

Safety Regulation Group

CAP 676

Guidance on the Design, Presentation and Use of Emergency and Abnormal Checklists

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Guidance on the Design, Presentation and Use of Emergency and Abnormal Checklists

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Revision History

Issue 1

September 1997

CAP 676, Guidance on the Design, Presentation and Use of Emergency and Abnormal Checklists, was the first guidance produced by CAA on how to design a checklist and concentrated mainly on the physical design and layout.

Issue 2

January 2006

This issue expands on the previous guidance to include more advice on the errors and problems that commonly occur when using checklists, and how to minimise these with further design advice. Examples of different checklist layouts are included, together with a checklist assessment tool.

Issue 3

30 August 2006

This issue presents minor improvements to the checklist assessment tool as the result of operational experience.

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Executive Summary

Concern has been expressed that the potential for an accident or incident is increased by the pilot misinterpreting the checklist due to poor design.

The primary goal of this guidance is to improve Emergency and Abnormal Checklist usability in assisting the flight crew to manage and contain system faults and other situations that adversely affect flight safety. Additionally this CAP will assist all stakeholders involved in the design, presentation and use of Emergency and Abnormal Checklists to take account of best human factors principles within their processes.

It is the responsibility of both the aircraft manufacturer and aircraft operator to work together throughout the Emergency and Abnormal Checklist design, development and amendment process to ensure that optimum system configuration following a failure is assured commensurate with best operational practice.

In addition to providing process information in Chapters 2 through to 6 of this document, guidance is provided in the application of good human factors principles in the design of the checklist. This covers the physical structure, content and layout. A Checklist Assessment Tool (CHAT) has been developed to allow Regulators, Manufacturers and Operators to review checklists against these design principles and thus be able to recognise a potentially error-prone checklist. The tool provides usability rationale to support the design attributes which are contained in Chapter 7 of this document. CHAT is a stand alone paper based tool and is presented as part of the Executive Summary.

Checklist Audit Tool (CHAT)

The purpose of CHAT is to determine whether your checklist complies with best human factors practice as defined in the appropriate paragraph in Chapter 7 of CAP 676 (paragraph references are given in the first column of the table).

Ch. 7	Title	Attribute	Y	N	N/A	Comments
Physical Characteristics						
1.1	Document size	Is the size of the document appropriate to the stowage space available?				The checklist must be able to be stowed in an accessible location and easily retrieved in an emergency.
		Can the document be used without interfering with the controls or obscuring the displays?				This check needs to be carried out on the flight deck. The document should be reduced in size if there is any interference or obscuration.
1.2	Binding	Can the document be opened through 360°?				Access to required page(s) needs to be accomplished without requiring the crew to hold the pages open. Thus ideally the checklist will be able to fold back on itself. Recommend change if this cannot be achieved.
		Can amendment pages be easily inserted?				Ring binders are recommended.
		Is binding robust?				Can it fall apart? If the binding is loose, pages could be lost. Recommend change binding.
1.3	Cover	Is the cover robust to protect pages within?				
		Is the colour significantly different to minimise incorrect checklist selection?				The Emergency and Abnormal operation should be easy to distinguish. Recommend change colour of cover.
		Is the cover easily distinguishable from the pages within?				If the checklist is folded back on a particular page when stowed it may not be easy to locate. Recommend change the colour or size.

Ch. 7	Title	Attribute	Y	N	N/A	Comments
		Does the title of the checklist and aircraft type appear on the front cover?				In a multi fleet operation this could result in the wrong checklist being used. Recommend change cover.
		Is the checklist stowed out of proximity of drink containers?				Drink stains could render the checklist unusable. Recommend protecting checklist in some manner (e.g. using laminated pages).
1.4	Tabs and dividers	Are the tabs clearly identified?				Tabs are used to assist in the location of drill. If they are not clearly identified this will cause delay in finding the correct drill. Recommend change tab numbering to be consistent throughout document.
		Are the tabs logically linked to the index?				If they are not logically linked this will cause delay in locating the correct drill. Recommend change tabs to provide logical linking (see Example 1, Appendix 3).
		Are the tabs wide enough to place a thumb on?				If the tabs are too small access to the correct drill will be more difficult. Recommend changing the size of the tabs (see Example 1, Appendix 3).
		Are the tabs and dividers consistent in colour?				Where colour coding has been used to discriminate drills the colour coding should be consistent. Recommend changing the colours of the tabs and dividers to maintain consistency.
1.5	Font type	Does the font type used provide clear differentiation between characters?				Difficulty in reading the text may cause errors to be made. Recommend sans serif fonts (without tails) such as Helvetica, Gill Medium or Arial fonts are used.
		Is lower case with upper case initial letters used for blocks of text?				Research has shown that lower case text is easier to read than uppercase (see Example 6, Appendix 3). Recommend change text to lower case. Upper case can be used for titles and attention getting warnings and alerts.

Ch. 7	Title	Attribute	Y	N	N/A	Comments
1.6	Print size	Is the checklist legible at arms' length?				Text must be legible under all lighting conditions at arms length (approximately 600mm). Smaller text will cause eye fatigue and may not be legible particularly in low visibility conditions. Recommend increase font size until it is legible at 600mm.
		Are the smoke procedures in large print? (Also consider any procedures that may be carried out under poor lighting conditions.)				Font size should be large to be legible in a smoke filled cabin. Recommend increase size of font.
1.7	Margins	Is there at least 19mm space between the binder and the text?				The binding should not hide the text. Recommend changing margin to typically 19mm.
		Can you use your thumb as a cursor to keep track of drill progress?				It should be possible to hold the list using the thumb as a cursor without obscuring the text. Recommend changing margin to typically 19mm.
1.8	Emphasis and differentiation	Are similar action items on the checklist clearly differentiated?				Similar lines of text could result in an action item being missed. Recommend highlighting the difference in the sentence using bold type.
1.9	Contrast and colour	Has black text on a white or yellow background been used?				Coloured backgrounds provide a poor contrast ratio, which is difficult to read. Recommend using white or yellow background. If other colours are used check legibility under low ambient lighting.
		Is all the text in black?				Coloured text is difficult to read particularly under low ambient lighting conditions and should be avoided. Recommend changing coloured text back to black. Alert cues may be coloured (see Chapter 7, paragraph 2.4).
		When the Emergency and Abnormal procedures are in the Operating Manual are the pages distinguished from the main drills?				It is important to be able to quickly and accurately locate the correct drill. Recommend using colour tabs - red for emergency and amber for abnormal procedures.

Ch. 7	Title	Attribute	Y	N	N/A	Comments
		Where colour shading has been used to discriminate actions or notes, is there sufficient contrast between the text and background?				Colour shading provides a good method of discrimination but must be used with care. Recommend the use of pastel colours (low saturation) for shading.
1.10	Contents list and index	Does the checklist have a tabbed content list at the beginning of the checklist?				The checklist is unusable without a contents list. Recommend adding a contents list (see Appendix 3, Example 1).
		Does the contents list clearly identify the sub-systems?				The pilots should be trained to know in which sub-system the fault has occurred. Recommend clearly listing each sub-system (see Appendix 3, Example 1).
		Are critical drills highlighted in the index?				The critical drills need to be attended to very rapidly. Recommend highlighting in some manner to make these drills easier to find. Alternatively put the critical drills at the top of the index.
		Does the checklist have an index of all fault captions covered in the checklist?				An alphabetical index will provide a quick route to the correct drill particularly when the Pilot is unfamiliar with the fault and does not know which sub-system to try first. Recommend including an alphabetical index.
		Is there a contents list at the beginning of each sub-system section of the checklist?				Lack of a list can make the checklist unusable. Recommend putting an index at the beginning of each sub-system section.
1.11	Numbering	Within each sub-system section do the page numbers correspond to the tab numbers?				Lack of numbering, incorrect or confusing numbering can make the checklist unusable. Recommend numbering each page in correspondence with the tab number or other logical manner.
		Is the number clearly identified on the page?				Lack of a page number can make the checklist unusable. Recommend putting the number at the bottom or top of the page. Large font size is recommended.

Ch. 7	Title	Attribute	Y	N	N/A	Comments
		Are actions consecutively numbered in the drill?				Research has shown that numbering actions assists in place keeping. Recommend consideration be given to numbering actions.
Checklist Content						
2.1	Structure	Have the number of action items been minimised to take account of time available to complete the drill? For example, landing gear problems are likely to be discovered when fuel is low.				It is essential that the minimum number of actions be carried out to establish a safe aircraft state. Consider carefully whether diagnostic actions that attempt to eliminate the source of the problem are essential when there are likely to be time constraints.
2.2	Checklist Instructions	Is a set of notes outlining the checklist coding philosophy contained in the checklist?				The notes should detail the coding and presentation philosophy used throughout the checklist. Recommend including instructions in the checklist or providing easy access to the instructions in the documentation suite.
		Do they adequately describe the presentation and philosophy principles used in the checklist?				The notes should provide explicit details on how to interpret the information contained within the checklist. They should also define terminology such as land as soon as possible and land as soon as practicable .
2.3	Title	Is a title prominently displayed at the start of each drill?				Lack of a title will make the checklist unusable. The drill must have a title (see Appendix 3, Examples 2 and 4).
		Does the title fully reflect the failure condition?				A misleading title could result in the incorrect drill being carried out. An unambiguous and practical title should be used (see Appendix 3, Examples 2 and 4).
		Is the title completely distinguishable from the rest of the drill?				The title must stand out from the action items and notes on the drill. Recommend using a method like boxing and/or bold font (see Appendix, 3 Examples 2 and 4).

Ch. 7	Title	Attribute	Y	N	N/A	Comments
2.4	Failure condition	Does the checklist contain a description of the failure condition(s)?				A repeat of the warning captions and failure states provides a useful confirmation that the correct checklist has been selected. Recommend including a description of the failure conditions (see Appendix 3, Examples 2 and 4).
		Does the checklist contain an illustration of the alerting trigger captions?				A repeat of the warning captions in the checklist (using the same colour as it appears on the flight deck) provides a useful confirmation that the correct checklist has been selected. Recommend including an illustration of the relevant warning captions (see Appendix 3, Examples 2 and 4).
2.5	Objective	Does the checklist contain an objective?				An objective statement serves as a useful confirmation that the correct checklist has been selected and the expected outcome of the drill. Recommend including an objective statement where appropriate in the checklist (see Appendix 3, Example 4).
2.6	Memory items	Are the memory items listed at the beginning of the drill?				Memory items should be carried out first and verified on the checklist. When they exist they must be the first set of action items.
		Are the memory items clearly distinguished from the other action items?				It is recommended that the memory items be distinguished in some fashion - boxing, shading, line marking, numbering (M1, M2),etc.
		Are there six or less memory items on a single drill				It is recommended that the memory items should be kept to a minimum - preferably four or less. Recall can be impaired under stressful situations.
2.7	Cautionary Notes	Are cautionary notes clearly discriminated on the checklist?				Cautionary notes highlight resultant performance constraints and should be differentiated from ordinary explanatory notes. It is recommended that appropriate colour shading highlights caution notes. Ideally they should be accompanied by the word 'caution'.

Ch. 7	Title	Attribute	Y	N	N/A	Comments
		Are the cautionary notes printed above the action item that they relate to?				It is essential that the crew are aware of the implications of any action item before they carry it out. Recommend moving the cautionary note to precede the action that it relates to.
2.8	Action items	Are the action items distinguishable from the notes in the checklist?				It is important to identify the 'do' list items in the list. Recommend that they are distinguished from other items in the checklist (e.g. text font size, font type or bold font are potential candidates).
		Are the 'read' and 'do' items clearly linked?				The items should be linked to avoid the possibility of associating the wrong challenge and response. Recommend using dots or dashes to link challenge and response items (see Appendix 3, Examples 2 and 4).
		Are the critical items (e.g. actions resulting in the deactivation of the flight controls) discriminated?				Critical items which could create a hazardous situation require positive verification by the monitoring crewmember and therefore it is important that these actions are clearly discriminated from other action items. Recommend changing presentation of critical items to provide discrimination.
2.9	Explanatory Notes	Are the explanatory notes clearly distinguished from action items?				The notes should not clutter the action items. It is recommended that they are visually distinguishable.
		Are the notes linked to the action item that they relate to?				It is essential that the notes either precede or follow the action item. It is recommended that notes are consistently placed close to the action items that they refer to.
2.10	Decision items	Are conditional steps clearly laid out?				An error prone situation exists with complicated conditional statements particularly when action items are embedded within them. It is recommended that decision items are discriminated either by using special bullets or line marking or choice directives (see Appendix 3, Examples 2 and 4).

Ch. 7	Title	Attribute	Y	N	N/A	Comments
2.11	Review of System status	Is a review of system status and operational capability provided on the checklist?				A system status review provides the crew with diagnostic information regarding system capability. They are useful in dealing with a failure situation, which cannot be rectified. It is recommended that consideration be given to including a table or list detailing system failures and alternate operational capability in the checklist (see Appendix 3, Example 5).
2.12	Deferred items	Are deferred items clearly identified?				Actions, which will be carried out at a later phase of flight, should be at the end of the checklist and should be clearly labelled. It is recommended that a label such as 'deferred item' precedes the final deferred action items (see Appendix 3, Example 5).
		Are they grouped accordingly?				Deferred items are easier to use if they are clearly grouped according to phase of flight or an environmental condition. It is recommended that grouping techniques are used.
		Is there sufficient information to carry out the deferred step?				When returning to a checklist to carry out items that have been deferred it is necessary to recall the system deficiencies and carry out the actions correctly. To aid recall it is recommended that 'do' actions be spelt out explicitly.
2.13	Crew responsible	Where appropriate does the checklist indicate who is responsible for carrying out the drill?				The instructions should indicate who is responsible for carrying out the drill but if this changes for any of the drills it should be specifically stated as to who is responsible for specific actions.
Layout and Format						
3.1	Drills per page	If the drill runs onto a second page is it split at a logical place in the drill?				Drills should be split into logical sections and the logical sections should not be split at a page break as it impacts continuity of the drill.
3.2	Start and finish	Does the drill have a clearly defined start?				The drill will be unusable if it is not clear where the drill starts. It must have a clearly defined start.

Ch. 7	Title	Attribute	Y	N	N/A	Comments
		Does the drill have a defined end?				The end of drill must be indicated with an 'end of xxx drill' indication or graphical equivalent (see Appendix 3, Examples 2 and 4).
		Are the end of drill indications provided in every place on the drill where it is complete, including decision steps?				The end of drill must be included at all places in the drill when it is complete (see Appendix 3, Example 2).
3.3	Continuation pages	Is it clear when the drill continues onto another page?				The drill may not be completed if it is not clear that it continues onto another page. It is recommended that a clear indication be provided at the bottom of the page and top of the continuing page (see Appendix 3, Examples 4 and 5).
3.4	Order	Does the order of the action items ensure that the failure is fixed at the earliest opportunity?				The design of the drill must ensure that priority items, i.e. those that will deal with the fault in the most time efficient way, are in the appropriate order.
		Are the action items listed in a logical, functional or physical cockpit layout pattern?				Procedures that are logically listed will be completed in a timely fashion.
3.5	Cross-referencing	Where cross-referencing is used within a drill is it clear as to which step should be carried out?				An error-prone situation exists with internal cross-referencing if it is not clear which step it refers to. It is recommended that the use of cross-referencing is minimised and that steps are numbered when cross-referencing is used.
		Where cross-referencing to other material is it clear which page and document it refers to?				It is not ideal to have to refer to other documents because it could result in the crew losing their place. However if it is necessary it is recommended that a place keeper symbol be used to aid return to the right place in the drill. It is also recommended that the document and page number if possible are clearly referenced.
3.6	Figures and tables	Are the figures and tables clearly linked to the drills they are associated with?				Errors will occur if the wrong figures or tables are referred to. It is recommended that the figures and tables should be clearly labelled to allow correct referencing.

Ch. 7	Title	Attribute	Y	N	N/A	Comments
		Are the figures legible and usable?				Performance data contained in graphs will not be usable if the presentation is too small particularly in low visibility situations. Ensure that performance data is legible under operational conditions.
3.7	Abbreviations and consistency	Do all captions and labels used in the drill correspond exactly to the labels used on the flight deck?				It is essential that exact correspondence is achieved and any differences must be corrected.
		Does the checklist identify clearly aircraft type, model, variant and modification state?				This could result in the wrong checklist or wrong drill being used. It is recommended that all checklists visually highlight any differences in variants relating to the drills. It is recommended that the checklist relates to the individual aircraft tail.
3.8	Special cases	Is the emergency evacuation drill easy to locate?				It should be on the cover of the Emergency Checklist and/or on a separate quick access card.
		Are the rejected take-off and overrun drills easy to locate?				They should be located on a cover of the Emergency Checklist.

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Glossary of Terms

TERM

DEFINITION

Abnormal/Non-Normal Procedures

Procedures that require actions to maintain safe flight, and prevent further incidents from occurring.

Action items

Those actions which are carried out as part of the drill. These are also referred to as reference items.

Aircraft Flight Manual (AFM)

The Aircraft Flight Manual produced by the manufacturer and approved by the CAA. This forms the basis for parts of the Operations Manual and checklists. The checklist procedures must reflect those detailed in the AFM.

Checklist

A set of written procedures/drills covering the operation of the aircraft by the flight crew in both normal and abnormal conditions. The checklist forms part of the OM. The checklist may be split into several parts, the Normal Flight Deck Checklist, the Emergency and Abnormal Checklist (or Quick Reference Handbook), and the Expanded Checklist. The Checklist is carried on the flight deck.

Deferred Items

Those actions, which form part of a drill, that are delayed until a later phase of flight.

Emergency and Abnormal Checklists

A checklist containing the Emergency and Abnormal procedures. This forms part of the OM. This is sometimes divided into two separate Checklists:

- i) an Emergency Checklist; and
- ii) an Abnormal Checklist.

Emergency Procedures

Procedures that require immediate action in relation to situations that threaten physical danger to people, and/or damage to the aircraft.

Expanded Checklist

Explanatory material associated with procedures may be supplied by the manufacturer and will be kept either separately or in the OM. This forms part of the OM.

Manufacturer's Operating Manual (MOM)	Detailed description of recommended operating procedures, produced by the manufacturer, which may or may not be adopted by the operator.
Flight Crew Operating Manual (FCOM)	
Flight Operating Manual (FOM)	
Memory Items/Mandatory Drills	Those actions normally resulting from an Emergency situation which must be performed immediately by the crew without reference to any checklist, but which, nevertheless, are included in the checklist for verification purposes. These are also referred to as recall items.
Non-Normal Checklist	This is equivalent to an Abnormal checklist and details the drills associated with non-routine operation.
Normal Flight Deck Checklist	The main Checklist used on the flight deck for normal operations. It may also include Emergency and Abnormal procedures for simple aircraft types.
Operations Manual (OM)	The aircraft OM is produced by the operator and may reflect part(s) of the information contained in the MOM. It contains all the instructions and information necessary for operational personnel to perform their duties. The OM may be divided into several parts, and includes a Normal Flight Deck Checklist and a separate Emergency and Abnormal/Non-Normal Checklist. Parts of the OM will be carried on the flight deck.
Pilot Flying	The Pilot who is controlling the path of the aircraft at any given time, in flight or on-ground.
Pilot Not Flying/Pilot Monitoring	The Pilot who is monitoring the events and actions on the flight Deck.
Quick Reference Handbook (QRH)	A handbook containing procedures which may need to be referred to quickly and/or frequently, including Emergency and Abnormal procedures. The procedures may be abbreviated for ease of reference (although they must reflect the procedures contained in the AFM). The QRH is often used as an alternative name for the Emergency and Abnormal Checklist.

Abbreviations

AFM	Aircraft Flight Manual
ASR	Air Safety Report
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CHAT	Checklist Assessment Tool
CHIRP	Confidential Human Factors Incident Reporting Programme
DODAR	Diagnose, Options, Decision, Assign Task, Review
FCOM	Flight Crew Operating Manual
FOI	Flight Operations Inspector
FOM	Flight Operating Manual
GPWS	Ground Proximity Warning System
HF	Human Factors
JAR-FCL	Joint Aviation Requirements – Flight Crew Licensing
JAR-OPS	Joint Aviation Requirements – Operations
M	Memory Item
MOM	Manufacturer's Operating Manual
MOR	Mandatory Occurrence Report
OM	Operations Manual
OODA	Observe, Orientate, Decide, Act
PF	Pilot Flying
PM	Pilot Monitoring
PNF	Pilot Not Flying
QRH	Quick Reference Handbook
SOP	Standard Operating Procedure
TCAS	Traffic Collision Avoidance Warning System
UK	United Kingdom

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Chapter 1 Introduction

Historically, CAP 676 has dealt with Emergency and Abnormal Checklist design and presentation. This revised document is produced to enable personnel associated with the design, presentation and use of Emergency and Abnormal Checklists to take account of Human Factors and usability issues. The document is compiled using data and research from a variety of sources and specialists. This best practice guidance is intended to maximise the effectiveness of checklists in order to assist flight crews in dealing with an emergency or abnormal situation.

The guidance relates to public transport operations, usually involving dual/multi-crew although the principles of Emergency and Abnormal Checklist design will equally apply to single crew and private corporate operations. These guidelines relate to paper-based checklists for emergency and abnormal situations. This document does not cover the Checklist associated with normal operations. CAP 708 'Guidance on the Design, Presentation and Use of Electronic Checklists' covers Electronic Checklists.

1 Goals

The primary goal of these guidelines is to improve the use of Emergency and Abnormal Checklists in assisting the flight crew to manage and contain system faults and other situations that adversely affect flight safety. As this must be achieved in a timely fashion, accuracy, clarity, consistency and brevity are essential design drivers for checklists. Further goals are to assist all users to discriminate between good and bad Emergency and Abnormal Checklist designs, and to recognise error-prone situations.

2 Target Audience

These guidelines are targeted at all personnel associated with the overall design, development, amendment and operational use of Emergency and Abnormal Checklists. This guidance should be used by personnel in the following categories:

- Manufacturers
- Technical Authors
- Airline Operators
- Flight Managers and Pilots
- Trainers
- Regulators

3 Human Performance Issues

Human performance issues associated with problem solving are captured within the OODA loop (Observe, Orientate, Decide, Act) but other models are equally applicable e.g. DODAR (Diagnose, Options, Decision, Assign Tasks, Review).

The pilot will initially observe a failure condition primarily by a visual and/or aural indication that something is not operating in the desired fashion. He then needs to comprehend the situation and the context in which it has occurred, decide what

course of action to take and then put that action into effect. The OODA loop continues throughout the retrieval and execution of the correct drill(s).

Depending upon the type of emergency or abnormal condition, the observation may take place in a poorly lit or smoke-filled cabin or in time - critical situations. The orientation and decision cognitive processes may be conditioned by high stress, high workload, general lack of familiarity with the situation and lack of system knowledge. The resultant action could be delayed through problems with finding and actioning the correct checklist.

In order to maximise the effectiveness of the OODA loop and reduce the likelihood for error, the following design attributes - which are provided in detail in Chapter 7 - should be adhered to:

- Observe
 - Make it easy to identify the correct drill.
 - Ensure that the text is legible under poor lighting conditions, including red lighting; (layout, size and font).
 - Ensure that text can be discriminated against the background.
 - Discriminate between required actions and notes.
- Orientate
 - Ensure that use of legends in Emergency and Abnormal Checklists correspond to flight deck legends.
 - Make use of standardised approaches to information presentation to aid recall and recognition.
 - Provide navigation via index to aid selection of the correct checklist.
 - Provide confirmation of correct checklist.
 - Discriminate between memory, action items and deferred items.
- Decide
 - Provide consequences of actions.
 - Provide context notes where appropriate.
 - Minimise the number of embedded steps to reach the required action.
 - Provide clear indications where choices and decision paths are involved.
 - Provide clear indications where the checklist continues onto another page.
 - Provide relevant performance information to support the decision process.
 - Provide clear indication when the drill is complete.
- Act
 - Keep checklist as brief as possible.
 - Number items to assist place keeping.
 - Take account of workload and time available.

4 Error Classifications

Human error has been classified into different types:

- Omission – a failure to do something e.g. miss out a step on a drill.
- Commission – performing an incorrect or inappropriate action.
- Slips – correct intention but carried out incorrectly e.g. inadvertent activation of the TOGA switch instead of Auto throttle disconnect.
- Mistake – intention based on incorrect situation assessment e.g. shutting down the wrong engine.
- Violation – deliberate non-compliance with procedure.
- Description Error - misinterpretation of a step due to ambiguous description.

Lengthy or confusing procedures will increase the probability that the crew, when pressed for time, will revert to their own methods, cut corners, omit items or even ignore the checklist entirely. If the design of a checklist presents the crew with a challenge or obstacle it can set the stage for error.

Typical error conditions found during use of Emergency and Abnormal Checklists include:

- Completing the wrong checklist.
- Difficulty in finding a checklist.
- Given the symptoms there is difficulty in confirming that the checklist is appropriate to the condition.
- Becoming disoriented within the checklist.
- Difficulty in confirming that the checklist action was carried out correctly.
- Inadvertently skipping a step.
- Forgetting to complete a step after an interruption.
- Problems in understanding and interpreting the checklist.
- Difficulty in following a conditional statement.
- Difficulty in reading a checklist.
- Difficulty in determining who should be carrying out the checklist actions.
- Failing to complete a checklist.
- Crew not alerted to aircraft performance issues.

Clearly, the approach to design, implementation, test and training can address the majority of these error situations; and Chapters 2 through to 6 of this document are intended to provide guidance on how these errors can be minimised.

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Chapter 2 Guidance for Manufacturers

The manufacturer is required, in accordance with the aircraft certification requirements for each aircraft type, to provide procedures, which will allow the flight deck crew to deal with emergency and abnormal situations. These are defined within the approved AFM. Further procedures may also be provided in documents such as the FOM. The drills contained within the operator's checklists should not vary, in terms of functional content, from the approved AFM procedures but may be required to be translated into operational terminology and may need to be expanded to cover relevant failure situations. The list of drills to be included within the Emergency and Abnormal Checklist is not specified within the scope of this guidance material. However, a suggested 'contents list' is given in Appendix 1.

1 Checklist Philosophy

In order to ensure consistency within the checklist procedures and across the manufacturer's aircraft types and variants, a philosophy document should be produced. This should cover the style guides used in the production of the checklists and include the approach to layout, presentation, colour, philosophy, coding principles and overall document characteristics in terms of size and form. Additionally include a discussion of the intended meaning of statements such as "Land as soon as possible" or "Land as soon as practicable" or "Land at nearest suitable alternate" in the philosophy document. Design aspects that should be considered are contained in Chapter 7 of these guidelines.

NOTE: The Emergency and Abnormal Checklist is a tool to assist the crew in achieving the goals of safe flight. It need not include "airmanship" issues.

2 Stowage

The Emergency and Abnormal Checklist documents should be capable of being stowed in a readily accessible location. Consideration should also be given to the proximity of food and drink containers on the flight deck and the likelihood of spillages. The checklist documents should be protected from such spillages in order to remain usable afterwards.

3 Design Process

The manufacturer will determine the emergency and abnormal situations, which need to be included in the Emergency and Abnormal Checklist. This should be consistent with the AFM and FCOM. This guidance identifies the steps involved in designing, validating and implementing the checklist procedures.

Step 1: Identify the engineering solution to the problem

This should be carried out in consultation with the specialist engineers for the relevant systems involved.

- Ensure that all possible conditions associated with the fault have been captured.
- Identify all performance data required.
- Identify consequences associated with resultant system or aircraft performance.

- Ensure that the relevant steps in the drill have been identified.
- Establish any actions which require cautions regarding the implication of that action.

Step 2: Translate the engineering drill into an operational procedure

This should be carried out in consultation with flight crew familiar with the aircraft systems and human factors, maintenance and publications specialists familiar with the style guides.

- Define a clear and unambiguous title for the checklist.
- Establish any prerequisite information that needs to be included at the top of the checklist – warnings, conditions, objectives, expected outcomes etc.
- Establish any memory or recall items associated with the checklist.
- Produce a layout of actions and notes in accordance with the style guide.
- Provide a clear indication when the drill has been completed where required.
- Provide a clear indication where navigation to other checklists is required.
- Establish actions which need to be deferred, and any performance consequences to the aircraft.

Step 3: Validate the drill

The validation of the new or updated checklist should be carried out by the designer of the checklist, in conjunction with other flight crew (preferably include some line pilots) and human factors, maintenance and publications specialists. It will involve trialling the checklist in a simulator under a range of operationally relevant conditions/ environments. The aim is to ensure that it is fit for purpose, takes account of other pilot tasks, is error-tolerant and can be carried out in the time required without imposing excessive workload.

- Establish the relevant fault triggers.
- Establish a range of operational scenarios.
- Monitor the time taken to complete the drill.
- Note any errors made or problems encountered.
- Debrief the crew and obtain comments and concerns.
- Update the checklist to address concerns.
- Repeat validation trials until the checklist design is deemed to be acceptable (minimised errors and acceptable workload).

Step 4: Review the drill

An independent review board, which may include safety specialists, technical specialists, technical pilots and human factors specialists, should review the checklist procedure. Where appropriate representatives from the Regulatory Authority should be included.

- Demonstrate drill on simulator or show results from simulator trials.
- Demonstrate that airworthiness safety aspects have not been compromised through any actions or activities during the drill.
- Use Checklist Assessment Tool (Executive Summary to ensure good human factors principles have been adhered to.

4 Feedback Process

When operators experience difficulties in using the checklists, they should be encouraged to send information about the difficulty to the manufacturer who should facilitate this process by seeking feedback. Where a UK operator believes that safety has been or could have been compromised, an Air Safety Report (ASR), or equivalent, should be raised and a Mandatory Occurrence Report (MOR) may be raised in accordance with CAP 382. Where necessary, the manufacturer should make changes to the checklists using the design process described in Chapter 2, Section 3. However the Operator feedback may also highlight problems with the manufacturer's style guide or design process, in which case these should be updated accordingly. The CAA tracks checklist-related MORs in order to monitor checklist-related safety issues. Manufacturers may request copies of checklist-related MORs for their aircraft types from the CAA as additional feedback.

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Chapter 3 Guidance for Operators

The operator is responsible for ensuring that the Emergency and Abnormal Checklists provided by the manufacturer are appropriate to their operation and do not compromise the safety of the aircraft. The operator is responsible for taking the necessary actions in rectifying all situations where problems with Emergency and Abnormal Checklists are identified. This guidance identifies the process by which this should be achieved.

It is the responsibility of operators to ensure that appropriate and current Emergency and Abnormal Checklists are placed on each aircraft.

It is the operators' responsibility to provide all flight crew with a set of OMs in order that they can adequately prepare for flight. This includes Emergency and Abnormal Checklists. A copy of the relevant QRH should therefore be made available to each flight crewmember or adequate copies should be provided in the company briefing room or library for private study.

The operator should establish a system of controlled documentation in relation to Emergency and Abnormal Checklists. An amendment number and date must be available on each page of the document. The amendment status, list of effective pages and other administrative items should be available in each document. Amendments should be incorporated as soon as reasonably practical. In the case of significant or important changes, a Flight Crew Notice or equivalent may be issued to ensure crew awareness.

1 Checklist Amendment Process

Step 1: Review the checklists

This should be carried out by the Flight Operations Manager, Technical Pilot, Fleet Training Captain or their equivalent in conjunction with the Chief Pilot.

- Check that the procedures correspond to those laid down in the AFM.
- Check that the checklist meets the design attributes identified in Chapter 7 of these guidelines.
- Use Checklist Assessment Tool (Executive Summary) to ensure good human factors principles have been adhered to.
- Ideally, test the procedures in a flight simulator using line crew members where possible.

NOTE: If the procedure in the AFM requires amendment, this must be carried out by the manufacturer or other organisation approved to make such amendments prior to changing the checklist.

Step 2: Update or redesign the drill

In the situation where the operator wishes to use the manufacturer's checklist, the operator will raise a problem report to the manufacturer requesting a change.

In the situation where the operator wishes to update or redesign the layout of the checklist, the operator should produce a philosophy and procedures document similar to that described in Guidance for Manufacturers (Chapter 2, Section 1) to ensure a

consistent approach. The following steps will be very similar to the design process described in Chapter 2, Section 3.

- Provide a clear and unambiguous title for the checklist.
- Establish any prerequisite information that needs to be included at the top of the checklist – warnings, conditions, objectives and expected outcomes etc.
- Establish the memory or recall items associated with the checklist.
- Produce a layout of actions and notes in accordance with the style guide (see Chapter 2, Section 1).
- Provide a clear indication when the drill has been completed in all places where this occurs throughout the checklist.
- Provide a clear indication where navigation to other checklists is required.
- Establish actions which need to be deferred and any performance consequences to the aircraft.

Step 3: Validate the drill

Validation should be carried out in conjunction with experienced company pilots and preferably someone with appropriate human factors knowledge (the larger the change the more important it is to involve someone specifically trained in human factors). It may involve trialling the checklist in a simulator under a range of conditions. The purpose will be to ensure that it is fit for purpose, takes account of other pilot tasks, is error tolerant and can be carried out in the time required without imposing excessive workload.

- Establish the relevant fault triggers.
- Establish a range of scenarios covering varying contexts (e.g. landing gear problems may well only be discovered at the end of a flight when in busy airspace with time pressures due to fuel state, changing weather etc. The usability of the checklist should be considered in this context).
- Monitor the time taken to complete the drill.
- Note any errors made or problems encountered.
- Debrief the pilot and obtain comments and concerns.
- Update checklist to address concerns.
- Repeat validation trials until the checklist design is deemed to be acceptable (minimised errors and acceptable workload).

Step 4: Review the checklist

Any changes to the checklist need to be accepted by the CAA. The operators' checklist amendment procedure should clearly identify the criteria for seeking manufacturers' input to the change if required and who is competent to make the judgments required.

- Demonstrate drill on simulator or show results from simulator trials.
- Demonstrate that airworthiness safety aspects have not been comprised through any actions or activities during the drill.
- Use Checklist Assessment Tool (Executive Summary) to ensure good human factors principles have been adhered to.

2 Checklist Maintenance

Manufacturers typically send amendments out every six months and it is the responsibility of the operator to ensure that the amendments are reviewed and distributed to the fleets.

- Checklist construction should enable pages or cards to be changed easily when amendments are necessary.
- Each checklist should contain a record of the amendment state of the checklist, ideally no more than one page.
- The amendment record page(s)/card(s) may be included in the checklist and should be differentiated from the pages/cards containing the drills.
- Each amended page/card should be dated (in small print).
- Worn or damaged checklists, or those with loose pages, should be replaced.

3 Problem Reporting and Investigation

When a problem (as defined in Chapter 2, paragraph 4) is encountered with a checklist the pilot will raise an MOR or company ASR. It is the responsibility of the operator to send the MOR or ASR to the following organisations:

- Manufacturer
- CAA

Operators should also consider sending information to the UK Flight Safety Committee.

One method for investigating an event is as follows:

Step 1: Identify Relevant procedures

- List the checklists that should have been used following the event.

Step 2: Establish problems encountered

- Identify the difficulties encountered by the PF or PNF/PM.
- Identify the error condition (listed in Chapter 1, paragraph 4), e.g. completing the wrong checklist).
- Identify the sequence of procedural deviations.
- List all the contributory factors e.g. distractions, high workload etc.

Step 3: Recommend and Implement Changes (where appropriate)

- Identify improvements that could be made to the checklist, SOP or training to prevent event from recurring.
- Work with manufacturers and CAA as required to implement changes.

4 Pilot Training

It is the operators' responsibility to ensure that a satisfactory training plan approved by the CAA is in place. The frequency and content of the emergency and abnormal situations and procedures training must cover the requirements of JAR-OPS 1, 3 and JAR-FCL as applicable, and provide training for the pilot so that emergency and

abnormal situations are recognised when they are encountered. Chapter 6 details the required training philosophies. In addition, if it is known that a checklist has a fault or anomaly leading to common mistakes or confusion, then these faults and anomalies should not be 'trained around'. The operator should amend the procedure.

Chapter 4 Guidance for Pilots

It is the responsibility of the pilots to ensure that they are familiar with the procedures laid out in the Emergency and Abnormal Checklists.

It is both the commanders' and/or operators' responsibility to ensure that the checklists are on board before each flight. In addition, it is the pilots' responsibility to ensure that company SOPs are rigorously applied in the use of and execution of Emergency and Abnormal Checklists. Ultimately the Captain will take all responsibilities for decisions on the flight deck which may include a veto of an SOP, if appropriate, in dealing with an emergency situation.

1 Standard Operating Procedures

- The Pilot Flying (PF) should not be distracted from controlling the aircraft to perform a checklist item that another crew member can or should accomplish.
- The crew-member responsible for reading the checklist should ensure that it is completed systematically and expeditiously.
- In the situation of two or more crew aircraft, checklists would normally be accomplished by one crewmember reading the checklist item and performing the action and a second crewmember monitoring and verifying that the action is correct.
- In the situation of a critical procedural step (e.g. shutting down an engine) a positive confirmation must be made by the monitoring crewmember before any action is taken.
- Following an interruption in a checklist it is recommended that the actions already completed are re-verified.
- SOPs should take account of the crew's workload and their ability to complete Emergency and Abnormal Checklists in conjunction with other tasks (for example, if an emergency occurs during an approach SOPs should consider whether it is better to abandon the approach before dealing with the situation).
- A policy for the management of a situation where an action is deferred must be identified.

2 Problem Reporting

It is the responsibility of the pilot to raise ASRs when problems with Emergency and Abnormal Checklists are encountered. The pilots should be proactive in notifying the Company Flight Safety Officer of checklist design issues, which could be a factor contributory to an incident or accident in the future.

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Chapter 5 Guidance for the CAA

The CAA's responsibility lies mainly with acceptance of the Emergency and Abnormal Checklists as part of the suite of documents supporting aircraft operations.

1 Review of Checklists

The Flight Operations Inspector (FOI) as part of his OM review will look at the Emergency and Abnormal Checklists to confirm technical accuracy and that they are consistent with CAP 676 best practice guidance. The FOI should:

- Use Checklist Assessment Tool (Executive Summary) as guidance to review checklist against good human factors principles.
- Identify areas of poor checklist design which could contribute to errors being made.

The manufacturers' checklists, if unchanged by the operator, will generally be acceptable to the CAA if they meet the guidelines of this document. It is however important to recognise that many operations require a checklist to be tailored to their operation in some way. It is therefore the operators' responsibility to make the appropriate changes using this CAP as guidance and in consultation with the manufacturer as defined in their procedures.

2 Investigation of Incidents

When an incident is reported to the CAA where the checklist was an issue it is important to establish all the factors that contributed to the incident using a consistent method. Very often a checklist incident can be indicative of problems with the operators' SOPs or flight training programme and the investigation should not be limited to the physical checklist. Prime responsibility for investigating incidents lies with the operator, with the CAA reviewing and accepting the operators' investigation and subsequent actions.

The CAA would expect the operators' investigation to include the steps detailed in Chapter 3, Section 1, Step 3.

3 Acceptance of Pilot Training Programmes

The CAA is responsible for review and acceptance of operators' pilot training programmes including training of checklist use and discipline.

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Chapter 6 Guidance for Trainers

Trainers must be conversant with the philosophy, content and use of the Emergency and Abnormal Checklist in order to deliver effective training.

Training providers are responsible for ensuring that the training in the use of the Emergency and Abnormal Checklist is conducted using training aids appropriate to the task.

A training course should address the use of the Emergency and Abnormal Checklists in a progressive manner. The following system of training may be used:

- An introduction to the checklist philosophy and layout, conducted in a classroom.
- The use of cockpit 'mock-ups' to practice familiarity with cockpit layout.
- Practice of emergency and abnormal drills in a Flight Training Device.
- Practice of emergency and abnormal drills in a Full Flight Simulator.
- Practice of emergency and abnormal drills in a static aircraft.
- Practice of emergency and abnormal drills in-flight.

This training should be conducted at a pace conducive to learning. Such training should highlight the need for prioritisation, crew co-ordination, and other non-technical skills.

The training plan should identify the training aids required to rehearse and learn the drills associated with a range of failures to achieve the required level of competency. This will include a description of the failure situations and the appropriate training device.

Training staff are in a unique position to see checklists being put into action. They are therefore able to identify shortcomings in checklist design and content. Where shortfalls are noted, trainers must feed the information back to the training organisation to enable appropriate corrective action to be taken.

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Chapter 7 Checklist Design Attributes

This Chapter details the attributes that should be applied in the design of a checklist. They are not intended to be prescriptive and design solutions can meet the high level attributes in different ways. Examples are provided in Appendix 3 to reinforce the intended messages.

There have been many incidents where use of checklists has been a contributory factor and four such incidents are detailed in Appendix 2 to further reinforce the need for good human factors principles in the design of checklists.

The key design driver is to ensure that the procedures can be carried out with minimum error to maintain the required level of airworthiness. This involves a clear process based upon HF principles. Chapter 1, Section 4 details a list of error conditions that could occur with the use of checklists. The table below outlines design approaches that could mitigate the risk of these types of errors occurring. Cross-referencing to the relevant paragraph in this Chapter is provided.

Table 1

Error Condition	Possible Mitigating Design Solution
Become disorientated within checklist.	Number items in list (1.11); improve layout (2.10).
Complete the wrong checklist.	Provide index (1.10); provide checklist objective (2.5); provide a description of the failure conditions and any alerting cues (2.4); provide a picture of the warning legend (2.4).
Difficult to find a checklist item.	Provide index (1.10); provide tabs (1.4).
Difficult to confirm checklist is correct.	Provide objective (2.5); provide a description of the failure conditions and any alerting cues (2.4); provide a picture of the warning legend (2.4).
Skip a step.	Provide numbers (1.11); provide emphasis where steps are similar in content (1.8).
Fail to complete a step after an interruption.	Provide numbers (1.11); interruption policy contained within SOPs (see Chapter 4, paragraph 1).
Difficult to understand a checklist.	Provide system status information (2.11); provide notes (2.9).
Difficult to follow a conditional statement.	Improve layout (2.10); clarify end of drills (3.2).
Difficult to read a checklist.	Increase font size (1.5, 1.6); improve contrast (1.9).
Not sure who does what.	Indicate PF or PNF/PM (2.13).
Fail to complete a checklist.	Training, familiarisation.
Difficult to interpret information in checklist.	Improve layout (2.10); provide notes (2.9); provide system status information (2.11).
Crew not alerted to performance issues.	Provide cautionary notes (2.7); provide system status information (2.11).

1 Physical Characteristics of Emergency and Abnormal Checklists

The checklist should not be a direct copy or photocopy of the AFM or FCOM or equivalent emergency and abnormal procedures. The presentation of the procedures should be appropriate for use in emergency or abnormal conditions.

The Emergency and Abnormal Checklists should be differentiated clearly from normal checklists, ideally by a separate and self-contained 'document', or contained in a QRH. Alternatively, emergency and abnormal drills may be contained in a separate section in the flight deck checklist as long as this section is clearly differentiated from the remainder of the document. The document should be robust enough to withstand normal handling by flight crew.

1.1 Size of Document

- The size of the document should be appropriate to the stowage space and workspace available.
- Consideration should be given in the use of the document in situ to avoid interference with controls or obscure the displays.

1.2 Binding/Spine

- The binding should ideally allow pages to be opened through 360°, to enable pages to be folded back onto themselves.
- The binding should be such that all the text on a page/card can be read.
- The binding should allow for replacement pages to be inserted easily by hand whilst being secure enough to prevent pages becoming loose.
- Rugged spiral or ring side binding is recommended.

1.3 Cover

- The cover of the Emergency and Abnormal Checklist should be sufficiently robust to protect the pages or cards within.
- The cover should be of a suitable colour, to allow the document to be easily located and distinguished (from all angles) from other documents.
- The cover should be easily distinguishable (e.g. slightly larger) from the other pages/cards such that it is easy to find if the checklist has been folded open at a particular page.
- The title of the checklist and the aircraft to which the checklist is applicable should appear on the front of the cover and, where appropriate, the spine.
- If fleets of aircraft are at different states of modification the title should reflect the modification state.
- It is a design feature of many modern aircraft that places the drinks cup holder directly above the Emergency and Abnormal Checklist stowages. It is recommended that operators take steps to ensure that QRH checklists are protected from spillage thereby ensuring that they are readable when required. Laminated pages or clear plastic bags are frequently used.

1.4 **Tabs and Dividers**

- The use of tabs is recommended to assist in the location of specific drills or groups of drills associated with sub-systems.
- Tabs may utilise printed titles, numbers and/or colour to assist with this task, as long as the titles, numbering and/or colour usage is consistent throughout the document (and, ideally, consistent in checklist documents throughout the fleet).
- The index and the tabs should be clearly and logically linked. (see Appendix 3, Example 1).
- Tabs should be wide enough for a thumb to be placed upon them, without mis-referencing. (see Appendix 3, Example 1).

1.5 **Font Type**

- Font types (such as Helvetica, Gill Medium or Arial), which have clear differentiation between characters are recommended.
- Sans serif fonts should be used (no tails).
- Font type should be consistent throughout the checklist.
- Use of lower case is recommended with upper case initial capitals; use of upper case for large blocks of text should be avoided (see Appendix 3, Example 6).
- Use of upper case for headings is desirable.
- Italics should not be used for drill actions. Use of italics for comments, notes, or supporting information is acceptable, although use of italics should be avoided for large blocks of text.

1.6 **Print Size**

The drill should be legible at 600 mm. The font size does vary between font types and sizes given in this paragraph are approximate based upon arial font type.

- The recommended type size for headings is 14pt (with a minimum of 12pt).
- The recommended type size for normal text is 12pt (with a minimum of 10pt).
- A larger font size is recommended for smoke-related procedures (and those procedures which may follow on).
- Bold type may be used to improve legibility. Note: it may be more important for a drill to be contained on one page, in which case a type size smaller than 12pt may be appropriate (but no smaller than 10pt).

1.7 **Margins**

There should be a margin to permit:

- a) binding without hiding text; and
- b) holding the list using the thumb as cursor.

1.8 **Emphasis and Differentiation**

- Emphasis and differentiation may be required to highlight a particular challenge or response.

- Alternatively it could be used where the checklist contains two similar lines of text, which can contribute to missing a step. See example below where a pilot missed the main gear release handle action.

L/G ALTERNATE RELEASE DOOR	OPEN FULLY & LEAVE OPEN
MAIN GEAR RELEASE HANDLE	PULL FULLY DOWN
L/G ALTERNATE EXTENSION DOOR	OPEN FULLY & LEAVE OPEN
Insert pump handle and operate until main landing gear locks down.	

The presentation of the checklist can be improved by using numbers, lower case text and bolding the text:

1.	L/G alternate release door	open fully & leave open
2.	Main gear release handle	pull fully down
3.	L/G alternate extension door	open fully & leave open

- The following techniques provide effective methods of emphasising or differentiating information on a checklist. They should be used sparingly to maximise the effect:
 - Bold type
 - Larger type
 - Underlining
 - Boxing text on a white or coloured background

1.9 Contrast and Colour

- Black text on a yellow background is recommended, with black text on a white background as an acceptable alternative.
- Coloured text is not recommended because of difficulties in reading colours in some lighting conditions.
- Use of colour to describe the alerting cues is recommended where the colour is the same as the warning caption on the aircraft, see examples in Appendix 3.
- Pastel shading can be used effectively to discriminate specific items on the checklist e.g. memory items, deferred items, cautions, consequences but they should be used sparingly (see Appendix 3, Example 4).
- Pink or red pages are not recommended.
- If colour is used for tabs/borders to distinguish between an Emergency and Abnormal Checklist, red should be reserved for emergencies, and orange/amber for abnormal procedures.
- If the emergency and abnormal drills are contained in the main aircraft checklist document, the pages should be distinguished from the normal drills by red, yellow or yellow-and-black edging, in addition to a suitable divider or tab page.

Whichever of the above methods is chosen the ability to differentiate Normal, Emergency and Abnormal Checklists under night lighting conditions should be checked.

1.10 **Contents List and Index**

- The Emergency and Abnormal Checklist should have a tabbed contents list at the front (see Appendix 3, Example 1).
- The contents list should list the aircraft subsystems.
- The contents list should not exceed a single page, if possible.
- The contents list should follow the same order as the drills whether in alphabetical order or critical system failure order.
- The drills within each subsystem should be listed on the front of the relevant tab page. They may also be listed in the main contents list at the front of the checklist, if appropriate.
- Critical drills may be highlighted in bold to aid recognition e.g. Fire and Smoke.
- Clear delineation of systems should be shown (e.g. by a line or colour) linking each system to the relevant tab (see Appendix 3, Example 1).
- The contents list page must be easy to access when the checklist document is folded back onto itself.
- If the Emergency and Abnormal Checklists form part of the main flight deck checklist, the contents list for the emergency and abnormal procedures should be:
 - at the front of the document; and
 - on the tab or divider which separates the two parts of the normal checks from the emergency/abnormal drills.
- An alphabetical index, as well as a contents list, is desirable. This should guide the user to the correct drill (e.g. 'engine fire' should be listed under both 'engine' and 'fire' in the index). This could be located near the back of the checklist or after the main contents list page.

1.11 **Page Numbering**

- All pages should be numbered consistently, including tab pages.
- If a page is blank it should have 'INTENTIONALLY BLANK' printed on it.
- Pages should be numbered within each section, starting at page 0 (for the tab page).
- Where tabs are numbered the page numbering should correspond to the tab number. E.g. Tab 06 Engines and APU failures page numbers should be 06-01, 06-02 etc.
- The number should be clearly presented at the top or bottom of the page.
- Large font should be used for page numbers.
- The dedicated page numbering is to ensure that the correct page can be located from the index and that the correct pages are replaced when the checklist is updated.

1.12 **Action Numbering**

- The actions in the drill may be numbered consecutively as an aid to place keeping and a means of distinguishing the action items.

2 Content of Emergency and Abnormal Checklist

2.1 Structure

The checklist must be adequately structured to take account of fuel, time and environment. Landing gear abnormal situation more often than not occurs during low fuel states.

- Ensure that the number of operations required in a drill is kept to a minimum in time or fuel critical situations.
- Avoid diagnostic actions that attempt to eliminate the source of the problem when smoke conditions pervade.

2.2 Checklist Layout Instructions

Philosophy notes should be provided to identify the coding philosophies used in the checklist. This should include any shape, position or colour coding used. The notes should also include all presentation items such as decision points, continuation overleaf indication etc. They should also include definitions of terminology where appropriate e.g. explain the differences between 'land as soon as possible' and land as soon as practicable'. The notes may either form part of the checklist or be provided as part of the aircraft documentation suite.

The checklist must be a controlled document with the appropriate date and amendment status and/or list of effective pages clearly visible. Ideally, a statement that this publication forms part of the operator's OM should be included.

Any changes to the checklist drills from the last amendment should be highlighted in the margins e.g. some operators use a short vertical line (change bar).

2.3 Title

The title should be displayed at the start of each drill. It must be meaningful and reflect the error condition. It must be prominently displayed and be clearly distinguishable from the action items and notes on the drill, see (Appendix 3, Example 2).

2.4 Failure Condition

A short explanation, if required, of the symptoms associated with that drill provides confirmation that the correct drill has been selected. The list of symptoms should be clearly differentiated from the subsequent list of actions and notes. The alerting cues may be included as shown in the example below (see Appendix 3, Examples 2 and 4).

A picture of the alert caption provides a powerful means of correct checklist confirmation (see Appendix 3, Examples 2 and 4).

NOTE: If the alerting cues could also be symptomatic of another failure condition an explanatory note may be required.

2.5 Objective

A short narrative, if required, explaining the expected outcome of the drill provides further confirmation that the correct drill has been selected and provides expectations for the Pilot (see Appendix 3, Example 4). This should be displayed below the title and be clearly distinguished from the action items.

2.6 Memory Items

Memory or Recall items are actions that are carried out immediately following the onset of a failure situation. They relate to situations where the safety of the aircraft is compromised. Pilots are trained to memorise the immediate actions and carry them out without reference to the checklist. However under stressful conditions memory

recall can be poor and error-prone therefore they should be strictly limited to only those actions necessary to stabilise the situation (Chapter 8, paragraph 1, Ref. 1).

- Memory items should normally be at the start of a drill.
- Memory items should clearly be indicated, e.g. by colour shading, or by 'boxing'. An explanation in the OM or Philosophy Notes showing how these memory items are indicated should be included.
- The number of steps in a memory item should be kept to a minimum (preferably fewer than four and certainly no more than six for multi-crew operations; single pilot operations may require a greater number of steps).
- Simple mnemonics can be used as an aid.

2.7 **Cautionary Notes**

Cautionary Notes have associated performance implications. They must occur before the related action. Cautionary Notes should be differentiated from other notes either by colour shading, textual highlighting and/or use of the word caution.

2.8 **Action Items**

- The action items should take the form of 'do' lists, in the 'read-do' format, with the action required at the left and the required execution response or status on the right (right justified).
- Responses to actions should be full, specific and unequivocal.
- The action and response should be clearly associated, ideally by dots or dashes (a suggested density is one dot/dash per 6mm) (see Appendix 3, Example 2 and 4).
- Action items should be clearly distinguished from explanatory notes.
- Critical actions which require a positive verification from the monitoring crewmember should be discriminated in some manner (e.g. font size, bold font etc.).

2.9 **Explanatory Notes**

- Explanatory Notes are required where the action has some unusual characteristic, e.g. a lever may have two detents, a long delay on activation, or require a high force to operate.
- Explanatory Notes should be clear, concise and succinct.
- Explanatory Notes should be clearly linked, by position on the checklist, to the action items to which they relate.
- They should be clearly differentiated from the action items. The following techniques are suggested as a means of differentiation:
 - Italics
 - Colour shading
 - Font size.

2.10 Decision Items

- Complicated decision items should be avoided, particularly those with embedded items.
- The following techniques can be used effectively to deal with decision choices:
 - Different style of bullets.
 - Choice directive (e.g. 'choose one').
 - Highlight choices using underline.
 - Margin lines if used, should be on the opposite side to change bars.
 - Indent to group items together.

LOSS OF BOTH ENGINE DRIVEN GENERATORS

Condition All TRANSFER BUS OFF, BUS OFF and GEN OFF BUS lights illuminated indicating the loss of both engine driven generators.

Objective: To restore Generator Power

⇒ **Memory item 1**

⇒ **Memory item 2**

⇒ **Memory item 3**

Caution With both buses off only one start attempt is recommended

➤ if **both** BUS OFF Lights remain illuminated then:

- Action item 1
- Action item 2
- Action item 3

➤ if **either** or both BUS OFF Lights extinguish then:

- Action item 1
- Action item 2
- Action item 3

Note: If the APU is the only operating generator connect it to the No 2 bus as it will power TR no 3

Land as soon as possible

2.11 Review of system status following completion of checklist

It is helpful to provide a review of system status and considerations of operational effects after equipment failure and completion of checklist items. This may include a set of performance limitations and constraints or provide a list of alternative operative systems.

Such guidance should be clearly distinguished and would normally be tabulated in a manner similar to the example shown in Appendix 3, Example 5.

2.12 **Deferred Items**

Deferred items are those items which need to be carried out at a later phase of flight. They will be at the end of the checklist and should be clearly labelled as “deferred items” (see Appendix 3, Example 4). Consider the following:

- Grouping according to phase of flight.
- Grouping according to operational environment e.g. low visibility operations.
- Deferred items should have sufficient information to avoid any risk of ambiguity and promote understanding.

2.13 **Crew Responsible**

If appropriate, in the event of a complex procedure (and particularly with a three person crew), an indication should be given in the checklist or SOPs as to whose responsibility it is to respond to any challenge.

3 **Layout and Format**

3.1 **Drills per Page**

- The number of drills per page depends upon the length of the drill and multiple drills per page are acceptable provided the start and finish of each drill are clearly identified.
- If a drill is too long to fit onto one page, it should be separated into logical sections where each section is contained within a page.
- If a drill runs onto a second (or further page) it must be clearly marked as incomplete and requiring to be continued (see Appendix 3, Example 4).

3.2 **Start and Finish**

Drills must have a clearly defined start and finish:

- The start of the drill will be indicated by a clearly defined and meaningful title.
- The end of the drill will be indicated by either an ‘end of drill’ statement or graphical symbol indicating completion (see Appendix 3, Example 2 and 4).
- Completion of a drill could occur in several places within a drill and these must all be clearly defined (see Appendix 3, Example 2).
- A completion call should be clearly defined by company SOPs.

3.3 **Continuation Pages**

Drills must clearly show when a drill continues onto another page:

- A clear indication should be provided at the bottom of the page.
- A clear indication should be provided at the top of a continued page together with drill title (see Appendix 3, Example 5).

3.4 **Order**

The following order is suggested:

- If not otherwise specified in the AFM or FCOM for reasons of priority emergency selection, actions or checks within a drill should be listed in a flow pattern (logical/ functional flow, or ‘geographical’ flow, i.e. listed according to the physical location of the instrument in the cockpit (e.g. left-to-right or right-to-left).
- Long procedures should be separated, where possible, into short groups of logically or geographically related steps.

3.5 **Cross-Referencing**

Cross-referencing should be minimised where possible. If steps need to be repeated within a drill then they should be duplicated. Internal cross-referencing should be used if drills become too lengthy to handle.

3.5.1 **Internal to Drill**

- When using cross-referencing within a drill it is strongly recommended that the action steps be numbered to ensure that the instruction is clear and unambiguous.
- When cross-referencing, be clear about the bounds of the instruction e.g. 'carry out steps 3 to 6'.

3.5.2 **External to Drill**

- Where reference to explanatory material is required, the relevant page number and title of the expanded checklist should be given.
- When a drill is complete but requires another to follow on then the appropriate checklist title, tab and page number, where possible, must be clearly stated.

3.6 **Figures and Tables**

- If figures, tables or graphs are to be included, they should be clearly linked to the drill(s) with which they are associated.
- Tables or graphs reproduced from AFMs should be legible and usable (see Appendix 3, Example 3).

3.7 **Abbreviations, Phraseology and Consistency**

- Drills should use no more words than required to ensure that drills are understandable and unambiguous. However excessive brevity can result in drills taking longer to read and understand.
- Phraseology should be straightforward and in standard aviation terms.
- Abbreviations other than the ampersand (&) should be avoided. However, if these are to be used, they must be standardised and clearly explained either in the Emergency and Abnormal Checklist document or in the expanded checklist.
- Where the checklist calls refer to a particular switch, light, lever or instrument, the entry must be the same as that used to identify it on the aircraft panel.
- Checklist design should be consistent within fleets.
- A consistent format should be maintained throughout each checklist (although not at the expense of making drills more difficult to understand).
- A purpose-designed checklist should be produced for each type or variant of aircraft. However, one checklist may be used for two variants of the same type of aircraft if there are only minor differences and the checklist shows clearly the differences between variants, provided:
 - the type prefix appears in the response column; or
 - clearly labelled, type-specific subsections are included within the checklist.

3.8 **Special Cases**

- The emergency evacuation drill should be easy to locate e.g. on the outside back cover of the Emergency Checklist. In addition a separate quick access card can be used.
- The rejected take-off and overrun drills should be easily and quickly accessible, e.g. located inside the back cover.

Chapter 8 References and Further Reading

This section provides a list of the document sources that were used in the preparation of these guidelines. It also provides a list of useful websites that provide access to further information:

1 References

- 1 Human Factors of Flight Deck Checklists: The Normal Checklist, Asaf Degani, Earl Wiener 1990. NASA Contractor Report 177549
- 2 On the design of Flight Deck Procedures, Asaf Degani, Earl Wiener 1994 NASA Contractor Report 177642
- 3 Human Performance Considerations in the use and design of Aircraft Checklists, FAA 1995
- 4 FAA Order 8400.10 Air Transportation Operations Inspector's Handbook, Volume 3 Chapter 15 Section 4 and Section 5
- 5 Human Factors for Pilots, Green, Muir, James, Gradwell, Green 1996
- 6 Human Factors in Multi-Crew Operation, Orlady, 1999
- 7 Human Factors in Aviation, Wiener, Nagel 1988
- 8 Human Factors in Flight, Hawkins 1987
- 9 Engineering Psychology and Human Performance, Wickens 1992
- 10 Human Performance and Limitations in Aviation, Cambell and Bagshaw 1991
- 11 Designing a tool to assess the usability of electronic flightbags, Chandra, Riley 2004

2 Websites

The following websites were used to access information relating to tools and procedures. However there is no guarantee that these websites are still active or being supported.

- 1 www.boeing.com/commercial/flighttechservices/ftssafety01.html
- 2 www.gainweb.org (Global Aviation Information Network)
- 3 www.airbus.com/about/safetylibrary.asp
- 4 www.flightsafety.org

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Appendix 1 Recommended Contents List for Emergency and Abnormal Checklists

Reference JAR-OPS 1 or 3 for items that must be included.

- Engine failure on take-off.
- Abandoned take-off at or before V1.
- After V1. Instruction must be given that drills are not to be performed before reaching a minimum safe altitude.
- Engine fire/failure after V1 drills. Include a reminder to carry out after take-off checks.
- Engine shut down.
- Engine fire.
- Propeller malfunctions.
- Failures of normal feathering system.
- Fuel filter de-icing.
- Re-lighting of turbine engines and re-light envelope graph.
- Instant re-light.
- Normal re-light.
- Re-starting reciprocating engines and re-start envelope graph.
- Bus bar and other serious electrical failures.
- Pressurisation failures.
- Emergency descent (to include oxygen mask and microphone).
- Malfunction of power control systems.
- Cabin and hold fires.
- Smoke removal (to include, where applicable, maximum IAS for flight with direct vision window open).
- Undercarriage fires.
- Landing with gear asymmetry or gear up.
- Overweight landing.
- Ditching.
- Evacuation drills.
- Pilot cockpit pre-evacuation drills.
- Imminent overrun of manoeuvring area drill.
- Crew incapacitation.
- Bomb threat.
- Hijack.
- Volcanic ash encounter (if appropriate).
- GPWS warning.
- Windshear.
- TCAS warning.

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Appendix 2 Incidents Involving Checklists

1 Example 1

1.1 Background

The aircraft failed to turn onto the required heading. An aileron warning was illuminated on the Master Warning Panel. Despite applying aileron trim the warning and condition persisted. The Aileron Disconnect Handle was pulled as a memory item but had no effect. The crew referred to the checklist for AILERON JAM OR UNCOMMANDED ROLL and followed the procedure. There was still no effect and subsequently the aircraft was diverted to Manchester Airport.

1.2 Findings

Insufficient force was applied to the aileron disconnect handle to achieve the breakout. The checklist contained this instruction as a note at the bottom, which the pilot failed to read.

1.3 HF Issues

- 1 Poor design of checklist in not emphasising the need to apply sufficient breakout force.
- 2 Lack of crew familiarity with the situation encountered.

2 Example 2

2.1 Background

A series of engine surges occurred. The crew decided to make an emergency landing at Birmingham. The crew had referred to the QRH for ENG 1(2) STALL but took no action as the procedure stated that there would be ENG STALL warning on the ECAM.

2.2 Findings

The flight crew were presented with symptoms for which the QRH or training provided little guidance. Explanatory notes at the beginning of the FCOM checklist had not been included in the QRH drill. Their inclusion would have ensured that the crew undertook the complete ENG 1(2) stall drill that would have resolved the situation.

2.3 HF Issues

- 1 Missing guidance information on checklist.
- 2 Lack of crew familiarity with the situation encountered.

3 Example 3

3.1 Background

The landing gear failed to retract and the pilot made the decision to divert to C where engineers familiar with the aircraft would be available. There was no checklist available for the landing gear retraction problem. As a result of the weight on wheels (WOW) signal remaining in the ground condition the LIFT DUMP FAIL and ANTI SKID

FAIL lights were illuminated. The pilot consulted the QRH for LIFT DUMP FAIL and was informed that the landing distance required was increased by 58%. The ANTI SKID FAIL checklist was not used and the ANTI-SKID switch was left in the ON position. The engineers at C found no problem with the WOW switch, Lift Dump or Anti-skid system but advised that the passengers be taken to B and the aircraft then be ferried to D for further technical evaluation. When the pilot landed at D the brakes did not work properly. He pumped them several times but the required deceleration did not occur. He aborted an attempted go-around and the aircraft overran the runway before coming to a stop at an embankment. The pilot was not hurt and managed to evacuate the aircraft, which was destroyed.

3.2 Findings

When a lift dump failure occurs on this aircraft it is necessary to apply and maintain continuous braking. This instruction is contained in the LIFT DUMP FAILS TO EXTEND checklist that was not used on this occasion. However a warning that is contained in the AFM states that brake modulation should not be used in this situation was omitted from the QRH. The ANTI-SKID FAILURE procedure also states that braking should be gradual and continuous. Thus the pilot failed to apply the correct braking technique, which would have stopped the aircraft.

3.3 HF Issues

- 1 Missing checklist to cover landing gear problem.
- 2 Lack of guidance on LIFT DUMP FAIL to include all the warnings that were contained on the LIFT DUMP FAILS TO EXTEND procedure. This necessitated two checklists where one would have been adequate and led to the situation where the important one was not referred to.
- 3 Important information contained in the AFM relating to brake modulation was not duplicated in the QRH.
- 4 Lack of use of the ANTI-SKID checklist.
- 5 Important information contained in the AFM relating to flap settings for Anti Skid fail situations was not duplicated in the QRH.

4 Example 4

4.1 Background

Whilst carrying out a non-precision instrument approach a problem was encountered with the landing gear at 4000ft. The captain instructed the first officer to find the QRH for the Landing Gear Malfunction – Alternate Gear Extension whilst he flew the aircraft. The first officer started to follow the procedures but was interrupted by the pilot who told him to skip through some of the checks. He omitted a step and tried to insert the alternate gear handle too early. The pilot was distracted from flying the aircraft and tried to help the first officer resolve the problem. The GPWS warning sounded four seconds before the aircraft hit the ground killing three passengers and one crewmember.

4.2 Findings

The aircraft was below its ideal approach path when the problem was initially encountered. The pilot did not achieve a safe altitude and heading before attempting to resolve the landing gear problem.

There were no SOP height callouts during the descent.

The checklist contained two very similar lines, which contributed to the first officer missing one of the steps:

L/G ALTERNATE RELEASE DOOR	OPEN FULLY & LEAVE OPEN
MAIN GEAR RELEASE HANDLE	FULLY DOWN
L/G ALTERNATE EXTENSION DOOR	OPEN FULLY & LEAVE OPEN
Insert pump handle and operate until main landing gear locks down	

The crew had never completed training for the full QRH drill for this situation.

There were anomalies between checklists, the engineering manual and the manufacturer's checklist.

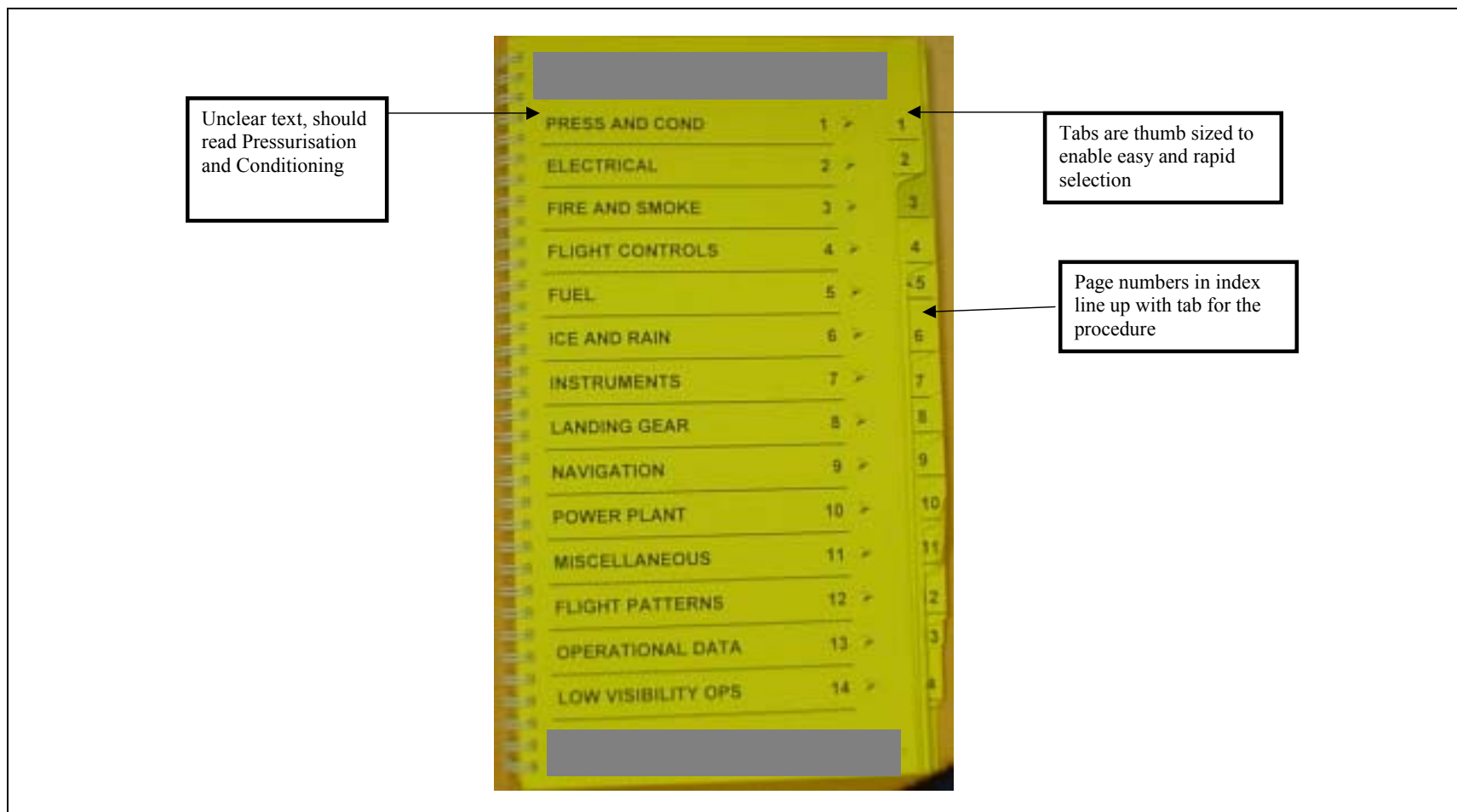
4.3 **HF Issues**

- 1 The crew elected to continue the approach rather than going into the hold.
- 2 Neither the pilot nor the first officer followed the QRH procedure.
- 3 A complete lack of situational awareness by both pilots with respect to aircraft trajectory.
- 4 Lack of training and familiarity with the QRH drill. This particular problem had occurred several times on this aircraft type.
- 5 The PF did not follow the SOPs to continue flying the aircraft whilst the FO carried out the checklist.
- 6 The design of the checklist was poor in that uppercase lettering was used throughout and there were two very similar actions resulting in an error prone situation.
- 7 The sequence and number of QRH actions did not account for the time available to complete the task.

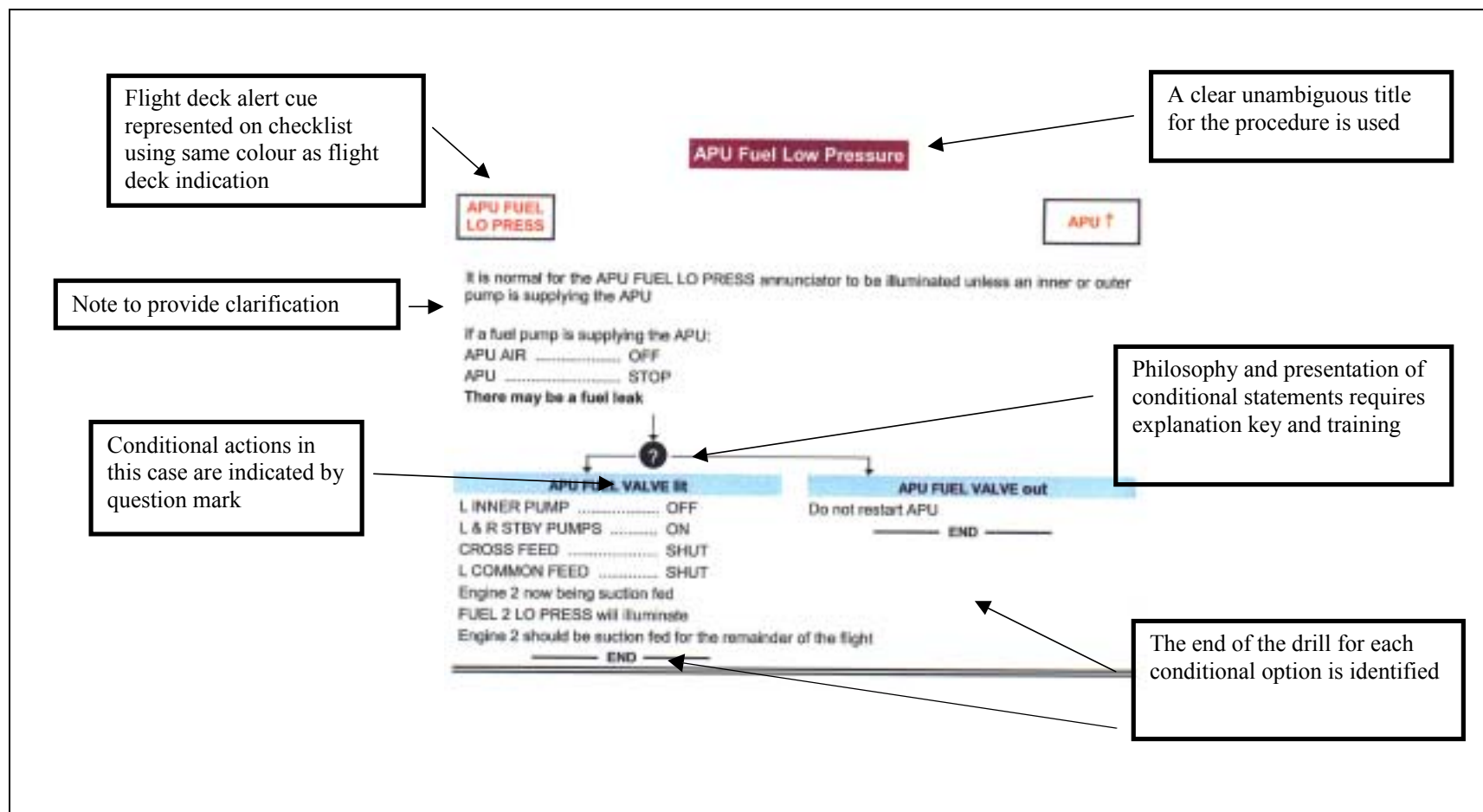
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Appendix 3 Checklist Presentation Examples

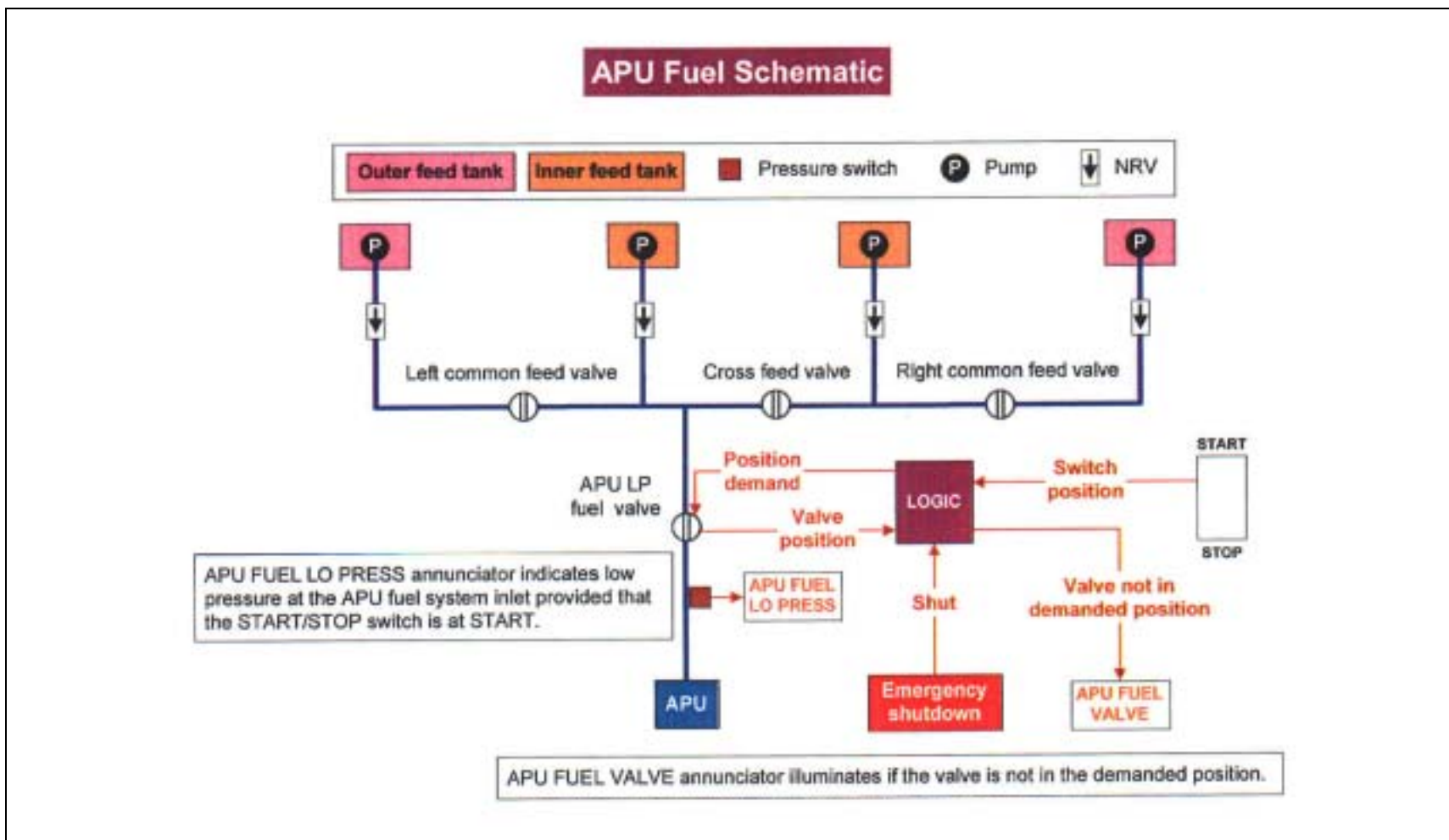
Example 1: Indexing of Emergency and Abnormal Checklist



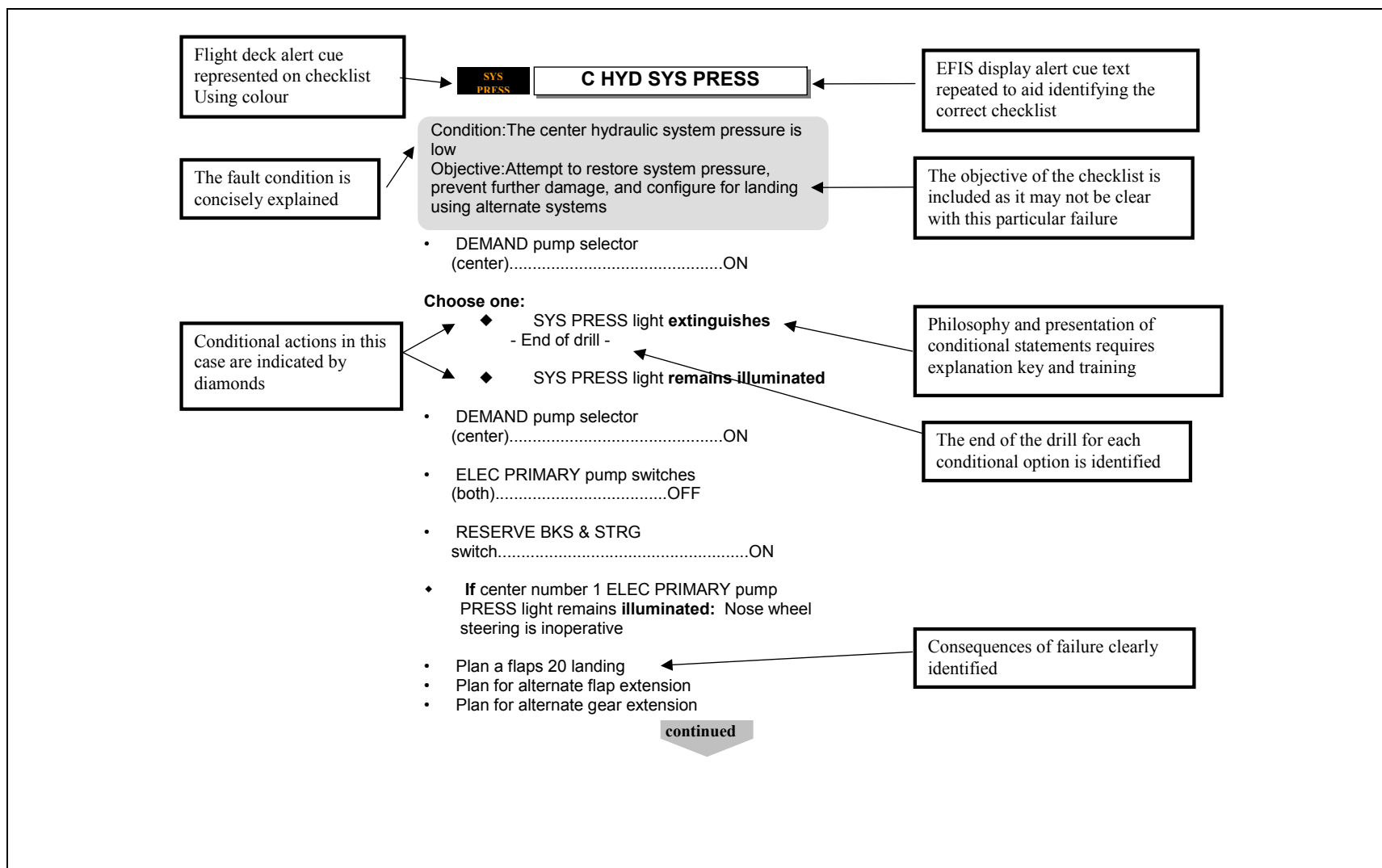
Example 2: Checklist Presentation



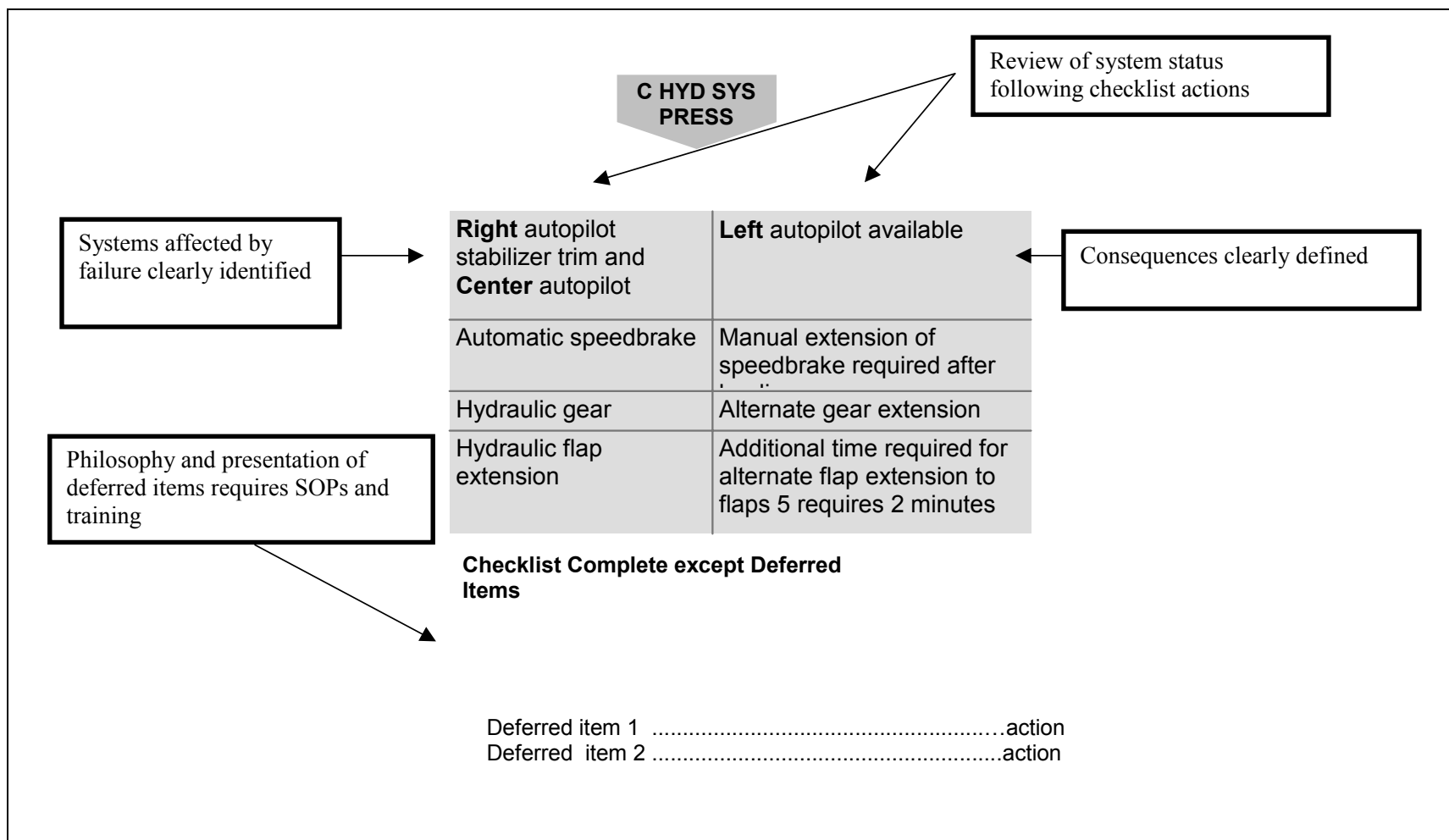
Example 3: Checklist Schematic



Example 4: Checklist Presentation



Example 5: Continuation Page



Example 6: Checklist Presentation Lacking HF or Usability Attributes

Abnormal Checklist

- HYDRAULIC SYSTEM FAILURES (Cont) -

HYD L & HYD R WARNING LIGHTS AND FLUID O/HEAT WARNING LIGHT ON

CHECK THE PUMP TEMPERATURE GAUGES, AND

1. IF ONLY ONE GAUGE IS INDICATING EXCESSIVE TEMPERATURES (ABOVE 115°C) SET THE APPROPRIATE PUMP INLET VALVE SWITCH TO SHUT
2. IF BOTH GAUGES ARE INDICATING EXCESSIVE TEMPERATURES ABOVE (115°C) OR IF THE OVERHEAT WARNING LIGHT DOES NOT EXTINGUISH WITHIN FIVE MINUTES OF SHUTTING THE APPROPRIATE VALVE, SET BOTH PUMP INLET VALVE SWITCHES TO SHUT.

TO ENSURE LUBRICATION OF THE PUMPS SET THE VALVE SWITCHES TO OPEN FOR ONE MINUTE IN EACH 15 MINUTE PERIOD & THEN RE-SELECT SHUT WHEN HYDRAULIC SERVICES ARE REQUIRED DURING APPROACH & LANDING

SET BOTH PUMP INLET VALVE SWITCHES TO OPEN & THEN IN AS SHORT A TIME AS POSSIBLE TO AVOID OVER HEATING, SELECT FLAPS AS REQUIRED, LANDING GEAR DOWN & PUMP INLET VALVE SWITCHES SHUT.

SET THE EMERGENCY BRAKE CONTROL LEVER TO EMERGENCY. ON THE EMERGENCY SYSTEM ANTI-SKID IS NOT AVAILABLE & THERE IS NO INDICATION OF WHEEL-BRAKE PRESSURES. WHEN THE BRAKE EMERGENCY SUPPLY PRESSURE FALLS TO 1,500 psi THE SUPPLY IS NEARLY EXHAUSTED.

End of checks

Capitals used throughout are difficult to read

Decision items poorly presented

Deferred items embedded in text

Mixture of actions and notes