The model illustrates that good (simple, intuitive, user-friendly) design requires less competences and/or procedural guidance (instructions) to be operated, and conversely that poor design requires

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6 For instance Flight Operations Briefing Notes "Standard Operating Procedures Optimum Use of Automation" by Airbus.

7 M. Masson, 2011, 2012. See the References section.

more guidance and/or competences from the user. The model also shows that pointing the finger at only one element of the system in case of performance breakdown is reductive and that overall system performance can by enhanced by improving any of these three basic components, individually or in combination.

Step 3 – Risk Assessment

Every flight crew-automation issue was risk assessed.

Risk Assessment was based on expert judgement and made use of the following simple risk classification matrix:

Importance	Evolution Reduction	Steady (No marked effect)	Increase
3			
2			
1			

Risk assessment thus combined importance of the issue and foreseen evolution.

<u>Example</u>: Inadvertent selection of mode or data input error (either mistake or typing error) can result in loss of mode awareness and/or unanticipated mode reversion. May lead to by Loss of Control (LoC) and Controlled Flight Into Terrain (CFIT) accidents.
Risk level: yellow = 2 (Importance 2, Evolution 2).

Accident and incident information was used as background for the risk allocation exercise. The following sources have been considered:

- FAA HF Team Report 1996, Appendix D: Examples of Incidents and Accidents Involving the Flightcrew-Automation Interface.
- CAST Safety Enhancement 30 Report 2008, Appendix C: Narratives to 50 ASRS Pilot Reports Analyzed in Detail.
- Flight Deck Automation Issues website, Accident Evidence and Incident Evidence (up to 1997) www.flightdeckautomation.com.
- Billings C. (1997). Aviation Automation. The Search for a Human-Centered Approach. Lawrence Erlbaum Associates. Mahwah, New Jersey. Appendix A: Aircraft Accidents and Incidents.

Step 4 - Assess Risk Mitigations provided by Regulatory Provisions

Regulatory provisions were reviewed, which includes the following references (not an exhaustive list):

- Design & Certification: CS and AMC 25.1302, EASA Rulemaking task CS Flight Crew.
- FCL: JAR-FCL 1.235, FCL 725.A et al., JAR-FCL 1.261 et al, Learning Objectives, EASA Rulemaking task FCL.002, etc.
- OPS: OPS 1.210, OPS 1.945, OPS 1.965, Appendix 1 to OPS 1.1045 B 2& B 3, OPS 1.978 (SOP), Appendix 1 to OPS 1.965, etc.

Step 5 – Identify and Rank Paths for Improvement
The final step consisted of identifying and ranking paths for improvement.

4. Intermediate Conclusions

The first conclusion of this assessment process is that the European aviation system is globally well protected against flight crew-automation issues, providing all regulatory provisions and best practices are well and uniformly implemented. Furthermore, certain regulatory developments planned in the Ops, FCL and CS domains will provide additional mitigations.[8]

The second conclusion is that a series of flight crew-automation interaction issues deserve further attention.

To prioritise these issues and also possible actions, a Cockpit Automation survey was conducted by the EASA IGPT in 2012.

5. EASA Cockpit Automation Survey

Published on the EASA website from 30 April to 23 July 2012, this survey was aimed at consolidating the Automation Policy by evaluating the degree of agreement with the identified automation issues and suggested paths for improvement. Results will help orienting future EASA work on the subject.

The survey questionnaire is provided in the Appendix. It features the following Sections:

1. Introduction
2. Respondent Identification
3. Automation Advantages
4. Automation Issues
5. Paths for Improvement – Suggested Actions

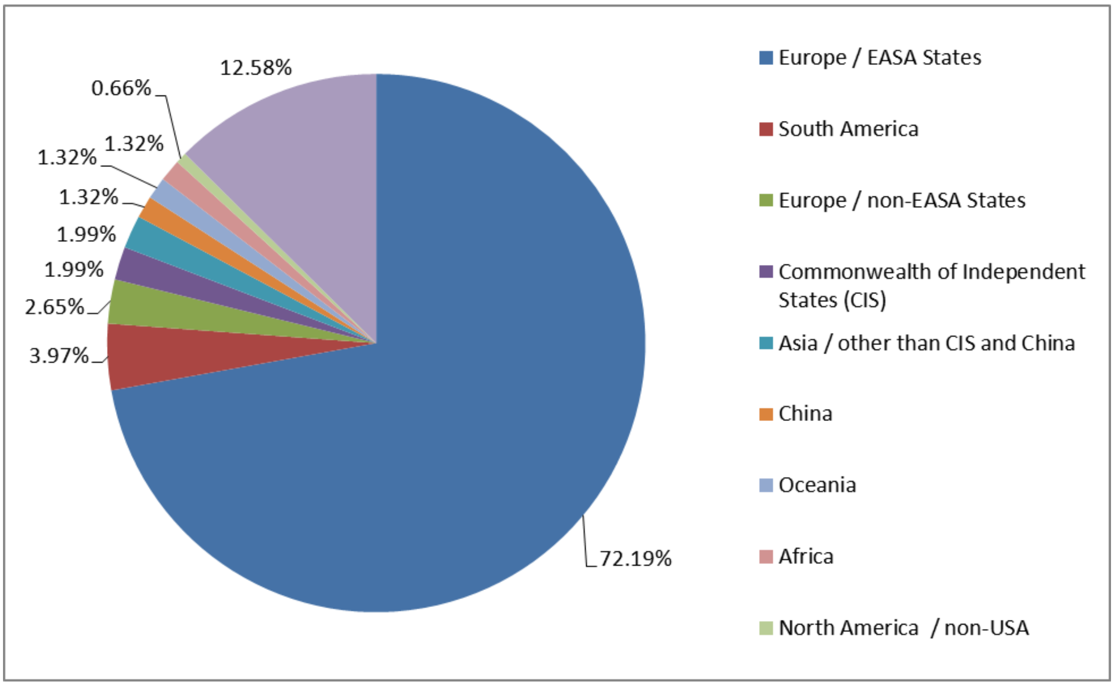
5.1 Respondents Profile

151 respondents participated in the survey.

Distribution by Geographical Origin

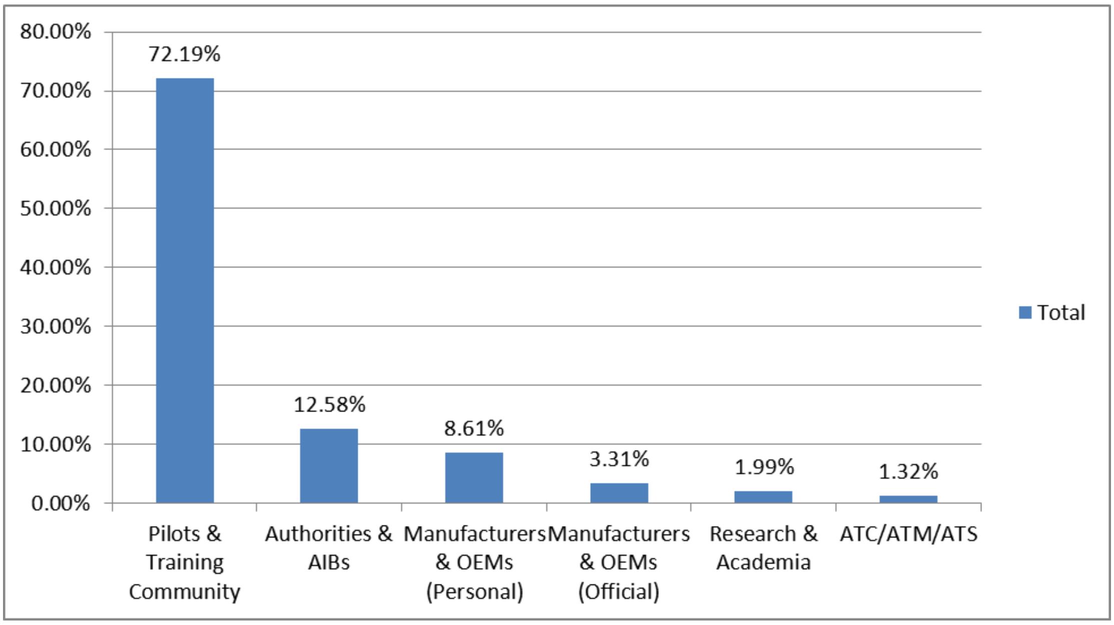
	Count
Europe / EASA States	109
United States of America (USA)	19
South America	6
Europe / non-EASA States	4
Commonwealth of Independent States (CIS)	3
Asia / other than CIS and China	3
China	2
Oceania	2
Africa	2
North America / non-USA	1
Grand Total	**151**

8 http://easa.europa.eu/rulemaking/annual-programme-and-planning.php



Distribution by Type of Respondent

	Count
Pilots & Training Community	109
Authorities & AIBs	19
Manufacturers & OEMs (Personal)	13
Manufacturers & OEMs (Official)	5
Research & Academia	3
ATC/ATM/ATS	2
Grand Total	**151**



So the majority of respondents came from the pilot and training communities.

5.2 Flight Crew-Automation Interaction Issues, Ranked

Prioritisation was based on the following criteria:

- Overall support from all respondents (rated on a 5 point ordinal scale),
- Support from the pilots and training community,
- Support from the manufacturers.

The top flight crew-automation interaction issues are those that were highly supported in overall and by both communities. They are presented in the Group 1 below.

Group 1 – Most Agreed and Consensual Flight Crew-Automation Issues

- Basic manual and cognitive flying skills tend to decline because of lack of practice and feel for the aircraft can deteriorate.

- Unexpected automation behaviour: engagement or disengagement of automatisms in an inappropriate context or un-commanded transition (for instance mode reversion) may lead to adverse consequences.

- Pilots interacting with automation can be distracted from flying the aircraft. Selection of modes, annunciation of modes, flight director commands may be given more importance than value of pitch, power, roll and yaw and so distract the flight/crew pilots from flying the aircraft.

- Flight crews may spend too much time trying to understand the origin, conditions, or causes of an alarm or of multiple alarms, which may distract them from other priority tasks and from flying the aircraft.

- Diagnostic systems are limited with regard to dealing with multiple failures, with unexpected problems and with situations requiring deviations from Standard Operating Procedures (SOPs).

- Unanticipated situations requiring to manually override automation are difficult to understand and manage, create a surprise or startle effect, and can induce peaks of workload and of stress.

- For highly automated aircraft, problems may occur when transitioning to degraded modes (e.g. multiple failures requiring manual or less automated flight).

- Data entry errors (either mistakes or typing errors) made when using Electronic Flight Bags (EFBs) in addition to avionics systems may have critical consequences. Errors may be more difficult to prevent and to detect as there is no system check of the consistency of the computed or entered values and technology gives a certain sense of confidence (if the data entered in the machine are accepted, they should be OK).

Group 2 – Other Flight Crew – Automation Interaction Issues

- In critical situations following disconnection or failure of the automation, although the action that the flight crew must take to regain control is known, the alarm system only indicates the condition met but not the action to take.

- It is difficult to understand the situation and to gain/regain control when automation reaches the limit of its operation domain and disconnects or in case of automation failure.

- When automation fails or disconnects, the tasks allocated to the pilots / flight crews may fall beyond their capabilities, individually and or as a team.

- Flight crew are not sufficiently informed of automation failures or malfunctions or of their effects.

5.3 Improvement Paths, Ranked

Paths for improvement were identified by the IGPT and submitted in the survey for prioritisation. Prioritisation was based on the same criteria:

- Overall support from all respondents (rated on a 4 point ordinal scale),
- Support from the pilots and training community,
- Support from the manufacturers.

Group 1 – Most Agreed and Consensual Improvement Paths

- Improve basic airmanship and manual flying skills of pilots.

- Improve recurrent training and testing practices with regard to automation management

- Improve the Multi Crew Cooperation (MCC) concept and training (instruction and testing) practices to better address automation management. Note: EASA has already planned to improve Crew Resource Management (CRM) guidance - Rule Making Task RMT.0411 (OPS.094).

- Improve the Competence Based Training (CBT) and Evidence Based Training (EBT) approaches to better address automation management.

- Develop automation policies specific to aircraft types and variants to account for differences regarding automation and flight path management.

- Improve the Multi-crew Pilot Licence (MPL) programme to better address automation management.

Group 2 – Other Improvement Paths

- Manufacturers to publish automation philosophies and policies, generic and specific to aircraft types and variants, for communication to the training (instructors and trainees) and operations communities.

- Improve air operator Automation Policies / provide guidance for the improvement of air operator Automation Policies.

- Consider introducing requirements regarding flight deck software customisation (e.g. electronic checklists and procedures, Flight Warning Systems) and enhancing the approval of safety critical functions of Electronic Flight Bags (EFBs) or introducing this approval in the frame of aircraft certification.

- Transfer the certification assumptions regarding flight crew competences required to safely fly the aircraft to the training and operations communities through appropriate means such as the Operational Suitability Data (OSD).

- Review Certification Specifications (CS) and Acceptable Means of Compliance (AMC) 25.1302 “Installed Systems and Equipment for Use by the Flight Crew”, 25.1322

"Flight Crew Alerting" and CS 25.1329 "Flight Guidance System" with regard to automation management, and the assumptions made regarding the flight crew capabilities required to take appropriate action.

- Extend the applicability of CS and AMC 25.1302 and CS and AMC 25.1322 to Part 23 (Normal, Utility, Aerobatic and Commuter Aeroplanes), Part 29 (Large Rotorcraft) and Part 27 (Small Rotorcraft).

6. Way Forward

The survey results are considered by EASA together with the results and recommendations from reference initiatives and projects addressing the prevention on Loss of Control in Flight (LoC-I) accidents such as LOCART[9], ICATEE and SUPRA.

Adopting a total system approach, actions can target rulemaking, safety promotion[10] or standardisation.

An EASA Workshop on Loss of Control is to take place in Feb 2013 to review the results of these initiatives and prepare a consolidated action plan.

Meanwhile, three actions have been launched by the Agency in Sep 2012:

- Publish an SIB on Stall and Stick Pusher Training, based on the FAA Advisory Circular 120-109 and the FAA Aeroplane Upset Recovery Training Aid (AURTA).This SIB will provide operators, aircraft manufacturers and training organisations with a standard procedure and best practices and guidance for training, testing, and checking of pilots, within the existing regulatory framework, to ensure correct and consistent responses to unexpected stall warnings and stick pusher activations. Publication is planned for Jan 2013.[11]

  Note: It is worth reminding the EASA SIB 2010-33 "Flight Deck Automation Policy - Mode Awareness and Energy State Management", was published on 18 Nov 2010. This SIB is based on Commercial Aviation Safety Team (CAST) Safety Enhancement 30 Revision-5, August 2008, "Mode Awareness and Energy State Management Aspects of Flight Deck Automation". Recommendations are provided to air operators to develop, and/or improve their Automation Policy and to ensure that each topic is regularly reinforced in operating procedures and training programs.

- The EASA MPL Advisory Board to review the comments collected in the survey and express an opinion on how to develop automation management and basic piloting skills/airmanship in the MPL frame.

- Continue promoting the OSD concept and process to transfer the type specific assumptions on flight crew competences assumed to safely fly the aircraft to training

9 LOCART stands for Loss of Control Avoidance and Recovery Training. On a proposal by the Royal Aeronautical Society and given the increasing number of safety initiatives addressing Loss of Control in flight (LOC-I), ICAO has activated a dedicated collaborative effort. LOCART incorporates an FAA ARC (Aviation Rulemaking Committee) and is composed from representatives from ICAO, the FAA, EASA, TCCA, manufacturers and several organisations such as Flight Safety and IATA.

10 Safety promotion includes actions other than rulemaking, such as the publication of Safety Information Bulletins (SIB) and of safety brochures or leaflets, presentations in conferences, diffusion of best practices through authority and industry channels and through safety partnerships such as ECAST and CAST, associations such as the Flight Safety Foundation, encyclopaedic systems such as SKYbrary and Wikipedia, etc.

11 http://ad.easa.europa.eu/sib-docs/page-1.

and operations. The IGPT recommends to use in-service HF related occurrences to test assumptions and feed the info back to design and training and operations.

The EASA Automation Policy also served as a basis for the Working Paper AN-Conf/12-WP/34 “Development of an Aviation Automation Policy" presented at the ICAO 12th Air Navigation Conference (ANC) by the Presidency of the European Union on behalf of the European Union and its Member States; by the other Member States of the European Civil Aviation Conference; and by the Member States of EUROCONTROL.

Further actions may require coordination with the ICAO, NAAs, the FAA, EUROCONTROL and the industry: manufacturers, operators and Air Navigation Service Providers (ANSPs)[12].

Coordination may also involve the European Human Factors Advisory Group (EHFAG)[13], the European Strategic Safety Initiative composed of the European Commercial Aviation Safety Team (ECAST), the European Helicopter Safety Team and the European General Aviation Safety Team, the ICAO Regional Aviation Safety Group (RASG) EUR, and the US Commercial Aviation Safety Team (CAST).

Appendix – EASA Cockpit Automation Survey Questionnaire and Results

The survey questionnaire and results are published at: http://easa.europa.eu/safety-and-research/safety-analysis-and-research.php.

12 For instance informal cooperation was initiated in 2012 with UK NATS, which was also developing an Automation Policy.

13 The European Human Factors Advisory Group (EHFAG) is an existing body of recognised. Human Factors experts from European National Aviation Authorities (NAAs), EASA the FAA, industry, professional associations and research organisations. This group is tasked to pilot the HF Section of the EASp on behalf of EASA.

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