

# Pilot training review – final report: recommendations and conclusions

CAP 1581



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# Preface

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This independent research, initiated and funded by the CAA, and part of the CAA's strategic approach to improving safety, reviews UK pilot training in the wider international context. Against a background of increasingly highly automated aircraft, with air travel as a major UK industry with a consumer expectation of the highest safety standards, it is essential that pilots receive effective, evidence-based training that keeps pace with technological, operational and organisational change. This report, together with associated sub-reports, detail current research directions, current training issues and opportunities. We will explore with the aviation industry how potential safety improvements may be achieved to maximise the benefits of this study.

## Sub-reports

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- [CAP 1581a – Gap Analysis](#)
- [CAP 1581b – Literature Review](#)
- [CAP 1581c – Interview Study](#)



**Pilot Training Review**  
**Final Report: Recommendations and**  
**Conclusions**

**FNC 46243/46562R Issue 1**  
**Prepared for Civil Aviation Authority (CAA)**

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## SUMMARY

This report provides a summary of the key findings, conclusions and recommendations from a human factors review of commercial pilot training in the UK conducted for the Civil Aviation Authority (CAA) under research Contract 2217. The high level project aim was to:

- ▶ Review recent training studies, activities and potential improvements to identify where CAA should be providing resource and developing policy to improve safety outcomes for UK citizens.

The need for the work arose from the growing scrutiny on the effectiveness of pilot training following a number of high profile air accidents (internationally) and evidence from the CAA's own reports on offshore-helicopter operations [1] and the Significant Seven [2]. The CAA had a particular interest in identifying practical approaches to improving training to provide good safety outcomes and wanted consideration of a full spectrum of issues including pilot selection and through-career support for both commercial and military fixed-wing and helicopters operations. The CAA highlighted that it was important not just to focus on recommendations around increasing complexity or duration of training as these would not be feasible to implement.

The project included three main tasks, plus recommendations development and final reporting:

1. Addressing Task 1 of the research specification, a literature review was completed to establish the 'state of the art' in pilot training, including to identify the current and latest training techniques, design philosophies and recommended content, including the results of training effectiveness evaluations, skill fade studies and consideration of issues around instructor training;
2. An interview study to establish the state of current practice and issues for pilot training in the UK from the perspective of operators, training schools, industry and professional associations and regulators for civil, military, fixed-wing and helicopter environments, this addressed Task 2;
3. Task 3 assessed residual risks that remain to be explored, this was achieved through conducting a gap analysis to compare the findings of interviews with stakeholders from the aviation training community and a review of the human factors and training research literature to identify gaps and other issues in pilot training, and from this a BowTie type analysis to identify and prioritise the risks for UK pilot training;
4. Task 4 includes the final delivery of this report with its recommendations and conclusions based on the previous activities.

This Final Report and three interim reports from these underpinning tasks provide full details of all the issues, analyses and results.

The key findings of the project are summarised as:

- ▶ Pilot training in the UK is under increasing pressure from external influences, so, in order to maintain high levels of quality and safety, it needs continuing development and ongoing support from regulators and within the industry;
- ▶ Threats to pilot training exist across the whole Training System including: Content and Delivery, Training Tools and Devices, Pilots, Instructors, and Governance and Regulation, and, so, must be managed in an integrated manner across the whole system;
- ▶ A wide range of barriers are needed to mitigate the risks posed by threats to pilot training and from broader challenges in aviation. Some of these barriers are already in place, representing industry good practice in the UK, others need either more consistent application or to be introduced to address identified gaps.

Based on the findings from the project the following recommendations have been identified:

1. In the long-term, the CAA and pilot training community should, through implementation of regulation, supporting guidance and checks, ensure that barriers are in place to mitigate the identified (and developing) threats to pilot training. The barriers presented in this Report provide an initial set for consideration but these should be reviewed and refined locally through consultation with the pilot training community (threats and barriers are defined in the Gap Analysis report);
2. The CAA and pilot training community should agree a definition and framework for the Pilot Training System that encompasses all elements of pilot training and use this as the basis for driving on-going and future developments in UK pilot training;
3. The pilot training community should develop a collaborative, industry-led governance organisation with stakeholders from all areas of pilot training, including the CAA, to lead co-ordination, sharing and on-going development across the pilot training system going forward;
4. The pilot training community, CAA and relevant experts should work collaboratively to provide practical guidance, support material, good practice guidelines and information sharing activities around a range of topics, including: training needs analysis (TNA), training evaluation, latest techniques for cognitive skills rating and knowledge development of automation, and strategies for skill retention;
5. The pilot training community and the CAA should work collaboratively to develop a research strategy for addressing gaps in knowledge, tools and techniques and collectively invest in supporting robust, evidence-based research and development that can deliver practical outputs with clear implementation plans;
6. The pilot training community and the CAA should explore ways to enhance and strengthen the instructor role for all stages of training, giving consideration to training and qualification requirements, job design tools and support, career management and reward;
7. The pilot training community, supported by the training regulations, should ensure that comprehensive TNAs are conducted to inform the balanced design of training throughout the training pipeline. Attention should be given to ensuring that fundamental topics around automation management, use of manual flying and core cognitive skills, e.g. decision making, are strongly represented across training;
8. The pilot training community should focus on making pilot training 'smarter' so that greatest benefits can be gained from the training time currently available. This could include: ensuring that training time is spent on completely relevant and necessary content; using of specific training techniques and lower cost training tools; introducing challenging topics earlier in training; and the use of mentoring, coaching and peer support.

Successful pilot training is a critical component of safety in UK aviation. Current practices, although sufficient, may not optimise the role of pilot training as a barrier to safety events. Indeed, as the aviation environment becomes more complex, it is essential that pilots are optimally supported in developing and maintaining high standards across the full range of competences needed for flying highly automated aircraft in an increasingly busy air space and with strong commercial pressures. To achieve this, pilot training needs to be continually reviewed and refreshed in response to changing demands and challenges. The findings of this project have highlighted that, going forward, this will increasingly require a community wide systems approach to training that considers all elements of pilot training, including governance developed in consultation with industry, enhancing the instructor role, and improved guidance and support.

Fortunately, this need to maintain focus on pilot training appears well recognised by the UK aviation training community with larger organisations seeking to be proactive, as far as permitted by regulations, in implementing developments from on-going analysis and research into their training programmes. There are also sections of the industry that would almost certainly benefit from additional support and guidance around modernisation. Across the aviation industry, commercial pressures place considerable demands on training departments, and resources are inevitably scarce; justifying the need for change is difficult especially if there

have been no specific safety events to drive the change. Easy access to the latest research findings, training techniques and analysis methods in a format that can be readily implemented could facilitate change across all levels of organisations. It is highly unlikely that commercial organisations individually would (or could) support investment into such a broad range of enabling activities; therefore, more collaborative developments between organisations – across the pilot training industry and with the CAA – and improved information sharing would be of benefit to everyone.

Finally, while this project has focussed on pilot training in the UK, the issues explored apply much more broadly. The exact nature of the threats and effectiveness of the barriers will inevitably vary according to location, but the general challenges are shared by aviation globally. So, while not all the recommendations may be relevant everywhere, addressing them in the UK could lead to new tools, guidance, ways of thinking and improved sharing that provide benefit far more widely, improving safety through presenting more, and more effective, barriers to risks associated with pilot training.



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## 1. INTRODUCTION

### 1.1 BACKGROUND

This Final Report provides a summary of the key findings, conclusions and recommendations from a human factors review of commercial pilot training in the UK conducted for the Civil Aviation Authority (CAA) under research Contract 2217.

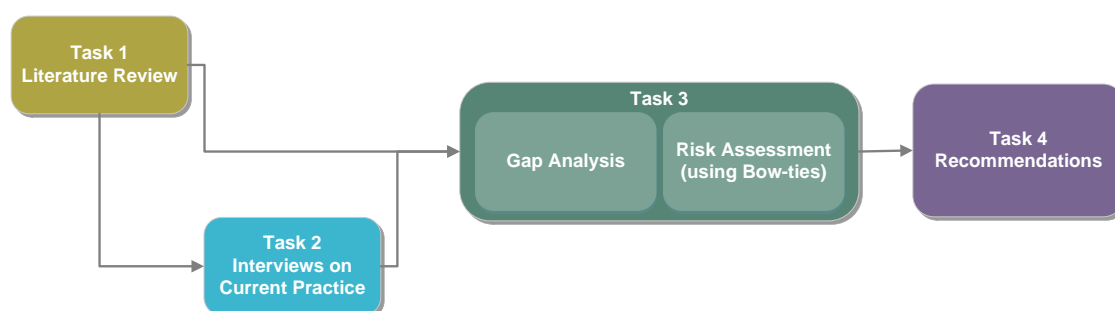
The project started in January 2015 with the aim to:

- ▶ Review recent training studies, activities and potential improvements to identify where CAA should be providing resource and developing policy to improve safety outcomes for UK citizens.

The need for the work arose from the growing scrutiny on the effectiveness of pilot training following a number of high profile air accidents (internationally) and evidence from the CAA's own reports on offshore-helicopter operations [1] and the Significant Seven [2]. The CAA had a particular interest in identifying practical approaches to improving training to provide good safety outcomes and wanted consideration of a full spectrum of issues including pilot selection and through-career support for both commercial and military fixed-wing and helicopters operations. The CAA highlighted that it was important not just to focus on recommendations around increasing complexity or duration of training as these would be unfeasible to implement.

### 1.2 DESIGN OF THE PROJECT

The project was conducted according to the flow diagram shown in Figure 1.



**Figure 1. Tasks in the pilot training review project**

The two main data collection activities were: a review of pilot training research literature and an interview survey of 16 stakeholder organisations, including operators, training schools, industry associations and regulators. Short summaries of these two underpinning investigations are provided in annexes A.1 and A.2, with full descriptions of the activities available in references [3] and [4], but very briefly it is worth noting the following key observations:

- ▶ The research literature tended to focus on topics around the content to be trained, e.g. for competencies around recognised problem areas, but the emphasis seemed to be more on 'what to train?' rather than new ways for 'how to train it?', or at least not to the extent of developing clearly exploitable tools for operators. Nor were there many evaluation studies reporting on the effectiveness of techniques currently being implemented. The majority of research was for fixed-wing pilots, and across the board very little around instructor activities, early career training or broader training system considerations;
- ▶ The issues emerging from the interviews were higher level than those being described in the literature, more around organisational challenges for delivering training, than details

of the specific content. A major point across all interviews was being able to deliver competence-based training in line with operational needs rather than being tied to training for prescribed technical failures, which were no longer felt to be representative. There was recognition that some skill areas, e.g. around decision making, automation, and manual flying skills, are still a challenge but there did not appear to be sufficient flexibility in the training footprint to allow for use of novel ways to address this. This appeared to be related to both regulatory and resource (i.e. financial) constraints. Ground school and early career training were considered less well developed than operational training.

The results from the literature review and interviews were then compared in a gap analysis to classify and prioritise threats to pilot training resulting from inadequate, variable or missing tools, processes, knowledge, guidance and support, etc. and to identify the barriers needed in the training system to address these. Given the broad range of issues to be considered, BowTie analysis was adapted to support the risk assessment and present the project findings. The key findings from this task are presented in section 2.

This Report relates to Task 4 and is the final output from the project. Its main focus is on the threats and mitigations identified (as taken from the gap analysis and risk assessment report, see reference [5]) and what this means in terms of next steps for the CAA and the pilot training communities. While the Report is written as a deliverable to the CAA, the conclusions and recommendations should be of interest to organisations across the pilot training community.

### 1.3 STRUCTURE OF THE REPORT

The remaining sections of the Report provide:

- ▶ A summary of current issues in pilot training in the UK;
- ▶ Emerging directions and recommendations;
- ▶ Final conclusions.

The Annex provides short summaries of the work conducted in previous phases of the project.

## 2. CURRENT ISSUES IN PILOT TRAINING

### 2.1 OVERVIEW

A central goal of this project was to identify the risks to aviation safety emerging from pilot training. While no evidence was found in the project to suggest significant problems with training for professional pilots in the UK, it is apparent that the overall training system is increasingly under strain from the demands being placed on it. However, it is important to say that the pilot training stakeholders who engaged in this project were very positive about the aims of the project and the opportunity it provided to consider how best to maintain the UK's traditionally excellent standards around pilot training going forward.

### 2.2 HIGH LEVEL CHALLENGES

At the highest level, there are a series of widely recognised external factors that increase the challenge faced by the whole pilot training community and will continue to do so going forward. Such challenges include:

- ▶ Increasing complexity of aircraft automation, growth in air traffic, and changes in the way this is managed;
- ▶ Commercial pressures affecting training departments and the time available for training;
- ▶ An increasing demand for pilots, resulting in initial selection criteria having to be broadened to meet capacity;
- ▶ The overall depth of experience amongst pilots and pilot training professionals is declining due to retirement of older generations, who inevitably had much deeper levels of manual flying skill and breadth of flying practice;
- ▶ Common licences are held across EASA nations but there is variation in standards (or the perception thereof) across countries and no formal mechanism in the UK for managing transfers.

These types of challenges are being faced across Europe and the world as the overall demand on aviation increases. As such, training, which is an essential cornerstone in aviation safety, must continue to progress in response.

**Key Finding 1: Pilot training in the UK is under increasing pressure from external influences so in order to maintain high levels of quality and safety it needs continuing ongoing support.**

### 2.3 THREAT PICTURE

A more detailed risk picture has been developed that describes the specific threats facing pilot training and that need to be managed to ensure sustainability and safety going forward. The analysis behind these threats is described in reference [5].

The top threats identified for pilot training combined across all types of training and operators grouped by theme are:

- ▶ Content and Delivery:
  - ▶ Training content not reflecting operational requirements;
  - ▶ Poor implementation of research findings;

- ▶ Training content is constrained by the training footprint;
- ▶ Skill fade;
- ▶ Prioritisation of training for risks over core skills;
- ▶ Variation in application of standards and checks in training;
- ▶ Problems with automation management and switching between automated and manual flying.
- ▶ Training Tools and Devices:
  - ▶ Low availability of training support tools;
  - ▶ Limited ability of simulators to emulate scenario complexity and abnormal conditions.
- ▶ Pilots:
  - ▶ Poor pilot provenance;
  - ▶ Reduced time to command;
  - ▶ A wider range of initial abilities;
  - ▶ Increasing breadth of the pilot role.
- ▶ Instructors:
  - ▶ Instructor and evaluator competence (all training levels);
  - ▶ Lack of information as to how training should be delivered;
  - ▶ Instructors at the edge of their envelope;
  - ▶ Instructors not up to date with latest developments;
  - ▶ Regulatory gaps in Instructor / Examiner (I/E) checks;
  - ▶ Increased demand.
- ▶ Governance and Regulation
  - ▶ Consistency in the application of regulator standards;
  - ▶ Lack of a competence-based approach flowing back down the training pipeline;
  - ▶ Reduction in knowledgeable, experienced support from the UK regulator;
  - ▶ Reduced regulatory oversight of instructors and evaluators;
  - ▶ Reduced capacity to provide support and guidance;
  - ▶ Inflexibility of regulatory approach to the wider uptake of competence based training;
  - ▶ Variation of interpretation of regulations across Europe;
  - ▶ Limited resource in aviation training community.

Note: this is a subset of all the threats identified, these are the ones considered the most critical and important.

Individually, the threats will not all pose the same level of risk, and the level of risk is also mediated by the type of organisation and operations. Left unaddressed, overall they contribute

to the possibility that, because of issues in training, pilots could perform sub-optimally in the cockpit, which could then result in a safety hazard. What is important to observe from this list is that the threats to pilot training cover multiple players and organisations. It is not enough to just consider individually the content of training or the simulators or instructors or the regulation when looking at maintaining effective pilot training, the whole training system must be considered. As with aviation safety itself, the training system needs defences to be built in depth to minimise the risk of failures. Furthermore, the threats identified cover the whole training pipeline from early career, through maintaining of competence when on-the-line, and promotion, irrespective of the type of aircraft flown.

**Key Finding 2: Threats to pilot training exist across the whole Training System including: Content and Delivery, Training Tools and Devices, Pilots, Instructors, and Governance and Regulation, and so must be managed in an integrated manner across the whole system.**

## 2.4 BARRIERS AND MITIGATIONS

Within the BowTie analysis conducted the barriers identified refer to the means of addressing the threats. The barriers were generated from the data collected during the literature review and interviews and the subsequent analysis – some relate to practices already in place and others have been added to address gaps identified. The barriers are the controls and mitigations that need to be in place across the training system to remove or reduce the likelihood of the threat causing a negative outcome. As with the threats, the barriers cover the full spectrum of the training system and require engagement of all the stakeholders. A single barrier may help address multiple threats but implemented together they help build a stronger, more robust training system.

For the threats that have been identified as the most critical, (see section 2.4), the most frequently occurring 30 barriers (each addressing three or more threats) are listed here, with brief explanations to assist in implementation. Full lists of all the barriers identified in the project and how these map to threats are provided in reference [5]].

### 1. Comprehensive Training Needs Analysis (TNA)

- ▶ This is needed to define relevant knowledge, skills, attitudes (KSA) and experiences, competence standards and content etc., across all stages and types of training; this should follow a robust systematic process; some areas of pilot training do this, but it is currently not required by regulations for all areas of training;
- ▶ Threats addressed = 12.

### 2. Provision of support resources and accessible guidance\*<sup>1</sup>

- ▶ Practical guidance on methods, tools and techniques are needed for use across the training pipeline;
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 11.

### 3. Consistent application of standards and checks

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\* The barriers marked with an asterisk are new barriers that have been added to address explicit gaps in current controls identified in the gap analysis study.

- ▶ This is a broader challenge than just within the UK, but is important across individuals (pilots, instructors), organisations, types of operations and nations;
  - ▶ Threats addressed = 8.
- 4. Regulatory oversight for compliance**
- ▶ This is needed for assessing effective compliance of both processes and output based regulation, and it should be a more 'challenge and response' form of oversight than just 'tick box checking'; this is particularly important given concerns about consistency in standards and checks;
  - ▶ Threats addressed = 8.
- 5. Defined ownership of development responsibility\***
- ▶ With changes in the role and capacity of the CAA, the UK pilot training community needs collectively to take up ownership responsibly for on-going development in pilot training;
  - ▶ Additional barrier to address gap;
  - ▶ Threats addressed = 7.
- 6. Formal training and continuous evaluation for all types of Instructor/Examiner\***
- ▶ Formal training and evaluation is essential for Instructors and Examiners across all levels of training and in all organisation types; there are currently some gaps in requirements for ground school instructors, early flight training instructors and line training captains;
  - ▶ Additional barrier to address gap;
  - ▶ Threats addressed = 7
- 7. Rigorous training evaluation processes informing iterative development and needs assessment**
- ▶ This is currently required in some areas but is not consistently applied across the training pathway; this can be especially challenging for early career and third party training providers who do not have sight of the downstream effects of their training.
  - ▶ Threats addressed = 7
- 8. Appropriate balance of technical and non-technical competencies**
- ▶ This is common in operator training, although there are still some inconsistencies in the approaches taken to the different areas (e.g. integration or the types of skills taught); it is also important in early training, and needs to be continually revised in line with role and aircraft requirements (see also #1 above: Comprehensive TNA);
  - ▶ Threats addressed = 6
- 9. Defined exploitation pathways and implementation processes for research outputs\***
- ▶ Research and development projects should be designed from the outset to facilitate translation of results into practical training programmes, guidance, etc. certainly more quickly than has historically been the case;
  - ▶ Additional barrier to address gap;
  - ▶ Threats addressed = 6.

**10. Understanding and managing skill fade for all competencies\***

- ▶ The need for this is discussed but it does not appear to be systematically considered, except in the military; also the focus tends to be on manual handling skills not on other aspects of modern flying;
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 6.

**11. Formal tracking of pilot and instructor training provenance\***

- ▶ This is particularly important where training, qualification or hours building have taken place outside of the UK; current processes for this seem to be lacking or rely on informal personal networks, which are not sustainable in the long term;
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 5.

**12. Information sharing, lessons learnt and benchmarking\***

- ▶ This needs to happen across all elements of the training system; it is particularly important to support smaller organisations with fewer internal resources as well as focusing across the training pipeline, so that early career training is truly focussed on building the pilot's core skills for the modern operating environment;
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 5.

**13. Job design and career management for Instructors/Examiners**

- ▶ In both training schools and operators, this is required to ensure that becoming an instructor remains a desirable professional career option;
- ▶ Threats addressed = 5.

**14. Understanding the 'how' of training\***

- ▶ There is a tendency for research and guidance to focus on 'what to train' rather than providing guidance and new developments on 'how to train it'; this can result in very traditional teaching that is not ideal for developing all of the competencies needed in modern aircraft;
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 5.

**15. Ability to justify training need and change\***

- ▶ This is a real challenge for organisations, particularly in difficult commercial markets; tools and techniques for data collection, evaluation and cost-benefit analysis would help make cases for ongoing investment;
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 4.

**16. Available appropriate supporting tools and training media\***

- ▶ Full simulation has long been considered the gold standard, but lower cost alternatives are available and could be used to support more flexible ways of learning; investment in new approaches seems to be lacking;



- ▶ Threats addressed = 4.

#### **17. Avoidance of minimum compliance\***

- ▶ In order to maintain high standards across the training system, all organisations should strive to do more than just seek to meet the minimum level for compliance. Achieving this will rely on other barriers being implemented and pan-community culture of excellence.
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 4

#### **18. CAA organisational structure based on industry need\***

- ▶ Regulatory approaches needs to develop as industries mature and to meet broader societal requirements, but regulators still need to be able to provide support to the full range of organisation types under their control; there is concern that the CAA is no longer able to provide the level of guidance and support needed by industry because of the streamlining of its services following the move to EASA (but should be considered alongside other barriers, e.g. #5 'Defined ownership of development responsibility' and #12 'Information sharing, lessons learnt and benchmarking');
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 4.

#### **19. Maintaining instructor currency in training developments, aircraft systems, etc.**

- ▶ Given the rapid pace of change in modern aviation and with on-going developments in training, instructors need to be supported in staying up-to-date with the latest technologies and techniques that they are training both for and with;
- ▶ Threats addressed = 4.

#### **20. Pilot selection**

- ▶ Training should not be solely relied upon for achieving safe and effective performance on the job; as professionals in a safety critical industry, pilots should expect to undergo rigorous selection at all stages of their careers; provenance of previous training and experience should be checked as per #11 'Formal tracking of pilot and instructor training provenance', and particularly given potential concerns about the effectiveness of #3 'Consistent application of standards and checks' and #4 'Regulatory oversight for compliance';
- ▶ Threats addressed = 4.

#### **21. Regular competence checks for Instructors and Examiners that consider ability to train**

- ▶ There seems to be less focus on the training specific knowledge, skills and ability of instructors; instructors must teach so that others can learn and conduct examinations effectively and consistently; this requires more than just the ability to fly oneself; instructing and examining competences need to be checked regularly to ensure they are present and they are not just assumed to be part of flying capability; this should be achieved through applying barrier 1; it is of note that this is a concern particularly at early stages of training with the capabilities of hour-building instructors;
- ▶ Threats addressed = 4.

## 22. Regulation supporting competence-based approach across training\*

- ▶ Current good practice in training for aviation and other professional groups is to follow a competence-based approach whereby training should be designed to support development of competences needed to perform the job to pre-set standards, the competences having been developed through a comprehensive TNA (see #1), EASA regulation does not yet enable this across all pilot training; it is understood that this is being addressed for different operation types but not for early or later licensing training;
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 4.

## 23. Training KSAs to support flexibility and resilience in performance

- ▶ Modern aircraft require pilots to have advanced capabilities around dealing with unexpected situations and changing environments, training should reflect the needs for such adaptive capacity; training needs analysis should address this but particular focus is needed on competencies around flexibility and resilience;
- ▶ Threats addressed = 4.

## 24. Advanced accreditation standards\*

- ▶ In the face of globalisation and opening of regulations across EASA, local accreditation standards could be used to allow high standards to be maintained under voluntary schemes; this would be particularly helpful for early career training where other controls on standards are less strong;
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 3.

## 25. Clear regulatory definitions of training terms and consistent usage\*

- ▶ A simple quick win, through ensuring consistency in use of language and improved understanding of definitions, for example, distinguishing between competence and competencies;
- ▶ Additional barrier to address gap;
- ▶ Threats addressed = 3.

## 26. Easy access to training facilities for self-guided and instructor-led practice

- ▶ Extra-curricular practise is an important tool available for pilots to help maintain skills and performance; simulators are recognisably expensive resources and time spent with instructors is usually focussed on assessment, but easier access to these or even lower-cost devices would help enable pilots to achieve more ongoing learning and development;
- ▶ Threats addressed = 3.

## 27. Industry influence on research and development agenda\*

- ▶ This is needed to address the disconnect between current research and development in pilot training and the issues being faced by training organisations, operators and regulators; efforts are needed to address this disconnect, this is also linked with #5 'Defined ownership of development responsibility' and #9 'Defined exploitation pathways and implementation processes for research outputs';
- ▶ Additional barrier to address gap;

- ▶ Threats addressed = 3.

#### 28. Instructor selection

- ▶ As well as selection to become a pilot (#20, and closely linked with #21) 'Regular competence checks for Instructors and Examiners that consider ability to train', instructors should be selected based on an assessment of the core needs for the particular instructing job; mechanisms for this appear to vary across sectors of the pilot training industry, selection criteria for early flying instructors in smaller schools may not be very tightly controlled;
- ▶ Threats addressed = 3.

#### 29. Regulation appropriate to different availability of resources of ATOs / Organisations

- ▶ This is already the case to some degree but it appears to be based more on broad criteria rather than consideration of an organisations' ability to work within a set regulatory regime, which may disempower some organisations; adoption of a 'training case' akin to a safety case might be one way to ensure regulation and associated support is appropriate for different types of organisation whilst encouraging ongoing development of the internal training system; this links also with #18 'CAA organisational structure based on industry need';
- ▶ Threats addressed = 3.

#### 30. Resilience and flexibility of training programmes

- ▶ It is clear from the high-level challenges facing aviation that training programmes needed to be both resilient and flexible so mechanisms that support for continuous evaluation and development should be in place; this links to a number of other barriers, it must also be considered along the length of the training pipeline so that changes in one part of training are reflected and supported in other parts of the system;
- ▶ Threats addressed = 3.

As indicated above and alongside the barriers themselves, many of these barriers identified are already in place within the UK's pilot training system, we have highlighted new barriers identified within the gap analysis study with an asterisk. The barriers represent the good practice identified in the interview survey and emergent ideas from the research literature that already help contribute to the effectiveness of pilot training. Others are not currently seen across all types of organisation or stages of training, and a final group of barriers (n=15) appeared to be lacking in the current training system. A full list of all additional barriers is provided in reference [5].

**Key Finding 3: A wide range of barriers are needed to mitigate the risks posed by threats to pilot training and from broader challenges in aviation. Some of these barriers are already established as industry good practice in the UK, others need either more consistent application or to be introduced to address identified gaps.**

### 3. EMERGING DIRECTIONS AND RECOMMENDATIONS

#### 3.1 OVERVIEW

At the highest level, the main recommendation from this project should be to ensure that the 30 barriers described in section 2.4 are in place across the relevant parts of pilot training system. These would help mitigate the risk that training related threats pose to aviation safety (amongst other things) and overall help sustain high standards of pilot training and, hence, pilot performance in the UK. The barriers should apply across all parts of the training system and be relevant across all types of professional aviation.

However, getting to a point where the training system has all the layered barriers in place would be a major undertaking for both the CAA and the UK pilot training community, so achieving Recommendation 1 (below) must be a long-term goal. Not least, some changes can only be achieved through the actions of external organisations, e.g. EASA development of regulations for competence-based approaches to training and even though there is a clearly stated desire for change across Europe, the mechanisms for producing new regulation are slow. Other mitigations will be easier and quicker to implement, and may help mediate concerns given the slower pace of change in the formal regulations, but will still require changes in ways of working across pilot training organisations to be successful.

**Recommendation 1: In the long-term, the CAA and pilot training community should ensure barriers are in place to mitigate the identified (and developing) threats to pilot training. The barriers presented in this Report provide an initial set for consideration but these should be reviewed and refined locally.**

Given the above, based on all the barriers identified and the wider findings of the project, a number of broader recommendations have been made in the sections below. These should assist the CAA and other stakeholders in moving pilot training forward in the UK so that it remains strong and resilient the face of the inevitable challenges that exist given the complex, demanding and financially constrained environment of modern aviation.

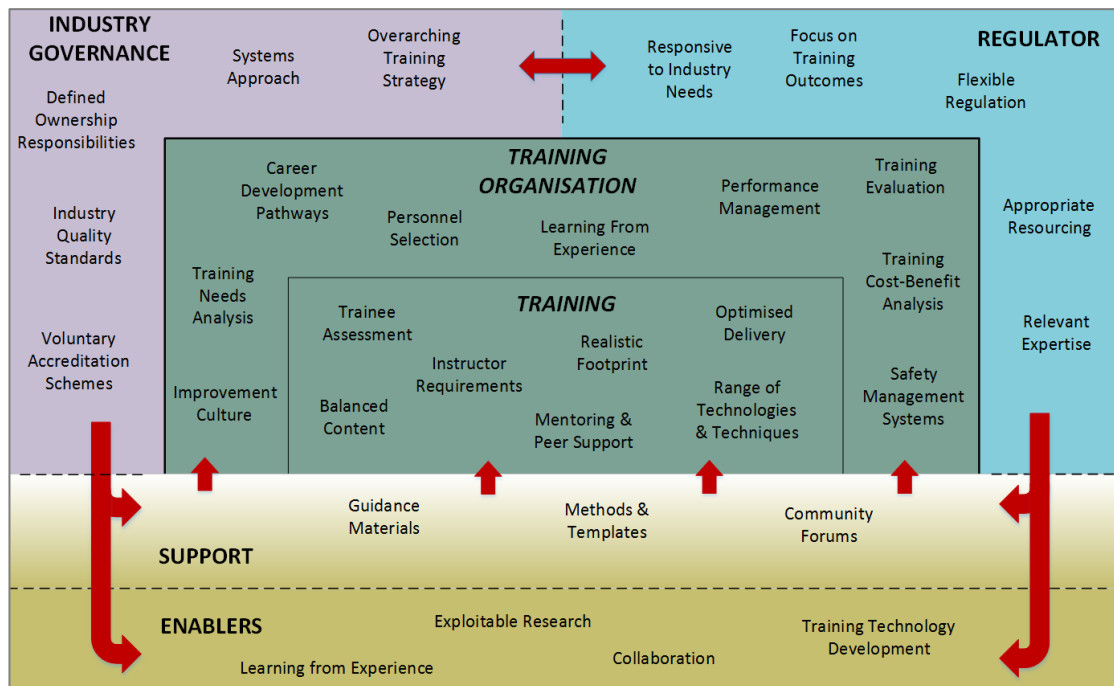
#### 3.2 DEVELOP THE PILOT TRAINING SYSTEM

A key theme that has emerged throughout the project is the need to think about pilot training in terms of the overall system. Successful training depends on a whole range of elements that, alone, are not sufficient to produce the required outcomes. Effective pilot training, as observed in section 2.1, is dependent on having the right content, being trained in the right way at the right time by the right people and according to the right regulations. Achieving this requires a co-ordinated training system and, these days, this system must extend beyond the individual operator (or training school), since it is unlikely that many pilots will spend their entire career from initial training until retirement with the same company; plus training is frequently outsourced for commercial reasons.

Based on the findings of this project, it is strongly recommended that the UK pilot training community and related stakeholders start thinking in terms of the Pilot Training System and how it can be used to best optimise the pilots training pathway.

**Recommendation 2: The CAA and pilot training community should agree a definition and framework for the Pilot Training System that encompasses all elements of pilot training and use this as the basis for driving on-going and future developments in UK pilot training.**

To illustrate what is meant by this, the diagram in Figure 2 provides an initial suggestion for the key elements to consider when describing the UK pilot training system.



**Figure 2. Suggested elements of the UK Pilot Training System**

In addition to defining the components of the system, the diagram helps to show how different parts of the system need to link up to help with threat mitigation and overall improvements across the training pipeline. Clearly not all aspects of the training system have been included, but this should provide a starting point for CAA, industry and other stakeholder discussions. What is critical is that organisations across the pilot training system can be engaged with it, and take part in collectively owning it.

### 3.3 BROADEN TRAINING SYSTEM GOVERNANCE

The experience of conducting this project suggests that at present the UK does not have mechanisms for cross-ways working and sharing between different parts of the pilot training system. As observed at the beginning of this Report, there is clearly some disconnect between research and the challenges industry report, plus other findings suggest that currently pilot training can become disjointed across careers. Helicopter operators and airlines seem to be considered separately because of the differences in the technologies used, but actually have much in common around the challenges for pilot training. Clearly some organisations work excellently together, which should provide examples of good practice that can be shared more broadly. However, there appears to be very few forums for such sharing. There is the annual International Flight Crew Training Conference, which is well attended by representatives from across the pilot training community, but this is a commercial event and so may not be the most appropriate places for all discussions. There is the CAA’s Flight Operations Liaison Group, which meets regularly, but these discussions are focussed on issues in flight operations so does not include stakeholders from across the full training pipeline. Indeed, following the introduction of EASA, the CAA’s role change means that it is less able to take the role of driving developments forward. In addition, the shift towards performance-based regulation suggest an aspiration for industry to take more responsibility for its own governance. Even the Royal

Aeronautical Society (RAeS) does not have a dedicated training section. Instead it has Specialist Groups for Flight Simulation and Human Factors, which cover elements of pilot training, but nothing that considers all aspects of training for pilots (or other aviation professional) across the whole training system.

Building on the concept of pilot training system and a number of the specific barriers identified in the project for mitigating risks to pilot training, it is recommended that the pilot training community develop a collaborative, industry led governance framework and working group with members from across the pilot training system. The aim of this framework and working group should be to drive on-going development and quality improvements in pilot training in the UK. This suggested outer layer of the pilot training system is shown in Figure 2. The mechanism for achieving this would need to be agreed amongst the stakeholders, but could be through an already recognised organisation like the RAeS or as a separate entity, similar to the offshore helicopter industry association, HeliOffshore.

Clearly, such industry governance would need to work within the regulations that exist and hence would have to co-ordinate closely with the CAA. This approach would also help reduce the burden on the CAA because there would be another source for guidance and support. Having a single pilot training governance group would improve communications with EASA, as it would provide representation from organisations who currently do not get the opportunity to engage with EASA rule making tasks, as well as facilitating co-ordination and sharing across the training pipeline, where at present, regulatory requirements for different licences seem to provide the only common thread. While this is not such problem for integrated training courses, such broader oversight would be beneficial to those involved in modular training.

Essentially, having an industry-led governance group that covers all aspects of pilot training system would assist the community in being able to address the challenges it faces going forward, through collective ownership of the problems and development of a shared solution. One of the main concerns raised during the interviews was around training standards. As regulations are now set by EASA and, overall, pilot training is being undertaken more globally, there are fewer national control mechanisms and at a time when numbers of pilots are being increased. One approach for maintaining high standards and encouraging organisations to strive beyond achieving minimum compliance would be to use voluntary accreditation schemes to demonstrate standards of excellence with the training organisations own systems. These could include following good practice around training needs analysis, training evaluation, instructor development programmes and calibration for assessment checking, which are all activities important for maintaining effective training.

An example of this is already in place for all military training through the Defence Systems Approach to Training (DSAT) [6] [7]. This is an effective management approach for training systems and, as an official Ministry of Defence policy, must be adopted for all military training to ensure that all elements of training design, delivery and evaluation are conducted according to systematic and robust processes. Therefore, DSAT provides a baseline for conducting quality assurance of the training system. The documentation – policy and associated guidance - is extensive but it provides a useful common toolset for training professional across all areas of training; it even includes extracts from recent research into key topics of interest such as understanding skill retention intervals. Clearly, it would be difficult for the pilot training community to introduce such an extensive approach in its entirety, but introducing elements of such an approach, such as validation of training, might provide a useful underpinning for system level governance around pilot training.

A key part of training system governance is still the CAA itself. As discussed previously, its role has changed somewhat and it has more limited resources now but it is still responsible for

maintaining the integrity of pilot training in the UK. The CAA must continue to support the pilot training industry through its influence with EASA, the use of national derogations around regulations to support UK organisation and by being the final source of authoritative guidance. To do this, it needs to be responsive to industry's needs, which may vary according to type of organisation. But equally with greater pan-industry ownership and governance, this role should become easier because effectively the responsibility for overseeing the pilot training system is being shared. As such, the findings of this Report would seem to mirror the CAA's own drive towards performance-based regulation. However, before this can happen some alternative mechanisms for support, such as described within this Report, must be in place.

**Recommendation 3: The pilot training community should develop a collaborative, industry-led governance organisation with stakeholders from all areas of pilot training, including the CAA, to lead co-ordination, sharing and on-going development across the pilot training system going forward.**

### 3.4 SUPPORT AND ENABLERS

A key advantage of having greater industry ownership of governance is that through this, the associated working groups can help ensure that collectively training organisations have access to the guidance, support and enablers they need. This part of the training system is shown as the foundation in Figure 2.

At present sources of practical guidance appear limited and the level of expert advice available from the CAA has reduced over recent years. Official guidance is available around regulations and the CAA still publishes material to address specific safety topics, e.g. Monitoring Matters [8]; however, there are lots of areas where little material is available. For example, a central aspect of developing competence-based approaches to training, of which Evidence-Based Training (EBT) is one form, is conducting TNA to identify what KSAs to train. However, no information is provided to the pilot training community on how to conduct a comprehensive TNA or even where to go for appropriate guidance. As a further example, a much earlier research study funded by the CAA [9] investigated the evaluation of Crew Resource Management (CRM) training. Asked why training effectiveness evaluations were not being conducted, at the time operators reported that they lacked the additional resources needed for this and, most relevant here, they lacked the tools to help them. Training effectiveness evaluation is now more common place but guidance on how to go about conducting a comprehensive evaluation is still missing. If the pilot training community worked together it could agree industry good practices guidance across a range of tools, techniques and topics that could then be shared and used to support them all.

**Recommendation 4: The pilot training community, CAA and relevant experts should work collaboratively to provide practical guidance, support material, good practice guidelines and information sharing activities around a range of topics, including: TNA, training evaluation, latest techniques for cognitive skills rating and knowledge development of automation, and strategies for skill retention.**

A clear advantage of greater industry communication and collaboration is developing opportunities for sharing lessons and even benchmarking performance. These activities clearly need to be conducted in a manner that protects commercial confidentiality, but there are still ways of sharing experiences of effective and ineffective approaches in training such that the overall knowledge and experience across the whole training community is broadened. As discussed above, there are a few events where this is possible now but given the limitations on

these there may be scope to strengthen the processes for information sharing across the pilot training system.

Another grouping of threat barriers that emerged is around enablers for the training system. Enablers can be considered the underpinning resources and mechanisms from which practical support can be provided. Several of these have already been covered, for example defining the training system, having strong industry ownership and providing improved sources of guidance. Another important enabler relates to driving forward the research and development agenda. For pilot training to move forward the tools and techniques used for training should also keep up with latest developments in technology. This should include updating full flight simulators so they can replicate the physical conditions of scenarios used in training for unusual attitudes and upset recover. But it could also mean exploiting advances in computer processing power to produce lower cost devices that offer high psychological fidelity training without the need of costly physical fidelity. Both of these needs industry (and other stakeholder) investment in research to enable the advances in development. This must be both in terms of funding for projects but also time spent in developing the research agenda and driving exploitation. The pull-through of findings from research into industry practice seems to be slow in aviation (however, this is also evident in other industries). This is likely partly because many research outputs do not seem to be presented in a way that makes implementation of the findings easy. More effort needs to be put into translating new knowledge and techniques into practical guidance and tools. A barrier to implementing research may be that the aviation training community is quite conservative and commercial pressures and regulations make it difficult to innovate. Examples of change were found in the research and current practice, but it is of note that many of the ideas in aviation associated with EBT and the recognition of the need for improved knowledge-based training around automation are 20 years old. If research and development activity was better focussed (and funded) in a way that addressed real problems facing the pilot training community then this may facilitate generation of new technologies, tools, training material that will be real enablers for pilot training.

**Recommendation 5: The pilot training community and the CAA should work collaboratively to develop a research strategy for addressing gaps in knowledge, tools and techniques and collectively to invest in supporting robust, evidence-based research and development that can deliver practical outputs with clear implementation plans.**

### 3.5 ENHANCE INSTRUCTORS

A strong theme emerging from the project has been around instructors. Consideration of instructors and instruction in the literature is notable by its absence, but from the interviews it is clear the instructor role is of the utmost importance in providing effective pilot training, that it is a demanding role and is becoming harder to fill. This is true across all stages of training. Given that instructors play such an important role in the development and maintenance of pilot performance standards, is essential to ensure that the instructor role is enhanced in all possible ways.

The increasing demand for pilots means more instructors are needed. As pilots progress more rapidly through training to meet demand, instructors giving training may have lower levels of experience to support them. But the systems for ensuring training and qualification of those involved in providing pilot training are not consistent. For example, there are no formal (or common) qualifications required by ground school instructors or line training captains to ensure they have the necessary competences for these roles. The task of training pilots is becoming more challenging, due to the complexity of aircraft systems and the operating environment and because of widening of the pilot population. It is therefore becoming increasingly important to



ensure that instructor standards remain at the highest levels by ensuring all those involved in training have the necessary (and current) KSAs and experience for the training they provide. Similarly to developing training for pilots, the training for instructors, examiners and instructor-examiners needs to be based on comprehensive training needs analysis. It is central that the capabilities associated with instructing and teaching, assessing performance, progressive intervention (should trainees not be coping, i.e. supporting resilience) and giving feedback, etc. needed to be considered alongside relevant theoretical and practical skills. There appears to be a tendency to assume that, because someone has the necessary pilots licence and experience, they will also be able to instruct. However, as these tasks require different skill sets, this may not be the case.

In addition to ensuring instructors have the right competences, there are a range of other considerations needed to enhance the instructor role. Feedback from a number of areas in the interviews suggested that it is no longer as desirable to become an instructor as it once was. There are a variety of reasons for this including pay and the heavy focus on assessments reducing teaching time. This suggests that more attention should be given to thinking about both the design of the instructor role – how to make it intrinsically more rewarding (or involve less anti-social hours), what tools are needed to help instructors deliver the best possible training, peer sharing forums – and how to build a clear career path that reflects the importance of the role in terms of remuneration and continuous professional development.

**Recommendation 6: The pilot training community and the CAA should explore ways to enhance and strengthen the instructor role for all stages of training, giving consideration to training and qualification requirements, job design tools and support, career management and reward.**

### 3.6 ENSURE THE RIGHT CONTENT

The need to ensure the right content in pilot training is essential, as is the need to deliver the associated training in the most appropriate manner. So while much of the discussion in this document is around broader system issues, this should not detract from the core requirement in that system to ensure that training is provided on the right things. Based on both research and current practice, it would seem there is a reasonable understanding of the core topics and themes that should be addressed within the pilot training community. Training content is a central consideration in the research literature, with a wide range of article describing the important of different aspects of performance and exploring how to train them. Examples include: automation management, upset recovery, decision making, communication, manual flying and stress management. There seems to be good recognition in industry of the importance integrating non-technical skills with technical skills, particularly because of automation but, interestingly, the current regulations still consider CRM as a separate thing, and how the competencies are discussed in guidance material is different again.

Where there is far less transparency, is around how individual training needs analyses for different licence and aircraft types are conducted and how these needs are translated into specific training activities that support develop of knowledge, skills, etc. The drive towards competence-based approaches to training, including EBT, are very important because they encourage a much more explicit 'needs based' approach, and should be advocated much more broadly across pilot training than current regulations require. As discussed in section 3.4, there is limited information provided to support organisation in doing their TNA. One of the top barriers for controlling a range of threats to pilot training is comprehensive training needs analysis, because this is the cornerstone from which training is built. There is a risk that without proper balanced assessment of needs, core competencies may be lost to more immediately

urgent requirements, particularly when time spent training is so constrained. For this reason, it makes sense that licence related training follows a standard competence-based approach to ensure development and maintenance of core knowledge, skills and aptitudes for flying modern automated aircraft (based on training needs analysis) including performance under stress, resilience and adaptability. Whereas operational training can focus on more immediate risk- or evidence-based requirements to ensure the local operational challenges are addressed. Both are related and both need to be developed following proper analysis and regularly refreshed. Two of the key criticisms of traditional training regulations is the predictability of the scenarios being presented and their limited relevance to current operations. On-going rehearsal is important for skill maintenance but pilots and instructors need to see how the training and assessment apply to the operational job.

A final point that must be made around getting the content of training right relate to the areas of training that remain of concern to instructors and that are continually highlighted in the research as critical for safety. These include: automation management and use of manual flying, and the core cognitive competency of decision making. Consistently, these appear as challenging areas for training. Solutions to improving performance in these areas do not just depend of training – aircraft design and procedures also need to be considered – but there are also difficult areas to address and research into the best ways to achieve results in training is ongoing and should continue. What is available was described in the literature review [3]. As results emerge they should be translated into usable outputs that will support all stages of instructor and pilot training. As discussed in the next section, thinking differently about how to use new technologies in training may also provide benefits for addressing these essential but difficult topics.

**Recommendation 7: The pilot training community supported by the training regulations should ensure that comprehensive training needs analyses are conducted to inform the balanced design of training throughout the training pipeline. Attention should be given to ensuring that fundamental topics around automation management, use of manual flying and core cognitive skills, e.g. decision making, are strongly represented across training.**

### 3.7 SMARTER TRAINING

There is a real opportunity for the pilot training community to look at achieving smarter training across the training pipeline. Systematic approaches for identifying training requirements (as per section 2.4, #1) and research into optimal training times, e.g. around knowledge and skill retention, should help inform this and ensure that course content and schedules are designed to maximise learning that is of real benefit. This may also allow any out of date material to be removed to leave space for focussing on core competencies and relevant risk-based requirements. When trying to gain space in training, consideration should be given to re-balancing across the whole training pipeline, to allow more time for essential topics, such as developing knowledge of the automation, and practising core cognitive and technical skills, such as decision making and manual handling. Given the importance of developing knowledge and understanding around automation, more elements of these could be introduced earlier in training, accepting that the specifics of an individual system can only be learned during type training. For example, practising switching between flying with automation and flying manually, including the associated shift in mental modes. Building training for non-technical skills and competency development for adaptability and resilience could also be started much earlier.

Several of the barriers to addressing threats in training refer to the use of new, lower-cost training technologies to support. This could be as simple as having training material easily

available on tablet computers or using serious games to help with cognitive skill development, e.g. decision making and planning. It is known that some training organisations are already implementing these approaches but it could be adopted more broadly. Other on-the-job development techniques could also be used more, such as coaching and mentoring. These approaches are recognised in some airlines as being especially valuable for new commanders, but could also be applied at other stages of training. For example, pilots starting their careers through modular training, could benefit from external mentoring schemes for support.

A clear message from the industry interviews was that individual training schools or operators would struggle to find the resources to develop new training tools and techniques. However, if organisations pooled resources this would support funding for the research and development as well as practical training expertise and pilots for testing new concepts. This is where the drive for smarter pilot training needs to be underpinned by a pilot training system approach with collaborative governance. Traditionally, the CAA was a key driver behind training research and development in the UK, but as their capacity has now changed some of the ownership responsibility for this must shift to industry. This way, the pilot training community can focus development of new tools and techniques around delivering the training changes they need, presented in a way that supports easy implementation and thus allowing them to get more benefit for comparatively less resource.

A clear request from the CAA when it commissioned this work was that the recommendations should not simply say that training time should be increased to address problems because doing so would be unfeasible for operators. However, with the increasing complexity of automation, more challenging air traffic control requirements and the broader passenger and commercial matters pilots have to consider, pilots are being required to master a far broader range of competences than ever before. At some stage training will have to expand to fit everything in. It is therefore important that operators hold realistic expectations about the overall training footprint required. Conducting thorough training evaluation and cost-benefit analyses can be used to make appropriate arguments for why training time is required and the benefit (or insurance) that it provides.

**Recommendation 8: The pilot training community should focus on making pilot training 'smarter' so that greatest benefits can be gained from the training time currently available. This could include ensuring the content of existing training is completely relevant and necessary and time is not spent on areas no longer needed, using of specific training techniques and lower cost training tools to support skills development and rehearsal, introducing challenging topics earlier in training to spread time for learning and use of mentoring, coaching and peer support.**

## 4. CONCLUSIONS

Pilot training is a critical component of safety in UK aviation. Indeed, as the aviation environment becomes more complex, it is essential that pilots are optimally supported in developing and maintaining high standards across the full range of competences needed for flying highly automated aircraft in increasingly busy air space and with strong commercial pressures. To achieve this, pilot training needs to be continually reviewed and refreshed in response to changing demands and challenges. The findings of this project have highlighted that going forward this will increasingly require a community wide, systems approach to training that considers all elements of pilot training, including industry-lead governance and support.

Fortunately, this need to maintain focus on pilot training appears well recognised by the UK aviation training community with larger organisations seeking to be proactive, as far as permitted by regulations, in implementing developments from on-going analysis and research into their training programmes. There are also sections of the industry that would almost certainly benefit from additional support and guidance around modernisation. Across the aviation industry, commercial pressures place considerable demands on training departments, and resources are inevitably scarce; justifying the need for change is difficult especially if there have been no specific safety events to drive the change. So easy access to the latest research findings, training techniques and analysis methods in a format that can be readily implemented could facilitate change in all organisations.

The UK CAA used to be in a position to provide more of a 'thought leadership role' for aviation training through extensive funded research, mini-conferences and the expertise of the Flight Ops and Training inspectors. The move to central regulation from EASA has led to a reduction in capacity in the CAA and so there are fewer resources available for supporting industry organisations and providing guidance material for training development and evaluation. The loss of this source of support was noted by industry in this project. However, the change also provides an opportunity for the aviation community to take on more responsibility for owning the pilot training system at the broadest level and collectively driving forward the development agenda to meet ongoing demands.

For example, military flight training is also subject to growing resource pressures but there is still good access to process guidance and on-going research to support training development. Their DSAT approach [6] [7] defines how to analyse, design and evaluate training in a systematic and evidence-based manner. There is also broader access to the latest research on skill fade, use of novel training technologies, and debriefing tools and techniques. But implementing such processes and learning is still resource intensive and even in military organisations it is important the research and development work is focussed on addressing real need (as well as a separate requirement for blue-sky thinking to encourage innovation), and that the outputs can be easily exploited in training and operational units. There is also a need to learn from the experiences of commercial operations that may have relevance to an increasingly wide role of flying operations in the military, whilst in return the systematic processes for training need analysis and strong management of careers may provide learning for industry training establishments.

It is highly unlikely commercial organisations individually would (or could) support investment into such a broad range of enabling activities, therefore, implementation of more collaborative developments between organisations and improved information sharing would be of benefit to everyone. Examples of this happening already exist. The Monitoring Matters [8] guidance was developed through a collaborative human factors project with the CAA and industry. Still more positively, it is understood [9] that a pan-industry association is now developing training videos

to provide practical tools to support training for helicopter pilots working in the offshore industry. By doing so they ensure easy access and a common approach to addressing an area of concern for the whole community, which long term should help everyone by raising standards across the board.

Indeed, it is this sort of pan-organisation collaborative approach to developing guidance (based on exploitable research) and offering practical tools for instructors, training schools, operators and regulators that will provide support needed for on-going improvement in pilot training. The range of areas for consideration is wide and should cover all aspects of the training system because threats occur at all levels: from the challenge of training pilots to deal with ever more automated aircraft to needing to broaden the spectrum of initial recruits to sustain numbers and also managing the impact of globalisation on training standards.

The main foci for attention going forward are suggested as:

- ▶ Defining and agreeing the concept of a Pilot Training System to encourage improved integration across the training pipeline;
- ▶ Developing a pan-Industry stakeholder organisation for providing governance across the UK pilot training system;
- ▶ Providing improved support and enablers for pilot training (using the above group), and sharing the learning across the whole community.
- ▶ Enhancing the UK's Instructor role and resources through consideration of training and qualifications, tools and career management across all instructor groups;
- ▶ Developing approaches to ensure appropriate training content across all stages of training;
- ▶ Finding ways to make training smarter so there is space to address emerging topics and achieve the best possible learning and development at every opportunity.

The issues and priorities in pilot training will change through time and should be reviewed by the aviation community in an on-going manner and for across the whole pilot training system. The key point is that a resilient, integrated system that strengthens pilot training across careers and for all types of operations is important long term to sustain high standards of pilot performance and in the future. Finally, while this project has focussed on pilot training in the UK the issues explored apply much more broadly. The exact nature of the threats and effectiveness of the barriers will inevitably vary according to location but the general challenges are shared by aviation globally. So while not all the recommendation may be relevant everywhere, addressing them in the UK could lead to new tools, guidance, ways of thinking and improved sharing that provide benefit far more widely.

## 5. REFERENCES

- [1] Civil Aviation Authority. (2014). Safety Review of Offshore Public Transport Helicopter Operations in Support of the Exploitation of Oil and Gas. UK: The Stationery Office.
- [2] Civil Aviation Authority (2011). CAA Significant Seven Task Force Reports. UK: The Stationery Office.
- [3] McDougall, A. and Fletcher, G. (2015). Pilot Training Review Interim Report: Literature Review. FNC 46243/42976R. [www.caa.co.uk/cap1581b](http://www.caa.co.uk/cap1581b).
- [4] Fletcher, G. (2016). Pilot Training Review Interim Report: Task 2 Interview Study. FNC 46243/46562R Issue 1. [www.caa.co.uk/cap1581c](http://www.caa.co.uk/cap1581c).
- [5] McDougall, A. and Fletcher, G. (2016). Pilot Training Review Interim Report: Gap Analysis and Risk Assessment. [www.caa.co.uk/cap1581a](http://www.caa.co.uk/cap1581a).
- [6] Ministry of Defence (2016). Joint Service Publication (JSP) 822: Defence Direction and Guidance for Training and Education. Part 1: Direction. Version 2.1, December 2016. Available from: <https://www.gov.uk/government/publications/jsp-822-governance-and-management-of-defence-individual-training-education-and-skills>
- [7] Ministry of Defence (2016). Joint Service Publication (JSP) 822: Defence Direction and Guidance for Training and Education. Part 2: Guidance. Version 2.1, December 2016. Available from: as [6].
- [8] Civil Aviation Authority. (2013). Monitoring Matters: Guidance on the development of pilot monitoring skills. CAA Paper 2013/5. UK: The Stationery Office.
- [9] Civil Aviation Authority (2002). Methods used to Evaluate the Effectiveness of Flightcrew CRM Training in the UK Aviation Industry. CAA Paper 2002/5. UK: The Stationery Office.
- [10] Personal Communication with ESE Consulting (November 2016). Regarding follow-on developments from the Monitoring Matters project, reference [7].

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## ANNEX A - UNDERPINNING INVESTIGATIONS

## A.1 SUMMARY OF LITERATURE REVIEW

### A.1.1 OBJECTIVE

The objective of the literature review was: *to establish the 'state of the art' in pilot training*, including to identify the current and latest training techniques, design philosophies and recommended content, including the results of training effectiveness evaluations, skill fade studies and consideration of issues around instructor training.

### A.1.2 APPROACH

The main search focussed on: human factors and aviation psychology journals and publications, such as the proceedings from Human Factors and Ergonomics Society Annual Meetings and the International Symposium on Aviation Psychology. A number of aviation researchers/training developers were contacted directly to obtain information on their latest research. The search also included sources of grey literature, e.g. CAA, FAA, European Aviation Safety Agency (EASA), IATA, International Civil Aviation Organisation (ICAO) and the Royal Aeronautical Society (RAeS). The regulations (and associated general guidance, e.g. CAP737) were not reviewed in detail as this material is well known and amounts to the current state of activity rather than latest developments. Nor were materials collected from individual air operators, as these experiences were to be elicited through the Interview Study.

The initial search terms used in this project covered a wide range of issues associated with pilot performance and aviation safety in combination with 'Pilot Training'. These included: automation management, monitoring, crew resource management (CRM), and non-technical skills, meta-cognitive competences, adaptability, crisis management including managing the 'startle factor', impact of changes in training pathway and reduced time to command. Additional searches were also made for: airline selection, skill retention, instructor training, training design and training evaluation. During the search it became apparent that the use of such detailed search terms was overly restrictive so the search phrases used were broadened to encapsulate more general topics on pilot training.

The main search considered material up to six years old but where nothing was available this was extended further back by a few years where required. No research was considered from more than 10 years ago because of the requirement to look at recent developments.

### A.1.3 FINDINGS

The key findings from the review were:

- ▶ The literature identifies a wide range of 'state-of-the-art' training activities; however the extent to which these are implemented in the aviation training community is not known.
- ▶ There is an increasing use of competence-based approaches in training, supporting trainee resilience, as it becomes impossible to train for every eventuality possible in a modern cockpit.
- ▶ Training that provides pilots with resilient skills enables the pilot to be adaptive to a wide catalogue of situations.
- ▶ To achieve implementation of the state-of-the-art in operational training, it is crucial that there are organisational pathways that bridge the gap between research and the development of training programmes and the day to day training of pilots.

Additionally, the literature review revealed key gaps in knowledge and available information, including:



- ▶ Clearly defined, detailed competency frameworks for pilot Knowledge Skills and Attitudes to be addressed in the competence based approach;
- ▶ Guidance on integration of technical and non-technical training from the early stage;
- ▶ Techniques for stress management training, including introducing more realistic stress to training sessions for stress inoculation;
- ▶ Evaluation of the effectiveness of training courses and programmes along the pilot career pathway.

A number of areas emerged from the literature review for consideration in the stakeholder interviews to explore how much 'state-of-the-art' thinking has transferred to initial and operator training, if any further advances exist that have not been reported in the public domain and to understand the barriers and enablers to changes in the pilot training system.

The full results from the literature review are provided in reference [3].

## A.2 SUMMARY OF INTERVIEW STUDY

### A.2.1 OBJECTIVE

The objective of the interview study was: *to establish the state of current practice and issues for pilot training in the UK* from the perspective of operators, training schools, industry and professional associations and regulators for civil, military, fixed-wing and helicopter environments.

### A.2.2 APPROACH

A semi-structured interview schedule was developed based on the findings from the literature review. Key topic areas in the interview were: overall approaches to training, content, instructors, pilots/careers, support, changes and challenges. Interview participants were from 16 organisations including: airlines, helicopter operators, training organisation, military aviation, professional and trade associations and regulators.

### A.2.3 FINDINGS

The results from the interviews were analysed to identify issues, concerns, new approaches and current activities from the organisations. The key findings from across the surveyed organisations were:

- ▶ There is a strong desire to move away from traditional technical proficiencies and time-base measurement of training to competence- and risk-based content and assessment for all operator types and across a pilot's career. Some organisations already report following TNA approaches to inform this training content but the exact details of these processes were not identified;
- ▶ Military flight training organisations adopt a systems approach to training that provides clear processes for identifying requirements and structuring development, delivery and evaluation all within a broader quality assurance and governance framework;
- ▶ The advantages of simulation are widely recognised and exploited but, with minimal training footprints, time for training and practice are limited. Lower-fidelity devices could be utilised, however, resources to invest in alternative technologies are limited; also there would need to be more flexibility in the regulation around use of flight training devices;
- ▶ There seems to be a common understanding as to the general content required for training; for example, integration of technical and non-technical skills was highlighted. Detail on specific techniques from training competencies were not covered but the need for more specific approaches to train elements of cognitive skills, e.g. decision making was identified. It also appears that knowledge for understanding and using automation is still a challenge for pilots, although this is a strong focus in simulator training and increasingly considered in early training. Specific approaches for maintaining manual flying skills – other than regular practice – were not identified although again this is recognised as important;
- ▶ A significant challenge and concern is the increasing demand for pilots and the reducing supply, and how to manage this without reducing quality and safety standards. There is a perception that standards vary across training establishments with the EASA region and that there is no longer any central control for this from the CAA or ability to check up on training history. Military organisations face similar challenges with numbers but they have

very strong selection and performance management mechanisms to manage standards, which other organisations may not be able to sustain;

- ▶ As with other professional areas, there is a growth in flexible working. This may have an impact on pilot training that needs to be considered;
- ▶ As with the increasing demand for pilots so there is an increasing demand for training instructors and a challenge in some areas with attracting people to the role. Improved salaries and reward was thought would be helpful. The need for instructors to have broader capabilities to address the greater demands of competence-based training (less prescriptive) and the growing complexities of the pilot role and aircraft operations was highlighted. The need for this is further reinforced given the reducing level of overall flying experience in the aviation community. Two anomalies were identified as regards training and qualification of instructors. It appears there is no formal regulatory requirement for either of these for Ground School Instructors and Line Training Captains which, given the importance of these roles, is surprising;
- ▶ Following the move to EASA, the role of the CAA has changed, as has its capacity. As a result, operators and training organisations report experience of reduced staff numbers, high turnover and, importantly, access to less expertise and guidance. EASA itself is viewed as reducing the pace of change in regulation and there is concern it has increased variability in standards. There was no sense that the levels of expert support and guidance previously provided by the CAA are now being provided by EASA or elsewhere, which may be particularly challenging for smaller or less developed organisations;
- ▶ Change is an ongoing challenge for aviation training. The need to be able to adapt training to address operational risks is critical not least because changes in ATM, continuing developments in aircraft automation and growing globalisation all influence the pilot's role and, therefore, the competences needed to support that safely and effectively.

Interestingly, much of the focus of discussion in the interviews was on the challenges facing organisations in delivering training than the training content itself. This is different to the findings from the literature review when the focus was more on the detailed content and training for specific skills rather than on the broader training system. Change is an ongoing challenge for aviation training. The need to be able to adapt training to address operational risks is critical not least because changes in ATM, continuing developments in aircraft automation and growing globalisation all influence the pilot's role and, therefore, the competences needed to support that safely and effectively

A significant point is that none of the organisations interviewed indicated that they thought current pilot training practice in the UK was unsafe, although there was a perception amongst organisations that it would be difficult for UK organisations to protect themselves from lower standards of training if supplied elsewhere in the EASA community. However, to ensure safety going forward, given the demands placed on pilots and the modern aviation system, there are clear areas for continuing improvement, scope for rationalisation and further development. The main concerns and challenges identified related to the capability of the current training system to meet increasing demands going forward whilst, importantly, maintaining high performance and safety standards in an ever more complex, global and commercially-driven aviation environment. Ultimately, if the training footprint cannot be increased to address the growing demands on pilots then the training provided and the system around that must be absolutely optimal.

A number of clear messages were identified around organisations' concerns, or opportunities for improvement, such as: the requirement for some form of Evidence Based Training (EBT) to be fully supported by EASA regulations for both airlines and helicopter operators (as is currently being developed under Rule Making Task .0599), and stronger competence and competency approaches flowing back down the training pipeline; simulation is recognised as providing enormous benefit in aviation training, and could be used further for 'non-jeopardy' (i.e. no assessment) training and practice perhaps through lower cost devices; the need to continually refresh training for automation; the need to update ground school training; the challenge of managing variation in standards across training suppliers; and, importantly, the desire for knowledgeable, experienced support from the UK regulator.

The full results from the interview study are provided in reference [4].

## A.3 SUMMARY OF GAP ANALYSIS AND RISK ASSESSMENT

### A.3.1 OBJECTIVE

This objective of the gap analysis was *to compare the findings of interviews with stakeholders from the aviation training community and a review of the human factors and training research literature to identify gaps and other issues in pilot training, and from this to identify and prioritise the risks for UK pilot training.*

### A.3.2 APPROACH

The first step was a desktop gap analysis comparing current practice as identified from the interview study with the state-of-the-art on pilot training as determined from the literature review. Due to the different foci and levels of detail of the two inputs and because of limitations in both sets of results there was only partial mapping between the literature review and interviews. As such gaps on both sides and any other issues, including good practices, were captured for use in the risk assessment and prioritisation that was conducted using a BowTie type analysis. The BowTie diagrams were structured with the gaps as ‘threats’ and existing and potential good practices and mitigations as ‘controls’.

### A.3.3 FINDINGS

The findings from the BowTie analysis were developed as shown in Figure A.3.1.

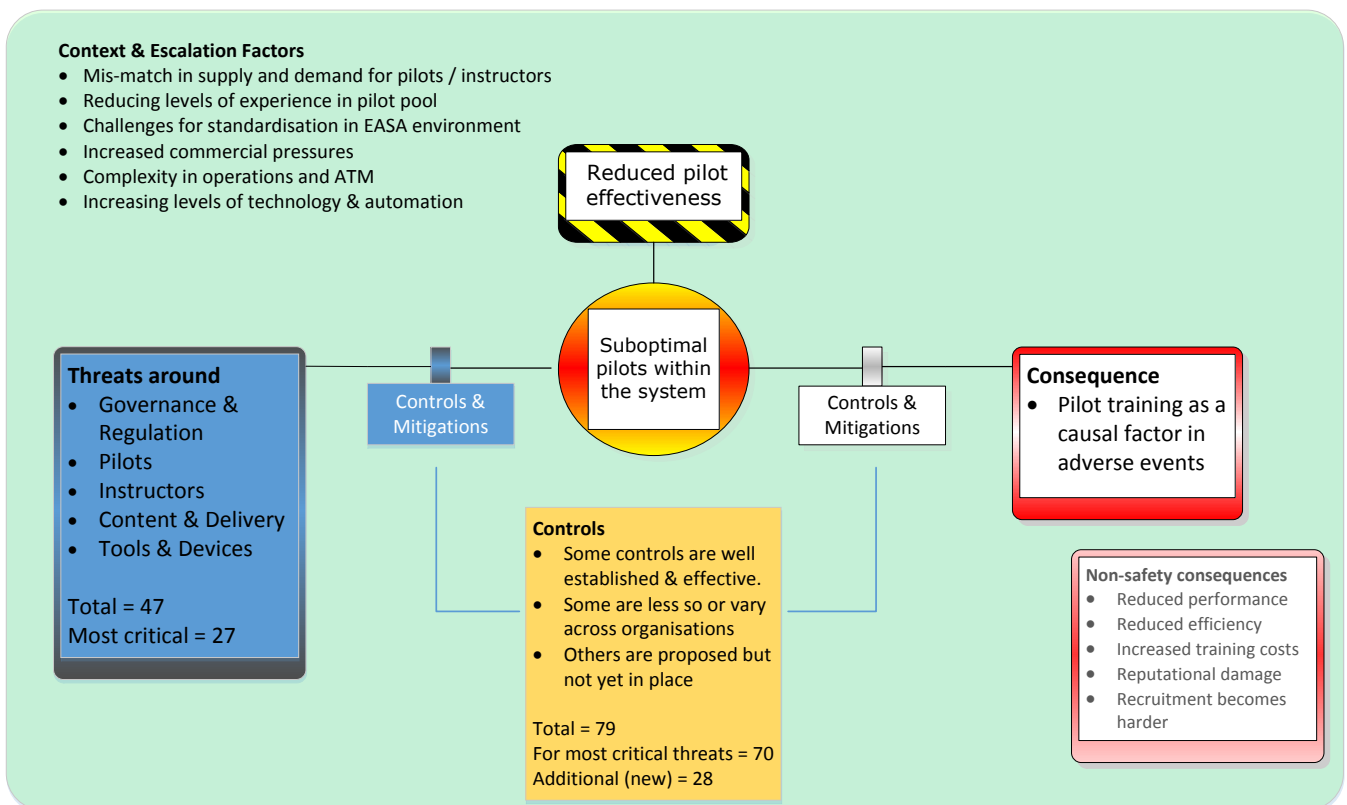


Figure A2-1. Overview of Pilot Training BowTie Analysis

Of the 47 threats identified, 27 were viewed as most critical and important based on previous analyses of current practice and literature in the project. For each threat a number of control (or barriers) were identified. The barriers are what prevent the threats turning into hazards that could then lead to an event. Some referred to systems and practices already in place; 28 were additional barriers to address gaps found during the analysis. Out of the total of 79 barriers identified, 70 applied to the most critical threats. It was suggested that the top 30, which each address three or more of the threats, should be the main areas to consider in future work to strengthen and sustain pilot training in the UK going forward; 15 of these were additional barriers. The lists of top threats and associated barriers are discussed in the main body of the report in section 2.

The full results from the gap analysis and BowTie are provided in reference [5], data were also provided to the CAA in a BowTie software format.



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