

Pilot training review – interim report: literature review

CAP 1581b

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Preface

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 reports below, 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.

Related publications

- [CAP 1581 – Recommendations and Conclusions](#)
- [CAP 1581a – Gap Analysis](#)
- [CAP 1581c – Interview Study](#)



Pilot Training Review

Interim Report: Literature Review

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SUMMARY

Following a number of air accidents where pilot training has been cited as a contributory factor, the effectiveness of pilot training has come under increased scrutiny. In response, the aviation community has been exploring approaches to address problem areas, and the CAA was keen to understand the extent of such activities, their impact, and any remaining issues not being addressed. To this end, the CAA commissioned this project to “review of recent training studies and activities and potential improvements in order to inform policy on taking the matter forward internationally.” (CAA Research Specification for Project 2217, 2014).

The project is divided into two main information collection phases:

1. Literature review
2. Interviews with aviation community stakeholders.

From these, a Gap Analysis will explore the shortfalls and any residual risk, with the results and emerging recommendations from this being presented to and discussed with stakeholders from the aviation community through an Industry Workshop. The overall project output will be a set of recommendations for interventions and/or further developments to improve training-related safety outcomes for UK aviation.

This document describes the findings of a review of recent training literature on pilot training and associated topics. The objective of the literature review is: *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.

The key findings from the study are:

- ▶ 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 training ;
- ▶ 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.

The findings will be used to inform the design of questions for the Interview Study and as an input to the Gap Analysis.

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1. INTRODUCTION

1.1 PURPOSE

This document is the first interim report from CAA project 2217: Pilot Training Review. It describes the findings of a review of recent training (research and development) literature on pilot training and associated topics. The literature review was conducted over Spring 2015. Later reports in the project will describe how air operators and training establishments deliver training against current regulatory requirements and will detail the gaps between this and the state-of-the-art.

1.2 PROJECT BACKGROUND AND AIMS

Following a number of air accidents where pilot training has been cited as a contributory factor, the effectiveness of pilot training has come under increased scrutiny. In response, the aviation community has been exploring approaches to address problem areas, and the CAA was keen to understand the extent of such activities, their impact, and any remaining issues not being addressed. To this end, the CAA commissioned this project to:

“Review of recent training studies and activities and potential improvements in order to inform policy on taking the matter forward internationally.” (CAA Research Specification, July 2014).

The project is divided into two main information collection phases: a Literature Review and Interviews with aviation community stakeholders. From these, a Gap Analysis will explore shortfalls and any residual risk, and the results and emerging recommendations from this will be presented for discussion with stakeholders from the aviation community. The overall project output will be a set of recommendations for interventions and/or further developments to improve training-related safety outcomes for UK aviation.

The project scope considers the breadth of civil commercial aviation including fixed- and rotary-wing aircraft, different operator types and training organisations, and also explores future changes in military aviation that could influence the pilot training pipeline.

1.3 LITERATURE REVIEW

1.3.1 Objectives

The objective of this literature review is: *to establish the ‘state of the art’ in pilot training.*

More specifically, the purpose was to review aviation human factors and training literature and available material published through various national and international aviation organisations 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.

The output of the literature review will be used to inform the design of questions for the Interview Study (Task 2) and to feed into the Gap Analysis (Task 3).

1.3.2 Approach

A standard literature review methodology was used:

- ▶ Identify search terms and information sources;
- ▶ Conduct the searches and down-select relevant documents;
- ▶ Review the material and extract pertinent issues;
- ▶ Collate findings and organise into report.

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. 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.

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. 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). However, not all of these sources yielded 'state-of-the-art' information. For example, no EASA documents were identified beyond the formal regulations and guidance. Additionally, a number of aviation researchers/training developers were also contacted directly to obtain information on their latest research.

The literature review did not include collecting materials from individual air operators, as these experiences will be collected through the Interview Study. Nor was the regulatory or formal guidance material on training course content, methods and evaluation, etc. reviewed, as this material is well known and amounts to the current state of activity rather than latest developments.

It became apparent that the use of detailed search terms was not entirely useful, and so the search phrases used were broadened to encapsulate more general topics on pilot training and modern aviation. This yielded more information but it became quite difficult to distinguish articles and reports describing training developments and techniques, i.e. 'the solutions', as opposed to the large number of investigations that describe 'the problems'. Numerous studies describe data on pilot performance problems, e.g. startle factor, automation awareness or monitoring skills, and then recommend that training be developed to address these. Unfortunately, they do not specifically provide any information on the design or delivery of that training. The result of this is that while training is frequently mentioned in a wide range of documents and reports, the amount of material identified on specific pilot training approaches is relatively small, certainly in terms of recent or emerging developments. Therefore, where apparent gaps exist in the research were identified they have been highlighted.

1.4 REPORTS STRUCTURE

The remainder of this report is divided into the following sections:

- ▶ Context: overview of key pilot performance, aviation safety and training issues to provide context for training developments;
- ▶ Training philosophies: brief discussion of development around broader approaches and philosophies in training;
- ▶ Competency-related developments: the main body of the review in terms of latest developments in training delivery, content, media, etc are presented around recognised pilot competencies and discussed;

- ▶ Other: discussion of a number of other factors that could influence training outcomes;
- ▶ Conclusions on the State-of-the-art: summary of the key training themes and gaps to take forward to subsequent tasks, and any recommendations for further literature investigation;
- ▶ References: detailed references and bibliography of material reviewed.

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2. CONTEXT

2.1 INTRODUCTION

This section provides high-level information of the overall context of current aviation training. It is included because training developments need to respond to issues from across the whole aviation system. This may be the need to strengthen key pilot skills because of safety concerns or to improve efficiency due to increasing demand. The main discussion is divided into three areas: high level information about the pilot training journey; pilot-related safety challenges, i.e. what are the current areas for concern; and some broader considerations mainly around the increasing growth of aviation worldwide. A final section lists some potential areas that might be expected to emerge from the literature to address some of these current and future challenges.

2.2 TRAINING JOURNEY

2.2.1 Traditional *Ab Initio* Training

The traditional *ab initio* training path focuses on the trainee's progression through clearly defined training phases. Each phase addresses specific contents and progression through the phases requires the trainee to be assessed as meeting a measurable standard. As a result of the structured, incremental nature of the training programme and the fixed assessment 'gates', the initial entry standards for training schools may be variable. Some training organisations will fix very high entry requirements. Others will adopt a more open selection approach, which theoretically should not be an issue because of the common assessment standard.

The first element of *ab initio* training is basic training. This is the acquisition of a Private Pilot's Licence (PPL). Following on from this, training focuses on hour - building, theoretical ground school training and advanced flight training (using both aircraft and simulators). Having achieved a frozen Airline Transport Pilot Licence (ATPL), trainees are then eligible to work as a First Officer with an airline once specific aircraft type training; when a requisite number of flying hours have been completed the ATPL is unfrozen.

There are two main pathways for trainees to choose between: integrated courses are full time (lasting 16 to 20 months) and provide the complete path, incorporating *ab initio* and type rating in a single approved training organisation; Modular courses offer more flexibility, with trainees gaining their PPL and further accreditations over a longer and flexible time period and with the opportunity to learn different modules from various training organisations.

2.2.2 Type Rating Training

Type rating training follows on from *ab initio* training, and provides trainees with the skills required to operate a specific type aircraft for a specific operator. This incorporates a technical ground school course, simulator training and aircraft base training (landings). Manual flying skills learnt in basic training are built upon with the development of automation flying skills, systems management skills (such as the use of flight management systems) and familiarisation with standard operational procedures.

Additional training can be appropriate prior to starting type rate training, to support trainee pilots' transition to a specific aircraft type. Multi Crew Cooperation (MCC) courses train single seat pilots in the team skills necessary for the safe operation of complex, multi crew, jet aircraft; and Jet Oriented Courses (JOC) support trainee pilots transitioning from flying propeller aircraft to jet engine aircraft, improving jet handling skills and incorporating some standard operating procedures.

2.2.3 MPL Training

The Multi-crew Pilot License (MPL) was introduced by ICAO in 2006 as an alternative to the traditional *ab initio* training route. The MPL approach trains participants specifically to join a known air operator flying an already identified aircraft type. Courses take a competency approach with trainees meeting specified performance criteria. Trainee screening at the selection stage is comprehensive because the trainees have been selected by the airlines for attend the training for their operations (for an overview of Pilot Screening, see Section 5.1). Following theoretical ground school training, Phase One focuses on basic flying training. In Phase Two, Three and Four, simulators are used to build type specific flight skills and multi-crew coordination. The training is operations-oriented and incorporates airline specific standard operating procedures (SOPs) from an early stage in the training whereas in MCC crew resource management skills and SOPs are taught as an additional. Each MPL course is bespoke, fitting the specific operator's needs.

2.2.4 Recurrent Training

The minimum frequency of recurrent training and checking is mandated at a high level by the regulation, e.g. yearly flight simulator aircraft system failure training to three year rolling for CRM. Delivery under this is defined by the operators and is type dependent. Recurrent training is required to: enhance aviation knowledge and skills (e.g. simulation of emergency or abnormal situations); train new equipment, regulations or procedures; and ensure a level of proficiency has been maintained. This normally incorporates both ground school training and Line-Oriented Flight Training (LOFT) in a flight simulator. This recurrent training should also cover non-technical skills for Crew Resource Management (CRM) in normal and emergency operations.

The introduction of Evidence-Based Training (EBT; IATA, 2013) over recent years is seeking to encourage air operators to base their on-going training on the specific requirements and issues associated with their operations.

2.2.5 Command Training

Command training programmes are defined by each air operator according to their operations and requirements. The regulator then certifies these courses to ensure that they meet high level requirements of what commanders 'shall' be able to do. The process for getting to the promotion point is again defined by internal processes, which have been approved by the regulatory Flight Operations Inspector. As such there is no standardisation across the industry and the time to reach a command post takes significantly different amounts of time, depending on the organisation. In some airlines this can be after 4-5 years as a First Officer/Co-pilot and in other airlines it can be as much as 15-18 years to reach Captain.

In addition to formal command courses, some airlines offer Command Mentorship programmes to help new commanders in post. A number of Command Preparation Courses are also available from independent training suppliers.

2.2.6 Conversion Training

Experienced pilots will undergo a reduced from of type rating training as part of a conversion course if they change aircraft types. The scope of this is likely to be dependent on the specific transition. For example, changing between two aircraft from the same manufacturer is like to create less of a training burden than changing between aircraft from completely different manufacturers, with different underpinning design philosophies.

2.2.7 Instructor Training

Current international guidance recommends that instructors hold or have held the equivalent qualification for the level being taught. They also may have gone through a selection process to

assess their competence, motivation and disposition (this is required for MPL and EBT) (IATA, 2013). Annual refresher training is also recommended by the IATA report (2013).

2.2.8 Helicopter Training

Helicopter training follows a similar route to the *ab initio* and type rating training described for fixed-wing aircraft (sections 2.21-2.24) but excluding the MPL specific approach.

A Commercial Pilots Licence (Helicopter) (CPL(H)) can be achieved through modular or integrated courses, both of which incorporate flight time experience and theoretical learning to gain the required level of knowledge and experience. Following this, trainees undertake a 35 hour Commercial Flying Course and a pilot 'skill test' to gain their CPL(H). The trainee can then progress to achieve an Airline Transport Pilots Licence (ATPL(H)) through gaining flight hours, instrument rating, experience of multi-crew helicopters and theoretical training.

Type Rating Training Organisations conduct 'post qualification' conversion training in respect of specified types and classes of helicopter. Recurrent training is as with airline requirements.

2.3 PILOT RELATED SAFETY CHALLENGES

2.3.1 Current Issues

Discussed below are the safety issues outlined across the literature that are most relevant to pilot training.

2.3.2 Loss of Control

Loss of Control In-flight (LOC-I) events resulted in the highest number of fatal events over the past decade (Significant Seven, CAA 2011). LOC-I events occur when the plane exceeds the normal flight envelope and subsequent crew action (or inaction) leads to loss of control of the aircraft. During LOC-I the crew needs to identify the true state of the aircraft, to understand the factors that are contributing to the incident and to take the appropriate action in light of these. This can require taking over with complete manual flight or adjusting the level of automation to use flight controls in a lower mode. The skills required for this are defined as Upset Recovery and training in this is now a regulatory requirement. . These events are unexpected, and often pilots struggle to define all of the contributing factors, leading to inappropriate recovery action. Issues of reducing levels of manual flying skill are also a concern here.

2.3.3 Rejected Landing

Go-around, due to rejected landings, is a challenging manoeuvre. Go-arounds may be ordered by air traffic control or determined by the flight crew in light of flight conditions, such as an unstable approach. The industry has identified them as a safety issue because they are often either poorly executed or a decision is made to continue the landing when a go-around should be performed.

2.3.4 Use of Automation

Over- reliance on automation can create an 'out of the loop performance problem' (Clegg et al., 2010). The 'out of the loop performance problem' is a consequence of the use of automation, where operators of automated systems struggle to take back control in the case of automation failure, as they are outside of 'the loop' due to their role as observer during normal operation. In PARC and CAST's¹ (2013) work group accident analysis, pilots were identified as being 'out of the control loop' in over 50% of accidents. In these situations the pilots have been found typically to over-delegate authority to the automated system control. This results in reduced

¹ Performance-based operations Aviation Rulemaking Committee (PARC) and Commercial Aviation Safety Team (CAST) Flight Deck Automation Working Group.

situational awareness and reduces the pilot's ability to anticipate aircraft behaviour, making it challenging to take control and manage unexpected events. Automation dependency is of equal concern in helicopter operators, with British Airline Pilots' Association (BALPA) raising their concerns that new helicopter pilots may rely too heavily on automated systems (CAA, 2014).

2.3.5 Mode Management / Awareness

Mode management refers to a pilot's ability to understand the character and consequence of autoflight modes. This includes choice of modes, disengaging and transitioning between modes and being aware of and anticipating automatic mode transitions made by the autoflight system (Hutchins, 2007). The issue of pilots being caught unaware by the automation or not understanding what it is doing is widely reported, particularly in the helicopter environment. Concerns regarding pilot mode awareness were raised in the FAA Human Factors Team report in 1996, which suggested training should better address understanding of automation and mode awareness. However, issues with mode management are still being identified as a concern nearly 20 years later.

2.3.6 Startle

Previously, in older aircraft pilots would expect engine and systems failures, now as accidents and faults do not occur regularly, pilots do not expect these problems and instead are used to a highly reliable system. As a result, pilots are often surprised by unexpected events and lack readily accessible mental action plans. Startle occurs when the information observed by the flight crew does not correspond with the flight crew's current understanding and expectation of the situation. This can result in startle: a strong physiological, psychological and emotional response, impairing cognitive and motor ability, and even resulting in 'freezing'.

Startle has been identified as a causal factor for loss of control events related to monitoring lapses (CAA, 2013). This report illustrates how low arousal can lead to pilot vulnerability, and how then sudden unexpected stimuli can cause a startle response, which in turn can lead pilots to loss of situational awareness, inappropriate actions and, ultimately, loss of control.

2.3.7 Threat and Error Management (TEM) / Crew Resource Management (CRM)

TEM is based on the fundamental idea that threats and errors, and the management of these, are part of everyday crew operations. Threats exist and are beyond the control of the crew, whereas errors originate from how the crew carries out their duties. For example, threats can be environmental, such as weather conditions; operational, such as time pressures; and equipment or maintenance failures. Examples of errors include communications errors such as misinterpretation of information; procedural errors such as a missed briefing; or handling errors such as mode selection or navigation errors. Whereas CRM emphasises the role of communication and skills in maintaining safety in the cockpit, TEM offers a broader framework for the management of threats, errors and crises and risks to encourage resilience. Within TEM, CRM and other technical and non-technical skills are used to manage the risks of threats and errors. Any breakdown in TEM increases the risk on incident on an aircraft and could result in LOC-I.

2.4 BROADER ISSUES

2.4.1 Growth in Air Travel

There is a rapid growth in air travel, leading to increasing air traffic. Where the aviation industry has traditionally centred on American and European carriers, current growth is mainly seen in developing markets such as Asia. This has an impact upon harmonisation. Much of the previous effort of harmonisation has been within Europe and between Europe and the USA.

For example, harmonizing the operation and maintenance of aircraft to improve interoperability and reduce issues of non-compliance. This will now need to be extended to incorporate other countries. Increasingly air operators will be multi-national organisations and so pilot training and crew procedures will need to become increasingly sensitive to cultural differences.

Despite the growth in capacity in air transport across the world, tolerance of air accidents is going down. Therefore, the levels of safety need to be, and be seen to be, improving all the time. Over the past decades much of this has been accounted for from improved aircraft technology but accidents do still occur, frequently related to the issues identified in section 2.3, and as a result the spotlight on the human in the cockpit is ever growing.

2.4.2 Pilot Supply and Demand

This growth in the market also creates a greater demand for pilots, placing pressure on training organisations to increase throughput and pilot availability. This increased demand results in the need to broaden the recruitment pool, both locally, increasing the throughput of training, and globally, through training organisations developing pilot training opportunities in other countries. An impact of this is the increasing likelihood that pilots will be working in crews with more diverse backgrounds, either having been trained by different organisations or different countries. An example of this is the increasing number of pilots who will not have English as a first language. Over the past 18 years there has been a significant increase in students choosing to receive flight training outside of their native country (Damos, 2014). This creates a requirement for language proficiency testing and training to be integrated within in pilot training courses. The increasing likelihood of multi-cultural flight crews may place a greater demand on a crew's resource management skills. For example, a crew member working with English as a second language may experience greater cognitive demands when managing an emergency situation, however no available research was identified that explored the requirements and difficulties of crew resource management in these settings.

While the demand for pilots grows, it has been observed that substantially fewer pilots are coming from a military background (Damos, 2014; Caligan, 2012). Military pilots fly high performance aircraft in a variety of different settings. The main difference between civilian and military training is that military pilots are taught to handle the aircraft with confidence throughout the entire flight envelope, including various stalls and spins as well as aerobatics and flying at speed. This manual handling is emphasised throughout training and therefore provides pilots from a military background with greater experience of manual flying skills. A reduction of ex-military pilots in the recruitment pool will lead to fewer pilots with a strong grounding in manual flying skills.

In addition to the change in the pilot training pool, the demand for pilots may also drive a reduction in time until command. Currently the progression from First Officer to Pilot requires extensive flight experience, as the demand for pilots increases the number of First Officers with such a high level of flight hours will reduce.

2.4.3 Instructor Demand

With the increasing demand for pilots, so comes an increasing demand for instructors. Not only must instructors be identified, they must also be trained and evaluated in order to train and evaluate others. This takes time; also as pilots move through the ranks quicker, in the future instructors could end up with less overall experience to meet the demand.

As aircraft become more complex, the training necessarily must deal with this. So not only must instructors have knowledge and skills associated with training and use of various types of modern simulation devices, they must also keep up to date with the changes in technology and automation. Major variations have been identified in recurrence of instructor training across the

industry. Some training programmes do evaluate instructors regularly, assessing manoeuvres and instructor technique (PARC & CAST, 2013). This is beneficial for instructor development, ensuring consistency and keeping instructors up to date. The concern over instructor standards is so great in some areas that the Offshore Helicopter Review (CAA, 2014) recommends that the (regulatory) requirement for instructor tutor training is reviewed, especially to support type rating instructors' knowledge of aircraft and the operating environment.

All these issues add considerably to the overall training burden in the aviation community and, therefore, as pilot training develops so consideration should also be given to the design of instructor and examiner tasks.

2.4.4 Cost

Cost is a constraining factor when considering training. Commercial aircraft operate with low profit margins, due to pressure to lower the cost of air travel, and operators are required to make ongoing improvements to operate more efficiently. Therefore, there is an organisational interest in reducing training investment. This means that course duration is being reduced, which will have an effect on the amount of material that can be covered (which becomes a problem as the amount of information to be covered goes up as aircraft get more complex) and the time available for practice and consolidation is reduced.

2.5 EXPECTANCIES ON THE STATE OF THE ART

Given the ongoing growth in air travel and the international concerns over pilot performance, of which training is one of the key mitigating factors, there is a wide range of developments in philosophy, content, delivery, and assessment that might be expected to characterise the state of the art in pilot training.

A list of possible examples of this would include:

- ▶ Approaches to improve the efficiency of pilot learning;
- ▶ Approaches to improve the effectiveness of training;
- ▶ Optimisation of instructor and examiner selection, training, calibration and certification;
- ▶ Development of specific techniques to address key knowledge, skills and attitudes (KSAs);
- ▶ Exploration of optimal design for training pilots for modern aircraft, including managing skill fade, switching from supervisory control to manual control, etc.;
- ▶ Greater selection for core competence;
- ▶ Clear definition of competencies or KSAs;
- ▶ Results from evaluations of different training philosophies, e.g. EBT and specific training interventions, e.g. TEM training.

This list is presented here to prompt the reader to what might be potentially relevant developments to be found in the literature on aviation training given the current safety and operating contexts.

3. LATEST TRAINING PHILOSOPHIES

3.1 EVIDENCE-BASED TRAINING

In recent years, the key direction in training across industries has been towards a competence-based approach. Competence-based training requires learners to demonstrate that they can do a task well enough to be assessed competent in the execution of that task. The focus is on the learner and what they can do at the end of their training, i.e. the output, and not on the input to the training, e.g. course duration. This approach has clear benefits in safety critical domains where it is vital to ensure that trainees can demonstrate the necessary knowledge, skills and attitudes in performance of their tasks in order to complete their training. As such, the approach is gaining traction for pilot training. For example, a competence-based approach is at the core of MPL, where instead of pilots meeting flight hour requirements the training focuses on skill development. MPL uses a systematic training methodology, where the curriculum takes into account the capabilities required in the role and the traits of the trainee population to create clear learning objectives. The other significant example is Evidence-Based Training.

Evidence Based Training (EBT) is a training approach developed by the International Air Transport Association (IATA, 2013). Its aim is for pilots to demonstrate competency in required areas during assessments rather than just successfully achieving a predetermined outcome, such as flying repetitive manoeuvres. As such, it is adopting the newer approaches to training that focus on what people can do, competences, rather than how long they have been doing it. This encourages trainees to demonstrate a higher level of performance, rather than passing with the minimum standard. The training aims to facilitate trainees' development of expertise and resilience to manage line operations and non-normal events. It incorporates technical and non-technical competencies. The documentation includes a set of pilot competencies and behavioural indicators developed by an expert industry working group:

- ▶ Aircraft flight path management, Manual flying skills;
- ▶ Aircraft flight path management, Automation flying skills;
- ▶ Situational awareness;
- ▶ Problem solving and decision making;
- ▶ Workload management;
- ▶ Application of procedures;
- ▶ Communication;
- ▶ Leadership and teamwork.

These are defined using a combination of the knowledge, skills and attitudes (KSAs) required to perform tasks to the prescribed standard. However, the list is effectively a summary of existing definitions of technical tasks and under-pinning non-technical skills, and because of this there is considerable overlap. For example, Aircraft Flight Management, Automation is described as:

“Controls the aircraft flight path through automation, including appropriate use of flight management system(s) and guidance.” (IATA, 2013, p65)

But achieving this would be impossible without the use of the identified non-technical competencies (e.g. situation awareness, problem solving and decision making, communication, etc. as listed overleaf). Hence the competencies as described could still result in valuable opportunities to integrate skill areas to be missed.

Only limited information is provided about the different elements of these KSAs. Indeed, in line with the 'risk-based' foundations of EBT, the Implementation Guide recommends that operators should develop their own competency frameworks to tailor the system to their needs. Unfortunately, the guide does not include information on how to conduct a KSA or training needs analysis or to develop a competency framework.

Todd and Thomas (2013) conducted a study which found that typically, trainees flight hours were very similar, reflecting the minimum training hours and the syllabus of the organisation within which they were training; this is not in line with the normal distributions associated with other elements of human performance. Indeed, Todd and Thomas argue that the minimum hours requirement of 150 hours total flight time in Australia is at odds with the competency-based training concept, with pilots who are competent at 150 hours of flight time may well have been competent before. They observed that competency-based training is difficult to implement due to problems in the definition of the competencies, implementation, and assessment. Therefore, aviation regulators tend to base decisions regarding flight training and flight training innovations on existing data and not an ideal view of what should be happening in the aviation training system. This said, the Australian aviation system has used the competency-based training approach for many years, incorporating the training of non-technical skills into its syllabus. Unfortunately, there is limited information about the evaluation of this training technique (Todd and Thomas, 2013).

3.2 IMPROVED PATHWAY INTEGRATION

As part of the European Airline Training Symposium, Greubel (2014) set out global training challenges including industry growth and experience loss, increasing automation, the need for effective CRM, threat and error management, threats from the growth and complexity of the system. It suggests that current *ab initio* training needs updating. There is a need to incorporate TEM and CRM in all training phases, providing a competency based training course that facilitates the understanding and application of knowledge. There is also a requirement for more rigour in the system, ensuring that trainers have the appropriate KSAs to deliver training, and that their competencies have been assessed and the necessary qualification provided. Additionally, data is needed to support a performance based environment, to assess trends and enable individual and generic feedback.

Barshi (2015) offers a framework for integrated pilot training. He suggests that there may be an opportunity to improve pilot routine training by making it all 'line oriented' so that training reflects the day to day tasks of pilots, integrating the training the skills required. To address this, Barshi developed a 'Comprehensive Line Oriented Flight Training (LOFT)' training approach. This approach addresses the elements of the system that the pilot needs to be familiar with to make strong operational decisions, training students in terms of flight phases rather than detailed subsystem knowledge. Currently, ground school training focuses on engineering aspects and different subsystems, comprehensive LOFT training embeds this knowledge within the skills and procedures required in operational context.

3.3 SYSTEMS APPROACH TO TRAINING

A systems approach to training development can be applied across different domains and circumstances. The aim of such an approach is to develop a cost effective training solution, providing a systematic approach to develop training based on training needs and in light of organisational issues. Figure 1 demonstrates the stages of training development, beginning with analysing the job which will identify the KSAs required for the role; this feeds into design, implementation and evaluation.

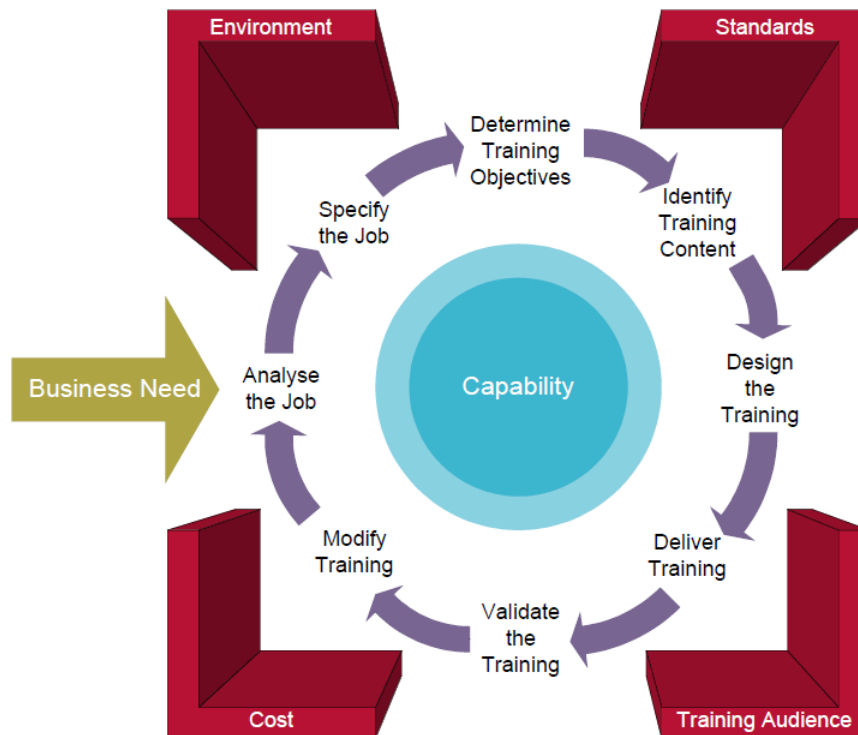


Figure 1 Elements of a systems approach to training development

It is key to realise that the cycle continues to ensure that training continues to address changing KSAs or changing training audience needs, and that evaluation needs to occur at all stages to ensure training is targeted and to provide evidence of training impact. The UK defence community is required to follow a standard set of processes outlined in the Defence Systems Approach to Training (DSAT; MOD, 2012), which provides a quality framework for ensuring the necessary processes are in place to develop appropriate, robust and integrated training solutions are developed.

3.4 DIRECTIONS IN TRAINING SCIENCE

Tiley and colleagues (2011) produced a review of the recent concepts, theories and emerging principles for training design to support Tri-Service training on behalf of the UK Defence Science and Technology Laboratory (DSTL). This report highlighted several areas of training design aiming to maximise cost effectiveness and manage the impact of increasing and changing technology. The key areas of development noted were:

Motivation Training: trainees' pre-training attitudes affect motivation in training. Motivation can be maximised by emphasising how training offers personal benefit to the candidate and articulating the positive benefits of training, managing expectations of training as well as providing regular, clear, goals and positive constructive feedback.

Stress-Resistant Skills: training should incorporate the use of stressors within training rather than developing the trainees' skills to a level and then introducing stress management. The aim of this is to make trainees more resilient to stress and increase trainees' familiarity with stressful operations by increasing their experience.

Team skills: it was identified that trainees that train together and are tested together facilitates better training transfer across KSAs.