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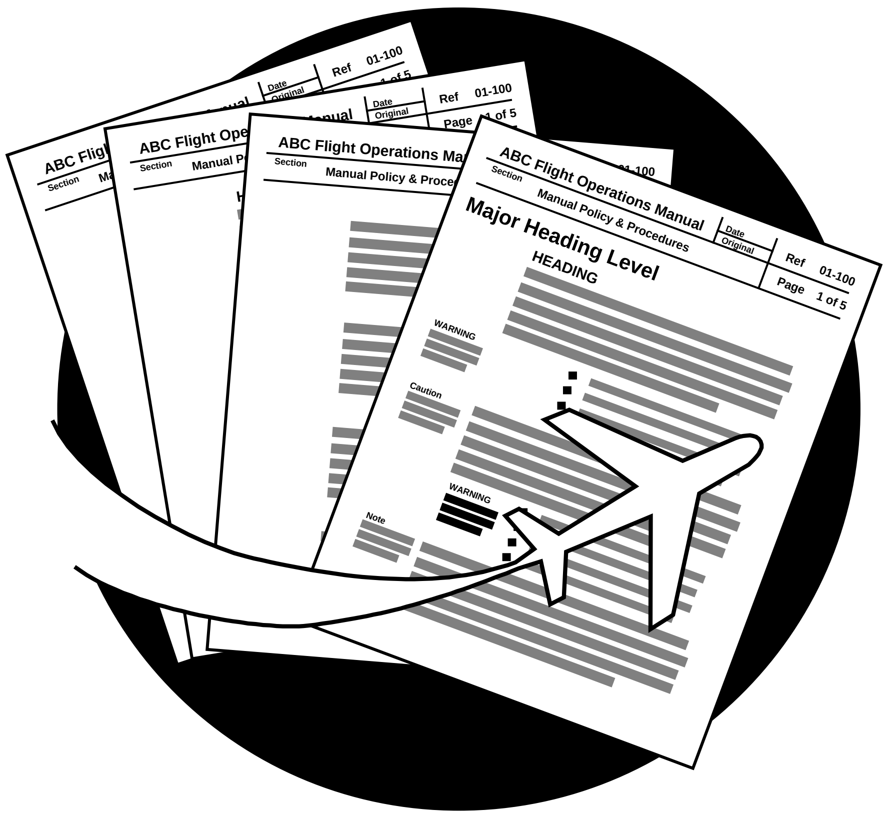
DIGEST

Principles of Design and Display for Aviation Technical Messages



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Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of flight safety. Nonprofit and independent, FSF was launched in 1945 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 660 member organizations in 77 countries.

Principles of Design and Display for Aviation Technical Messages

Effective document design requires an understanding of how readers perceive what is presented. Communication takes place not only through words but also through visuals, structure and typography. Optimizing all these elements will deliver the intended message clearly and meaningfully.

Anthony J. Adamski
Albert F. Stahl

The relationship between message design and decision making is critical. The way that aviation technical documents are designed can facilitate or hinder good decision making.

Technical messages are vital components of the aviation environment. Messages represent routine confirmation of operational activities; provide information about the company's flight or maintenance procedures; provide equipment and system reference information; or provide guidance for dealing with emergency situations.

Writers and designers of aviation technical documents try to provide all the information that crews and maintenance staff might need. Nevertheless, the effectiveness and the usefulness of a message depend not only on the information it contains, but also on message design, reader perception and reader understanding. Those processes represent filtering that affects the understanding and the use of the message (Figure 1, page 2).

Messages must be designed to facilitate processing by the receiver so that key information is recognized, prioritized and used in making subsequent decisions. Too often, the design of important messages inhibits or restricts their utility, resulting in misinterpretation, misunderstanding or poorly timed decisions.

Unfortunately, presentation of technical messages is often determined more by the message designer's style or the organization's style — either of which might not be appropriate — than by design principles.

Research findings and recommendations regarding technical-message design are abundantly available, but they are widely scattered among reports, journals and textbooks. Moreover, few of them apply directly to aviation.

An analysis of the research on message design suggests that the application of message design principles should begin with:

- Analyzing the audience that will receive the message, their language- and visual-interpretation capabilities, their common experiences and their prerequisite skills;
- Understanding the desired action(s) to be undertaken by the receiver following receipt of the message;
- Understanding the display medium that will be used to transmit the message; and,
- Knowing the circumstances under which the message will be displayed.

The U.S. National Transportation Safety Board (NTSB) and aviation human factors specialists have identified various problems in the design and use of technical messages.

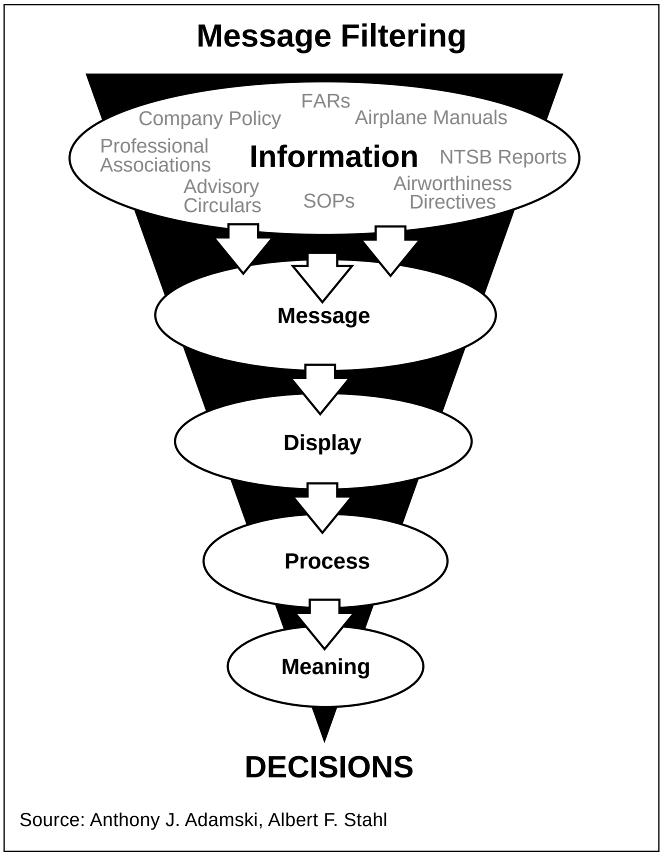


Figure 1

Unfortunately, few operations can afford a staff dedicated solely to the design of technical messages. In most organizations, management delegates the responsibility to persons who show an interest in technical message design or to specialists in the subject matter of the message.

Crew members, maintenance technicians, dispatchers and other support personnel want clear, concise and accurate information that is easy to find, unambiguously stated and easy to comprehend.

There are two methods for the design of technical messages that are most relevant to aviation. With the message-logic method, the message purpose is identified and used in the design. The second method involves categorizing messages by message type. There are three major types of messages: persuasive, informational and instructional. Each type has its own purpose and characteristics.[1]

The persuasive message is intended to motivate the reader to change an attitude or a behavior. Advertising is one type of persuasive message. Persuasive messages are short and to the point, and are designed to motivate the reader to take action.

The informational message is self-defining. Informational messages include technical manuals, policy manuals, forms, reports, financial statements, etc. Informational messages can involve complex subjects and can use large bodies of text.

Informational message producers typically write the text and then, if visuals are desired or required, fit the visuals to the textual presentation. Another method, for conveying extremely complicated data or very lengthy information, uses the opposite technique: First, design graphics (visual elements) to tell the story, then add text to supplement the graphics. Typically, this technique is used by professional designers of passenger safety–information cards. It is similar to a technique developed by the U.S. Navy for use in its manuals.[2]

The instructional message is designed to provide the reader with knowledge and skill he or she did not previously possess, by informing the reader how to do something, and it usually explains why.

The authors have combined the message-type concept, as used in persuasive, informational and instructional messages, with the message-logic concept and adapted them for the aviation industry. The results are called aviation-specific messages (Figure 2, page 3). Aviation-specific messages include:

The alert message. A form of persuasive message, the alert message calls for action or, sometimes, urges the recipient *not* to take an action. Examples include the emergency-exit placard in the aircraft cabin that states PULL HANDLE and the NO STEP warning often seen on an airplane wing.

The persuasiveness of an alert message may be enhanced by its presentation: for example, color (such as white lettering on a red background to signify danger); type style (such as large block letters to signify importance); and placement (such as a warning label on the critical area of a wing).

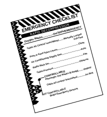
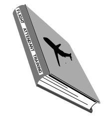
In many examples, alert messages may appear to be informative (for example, informing a pilot of a system malfunction, or displaying an error message on a dispatcher's computer screen). Nevertheless, the primary purpose is to alert the receiver to take or not to take action.

The regulatory message. A form of informational message, the regulatory message addresses compliance issues. It presents legally binding information or company rules, and is usually approved by a regulatory authority such as the U.S. Federal Aviation Administration (FAA) — or its equivalent in other nations — or company management. Regulatory messages include flight operation manuals, maintenance operation manuals, minimum equipment lists, company policy manuals and other messages that demand specific actions or procedures to be followed.

L.R. Zeitlin, a human factors specialist, explored the question of why people fail to follow safety instructions, which are a form of regulatory message.[3] He found that people make a subjective assessment of risk and that attitudes and experience often prompt readers to ignore safety instructions.

Zeitlin argues that a well-crafted safety instruction provides information about the hazard (hazard avoidance) and, most

Examples of Aviation-specific Messages

 **Alert Messages**	 **Regulatory Messages**	 **Procedural Messages**	 **Instructional Messages**
• Aircraft Placards • Shop Placards • Warning Labels • Warning Tags • Airworthiness Directives • Service Bulletins • Emergency Lights • Warning Horns • Warning Bells • Chimes	• Flight Operations Manuals • Maintenance Operations Manuals • Company Policy Manuals • Standard Operations Procedures • Airplane Flight Manuals • Minimum Equipment Lists • U.S. Federal Aviation Regulations	• Aircraft Checklists • Passenger Safety–Information Cards • Flight-plan Forms • Weight-and-balance Forms • Load-manifest Forms • Maintenance-job Forms	• Aircraft Training Manuals • Maintenance Training Manuals • Flight-attendant Training Manuals • Company Indoctrination Manuals • Job Aids • Advisory Circulars

Source: Anthony J. Adamski, Albert F. Stahl

Figure 2

important, a rationale for obeying the message. Thus, he believes this rationale is applicable to regulatory messages. Zeitlin's findings also emphasize the need for regulatory messages that are easy to find and easy to use.

Focus, centering on comprehensibility through user orientation, is a primary factor in designing effective regulatory messages for aviation technical documents. The regulatory message is a "reading-to-do" communication rather than a "reading-to-learn" communication, such as a training manual.

The procedural message. A procedural message is an abbreviated version of a regulatory message. Aviation procedural messages include aircraft checklists, flight-release forms, passenger-information cards, etc. The procedural message usually has a sequential format and tells the reader the steps that are necessary to complete a task or to comply with a regulatory message.

Asaf Degani provides an excellent review of the concepts, design and use of the cockpit checklist.[5] Flight Safety Foundation (FSF) has also explored methods to optimize checklist design.[6] The following analysis examines the perceptual and visual elements found in effective procedural messages.

The instructional message. Aviation instructional messages include pilot training manuals, maintenance training manuals, flight attendant training manuals, interactive computer training programs, company indoctrination programs, etc. Instructional messages intended for use in a professional aviation organization are designed for adult learners.

Integrated messages. Some messages have elements of more than one message type. For example, effective passenger safety–information cards, which are classified as procedural messages because of their abbreviated format, also have elements of alert, regulatory, procedural and instructional messages. They are designed to be used at various times during a flight. With integrated messages, the time of use determines the type of message.

Just prior to flight, the passenger safety–information card is used as a regulatory message presented in a procedural-message format. The card is also designed to provide alert data and instructional information during an emergency. Thus, the design of such documents involves more than just the combining of visuals and text to attain FAA approval.

[A U.S.-based airline's regulatory messages and its passenger safety–information cards must be approved by the FAA principal operations inspector for the airline. There are no mandatory message design requirements (although there are content requirements) in FAA regulations, but guidance is offered for some documents. For example, Advisory Circular (AC) 121-24A, *Passenger Safety Information Briefing and Briefing Cards*, says that "the use of international symbols is encouraged."]

Not every principle of effective message design applies to every message type. For the most part, research on readability, accuracy, speed, comprehension, visuals, etc., focus on only one message type. Consequently, it is important to understand the type of message being designed and to identify its category to determine which principles apply. Some of the elements that affect message-design effectiveness are described below.

Perception. The principles of perception influence the readability of the technical message in ways that can be either good or bad. A reader's perception of a technical message occurs in two phases, the preattentive process and the attentive process. The preattentive process is the impression conveyed by the document without the user processing the message content. Visual presentation, type style, size and color may influence the preattentive process.

An effective document suggests, at the preattentive level, a sense of professionalism, accuracy, attractiveness and ease of use. Thus, the role of the preattentive process is pivotal in message design. A document that conveys a sense of poor organization and a lack of professionalism is easily discredited by the reader, no matter how important the content.

The second phase of perception is the attentive process, the reader's assimilation of the message. Through the attentive process the reader judges the message organization, structure, content, sensory stimulation, sequencing and other elements. The attentive process involves focused attention; thus, it is slower than the preattentive process and relies heavily on memory. The design of the message provides the reader with the means to use the content in short-term memory or to transfer the information into long-term memory, which is the purpose of instructional messages.

["Short-term memory" and "long-term memory" are derived from information-processing theory, which attempts to explain what happens after the human brain receives stimuli and transforms them into perceptions. According to the theory, the perceptions can be filed as either short-term memory or long-term memory. Short-term memory is "working memory," analogous to a computer RAM, and long-term memory is analogous to the data stored on a computer hard disk.

[Because short-term memory is extremely limited in capacity, it is important that aviation technical documents be designed appropriately for short-term memory or long-term memory, as needed. Many of the organizational and structural principles that follow are designed to facilitate the storage of information in long-term memory, rather than in short-term memory where they will quickly be displaced by new perceptions.]

Perceptual organization. Early in this century, a group of German psychologists explored how the mind organizes sensations into perceptions. Given a cluster of sensations, the mind organizes them into a *Gestalt* (a German word meaning a "form" or "whole"). Gestalt psychologists say that in perception, the whole is greater than the sum of its parts.[7]

Gestalt theory attempts to explain how visual experiences are organized and interpreted by the mind. The application of Gestalt psychology to message design suggests important principles.

The first principle is *equilibrium*. Consciously or not, the preattentive process needs balance. Humans naturally seek stability in everything they see. Thus, to be effective, aviation technical messages must have balance, which is achieved by taking into account the Gestalt principles of figure and ground, proximity, similarity, continuity, closure and connectedness.

The principle of figure and ground is a fundamental element of perception that relates to the contrast between light and dark, and between black and white (Figure 3). The first step in perception is "to perceive any object, called the figure, as distinct from its surroundings, called the ground."[8]

Gestalt Principle of Figure and Ground

When the figure and ground contain no contrast we cannot see the figure. We can see the airplane (the figure) only when there is sufficient contrast with the ground of white.The interaction between the figure and the ground governs perception.

Is there a "word" in this graphic?

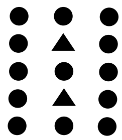
When the figure and ground are displayed in a manner to which the reader is not accustomed, the reader's perception process is easily confused.

Adapted from HBAcorp FACTS® Training International

Source: Anthony J. Adamski, Albert F. Stahl

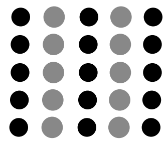
Figure 3

Gestalt Principles of Visual Organization



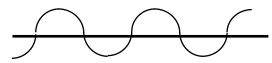
Proximity

Our perception groups nearby things together, even if they are dissimilar. In the example, we see three vertical columns because the horizontal distance between the objects is greater than the vertical distance. Notice that the middle column contains dissimilar objects.



Similarity

If figures are similar to each other we group them together. Our eyes easily pick out and group objects that are similar, regardless of their proximity. The example depicts dots of equal size and space, but we see columns because of the similarity of grays. Similarity can be a powerful tool for reinforcing underlying messages.



Continuity

We perceive smooth, continuous patterns rather than discontinuous ones. This example could be a series of semi-circles, but we perceive it as a wavy line and a straight line. The principle of continuity is used in typography and graphic arts to guide the reader's eye.

Closure

If a figure has gaps, we fill in the gaps to complete a whole object. In the example above, we perceive a rectangle instead of dashed lines. Closure explains why we see things that are not actually displayed in the message.

Connectedness

Throttles -------------------- Idle

We perceive spots, dashes, dots, lines or objects as a single thing when they are uniform and linked. It is the principle of connectedness that is most critical in the design of procedural messages (such as aircraft checklists) where a check-and-response format is used.

Source: Anthony J. Adamski, Albert F. Stahl. Adapted from Myers.[8]

Figure 4

The principle of proximity states that people tend to group things together on the basis of proximity or nearness (Figure 4). When separate elements are grouped, even when they are not alike, the perceiver tends to group them together, simply because their closeness suggests a relationship. Reader comprehension can suffer unless sufficient distance (traditionally referred to as "white space," more appropriately called "open space") is provided between and among different elements.

Too many technical message designers use all the space on a page. Without enough open space, the perception of words and phrases may be affected, and comprehension can be seriously impeded. The principle of proximity is often neglected in checklist design. For example, if all upper-case letters are used and too little open space is provided between the lines (which is often done to reduce the physical size of the checklist), the text tends to blend into one large block of type, and the user can easily lose his or her place, increasing the risk of missing a procedural step.

The principle of similarity states that objects of similar shape, color or other attribute appear to belong together (Figure 4). If figures are similar to each other, we mentally group them together. Similar objects seem to "pop out" from the background, even when they are not in proximity. That is one reason that designers use dissimilar type styles in the body of a text and in the headings. The principle of similarity is best when differences are obvious and easily seen.[9]

Perception leads us to identify and perceive smooth, continuous patterns rather than discontinuous ones. This is the principle of continuity, the eye's natural tendency to follow a path (Figure 4). Continuity is particularly important for procedural messages, such as the aircraft checklist and the passenger-information card. Because procedural messages are typically abbreviated information messages, continuity is the key to user comprehension. Continuity is crucial to providing visual organization and clarity for the user.

The principle of closure says that if a figure has gaps, it should be completed (Figure 4). For example, the pictures on a passenger-information card typically illustrate a series of steps to complete a task, such as opening a window exit. Closure provides the reader with a means of realizing the nonillustrated actions.

If a figure has uniform spots, lines or objects, they are perceived as a single unit. This is the principle of connectedness (Figure 4). Connectedness is why the sections of a well-designed aircraft checklist are perceived as separate units identified by phases of flight.

These visual principles of Gestalt psychology explain the natural tendency to organize visual patterns and to seek a balance in what is perceived. By employing the visual principles of Gestalt, the designer "sets the user's perceptual stage" to achieve message clarity, accuracy and ease of use.

Communicating through structure. In using the principle of structure, design techniques help the reader comprehend meaning through the integration of visuals and text.[10] Communicating with structure means organizing and designing the document to ease the burden on the reader's working memory. It allows the reader to more easily make sense of what is being presented. It provides a sense of order and affords a visual path to meaning.

One researcher suggests that "the stronger the organization of text, the more likely it will be assimilated by the reader ... ."[11] Structured text design is extremely beneficial to regulatory messages involving large bodies of text, such as those in a flight or maintenance operations manual.

Research confirms three basic principles about text structure that apply to lengthy aviation regulatory messages:

- There is a positive correlation between the use of an outline or other writing plan and the quality of the subsequent text;
- Reading consists of two complementary levels of mental processing: microprocessing and macroprocessing. Microprocessing is how a reader focuses on individual elements of the document. Macroprocessing is the reader's perception of the various levels of meaning or importance among the elements, which creates a mental map (a "flight plan" through a maze of complex information); and,
- Signaling within the document, such as using headings, outlines, typographical cues and other devices, influences the comprehension and retention of the information.[12]

Good technical document designers spend more time on issues that affect the reader's macroprocessing (by preparing outlines, strategies and sequences) than they spend on issues that affect the reader's microprocessing (sentence structure, grammar, spelling, etc.).

Without design that addresses the macrostructure — the hierarchical arrangement that creates the "mental map" — the reader might well focus on items that are low in importance. Lack of macrostructure is often the reason that a user fails to see the big picture. When each piece of information is related only to the immediately preceding information, the reader's understanding is fragmented.

Sound macrostructure frees the user's memory capacity by providing a way through which individual information units can be related during microprocessing. Well-structured technical documents are more readily understood and remembered than unstructured technical documents.[13]

Other macrostructure-design factors that the technical message designer must consider include:

- The nature of the document — is it of interest to the user?
- The purpose of the document — is it intended for immediate use or delayed application?
- The experience level of the reader — is the reader an experienced professional or a novice to the task?
- The reading skill and verbal abilities of the user — does the document present the information in a way that is understood by the user? Or does it contain an overabundance of technical terms, abbreviations and acronyms that confuse the user?
- The user's previous knowledge of the subject matter.
- The reader's perception of the importance of the message — does the message motivate the reader to learn what it has to say? This principle involves signaling.

Signaling is a means of revealing the document structure to the reader. Structure provides continuity, closure and connectedness. A well-structured document design:

- Improves reader comprehension;
- Provides for faster and easier scanning of information; and,
- Increases cost-effectiveness. (A utility company saved US$850,000 per year by incorporating structured text design to standardize its document system.)[14]

One communications specialist argues that "technical communicators now require the skills of knowledge engineers."[15] These skills involve:

- Taking complex processes and breaking them into discrete components;
- Organizing the components logically; and,
- Arranging the components in a logical sequence.

The aviation technical message designer must analyze the data, separate it into comprehensible components, provide adequate explanation and organize the components into logical sequences.

Message design for aviation safety. The aviation technical document designer should keep in mind the following recommendations, which apply to lengthy regulatory and instructional messages as well as to shorter procedural messages such as cockpit checklists:

- Use clear and complete headings. Many technical documents use too few headings and leave the reader without adequate signals for situational awareness. Headings provide "waypoints" for the user to follow, like a "flight plan" through an information maze. Each heading and subheading should answer as many of the "who, what, why, when, where and how" questions as possible. Headings also provide a visual and mental break for the user. They signal the reader to put aside one thought and prepare for another.

- Use typographical cues and formatting contrast to show heading hierarchy. Heading levels can be indicated by placement on the page, the choice of upper- or lower-case letters, bold type, italics, type size, color and contrasting typefaces. Different designers have their preferred ways of organizing material. The important point is to arrange the information into a hierarchy that supports the message goal and is consistent throughout the document.

- Sequence the information appropriately. To determine sequence, consider the items of information as one of two types: nouns (persons, places or things) or verbs (actions or events).

  Nouns are usually sequenced in a logical order such as by quantity (e.g., more before less), quality (e.g., better before worse), space (e.g., high before low), alphabetically (e.g., A before B) or rank (e.g., captain before first officer).

  Verbs are sequenced chronologically (e.g., step one before step two, cause before effect). Too often, written text is presented in the order in which the information occurred to the writer. It is important for the designer to consider which sequencing will be most meaningful.

- Communicate the text structure early. Headings do not guarantee structure. Research has shown that despite the importance of headings, they are not always read. Therefore, display the text scheme in the document as early as possible. For example, when using a numbered-paragraph system in an operations manual, begin it early and do not precede it with unnumbered paragraphs. Explaining the text structure in the document introduction is effective. Other techniques include using a table of contents, page tabs and color coding of page edges.

Perhaps the most important messages in the aviation organization are the regulatory documents that list flight- and maintenance-operations procedures. Without structure, the vast amount of information in these documents easily becomes fragmented and is lost to the user. Figure 5 shows a regulatory message found in a flight operations manual and shows the same message using the principles of structured text.

The heading in the revised message in Figure 5 is set in a type style dissimilar to that of the text. The paragraph identifier, 6.20, uses the same type style as the body of the text to maintain consistency with all paragraph. (A paragraph identifier is a labeling device that supports the major headings.) The revised

Comparision of Text Designs for Regulatory Message

Text Design in Manual

```
6-25 POSTFLIGHT DUTIES AND RESPONSIBILITIES

     Postflight duties and responsibilities
     will be vested in the Pilot-in-command
     and delegated as necessary until
     relieved from duty by the Operations
     Department.

     Upon arrival in the terminal or
     passenger unloading area, the Pilot-in-
     command will ensure that the aircraft
     is properly parked in the assigned
     area. He will ensure that control
     surfaces are locked and that the
     aircraft wheels are choked. Doors,
     windows, hatches and other assess ports
     will be closed when the aircraft is
     left unattended.
```

Revised Text Design

6.20 Postflight duties and responsibilities

6.21 The Pilot-in-command (PIC) is responsible for postflight duties and responsibilities.

The PIC may delegate duties and responsibilities to other members of the crew.

The PIC will retain responsibility until relieved by the Operations Department.

6.22 The PIC will ensure that the aircraft is properly parked in the assigned area.

The PIC will ensure that all control surfaces are locked.

The PIC will ensure that all doors, windows, hatches, and access ports are closed when the aircraft is left unattended.

Source: Anthony J. Adamski, Albert F. Stahl

Figure 5

text has been rearranged so that each sentence starts on a new line, and the sentences are arranged in a logical sequence. Paragraph 6.21 uses noun sequencing based on importance of responsibilities. Paragraph 6.22 uses verb sequencing based on an order of events. Starting each sentence with a new line is not always necessary. Nevertheless, some research indicates that “opening up” the presentation of complex information in this way improves readers’ comprehension.[16]

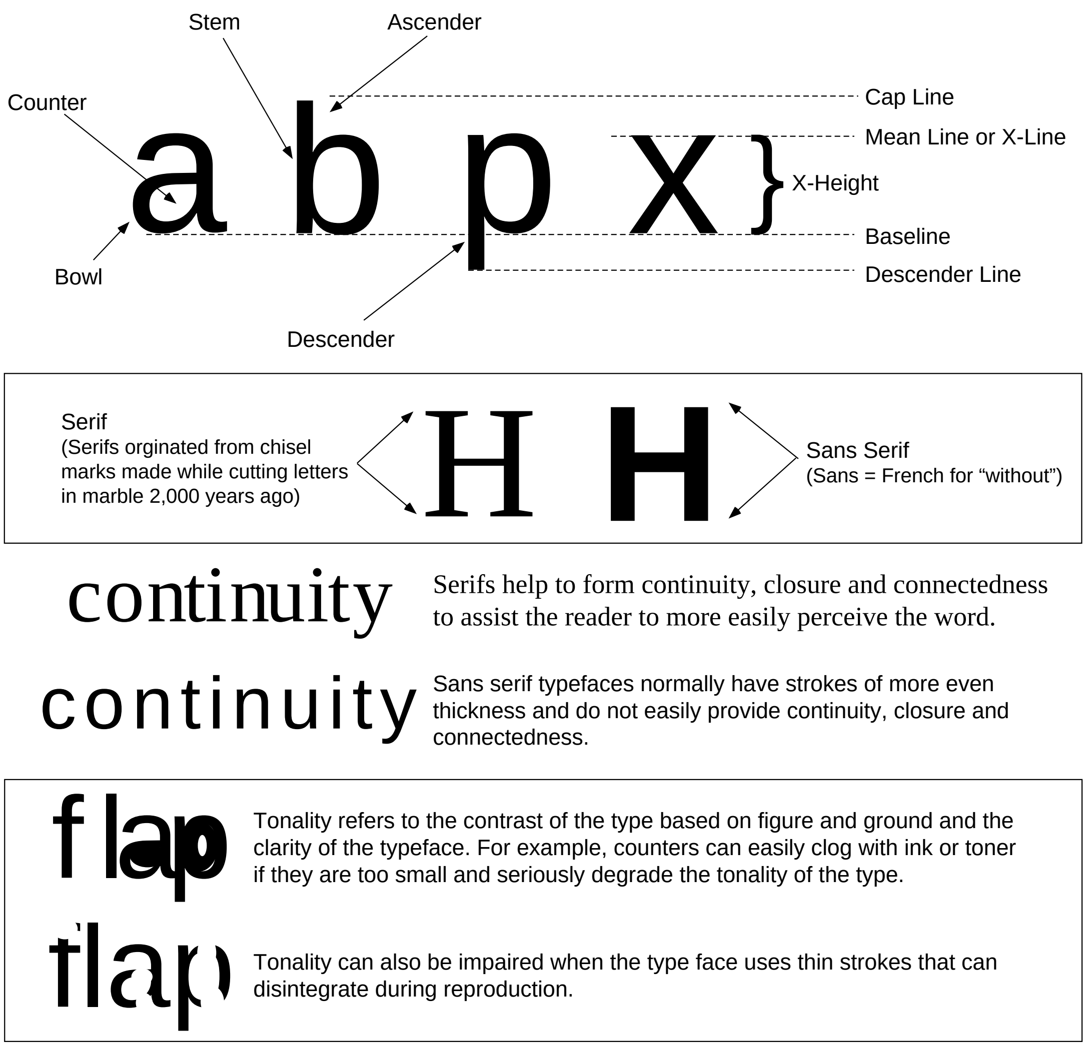
In addition, the body-text alignment of the revised message is not right justified. As will be discussed later, unjustified text alignment allows the designer more flexibility in deciding where to end each line and eliminates unsightly gaps in the flow of the text.

Inconsistencies in spacing and multiple cueing are confusing to readers. The goal in the revised text is to seek clarity through consistency.

Computer technology has made many of the features of professional typesetting widely available. As a result, people in the aviation industry who have no training in typesetting, graphic arts, technical writing or other skills for developing quality messages frequently choose a type style based on personal preference rather than principles of message effectiveness. Nevertheless, to develop effective messages, a designer must have the basic knowledge of typography necessary to use computer typesetting capabilities appropriately and effectively.

Type styles (Figure 6), often referred to as fonts, can provide readability, a sense of direction and purpose, and even personality to a document, depending on the typeface, size, weight, width, slant, case, underlining, letter spacing (kerning), word spacing, line spacing (leading), column width, alignment and other factors.

Characteristics of Type



Source: Anthony J. Adamski, Albert F. Stahl

Figure 6

Type Sizes: Inches, Decimals, Points, Picas

Converting Inches to U.S. Points

Fractions of an inch	Decimals of an inch	Approximate U.S. points
1/72	0.01388	1
1/8	0.0125	9
1/4	0.025	18
3/8	0.375	27
1/2	0.5	36
5/8	0.0625	45
3/4	0.75	54
7/8	0.875	63
1	1	72

Coverting Points to Inches

points	inches	picas
1	0.01388	
2	0.02766	
3	0.04149	
4	0.05532	
5	0.06915	
6	0.08298	
7	0.09681	
8	0.11064	
9	0.12447	
10	0.13830	
11	0.15213	
12	0.16596	(1 pica)
18	0.24894	
24	0.33192	(2 picas)
30	0.41490	
36	0.49788	(3 picas)
42	0.58086	
48	0.66384	(4 picas)
54	0.74682	
60	0.82980	(5 picas)
66	0.91278	
72	0.99576	(6 picas)

Type is specified in standard sizes. Type up to 12-point size is considered text type, and type over that size is considered display type.

6 POINT abcdefghijklmnopqrstuvwxyz
9 POINT abcdefghijklmnopqrstuvwxyz
10 POINT abcdefghijklmnopqrstuvwxyz
12 POINT abcdefghijklmnopqrstuvwxyz
14 POINT abcdefghijklmnopqrstuvwxyz
18 POINT abcdefghijklmnopqrstuvwxyz
24 POINT abcdefghijklmnopqrstuvwxyz
36 POINT abcdefghijklmnopqrs

Source: Anthony J. Adamski, Albert F. Stahl

Figure 7

Type size. Type size is selected according to the way a message will be used. The farther the display will be from the reader or the more adverse the environment (such as a cockpit at night in turbulence), the larger the type should be. This principle is related to the x-height (the height of the lower-case letter x) of the type style (Figure 6). The x-height affects the apparent size of a typeface. Generally, the larger the x-height, the easier the type is to read. Two different fonts of equal size may appear different in size, which affects readability, because of differences in x-height.

Type size is usually specified in point sizes (Figure 7). In countries that use the metric system, the Didot system is used, and the points are slightly larger. In the United States and the United Kingdom, there are 12 points in one pica and about 72 points in one inch (2.54 centimeters). The pica is the traditional unit of measurement used in professional typesetting: six picas equal roughly one inch, and a pica is subdivided into 12 points.

Normally, font sizes up to 12-point are considered text fonts, and larger sizes are considered display fonts. Designers generally agree that 10-point type or 12-point type is legible for most messages, but it is important to consider the way the message will be used. The question is, of course, what is the optimum type size for the display? Up to a certain point, the bigger the type size is, the more legible the type. It is also important to consider the x-height and its effect on the apparent size of the typeface. The following recommendations are offered:

- The x-height of a font should not be less than 0.10 inch (0.25 centimeter [8 points]) for important flight deck documents.[17]

- The "rule of X's" provides guidance on the size of headings in relation to the following text. The rule suggests that the upper-case X of the text font should be the same height as the lower-case x of the heading font.[18]

- When different sizes of the same font are used within a document, the size difference should be great enough to be readily recognized. Most people cannot differentiate between type sizes that are different only by a single point (e. g., the difference between 11-point and 12-point type).

- One source recommends that checklist headings should use 14-point type, upper-case letters and boldface, with checklist text in 12-point type, upper-case letters and boldface.[19] These recommendations will be discussed later.

- Type sizes between 8 points and 12 points allow comfortable reading in normal situations.[20] (But these sizes may not be adequate for use by flight crews.)

Legibility is also related to the open spaces — the counters — inside the letters (Figure 6) as well as the black lines that create them. When the font is "big on body" (letters are relatively full and round), the lower end of the 8-point to 12-point spectrum can probably be used.

The most important principle was summarized by one researcher, who wrote, "Look at what you are dealing with and trust your visual instincts; don't go by mathematical size specifications."[21]

Few readers can name the typefaces that are used in a technical message. They do, however, respond to the impression that the type conveys. The type style must fit the message. Figure 8 (page 11) depicts important type considerations, including upper and lower case, italics, weight, boldness and width. Each of these considerations can contribute to or detract from the readability of the font.

Type style: serif vs. sans serif. There is considerable debate over the relative merits of serif and sans serif typefaces (Figure 6). Some psychologists and human factors experts argue that sans serif fonts are usually more legible than serif fonts because serifs create distraction.[22] Other instructional designers believe that serif fonts are easier to read because the serifs lead the eyes from letter to letter, so designers recommend that they be used in any lengthy body text.[23]

White suggests that sans serif fonts are most appropriate to provide contrast in separate materials such as headlines, sidebars, running glossaries or advanced organizers. But White says that serif fonts also emphasize the horizontal plane, which assists the eye in binding the individual letters into letter groups.[24] During reading, the eyes skip and stop in jerky movements known as "saccadic jumps." Serif fonts seem to help the reader form letter groups during these jumps.

Another consideration in font selection is the medium that will be used to transmit the message. White's recommendation relates to print. Yet, for electronic displays, sans serif type is generally more readable than serif type. One must carefully consider (and test) the message display and the conditions under which the message will be presented.

The authors believe that serif fonts are best for the body text of lengthy regulatory or instructional documents such as operations manuals or training manuals; sans serif fonts seem better in short documents such as aircraft checklists, flight-plan forms or electronic displays. Otherwise, the choice depends on the preference of the designer. Either way, font use should be consistent throughout the document.

Type alignment. The alignment of type is called justification (Figure 9, page 12). When both margins form a straight vertical line, creating even left and right margins, the alignment is called justified. When the type is aligned only at the left margin, creating a ragged right margin, the alignment is called flush left or, more commonly, unjustified. In rare situations, text is set flush right, producing a ragged left margin. Finally, text can also be set center justified. In this alignment, each line is centered vertically on the page, and both left and right margins are ragged. Although it appears that justified alignment is satisfactory for alert and procedural messages, the major question is whether to use a justified or unjustified text alignment in regulatory and instructional messages.

Right-justified alignment seems appropriate for certain documents, such as a checklist (a procedural message) or a warning note in an operations manual (an alert message). This style helps the reader to perceive each entry as a procedural step and, further, provides for the chunking of information into discernible topics such as a before-takeoff checklist, a climb checklist, etc. For regulatory and instructional messages, research supports the use of ragged-right text alignment as the most efficient text alignment.

Some argue that justification provides balance to a document and is aesthetically more pleasing than unjustified text. Also, the argument states that readers are accustomed to justified text in newspapers and books, and these favorable associations with justified text do not warrant its dismissal.[25]

Although research indicates that a justified text alignment increases reading time, there seems to be no loss of comprehension on the part of the reader. There is some

The Variety of Type

Type is an extremely varied medium. The variations can be very obvious or quite subtle. Type styles have numerous minute details that add up to major differences. For each typeface there is a font, which is a collection of all the characters within that typeface. The type style affects how well a document will be read and understood. To get an idea of the numerous features of type, consider the following examples:

Type is normally presented in upper-case letters or lower-case letters. Research has shown that an all-upper-case style is more difficult to read than a combination of upper- and lower-case letters.	AEROSPACE (all upper case) aerospace (lower case) Aerospace (upper and lower case)
Two basic variations are available for most typefaces: vertical and oblique.	AEROSPACE (vertical) *AEROSPACE* (oblique or italic)
Another basic variation is weight. This variation is normally referred to as bold. The bold variation is used typically in headlines and for other cueing roles.	AEROSPACE (regular) **AEROSPACE** (boldface)
Wide variations of boldness are available. Many times the name of the typeface refers to the weight of the type. The various names are not standard and what they seem to describe can vary greatly. Confirm your choice by what is produced and printed on your equipment. (Note: all examples are 10 point.)	HELVETICA PLAIN NEW HELVETICA NARROW **HELVETICA BOLD** **BOOKMAN BOLD** **CHELTENHAM BOLD** **WIDE LAT IN BOLD**
The various typefaces also have a great variety of widths. The ultrawide typefaces can become difficult to read, especially in long phrases. It is best to use basic type styles and avoid the vast array of special styles now available.	**Aerospace** AEROSPACE **AEROSPACE**
Additional variations provide a number of ways to achieve different results. Condensing and expanding type are among the many variations available in most modern word processing and page-layout computer software programs. These techniques should be used sparingly and only for specific purposes.	Ultra Compressed Compressed Regular Extended Expanded Wide

Source: Anthony J. Adamski, Albert F. Stahl

Figure 8

evidence that the increased reading time and reprocessing of material that takes place with reading justified text actually increase comprehension.[26] Those who argue for using a justified alignment feel that justified text is preferable for long documents that require continuous reading and concentration.

There are a number of arguments for unjustified text. Setting justified text requires spreading the spaces between words (in some cases even between characters) to make the lines an even length. In the example of justified text in Figure 9, there are a number of spaces or gaps between words. When these gaps become large, they are unsightly; they decrease the legibility

Examples of Text Alignment

10-point Serif Font

Flush-left, ragged-right, unjustified text

Appliance means any instrument, mechanism, equipment, part, apparatus, appurtenance, or accessory, including communications equipment, that is used or intended to be used in operating or controlling an aircraft in flight, is installed in or attached to the aircraft, and is not part of an airframe, engine, or propeller.

Full-justified text

Appliance means any instrument, mechanism, equipment, part, apparatus, appurtenance, or accessory, including communications equipment, that is used or intended to be used in operating or controlling an aircraft in flight, is installed in or attached to the aircraft, and is not part of an airframe, engine, or propeller.

Flush-right, ragged-left, unjustified text

Appliance means any instrument, mechanism, equipment, part, apparatus, appurtenance, or accessory, including communications equipment, that is used or intended to be used in operating or controlling an aircraft in flight, is installed in or attached to the aircraft, and is not part of an airframe, engine, or propeller.

10-point Sans Serif Font

Flush-left, ragged-right, unjustified text

Appliance means any instrument, mechanism, equipment, part,apparatus, appurtenance, or accessory, including communications equipment, that is used or intended to be used in operating or controlling an aircraft in flight, is installed in or attached to the aircraft, and is not part of an airframe, engine, or propeller.

Full-justified text

Appliance means any instrument, mechanism, equipment, part, apparatus, appurtenance, or accessory, including communications equipment, that is used or intended to be used in operating or controlling an aircraft in flight, is installed in or attached to the aircraft, and is not part of an airframe, engine, or propeller.

Flush-right, ragged-left, unjustified text

Appliance means any instrument, mechanism, equipment, part, apparatus, appurtenance, or accessory, including communications equipment, that is used or intended to be used in operating or controlling an aircraft in flight, is installed in or attached to the aircraft, and is not part of an airframe, engine, or propeller.

Note: The information is set without hyphenation to clearly depict the characteristics of serif and sans serif fonts, justified and unjustified text, and flush-left and flush-right alignment.

Source: Anthony J. Adamski, Albert F. Stahl

Figure 9

of the text; and they negate the principles of continuity, closure and connectedness. The resulting uneven spacing affects the visual rhythm of each line as the reader tries to compensate for the imbalances. Research found that justified text degraded reading performance, as compared with unjustified text.[27] Reading speed was reduced with the use of computer-generated justified text.[28]

In addition, flush-left alignment overcomes the problems of spacing and loss of continuity, closure and connectedness. Flush-left alignment provides a reference point for the reader's eyes as they sweep back to begin another line. A neat left margin provides an easy reference point for finding the start of the next line. The eye always returns to the left edge of the text.

The authors believe that the arguments for flush-left, ragged-right text far outweigh the arguments for full-justified text, particularly in long messages, such as regulatory or instructional documents.

Typographical cues. Using typographical features to provide visual organization and structure is called *typographical*

Examples of Typographical Cueing in Text

Which cue do you prefer? There is no right or wrong answer. It depends on your preference. Use cues sparingly and with consistency.

Boldface to emphasize the word "never."	The pilot flying shall **never** descend below the minimum descent altitude or decision height until absolutely assured of a safe landing.
Italics to emphasize the word "never."	The pilot flying shall *never* descend below the minimum descent altitude or decision height until absolutely assured of a safe landing.
All-upper-case letters to emphasize the word "never."	The pilot flying shall NEVER descend below the minimum descent altitude (MDA) or decision height (DH) until absolutely assured of a safe landing.
All-upper-case letters and boldface for emphasis.	The pilot flying shall **NEVER** descend below the **MDA** or **DH** until absolutely assured of a safe landing.
Underlining for emphasis.	The pilot flying shall never descend below the MDA or DH until absolutely assured of a safe landing.
A different font for emphasis.	The pilot flying shall never descend below the minimum descent altitude or decision height until absolutely assured of a safe landing.
Bold and italic cues for the word "never."	The pilot flying shall ***never*** descend below the MDA or DH until absolutely assured of a safe landing.
Simultaneous use of different cueing methods can easily become confusing.	The pilot flying shall ***NEVER*** descend below the MDA or DH until *absolutely assured* of a safe landing.
A box or border sets the entire message apart from other text, rather than emphasizing key words.	The pilot flying shall never descend below the minimum descent altitude or decision height until absolutely assured of a safe landing.

Source: Anthony J. Adamski, Albert F. Stahl

Figure 10

cueing. Changing type size, weight, case, typeface, etc., signals the reader what the text contains and how it is organized.

This visual structure, based on the use of space, is perceived in the preattentive process and strongly influences how the reader will read, understand, remember and use the information. The aviation technical document designer, however, must not overtax the reader's ability to interpret such cues.

Typographical cues can consist of changes in the features of type, including boldface, italics, upper-case letters and underlining. Other kinds of typographical cues include lists, borders, boxing, rules (lines drawn above or below text) and headings used to highlight relevant information. It is important to know the limitations of these devices and in what message types they work best (Figure 10). A basic principle is to use typographical cues sparingly and consistently.

Boldface and italics are the most popular typographical cues, but they should not be overused or their effect will be diminished. The rule of thumb is to limit these cues to 10 percent of the page content. For some message types, such as alert and procedural messages, boldface is sometimes suggested for the entire message, although in that case, the boldface loses its cueing properties because it becomes the norm.

The same can happen with italics. When almost all words are italicized, the nonitalicized words are the ones that stand out. Misanchuk argues, "If more than one or two words on one or two pages are italicized for emphasis, the device is probably being over-used."[29] He also suggests that boldface type is preferable to italics for emphasis, but italics are more appropriate for differentiating technical terms.

The use of all upper-case letters is another cueing device often seen in aviation documents. Research has shown that the use of all upper-case letters decreases legibility, and reduces reading speed by nearly 12 percent. It is, however, frequently used for alert messages. Degani reports that the "readability of lower-case words is superior."[30] Lower-case letters, however, do not attract the attention desired for alert messages. The recommendation is to use all upper-case letters only when the message is short and crisp and to achieve a startling effect. Degani points out that most of today's flight deck documentation and checklists use all upper-case letters.

As stated earlier, regulatory messages are reading-to-do documents rather than reading-to-learn-about documents. Consequently, the user scans the document for the section of needed and reads only that section; thus, the use of acronyms, such as FATS for "flaps and trim and speed-brake" check, and abbreviations, such as PNF for "pilot not flying," all must be used carefully to avoid confusing the reader.

In addition, operations personnel might not understand the acronyms and abbreviations in the message. A good practice is to provide a glossary of terms that includes all acronyms and abbreviations used or to spell out each term and follow it with the acronym or abbreviation in parentheses at least once in each section of the message.

Underlining words or phrases for emphasis is a technique still found in many aviation technical documents. Before desktop publishing, when text was produced on a typewriter, typists used underlining to indicate to the typesetter that the underlined text was to be set in italics. Because word processing now makes it easy to italicize text, underlining is redundant and, according to Misanchuk, "lends ... an aura of amateurism to printed copy. Avoid it."[31]

Another widely used technique is the capitalization of the first letter of every word, such as in headings, important phrases, etc. A style in which the first letter of every word is capitalized is known as an up-and-down style. This style prevents distinguishing the words that legitimately require capitalization, such as names, proper nouns and proper adjectives. It also slows the reader. White advises that to achieve a message that reads smoothly and is logically crafted, message designers should avoid this style.[32]

List design. Another feature that can help the reader comprehend complex information is the list. A list presents text material in a visual pattern that is broken into component parts (Figure 11). It emphasizes each item of information by starting each item on a new line. The typography visibly identifies each part, and the structure of the text on the page shows the relationship of each part to the other parts. Lists can provide additional visual graphic or word cues to help ensure correct interpretation by beginning each line with visual symbols such as:

- Bullets (e.g., • , ✦, ❒);
- Sequential numbers (e.g., 1, 2, 3); or,
- Words indicating position (e.g., First, Second).

A list is effective for presenting complex information, such as a procedure that involves a number of steps (e.g., an engine-start checklist). Some of the following recommendations are based on the visual principles of Gestalt psychology. A list should:

- Have a clear purpose;
- Have a visual shape that reveals the organization of the data;
- Be typographically clear, legible and distinct from the text background;
- Have a different shape from the space that frames it;
- Be indented from the main text and, for regulatory messages or instructional messages, be unjustified (with a ragged-right margin);
- Use sufficient vertical and horizontal spacing to separate each item from the others;
- Use similarly short sentences for each item;
- Use the same type size as the rest of the text when it is an integral part of the material; and,
- Use a visual or verbal cue to begin each item.

Grammar plays a role in list design. The proper use of grammar in a list requires that elements of the list have a parallel structure; i.e., words and phrases should be constructed in a

Examples of List Construction

Example 4.20 shows parallel structure, as each item is similar in content and function.

Space and structure provide visual and verbal cues for the reader.

4.20 Each passenger shall be required to fasten his or her seatbelt:

- During aircraft movement on the surface.
- During takeoff and landing.
- When the seatbelt sign is illuminated.
- When instructed by a crew member.

Example 4.21 depicts nonparallel structure, both visually and verbally.

Notice the lack of correspondence between the lead statement and each item because of different grammatical form and lack of spatial cueing.

4.21 Smoking is prohibited:
* The no-smoking sign is illuminated.
* Aircraft movement on the surface.
* During takeoff and landing.
* Oxygen is in use.
* At all times in the lavatory.

Examples of types of bullet symbols available in current word processing programs: ✻ • ✦ ⊗ ∅ ⊕ ⋗

Source: Anthony J. Adamski, Albert F. Stahl

Figure 11

similar form. When this principle is violated and the form varies, a nonparallel structure is created that annoys the reader and reduces comprehension (Figure 11).

Borders, boxes and rules can be used to highlight parts of the text (Figure 11 uses both borders and rules). They can attract the reader’s eyes to certain parts of the page and can act as barriers that say “stop here.” Borders may enclose large chunks of information, such as an entire page, or a lengthy, complex procedure. In contrast, boxes contain smaller chunks of information such as warnings, cautions and notes. Rules, or lines, are used to organize and separate elements on a page.

Different rule weights can signal different meanings. Heavier lines usually indicate more important information, while lighter lines can indicate less important material. Contrasting rules (a heavy line next to a light one) set up a progression from thick to thin and lead the eye to focus on the message, as in Figure 11.

Headings. Words set apart in display type to describe the topic in the accompanying text are headings, which also include titles, headlines and heads, depending on how they are used. Headings label the content to help readers locate quickly the information that they need. The important principles for headings in technical messages are:

- Keep headings short and succinct;
- Do not begin the accompanying text with a pronoun (such as “it”) in the first sentence. Headings are self-contained units of information, independent of the text that follows. Readers do not normally refer to a heading;
- Use typographical cues to set the heading apart from the text. Such cues may include boldface, contrasting fonts (sans serif for headings and serif for the body text) and contrasting type sizes;
- Use a “down style” (capitalize the first word only), which is easier and quicker to read and comprehend than an all-upper-case or up-and-down style;
- Tighten the space between the letters (letter spacing). The larger the letter size, the larger the gaps between letters;
- Do not place a period at the end of a heading. It might signal the reader to stop;
- Differentiate heading levels with typographical cues, spacing and location (i.e., flush left, centered, flush right or set off in the margin);

- Allow sufficient space before and after a heading to set it apart from the body text. (One method is to divide the space between different topics into thirds. One-third of the space is set below the heading and two-thirds of the space is set above it); and,

- If the heading requires a large unit of information, consider using a longer subheading to accompany a short main heading.

Achieving cues with visual structure. Excessive typographical cueing will nullify its effect, so visual structure is required. Visual structure involves the principles of chunking, queuing and filtering (Figure 12, page 17).[33] These techniques are often used unconsciously in document design, but their principles should be understood.

Chunking, the first step in information organization, divides continuous text into manageable units. Chunking has two dimensions: division by separating and consolidation by grouping. Queuing arranges the text in recognizable units. Filtering creates levels of importance within the text, and visually identifies information types such as warnings, cautions or notes.

Proper chunking, queuing and filtering techniques use space effectively, whether open space on a page or background screen color on a computer display. These techniques are very important in the design of a regulatory message such as an operations manual.

Just as the spacing between words affects legibility, the spacing between lines of type and between blocks of information is also important for readability. These vertical and horizontal spaces provide navigational guides for the reader.

Vertical spacing identifies "positions" and horizontal spacing creates "chunks."[34] Vertical spacing defines information zones on each page and creates visible subdivisions within the information zones. It gives cues regarding key information or critical procedural elements (e.g., warnings, cautions, notes, procedural steps and critical actions).

Horizontal spacing defines hierarchical levels by chunking information, taking advantage of the reader's perceptual process (Figure 12). It allows the reader to perceive a structure and to group related text into similar elements. Chunking divides dissimilar elements by separation and consolidates similar elements by grouping. Chunking leads to the principle of queuing.

Queuing groups information into a visual hierarchy. It prioritizes information and indicates the relationships among lower-level chunks and higher-level chunks. Queuing relies primarily on changes in spacing and changes in type size, with density as a secondary cue. Fine tuning the visual hierarchy and clarifying the differences among types of information are accomplished through filtering.

Filtering creates layers that identify information types within the visual hierarchy. Filtering identifies and differentiates types of information such as warnings, cautions, procedural steps or detailed explanations. It can identify information types that are not part of the hierarchy, such as a caution relating to a particular procedural step. It increases the visual contrast and amplifies the typographical cueing. But, as with typographical cueing, overuse leads to confusion.

Visual structure is important for all aviation technical documents. It provides standardization and eliminates confusion for the reader by reducing the time and effort required to figure out how each part of the document relates to the overall message.

Indents, sentence spacing and leading. Additional considerations include indenting the first line of each new paragraph, determining the number of spaces between sentences and the spacing between the lines of type.

Before computerized typesetting and the mass production of paper, indentation was used to signal the start of a new paragraph. This style was developed as an economy measure to save paper. Traditionally, a paragraph was indented from the left margin by a space equivalent to the width of an upper-case M.

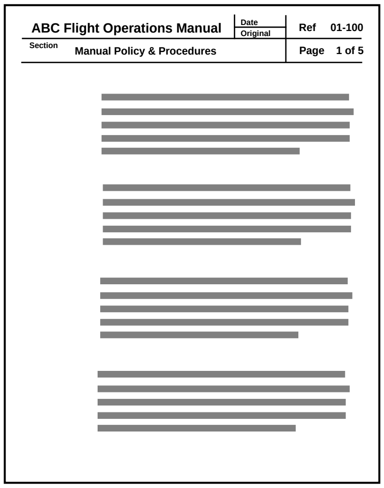
Today, however, the convention is no longer universal. Different authors take varying approaches to the question of whether paragraphs should be indented, separated by extra space or both. Those who favor indented paragraphs disagree about how large the indentation should be.

The authors prefer extra spacing between paragraphs (as in the style of FSF publications), rather than indentation, for signaling a new paragraph. Of course, the key is consistency. If the paragraphs of one section of a document are indented, they should all be indented. If spacing is used, it should be the same throughout. If both indentation and spacing are used, the specifications should not be changed within the message.

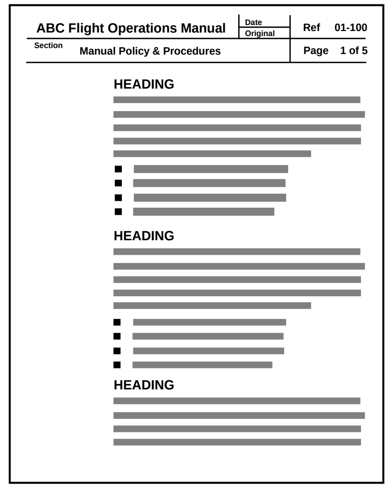
Designers disagree about the number of spaces that should be used between sentences. Traditionally, typesetters set one space after a period at the end of a sentence for economic reasons — double spaces required more paper. Many document designers contend that a single space is still the best choice, but others suggest that the extra space between sentences makes the end point and the start point of a sentence visually clear. The authors recommend trying both conventions, printing sample pages and selecting the one that appears best for the message.

Finally, one must be aware of the effects of spacing between lines of type (leading, pronounced "ledding") in the body text. The longer the lines of type, the more difficult for the reader's eyes to navigate from line to line. The space between the lines of type provides a path from line to line for the reader's eyes to follow. This path is critical when the information is lengthy and complex.

Principles of Visual Information: Chunking, Queuing and Filtering

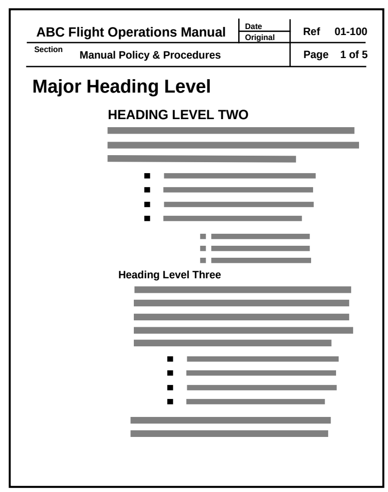


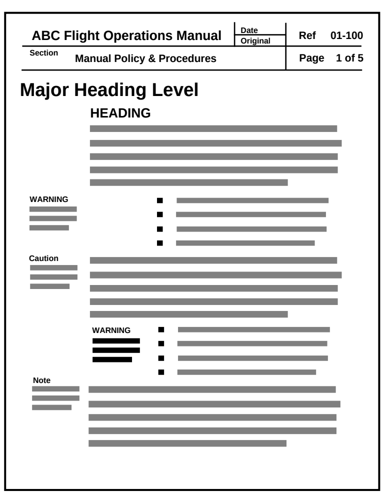
Chunking is achieved through changes in spacing. The horizontal spaces between the information units group the text into individual information blocks.



Here, not only is spacing used to divide the text into information blocks, but the text is further consolidated by breaking out smaller units as bullet items.The information blocks are further separated by use of contrasting type.

Queuing uses alignment and position to create hierarchical levels, which are information units to be processed by the reader. This example displays the principle of queuing. The signals are provided to the reader primarily by means of changes in spacing and, second, by means of type size, density and position.





The principle of filtering provides more complex visual information structure. In this example, filtering cues manipulate type size, density and spacing to signal the different information types. Margin notes cue the reader to warnings, cautions, notes or other important information. Filtering also points to the limits of typographical cueing. If too many cues are incorporated into the page design, they will confuse the reader and the information structure will be lost.

Source: Anthony J. Adamski, Albert F. Stahl. Adapted from Keyes.[33]

Figure 12

Serif type styles normally require less leading than sans serif type styles because the serifs help create a path for the eyes to follow. But as White warns, " ... watch that x-height proportion: If your typeface has a very small x-height, there is a lot of open space above and beneath it in the ascenders and descenders. That space is added visually to the space between the lines, so you need less extra space to help the eye travel along."[35]

There is somewhat greater agreement on how much space to use between lines. Some researchers suggest line spacing that is approximately 20 percent to 25 percent of the type size. Others suggest adding two or three points to the point size of the type, which results in approximately the same spacing. This method is expressed by describing the type size and leading together numerically, separated by a slash. For example, a 12-point type size with 14-point leading (adding two points to the type size) is expressed as 12/14. This convention is common in desktop publishing.

Regardless of the convention used, it is important that the leading is sufficient to provide a navigable path for the reader's eyes. On the other hand, the leading must not be so great that the reader must expend undue effort to move his or her gaze to the next line.

Increasingly complex information is being thrust at the crew member with the expectation that he or she will fully comprehend what is presented. Visuals can help the reader accomplish this task.

Visuals in technical documents take such forms such as photographs, illustrations, line drawings, charts, diagrams and tables. They present facts, data, directions, procedures, processes and concepts that are often complex. According to Keller and Burkman, prominent instructional technologists, "almost without exception, good writers and experts on written communications recommend the use of maps, tables, charts, graphs and diagrams in dealing with quantitative data, complex relationships and large data sets."[36]

Visuals are becoming more prevalent in aviation technical documents because desktop publishing has made the creation of such images more readily available to designers and nondesigners. Nevertheless, there are principles related to the use of visuals, just as there are principles related to text presentation. As in the text message, one visual form may have an advantage over others, depending on the purpose and type of message.

Readers process text and visuals differently. Williams explains that the difference lies in the degree to which conscious attention must be employed to interpret the intended message. He maintains that the nature of visuals makes them more accessible to the preattentive process. The patterns, shapes and spatial relationships that the reader perceives contribute significantly to the meaning of the message.[37] Thus, the principles of figure and ground, proximity, similarity, continuity, closure and connectedness play an important role in the design of effective visuals.

Rankin says that a common visual language must exist between the designer and the reader of the message before effective communication can occur.[38] In other words, the pictures selected, the graphics employed and the verbal symbology used must be understood by the reader. Without such considerations, the visual easily becomes a space-filling artifact that is lost between the lines of type.

Visual continuum. Different types of visuals form a continuum from concrete to abstract.[39] That is, a visual can consist of an image that appears very much like the thing it represents, or it can consist of words, which appear nothing like the things they represent.[40] The designer must choose an appropriate point on this visual continuum (Figure 13, page 19).

Three points on the visual continuum identify the major categories of pictorial visuals: realistic or representational, analogical and arbitrary (or logical).

The realistic visual requires little conscious effort to interpret. The preattentive process easily interprets the representation. Realistic visuals include photographs, illustrations and detailed line drawings. Although realistic visuals easily convey a representation, they do not necessarily convey the intended message. For example, what message does a realistic visual of an aircraft convey in a technical document? Was the intent of the designer to convey a concept of aircraft, a type of aircraft or a broader concept of aerospace?

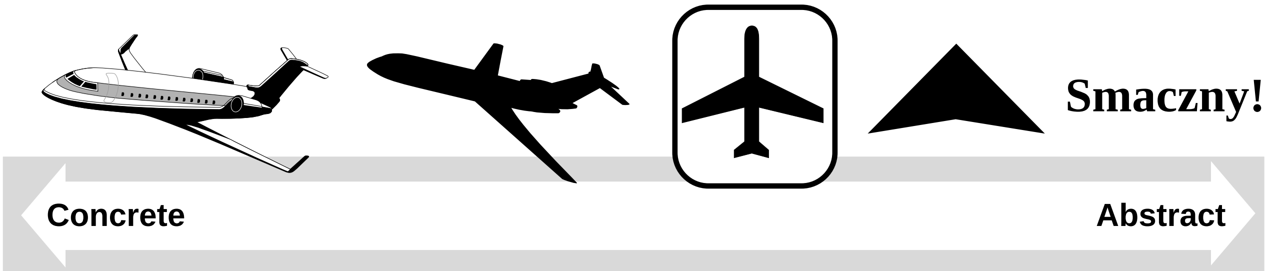
Analogical visuals are realistic, but they represent something other than what they portray. For example, a visual showing a hydraulic system might appear as pipes, valves and pumps, without appearing as any particular aircraft hydraulic system. Nevertheless, the visual might help the reader understand aircraft hydraulic systems in general. Analogies are useful tools in instructional messages, but the designer must remember that the common visual language must be established with the reader.

The arbitrary or logical category includes visuals that depict elements of information in a symbolic or abstract way, while reflecting actual relationships. A typical flight-operation organizational chart represents various positions with a series of boxes (symbolic) and, at the same time, reflects a chain of command (relationships). Another example is an electrical circuit diagram. The elements of the visual are arbitrary and symbolic, but the connections and relationships are real. Again, the designer must establish the common visual language.

Some information is more effectively presented as text, and other information is better presented as a pictorial visual. The successful designer is one who understands the strengths and weaknesses of both types of presentation.

The Visual Continuum

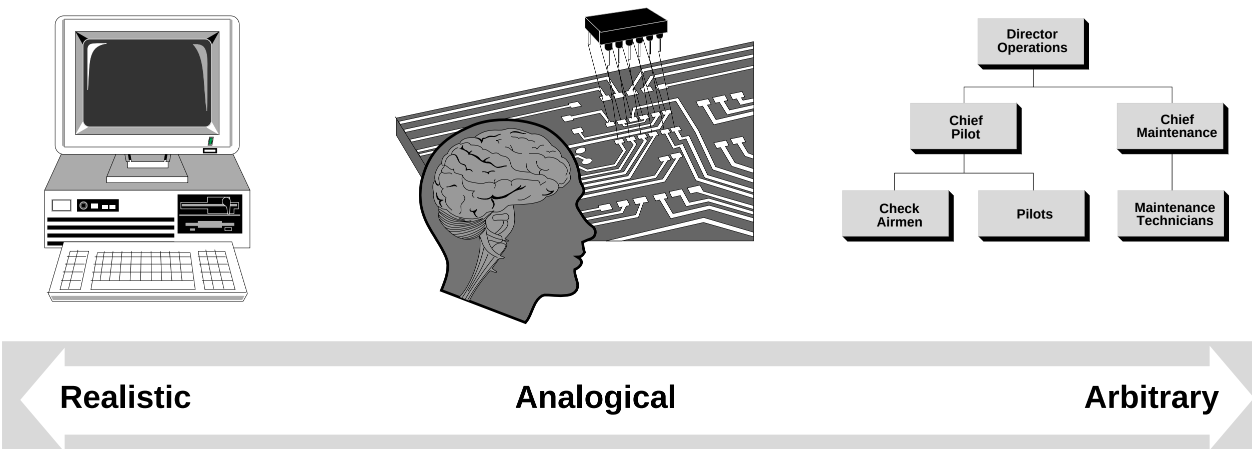
Continuum Range



The visual continuum ranges by degrees from the concrete, such as the realistic aircraft pictured, to the abstract, such as the verbal symbols shown. For the abstract example, without a common language the reader has no idea of what the word represents.

Note: Smaczny is the verbal symbol in Polish that represents "good appetite."

Continuum Major Categories



The realistic visual provides a high degree of similarity to the referent, such as this representation of a computer.

The analogical visual appears realistic but actually represents something else. This visual could be used as an analogy of the human brain with a computer circuit board or vice versa.

The arbitrary visual depicts information in an unrealistic way, such as boxes representing people within a flight department. The relationships of the people, however, such as those shown on organization chart, are correct.

Source: Anthony J. Adamski, Albert F. Stahl

Figure 13

Unfortunately, pictorial visuals are often used only to break the monotony of the printed page. Although such visuals can make the page more appealing, they serve little function in the technical document. Research suggests that the designer must carefully use a point on the visual continuum to identify the conditions under which the visual is to be used. The following recommendations apply to aviation-specific messages:

- Pictorial visuals should be used as examples of concepts that have concrete referents (e.g., a complex aircraft maneuver depicted in a training manual);

- Pictorial visuals are helpful when presenting readers with new concepts, objects, or events for which they have little knowledge (e.g., a passenger-evacuation flow diagram as used in passenger safety–information cards);

- Complex procedures can be facilitated with flowcharts (e.g., the steps required to program a flight management system).[41]

Although visuals can be extremely effective, they must be used carefully to avoid confusing the reader. As Tufte notes, "Confusion and clutter are failures of design, not attributes of information."[42]

Visuals can offer numerous advantages over text for the design of technical messages. They can present more information in a given amount of space, simplify complex information, and increase the reader's comprehension of the material.[43]

Visual referents. Text and visuals both rely on visual channels. There are, however, critical differences. The most obvious is the degree to which a visual represents its intended referent. One must be careful — even with a highly realistic photograph — because the visual may not be perceptually processed by the reader in the way that the designer expects.

Another important difference between text and visuals is the way that each represents its referent. Because words by themselves evoke broad concepts, modifiers are used to narrow their meanings. For example, we modify the word "airplane" with such terms as jet, multi-engine, swept-wing or turboprop to narrow the meaning. Visuals, by their nature, tend to evoke a very narrow meaning.

But what the designer perceives in a visual is not necessarily what the reader will perceive. For example, when a picture of an aircraft is used to introduce a message about aviation safety, the reader most likely will perceive a specific kind of aircraft and not the concept of safety. Williams says that "broadening a concept evoked visually, however, is much more difficult and much less precise enterprise than is narrowing a concept communicated verbally."[44]

There has always been a debate as to whether the photo or the illustration is a more effective medium. Research has been conducted by Altman concerning the most effective medium for passenger safety–information cards.[45] The research found no significant difference between photographs and illustrations in the level of reader comprehension.

Comprehension is, however, affected by visual "noise" (extraneous information in the image). Illustrations can eliminate the visual noise that may be found in a photograph, and the designer can provide cues (arrows, circles, symbols, etc.) to emphasize specific information (Figure 14, page 21).

Computer technology makes it possible to erase visual noise from a photograph and to add elements of distinguishment or separation. Altman's research also found that readers became engrossed in physical features of a human model in a photograph rather than focusing on the procedure being demonstrated, thereby missing the intended message. Altman's findings suggest that illustrations may work better than photographs for certain message applications, such as passenger safety–information cards.

The visual structure of diagrams. Diagrams incorporate the properties of illustrations, such as a schematic drawing of emergency equipment location in a passenger safety–information card, or a company organizational chart in a policy manual. Diagrams represent things visually and spatially on the page rather than textually. Conceptual or real-world relationships are reflected in the spatial arrangement of the design (Figure 15, page 22).

A major concern for the designer is determining the degree of spatial accuracy required. This refers to the relationships that may be perceived by the reader among the elements of information depicted.

Spatial accuracy does not always refer to physical distance. It may refer to relationships between actual things or to superordinate concepts vs. subordinate concepts. An organizational chart is an example of depicting relationships visually. The organizational hierarchy is usually presented in a top-to-bottom spatial arrangement.

Again, the basic principle is that a common visual language must be established with the reader to achieve effective design. Diagrams are not always interpreted correctly by readers. Therefore, in some situations, instructions should be provided on how to interpret and to use a diagram. The following guidelines are suggested:

- The accuracy with which information is processed depends on the locations of the elements in relation to each other;

- The perception and interpretation of diagrams can be influenced by graphic techniques. These techniques require a common visual language for interpretation;

- The strength of a relationship between two elements can be suggested visually by the thickness of the line or arrow connecting them;

- The perceived relationships among elements depend on their relative position;

- Instructions for using and interpreting a diagram may be necessary;

- The distances between elements should correspond to the semantic distances that they represent. Closely related elements should be set closer visually and vice versa; and,

- Text to supplement diagrams should be used cautiously. Readers tend to exert the least possible amount of effort to comprehend information; hence, they often revert to their most familiar medium, which is text.[46, 47, 48]

Pictorial Visual Images

This illustration is an example of the type of visual used in a passenger safety–information card. Note that all extraneous information has been erased. Eliminating visual noise focuses the reader's perception on the content of the message.

This illustration presents the procedural steps to don a life jacket. The steps are visually organized and cued with text. Critical actions are magnified and cues (arrows) are used to signify required actions. Notice that an abstract symbol is used to represent the locator light in step six.

The actual illustration is in color and not the gray scale, as depicted. The color is applied to emphasize the life jacket and required actions. The life jacket is printed in bright yellow and the cues are printed in bright red. The shirt color and the model's flesh tone are subdued.

Notice the use of the visual principles of Gestalt psychology. The illustration incorporates proximity, similarity, continuity and connectedness.

Source: Anthony J. Adamski, Albert F. Stahl

Figure 14

The visual structure of tables. The table is often used in aviation technical documents. A table is a systematic list of details arranged in an orderly vertical fashion to display statistical or factual information. Statistical information presents data in numerical form, whereas factual information presents data in verbal form. Although tables consist of primarily verbal symbols in the form of words or numbers, they are considered visual devices because of their display structure. See Figure 16, page 23, for the design elements in a table.

Tables are often used to present a maximum amount of numerical or verbal information in a minimum amount of space. Figure 17 (page 24) depicts excerpts from two tables. The first, from a training manual, reflects U.S. Federal Aviation Regulations (FARs) requirements for emergency equipment and the second, used in a checklist, is an engine-out driftdown table.

The primary benefit of a table over text is compactness. A table provides a concise means of compressing a lot of information into a small space. A table shows exact numerical values and allows for easy comparison of values. A table is excellent for professional audiences because it provides precise data. Aircraft checklists, operations manuals, technical forms and instructional manuals are often well presented in table format.

The major problem in table design is "to make the left-to-right relationships clear. The up-and-down relationships are much easier to understand and can take care of themselves."[49]

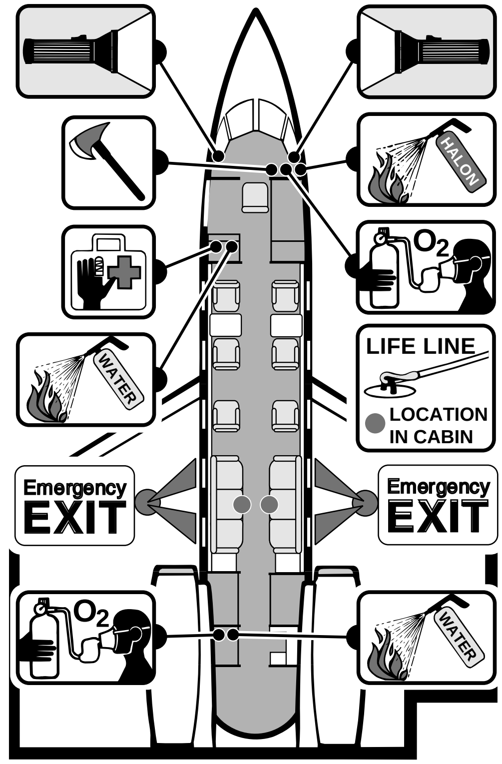
Diagrams

Aircraft Emergency Equipment Diagram

The diagram of emergency equipment location used in a corporate aircraft passenger safety–information card borrows from both the realistic and the abstract ends of the visual continuum. Each piece of equipment is reflected by a graphic symbol.

The locations of the emergency exits, however, use words, which are on the abstract end of the visual continuum. Unless the reader understands the printed words, the location of the exits would not be known, but the location of emergency equipment is shown by illustrations.

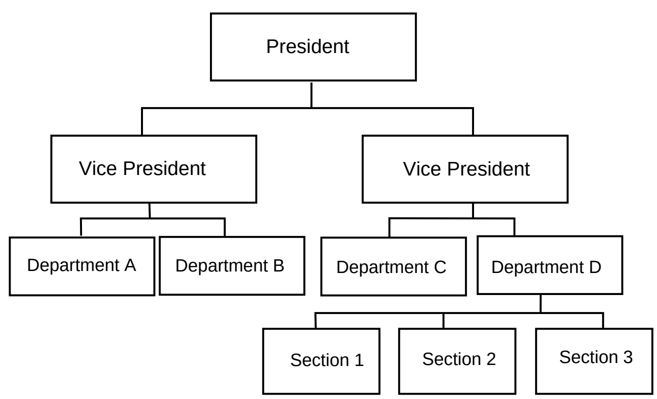
The spatial relationships for the equipment and exits lean toward the concrete end of the visual continuum, as the real-world locations in the aircraft are depicted. Nevertheless, the reader must be able to interpret the cabin diagram to comprehend the message.



Organizational Diagram

The organizational diagram as used in many flight organizations uses abstract symbols to represent each position reflected on the chart. The relationships, usually shown with a top-down diagram, reflect a chain of command.

Note: The typical organizational diagram depicts linear relationships, which may not be the actual relationships.



Source: Anthony J. Adamski, Albert F. Stahl

Figure 15

Many people find tables confusing and difficult to use correctly and quickly.[50] Hence, effective table design is particularly important. Recommendations for the design and use of tables include the following:

- Present data systematically, to make interrelationships as visible as possible. The presentation must facilitate comparison both within the table and between tables;

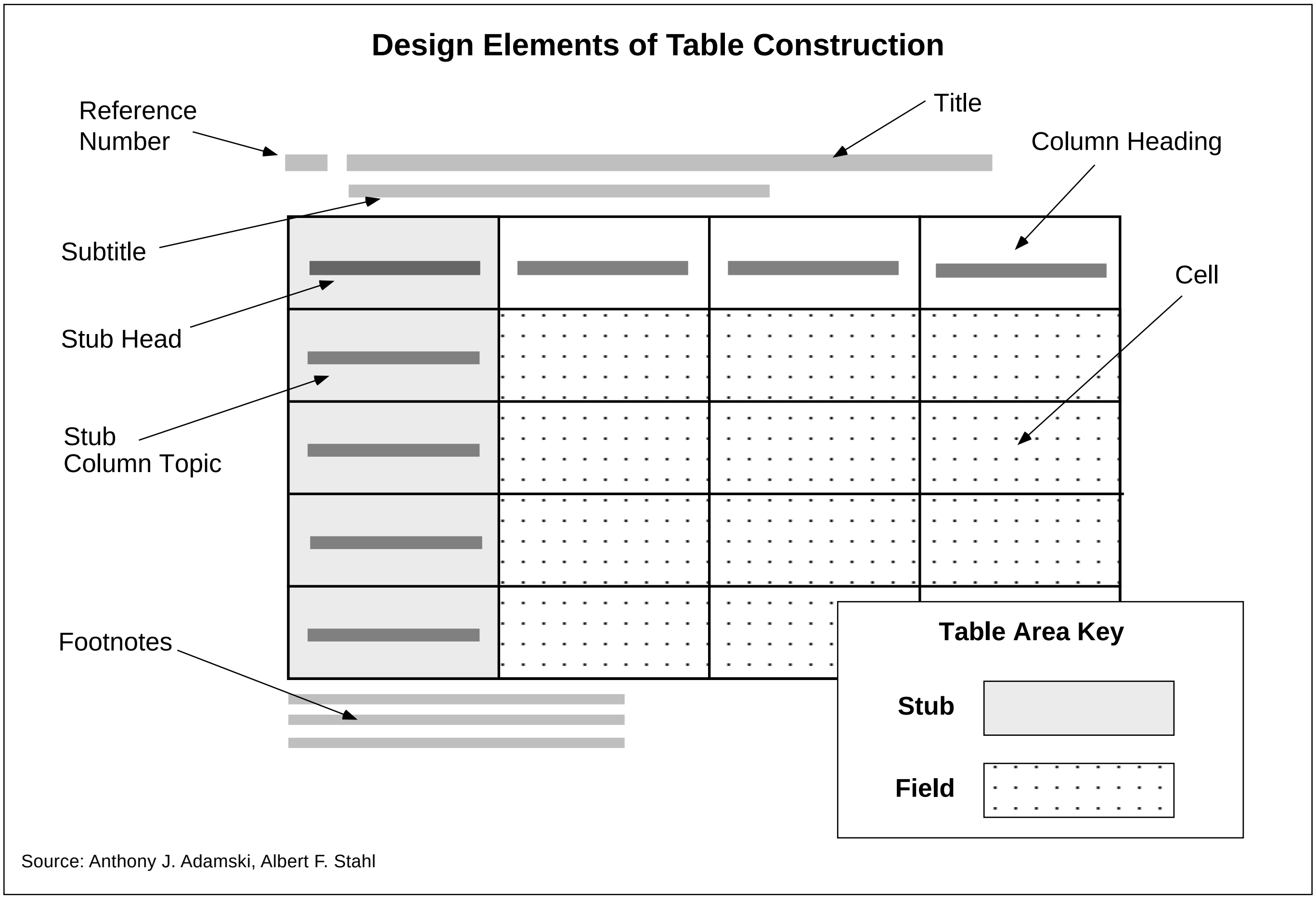


Figure 16

- If the table accompanies text (as in an operations manual), do not simply duplicate what is stated in the text; rather, make the text and the table complement and supplement one another;
- Condense statistical data or numerical data as much as possible without losing meaning;
- Keep all explanatory wording clear, even though it must be condensed because of space limitations;
- Align numerical data vertically on the decimal point or flush right. Align verbal information flush left;
- Consider setting table titles flush left instead of centered on the page. The reader's perceptual process enters the table at the top-left corner;
- Consider setting column heads flush left instead of centered, if the subject in each cell is verbal;
- Use grid lines sparingly and consistently in complex and lengthy tables. Grid lines between every entry add unnecessary clutter;
- Make the spaces between columns as narrow as possible. Wide gaps can confuse the reader;
- Try not to set a table the same width as the text column in which it appears; and,
- Consider setting a bold rule across the top and bottom of the table. This creates an illusion of a rectangle, in keeping with geometric page formats (Figure 16). It is not necessary to place a table in a box.[51]

Most tables have some standard elements (Figure 17). Most have a number for reference, as well as a title. Technical messages call for a terse, concise title describing the table purpose. If further explanation is required, it is acceptable to use a subtitle set in a type style that is visually related to, but smaller than, the type style of the main title.

The stub is the left-hand column. It lists the subjects or categories into which the table is divided. At times, it is necessary to provide more information about the categories listed in the stub, and this is termed a stub head. Each category in the stub is called a stub column topic. At times, the stub may contain more than one column, as in the checklist example in Figure 16.

Examples of Tables

A-01 Emergency Equipment Regulatory Requirements

Equipment	FARs Part 91	FARs Part 121	FARs Part 125	FARs Part 135	FARs Part 25
Advisory Signs	91.57	121.317	125.207, 217	135.127, 177	25.791
Assist Devices		121.310,570	Appendix A	135.178 (1)	25.810
Crash Axe	91.513 (1)	121.309	125.207 (4)	135.177 (1)	
Emerg. Exits	91.607	121.310	Appen	[illegible]	[illegible]
Emerg. Lighting		121.310	Appen	[illegible]	[illegible]
ELT	91.207, 509	121.339	125.2	[illegible]	[illegible]
Fire Extinguisher	91.513	121.309	[illegible]	[illegible]	[illegible]
First Aid Kit	91.513	121.309	125.20	[illegible]	[illegible]
Flashlight	91.503	121.309	[illegible]	[illegible]	[illegible]
Life Jacket	91.509	121.339	125.209	135.167	25.1411, 1415

Example A-01, which is a typical table construction, uses bold rules to depict the boundaries of the table. Grid lines set off each cell, and a light gray tint sets off the stub area.

Note: FARs Parts 91 — 135 are operating rules. FARs Part 25 is certification rule.
(1): More than 19 passenger seats. (3): More than nine passenger seats.
(2): More than 60 passenger seats. (4): 20 or more passenger seats.

B-01 Engine Driftdown ISA Chart

Initial Altitude OAT (° C)			Initial Driftdown Weight — 1,000 LB										
			76	74	72	70	68	66	64	62	60	58	56
45000 -56.5	Speed	KCAS	····	····	····	246	243	241	238	236	233	230	228
	Time	MIN	····	····	····	51	50	49	48	48	46	46	44
	Fuel	LB	····	····	····	2400	2310	2206	2122	2074	1948	1916	1783
	Distance	NM	····	····	····	318	313	306	302	300	290	290	277
	Final Alt	FT	····	····	····	21300	22300	23200	24200	25000	26100	27000	28000
43000 -56.5	Speed	KCAS	····	250	247	246	243	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Time	MIN	····	53	52	51	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Fuel	LB	····	2567	2470	2388	2296	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Distance	NM	····	324	319	314	309	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Final Alt	FT	····	19600	20600	21300	22300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
41000 -56.6	Speed	KCAS	252	250	248	246	243	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Time	MIN	53	52	50	50	49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Fuel	LB	2657	2547	2427	2363	2266	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Distance	NM	326	319	310	307	310	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Final Alt	FT	18700	19600	20500	21300	22300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Example B-01 encloses the entire table in a rectangle. The column heading area is subdivided into a span head as well as column heading units. The stub is also subdivided using altitude as the major unit. The cells, however, contain chunks of data that allow the user to easily find the information needed.

Source: Anthony J. Adamski, Albert F. Stahl

Figure 17

The information used to describe each column is referred to as a column heading. The body of the table is called a field, with each unit of the field, where a horizontal item intersects with a vertical column, called a cell. Empty cells usually carry a dash.

At times, footnotes are necessary to provide supplemental information to qualify or explain information in a table. Because a table is an independent item, write each footnote without referring to any accompanying text or to other tables in the same document. Design convention calls for preceding a footnote by the word "Note." The word "Source" precedes a note crediting the source of the information.

Although many sources state that the average type size used in tables is 6 point, 6-point type will not be legible in low-light or turbulent conditions.

A moderately condensed typeface that will provide the greatest ease of reading should be used. The authors recommend an 8- or 10-point type size. Many of the type styles observed in aircraft-checklist tables fall short of readability in any but ideal conditions. Although space and volume are problems in the cockpit, these considerations do not outweigh the importance of being able to read and process critical information.

The design of the page on which the text and visual fall also requires consideration. The document designer must take into consider the following:

- Is there sufficient contrast between the content of the page and the page itself to provide for an adequate figure and ground relationship? Or is the content so visually heavy that it diffuses the contrast?

- Are similar informational elements grouped together?

- Are the typographical and visual cues consistent?

- Is there an overall sense of continuity from page to page of the document?

- Does the document provide closure when necessary, or does the design leave the reader wondering what is next or where to go next?

The page layout is the first thing the reader notices through the preattentive process. Messages are more effective and efficient if the reader knows how to process the text simply by the look of the page.[52] One researcher explains that "if the reader can get an overview of the information merely by looking at the page, the page layout serves as an advanced organizer."[53] Advanced organizers are elements on the printed page that help the reader make connections between new information and prior knowledge.

Horizontal and vertical spacing define the basic framework of the page layout. Therefore, dividing the page spatially is the primary design task. The space on the page consists of two parts: the outer margins and the area within the margins containing the text and visuals. Careful use of open space is important to structuring the page effectively. As discussed earlier, the concepts of chunking, queuing and filtering are effective techniques to be used in page layout.

Achieving an aesthetically pleasing page layout is more an art than a science. The primary principle is to maintain an overall consistent pattern. Readers should never have to ask themselves "Where am I supposed to go from here?" There are, however, some basic design decisions that the designer must make.

The first decision is to determine the size of the finished page. Depending on the document, the page size may be a standard letter-size page, or it may be smaller or larger. Regardless of page size, the page should be designed using the actual to-be-published size rather than using a standard letter-size format and later reducing the page size.

The next decision involves margins. The side margin must be wide enough to accommodate binding or folding. The top margin can be as deep as desired, but a narrow top margin makes the page look oppressively heavy and degrades the figure and ground relationship.

Generous margins make the content appear more usable and valuable. Margins also provide resting space for the eyes. Using wide margins does not waste space; it increases effectiveness. Considering the possible consequences of poor design in aviation technical messages, the extra pages resulting from wide margins are a small price for making the message easier to read and understand.

There are numerous variations in margin design. Figure 18 (page 26) shows some of the more conventional ones. After the margin specifications have been determined, they should remain a constant.

The next design decision involves the live-matter area. The live-matter area may consist of pure text (such as in a flight-release form), a combination of text and visuals (such as in an instruction or operation manual), or primarily visuals (such as in a passenger safety–information card). A large degree of flexibility is available in the design of the live-matter area.

Messages that consist primarily of text require a decision as to the number of text columns to use. Although many designers suggest that text laid out in multiple columns (two or three) is easier and faster to read in technical reports,[54] a single-column format is preferred for the majority of aviation technical messages. This convention probably originated when technical documents were created on a typewriter, and multiple columns were not easily constructed.

Nevertheless, research has shown that a single-column format may be better for presenting complex information when reading comprehension and ease of use are important.[55] The chief advantage of the single-column format is that it easier for the designer to work with. This is no small matter for documents that are revised frequently. The primary disadvantage is line length. The length of the line is important because a line too long can reduce reading speed and comprehension. This problem can be avoided by making the text column narrower and allowing more margin space.

Wider columns call for larger type sizes and more space between the lines. One guideline is to use 10-point to 12-point type and to make each line 50 characters to 70 characters long (approximately eight to 10 words).[56] If the document is a single page, the open space should be on the left side of the page. If the document uses a two-page spread, the open space should generally be toward the inner margins. But keeping

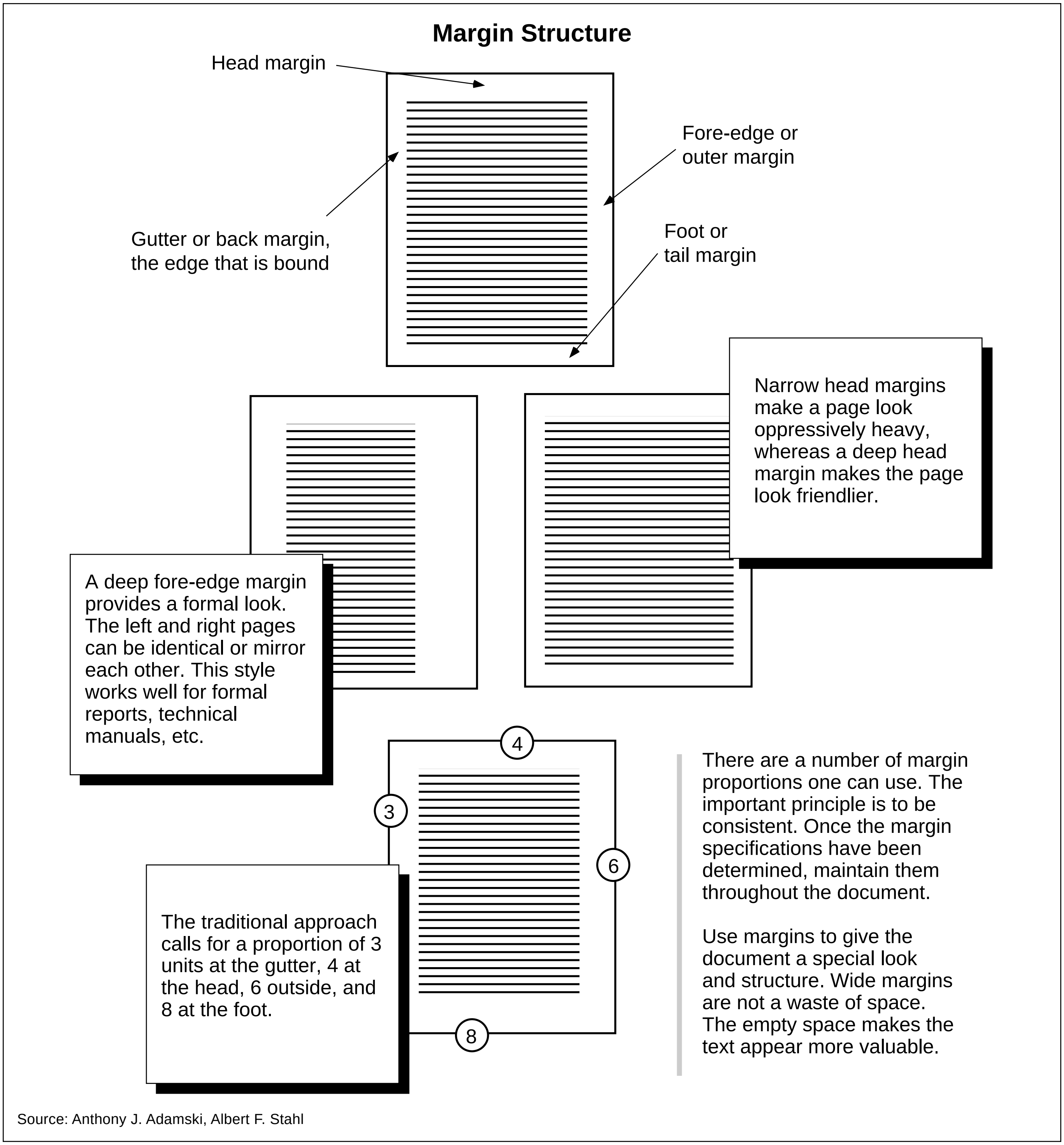


Figure 18

the open space consistently on the left, even on a two-page spread, might sometimes be advantageous because doing so allows the use of the open space for notes, cautions and warnings.

Although these techniques primarily address lengthy messages, such as an operations manual, many of the principles also apply to the design of procedural messages, such as the aircraft checklist. The appropriate use of open space in a checklist provides structure to the document and makes an easier path for the eyes to follow. Consequently, there is less likelihood of items being overlooked or the reader losing his or her place when distracted by other flight tasks.

Visuals can greatly enhance an aviation technical message. The following are the key points about visuals:

- Visuals can present more information in a given amount of space than text can;
- Visuals can enhance learning of complex procedures;
- Visuals can provide organization and meaning to complex information;
- Visuals can facilitate accurate interpretation of complex data;
- Visuals can simplify the reader's search through complex information;
- Visuals can reduce the burden on the reader's short-term memory when processing complex data;
- Analogical visuals can clarify abstract or complex ideas and are well suited for instructional materials; and,
- Schematic visuals can be used to depict real relationships among conceptual ideas or system components, such as an organizational chart.

Visuals also have limitations:

- Readers do not automatically associate visuals with corresponding text or focus on the relevant parts of a visual. A direct reference in the text that links the associated text with the visual is necessary;
- Realistic visuals should be used primarily for discrimination, such as identifying specific components of an aircraft system;
- Purely decorative visuals can dilute the importance of relevant visuals and should be avoided;
- Overly detailed illustrated visuals do not improve information retention;
- Photographs can contain visual noise when used for instructional messages;
- Visuals can convey an unintended message. Interpretative visuals should be simplified and should be labeled to identify the elements that relate to the intended message;
- The useful level of visual concreteness or abstraction useful depends on the previous knowledge of the reader; and,
- The effective use of visuals requires a common language between the designer and the reader.

Perhaps the best recommendation is found in R.E. Wileman's words, which provide an excellent message-design principle: "Visual message design requires a great deal of mental and physical action; it depends on intelligent decision making at every stage of the process."[57]

Basic message-design principles for the aviation technical message designer can be summarized as follows:

- The principles of perception influence for better or worse the readability of a technical document;
- Communication is accomplished not only with words and pictures, but also with structure;
- Typography is an art and a science, and should be used in both ways. Type should be incorporated into the design as a forethought rather than an afterthought;
- If a picture is not well selected and will integrated within the message, it can present a conflicting message;
- Visuals can be very effective, but they must be used in the right place;
- Confusion and clutter are failures of design, not attributes of information;
- Technical message construction is a design process that requires the presenter to have the skills of a "knowledge engineer."

The following are recommendations for effective technical message design:

- Experiment. Design effectiveness is often a result of trial and error;
- Be consistent. The objective is to provide accurate and comprehensive information. Inconsistency leads to error; and,
- Use rules as guides, but modify them as necessary for any unusual characteristics of the document being created or its readership.

The principles of design and display for aviation technical messages cannot be reduced to a science. Specialists in the field do not agree on every point, and some aspects of presentation will probably always depend on choices made by the designer in the belief that they are the best option for a specific document.

Yet further research may provide evidence concerning points that remain controversial, and with time, the field will probably become more science-like. And improved design and display of aviation technical messages based on the criteria set forth here, or on any other valid criteria, will directly benefit both efficiency and safety in aviation.♦

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About the Authors

Anthony J. Adamski holds an airline transport pilot (ATP) certificate, a master's degree in technology and is completing a doctorate in instructional technology. He has more than 30 years of experience in aviation and is rated in the Boeing 707, Learjet, Falcon, Gulfstream and Cessna Citation. Adamski is on the faculty at Eastern Michigan University, Ypsilanti, Michigan, where he instructs in the aviation management technology program.

Albert Stahl, Ed.D., is a professor at Wayne State University, Detroit, Michigan, with more than 30 years of experience in message design. Stahl also acts as a consultant with many multinational companies to research and develop standards for technical publications. He is the author of Writing for Effect*, a business-writing course that has been adopted by the Ford Motor Co. as its corporate writing standard.*

Pilot Error, Weather Were Most Frequent Initial Sources of Commercial Jet Transport Approach-and-landing Accidents, 1958–1995

Hard landings were the most common event in landing/taxi accidents.

FSF Editorial Staff

Pilot error was the most frequent initial source of approach-and-landing accidents of commercial jet transport aircraft worldwide during the period from 1958 through 1995, representing approximately 59 percent of accidents in that category. Weather and landing-gear failure were the second- and third-most frequent initial sources, each accounting for approximately 19 percent of the 786 approach-and-landing accidents in the period (Figure 1, page 31).

The statistics were compiled by McDonnell Douglas and published in *Commercial Jet Transport Aircraft Accident Statistics: 1995*. "Initial source" means the event or factor that precipitated the accident, not necessarily the primary causal factor.

Pilot error was also the most common initial source of commercial jet transport approach-and-landing accidents during the period 1991 to 1995. The pilot-error percentage was greater than it was in the 1958–1995 period, and was as high as 75 percent in 1995. Weather and landing-gear failure again ranked second and third, respectively, as initial sources between 1991 and 1995.

McDonnell Douglas further categorized the accidents during 1958 to 1995 in which pilot error was the initial source. "Judgment less than adequate" was found in 176 of 467 pilot-error accidents, or 38 percent. "Failure to go around" occurred in 97 accidents in the category (21 percent), followed by "failure to monitor instruments" in 91 accidents, "misjudged altitude" in 89 accidents and "landed hard" in 88 accidents (each about 19 percent).

Among the 1958 to 1995–period accidents in which weather was the initial source, "heavy rain" occurred in 63 of the 151 accidents (42 percent), "fog/haze" in 44 accidents (29 percent), "darkness" in 34 accidents (23 percent) and "winds" in 32 accidents (21 percent).

Landing/taxi accidents involving commercial jet transport aircraft between 1958 and 1995, and for the 1991–1995 period, were also analyzed (Figure 2, page 32).

For the longer period, "landed hard" was the most common type of event, occurring in 133 landing/taxi accidents shown. That number was closely followed by "landed or ran off the side of the runway," represented in 125 accidents, and the third-most common type of event in the category was "ran off the end of the runway," occurring in 111 accidents.

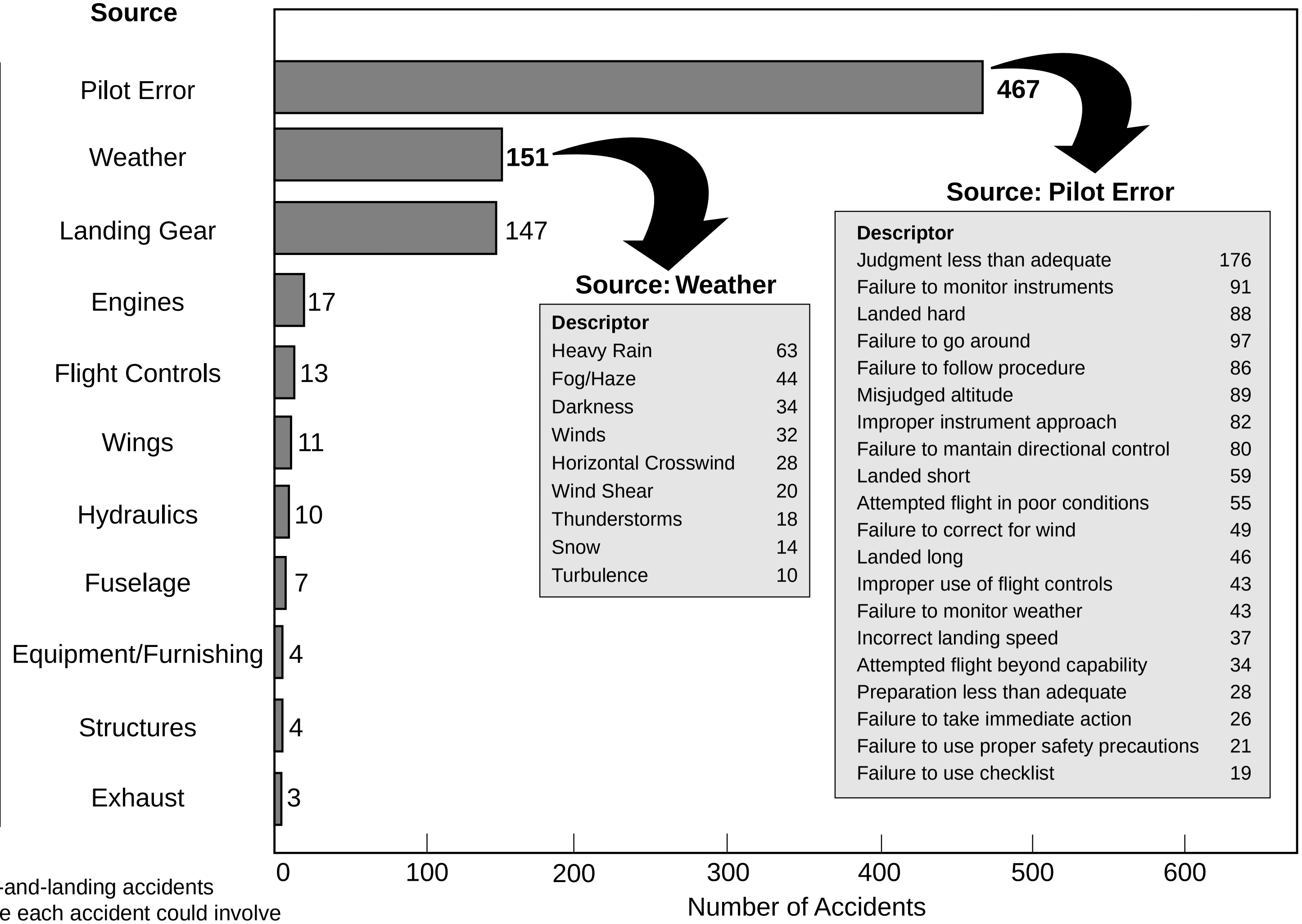
For the 1991–1995 period, "landed or ran off the side of the runway" (33 occurrences) and "ran off the end of the runway" (32 occurrences) were the most common, followed by "landed hard" (25 occurrences).

McDonnell Douglas used accident definitions that were consistent with those of the U.S. National Transportation Safety Board (NTSB) and the International Civil Aviation Organization (ICAO). The statistics included only accidents involving western-built aircraft.♦

Approach-and-landing Accidents, Commercial Jet Transport Aircraft, 1958–1995

Source	91	92	93	94	95
Pilot Error	10	18	15	17	15
Weather	7	7	7	4	4
Landing Gear	5	5	1	7	0
Engines	0	3	2	1	0
Flight Controls	1	2	1	1	0
Wings	0	0	0	0	0
Hydraulics	0	0	1	0	0
Fuselage	0	0	3	0	0
Equipment/Furnishing	0	0	0	0	0
Structures	0	0	0	0	1
Exhaust	1	0	0	0	0

Years: 1991–1995



Source: Weather

Descriptor	
Heavy Rain	63
Fog/Haze	44
Darkness	34
Winds	32
Horizontal Crosswind	28
Wind Shear	20
Thunderstorms	18
Snow	14
Turbulence	10

Source: Pilot Error

Descriptor	
Judgment less than adequate	176
Failure to monitor instruments	91
Landed hard	88
Failure to go around	97
Failure to follow procedure	86
Misjudged altitude	89
Improper instrument approach	82
Failure to mantain directional control	80
Landed short	59
Attempted flight in poor conditions	55
Failure to correct for wind	49
Landed long	46
Improper use of flight controls	43
Failure to monitor weather	43
Incorrect landing speed	37
Attempted flight beyond capability	34
Preparation less than adequate	28
Failure to take immediate action	26
Failure to use proper safety precautions	21
Failure to use checklist	19

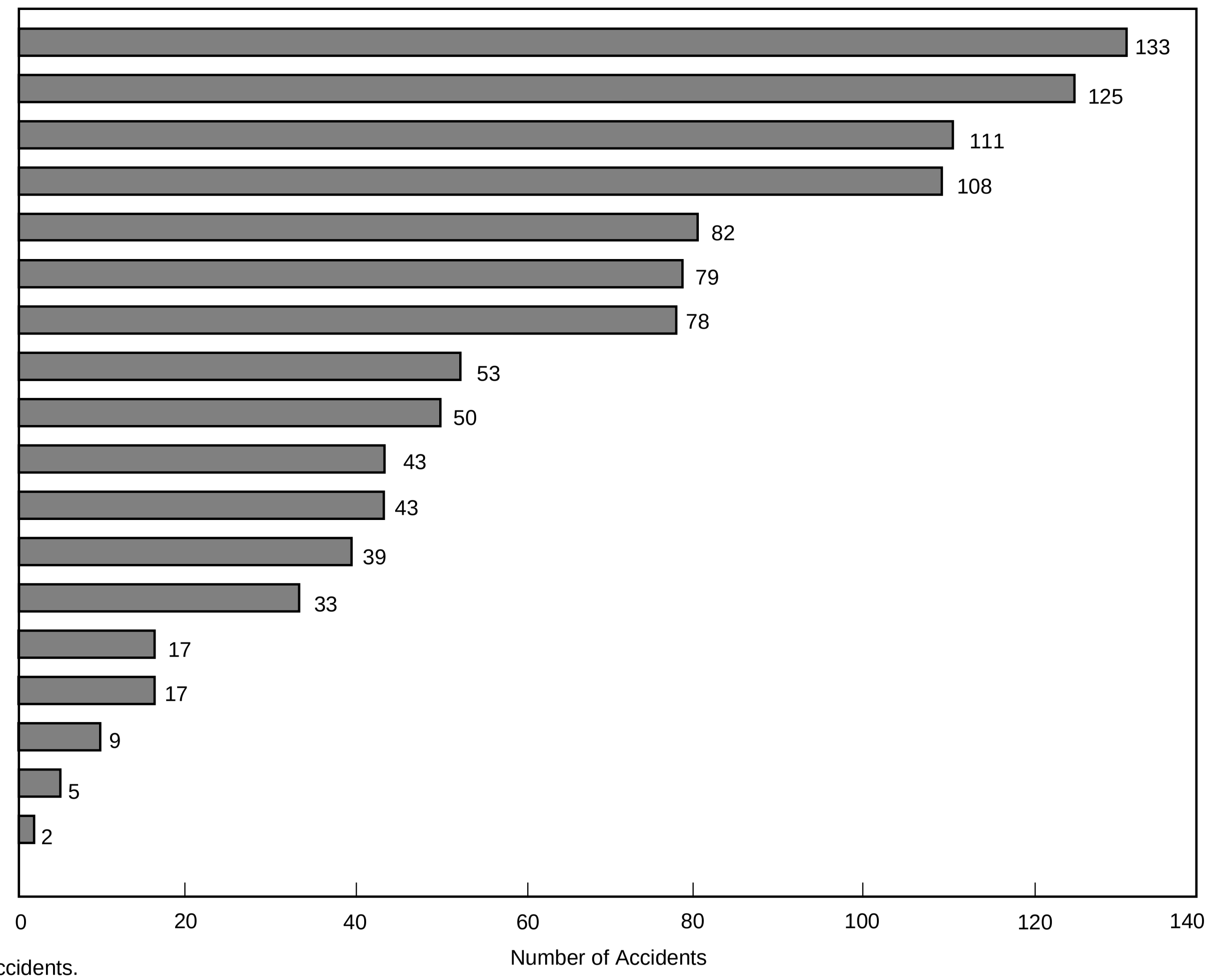
There were 786 approach-and-landing accidents during this period. Because each accident could involve more than one source, the sum of the sources is more than the total number of approach-and-landing accidents.

Source: McDonnell Douglas

Figure 1

Landing-and-taxi Accidents, Commercial Jet Transport Aircraft, 1958–1995

Years: 1991–1995 91	92	93	94	95	Type of Event
3	9	6	5	2	Landed Hard
9	8	7	5	4	Landed or Ran Off Side
5	4	10	7	6	Ran Off End
6	0	6	3	3	Wet/Icy Runway
4	0	0	0	2	Gear Up
0	1	1	4	4	Landed Short
2	2	4	3	4	Lost Directional Control
2	1	5	1	0	Fuselage Contacted Runway
1	0	3	3	5	Landed Long
6	7	4	1	0	Unscheduled Landing
3	4	1	1	2	Wing Contacted Runway
0	2	4	1	0	Nacelle Contacted Runway
0	0	0	0	0	Braking Difficulty
1	1	0	0	0	Go-around
0	0	2	0	1	Tail Contacted Runway
0	0	1	1	1	Landed Heavy
0	1	0	0	0	Landed on Wrong Runway
0	0	0	0	0	Ditched



Each accident could involve more than one type of event. Therefore, the sum of the accidents involving types of events is greater than the total number of landing-and-taxi accidents.

Source: McDonnell Douglas

Figure 2

Publications Received at FSF Jerry Lederer Aviation Safety Library

Advisory Circular Provides Suggestions to Airlines for Responding to Passengers Who Interfere with Crew Members

Two books explain compliance with U.S. Occupational Safety and Health Administration (OSHA) regulations.

FSF Editorial Staff

Advisory Circulars (ACs)

Voluntary Industry Distributor Accreditation Program. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 00-56. Sept. 5, 1996. 10 pp. Appendices. Available through GPO.*

This AC outlines a system for the voluntary accreditation of civil aircraft parts distributors based on voluntary industry oversight and provides information for developing accreditation programs. The FAA believes that such programs will help alleviate lack of documentation and improve traceability.

Appendix 1 contains a documentation matrix that is recommended as a guide for the documentation and certification of parts. The matrix consists of the following categories: "Class of Parts," "Required on Receipt" and "Required for Shipment." Appendix 2 contains the following "Sample Certificate Statements": (1) Sample Statement for Raw Material, (2) Sample Statement for Standard Parts, (3) Sample Statement for New Aircraft Components, (4) Sample Statement for Used Aircraft Components and (5) Sample Statement for "As Is" Components. These statements guide parts distributors in certifying that they are accredited under the provisions of AC 00-56. [Adapted from AC.]

Pressurization, Ventilation and Oxygen Systems Assessment for Subsonic Flight Including High Altitude Operation. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 25-20. Sept. 10, 1996. 12 pp. Available through GPO.*

This AC presents guidance on methods of compliance with the requirements of U.S. Federal Aviation Regulations (FARs) Part 25 relating to pressurization, ventilation and oxygen systems, especially for high-altitude subsonic flight. Alternate methods may be used provided that the alternate methods are found by the FAA to comply with the requirements of Part 25. [Adapted from AC.]

Tundra Tires. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 23.733-1. Oct. 10, 1996. 8 pp. Appendices. Available through GPO.*

This AC serves three purposes. First, it contains a summary of the results of flight tests recommended by the U.S. National Transportation Safety Board (NTSB) and conducted by FAA to investigate the effects of tundra tires installed on a Piper PA-18-150 Super Cub (the airplane most often equipped with tundra tires). Second, it gives information about hazards associated with the type of operations common for tundra-tire users, in addition to the possible hazards of tundra-tire installation on airplanes other than the PA-18. Third, it contains general information about the certification process for oversize tundra tires, including a sample "compliance checklist" for the installation of these tires on light airplanes, whose certification basis is U.S. Civil Air Regulations (CARs) Part 3. [The CARs are the predecessors of the U.S. Federal Aviation

Regulations (FARs). CARs that have not been superseded by FARs remain in effect.] [Adapted from AC.]

Interference with Crewmembers in the Performance of their Duties. U.S Federal Aviation Administration (FAA) Advisory Circular (AC) 120-65. Oct. 18, 1996. 6 pp. Appendices. Available through GPO.*

This AC provides information to air carriers, crew members, law enforcement officers, and the public about methods of managing and reducing passenger interference with crew members.

The AC examines the subject under the following headings:

Policy of the operator. The AC says that airlines "should make it clear to all employees what action should be taken when an incident occurs ... "; that operators should define their philosophy concerning "zero tolerance" of passenger-interference incidents; and that operators should provide material to passengers about the seriousness of inappropriate behavior on an airplane.

Written programs. The AC says that written programs should be developed by airlines to clarify the actions that should be taken when an incident occurs, and that these programs should be included in crew manuals. The written program should encourage crew members to file detailed written reports in cases of interference and designate personnel in the company who should contact law-enforcement agencies and the FAA about the incidents.

Training. The AC recommends training in responding to imminent danger and reporting the information to law-enforcement officials.

Law-enforcement and FAA responses. The AC describes the legal basis for actions against an offending passenger and considers the question of legal jurisdiction (depending on the nature of the offense, action may be taken by the local law-enforcement agency responding to the crew report, by the U.S. Federal Bureau of Investigation [FBI] or by the FAA).

Appendices include a table categorizing types of passenger misconduct and appropriate responses to each type; a sample airline policy bulletin; a sample airline information bulletin for crew members; sample procedures for response to flight-attendant assault; a sample reporting form; and possible language for warning notices to passengers.

Reports

Special Investigation Report: Robinson Helicopter Company R22 Loss of Main Rotor Control Accidents. U.S. National Transportation Safety Board (NTSB) Safety Study No. NTSB/SIR-96/03. April 1996. 107 pp. Figures, tables, appendices. Available through NTIS.**

In response to a 1992 Richmond, California, U.S., accident involving a Robinson Helicopter Company (RHC) R22 helicopter, the NTSB began a special investigation into similar accidents involving loss of main-rotor control in the RHC R22. This report presents the findings of that investigation.

The NTSB reviewed fatal accidents involving certificated helicopters, examined the wreckage of the Richmond accident and reviewed both the U.S. Federal Aviation Administration (FAA) certification process and requirements for the R22 and the NTSB recommendation history for the helicopter. The NTSB analyzed scenarios that could result in a loss of main-rotor control.

Safety issues addressed in this report as a result of the special investigation include the following: (1) measures to reduce the likelihood of main rotor–control accidents; (2) the need for further research into flight control systems and rotor-blade dynamics in lightweight, low–rotor inertia helicopters, such as the R22; (3) the establishment of operational requirements for the certification of lightweight, low–rotor inertia helicopters; and (4) the necessity for FAA internal recommendations to be appropriately resolved.

During this special investigation, the FAA implemented changes to ensure that pilots and flight instructors flying the R22 receive better training and that R22 flights are restricted during certain adverse weather conditions. There have been no accidents involving loss of main-rotor control in the R22 in the United States since these changes were implemented. [Adapted from Abstract and Executive Summary.]

Aviation Accident Forensic Assessment: Comprehensive Single-Extraction Urine Screening Procedure. Canfield, Dennis; White, Vicky; Soper, John; Kupiec, Tom. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-96/17. May 1996. 9 pp. Tables, figures, references. Available through NTIS.**

Keywords:
1. Screening
2. Drugs
3. Urine

One of the missions of the FAA Civil Aeromedical Institute (CAMI) Office of Aviation Medicine (OAM) is to help assess the role of medical- or drug-related pilot impairment in aviation accidents. This requires the ability to identify a wide range of drugs and the medical conditions for which these drugs are prescribed. Therefore, a single-extraction screening procedure was developed to identify as many drugs as possible in urine, with minimal effort and cost.

A single sequence of identifying drugs by using high-performance liquid chromography (HPLC) and validating the result by using mass spectroscopy or thin-layer chromatography (TLC) reduces the time necessary to complete cases. This procedure helps prevent false-negative and false-positive results, which might lead aviation accident investigators to incorrect conclusions. All positive results are later reconfirmed with a second acceptable procedure. [Adapted from Abstract and Conclusion.]

Use of Off-the-Shelf PC-Based Flight Simulators for Aviation Human Factors Research. Beringer, Dennis B. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-96/15. April 1996. 13 pp. Tables, figures, references, appendix. Available through NTIS.**

Keywords:
1. Personal Computer–based Aviation Flight Simulation
2. Simulator Research
3. Instrument Flight Psychology
4. Applied Psychology

Flight-simulator training has been available in various forms for over 75 years and usually has been an expensive undertaking. Nevertheless, advances in computer technology have allowed the recent development of a modular, "off-the-shelf" flight-simulation program that includes such features as variable flight instrumentation, forward 45 degree–left and 90 degree–left external views and a map display. This simulator has been adapted by the FAA Civil Aeromedical Institute (CAMI) general-aviation human-factor research program for test and research purposes.

This report describes the simulator program, its modifications, its advantages and the limitations of its research potential. The report concludes that the simulator provides a level of task fidelity that is comparable to other, more expensive, simulator devices; and preliminary investigations indicate that the simulator system can be a useful and economical tool for the examination of questions involving general-aviation piloting. [Adapted from Abstract and Introduction.]

[For a detailed account of this report, see the Flight Safety Foundation *Human Factors & Aviation Medicine*, Volume 43 (July–August 1996).]

Aircraft Evacuations onto Escape Slides and Platforms I: Effects of Passenger Motivation. McLean, G.A.; George, M.H.; Funkhouser, G.E.; Chittum, C.B. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-96/18. June 1996. 13 pp. Tables, figures, references. Available through NTIS.**

Keywords:
1. Aircraft Evacuation
2. Motivation
3. Escape Slide
4. Competitive Behavior

The results of aircraft emergency evacuation studies may vary considerably depending on such factors as subject motivation and the type of escape route used. This study examines those variable factors by comparing cooperative and competitive subject behaviors and comparing inflatable escape slides with door sill–level platforms attached to rigid ramps. The effects of cabin air visibility — smoky vs. clear air — are also considered.

The simulated evacuations revealed that competitive behavior and door sill–level platforms produce much faster egress times. Visibility, however, had no statistically significant effect on evacuation speed.

This report concludes that findings derived from emergency evacuation studies are susceptible to variations in individual subject motivation and experimental protocols or techniques. The combination of independent variables may produce unexpected interactions that invalidate previous assumptions. The report suggests that future studies designed to assess the evacuation potential of specific aircraft configurations or operating procedures should control such variables to prevent them from confounding study results. [Adapted from Abstract and Introduction.]

[For a detailed account of this report, see the Flight Safety Foundation *Cabin Crew Safety*, Volume 31 (September–October 1996).]

Human Factors: Status of Efforts to Integrate Research on Human Factors into FAA's Activities. Report to the Chair, Subcommittee on Technology, Committee on Science, U.S. House of Representatives, by Gerald L. Dillingham, associate director, transportation issues, U.S. General Accounting Office (GAO). June 1996. Report No. GAO/RCED-96-151. 25 pp. Tables, appendices. Available through GAO.***

Human error contributes to about 80 percent of fatal aviation accidents, according to U.S. Federal Aviation Administration (FAA) officials. The study of human factors, which identifies and tries to reduce the chances for human error through improvements in design and training, has emerged as one of the most promising means of increasing aviation safety. Consisting of both research and its applications, the human factors discipline is used to (1) identify systematic errors in the operation of machines or the implementation of procedures and (2) design equipment or procedures that eliminate or reduce the effects of such errors.

Recognizing the importance of human factors in aviation, the U.S. Congress enacted the Aviation Safety Research Act of 1988, which required the FAA to supplement its research on human factors and coordinate its work with that of the U.S. National Aeronautics and Space Administration (NASA) and the U.S. Department of Defense (DOD).

To determine how the FAA has incorporated human factors considerations into its research, acquisition and safety programs, the authors examined the FAA organizational structure and reviewed FAA policy orders, formal guidance and strategies for compiling and applying information on human factors. FAA officials were interviewed in research and acquisitions, regulation and certification, and air traffic services. The consideration of human factors in airports and civil aviation security units was not examined because of time constraints.

To determine the processes that the FAA uses to identify issues in aviation-related human factors research and compare these processes to those of the aviation community, the authors reviewed FAA plans and research abstracts, interviewed agency officials and contacted members of the aviation community.

The legislative requirements for these activities were also reviewed. This report contains two appendices: "Definition of Human Factors" and "Human Factors Research Areas and Ongoing Research Projects." [Adapted from Introductory Letter and Scope and Methodology.]

Books

Aircraft Safety: Accident Investigations, Analyses, and Applications. Krause, Shari Stamford. New York, New York, United States: McGraw-Hill, 1996. 379 pp. Figures, index.

The purpose of this book is to provide pilots and aviation professionals, of all experience levels, with the lessons learned from accidents. The book contains four parts: "Human Factors," "Meteorology and Atmospheric Phenomena," "Collision Avoidance" and "Mechanical Deficiencies and Maintenance Oversights." Each part includes a complete study of issues associated with that topic, and each chapter contains case studies of accidents in that category.

"Human Factors" includes accidents associated with crew resource management (CRM) — distraction in the cockpit, communication errors, cockpit discipline, pilot judgment, aeronautical decision making and substance abuse. "Meteorology and Atmospheric Phenomena" includes accidents associated with severe thunderstorm activity, microbursts, wind shear, turbulence and icing conditions. "Collision Avoidance" includes accidents associated with physical limitations, equipment shortcomings and air traffic control constraints in a collision-avoidance environment. "Mechanical Deficiencies and Maintenance Oversights" includes accidents associated with aircraft maintenance and mechanical problems. [Adapted from Introduction.]

The Complete Guide to OSHA Compliance. Peterson, Robert D.; Cohen, Joel M. Boca Raton, Florida, United States: CRC Press, 1996. 395 pp. Figures, appendices.

This manual provides a general overview of the U.S. Occupational Safety and Health Administration (OSHA). It is intended to familiarize the reader with the occupational health and safety regulations that apply to his or her workplace and to provide guidance on compliance with those regulations.

Topics include what to expect from OSHA in the event of an inspection, how to participate in the inspection and what responses are available in the event of citations or penalties. Appendices include a list of OSHA offices, the U.S. Code of Federal Regulations (CFR) sections that relate to OSHA and an example of a company inspection procedure. [Adapted from Introduction.]

Accident Prevention and OSHA Compliance. Michaud, Patrick A. Boca Raton, Florida, United States: CRC Press, 1996. 292 pp.

This manual is a guide for managers who must understand the Occupational Safety and Health Act (OSHA), enacted in by the U.S. Congress in 1970, and the U.S. Occupational Safety and Health Administration, which shares the same acronym and enforces the occupational and health standards set forth in Title 29 of the U.S. Code of Federal Regulations (CFR).

This manual emphasizes accident prevention; its goal, the author writes in a preface, is to offer "easy-to-apply principles ... to prevent accidents, injuries, illnesses, fires and other disasters. The chapters are written in everyday English without buzz words. The methods presented are sensible [and] businesslike, and they work."

Appendices include "useful OSHA information," such as lists of frequently cited OSHA standards, OSHA booklet publications, fall-prevention requirements, OSHA's 25 most common workplace safety violations, a list of possible problems to be inspected and a glossary.♦

Sources

* Superintendent of Documents
U.S. Government Printing Office (GPO)
Washington, DC 20402 U.S.

** National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161 U.S.
(703) 487-4600

*** U.S. General Accounting Office (GAO)
P.O. Box 6015
Gaithersburg, MD 20884-6015 U.S.
Telephone: (202) 512-6000; Fax: (301) 258-4066

Updated U.S. Federal Aviation Administration (FAA) Regulations and Reference Materials

Advisory Circulars (ACs)

AC No.	Date	Title
21-20B	04/22/96	*Supplier Surveillance Procedures.* (Cancels AC 21-20A, *Supplier Surveillance Procedures*, dated 07/25/94.)
39-6R	05/15/96	*Announcement of Availability — Summary of Airworthiness Directives.* (Cancels AC 39-6Q, dated 02/15/94.)
20-62D	05/24/96	*Eligibility, Quality and Identification of Aeronautical Replacement Parts.* (Cancels AC 20-62C, *Eligibility, Quality, and Identification of Approved Aeronautical Replacement Parts,* dated 08/26/76.)
150/5200-28B	06/20/96	*Notices to Airmen (NOTAMs) for Airport Operators.* (Cancels AC 150/5200-28A, *Notices to Airmen (NOTAMs) for Airport Operations,* dated 10/29/93.)
150/5380-5B	07/05/96	*Debris Hazards at Civil Airports.* (Cancels AC 150/5380-5A, *Debris Hazards at Civil Airports,* dated 02/25/81.)
91-51A	07/17/96	*Effect of Icing on Aircraft Control and Airplane Deice and Anti-ice Systems.* (Cancels AC 91-51, *Airplane Deice and Anti-ice Systems,* dated 09/15/77.)
00-2.10	08/15/96	*Advisory Circular Checklist and Status of Other FAA Publications.* (Cancels AC 00-2.9, *Advisory Circular Checklist and Status of Other FAA Publications,* dated 08/15/95.)

Federal Aviation Regulations (FARs)

Part	Date	Subject
Part 1	08/01/96, 08/19/96	*Definitions and Abbreviations.* (Incorporates Amendment 1-45, "Aircraft Flight Simulator Use in Pilot Training, Testing, and Checking and at Training Centers," adopted 05/23/96, and Amendment 1-46, "Airworthiness Standards: Aircraft Engines, New One-Engine-Inoperative (OEI) Ratings, Definitions and Type Certification Standards," adopted 05/30/96.)
Part 61	08/01/96	*Certification: Pilots and Flight Instructors.* (Incorporates Special Federal Aviation Regulation 58-2 and Amendment 61-100, "Aircraft Flight Simulator Use in Pilot Training, Testing, and Checking and at Training Centers," issued 05/23/96.)
Part 91	08/01/96	*General Operating and Flight Rules.* (Incorporates Amendment 91-251, "Aircraft Flight Simulator Use in Pilot Training, Testing, and Checking and at Training Centers," adopted 05/23/96.)
Part 125	08/01/96	*Certification and Operations: Airplanes Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or Greater.* (Incorporates Amendment 125-27, "Aircraft Flight Simulator Use in Pilot Training, Testing, and Checking and at Training Centers," adopted 05/23/96.)
Part 13	12/16/96	*Investigative and Enforcement Procedures.* (Incorporates Amendment 13-27, "Rules of Practice for Federally-Assisted Airport Proceedings," adopted 10/08/96.)
Part 13	12/28/95	*Investigative and Enforcement Procedures.* (Incorporates Amendment 13-25, "Revision of Authority Citations," adopted 12/20/95; Amendment 13-26, "Civil Penalties: Streamlined Enforcement Procedures for Certain Security Violations," adopted 08/23/96.)
Part 71	12/28/95	*Designation of Class A, Class B, Class C, Class D, and Class E Airspace Areas; Airways; Routes; and Reporting Points.* (Incorporates Amendment 71-27, "Revision of Authority Citations," adopted 12/28/95; Amendment 71-28 "Airspace Designations; Incorporation by Reference," adopted 09/14/96.)

Accident/Incident Briefs

Unserviceable ILS Misleads DHC-8 Crew That Failed to Receive NOTAM

Fatal accident follows an instrument flight rules (IFR) flight plan cancelled by pilot of Cessna twin despite night instrument meteorological conditions.

FSF Editorial Staff

The following information provides an awareness of problems through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

Air Carrier

Runway Incursion Forces Go-around

Boeing 727. No damage. No injuries.

The Boeing 727 was pushed back from the gate on time, and all three engines were started for a short taxi to Runway 17R, the runway nearest the terminal.

The captain asked for the before-takeoff checklist, and the second officer informed him that final weights were not yet available. As they reached the "Trim, Weight, Speeds" section on the checklist, the final weights were being received via data link. The second officer noted that the actual weights were greater than the planned weights, and he began reviewing takeoff data to ensure that the additional weight was within runway and performance limits.

The captain planned for a smooth, continuous taxi to Runway 17R and told investigators he believed he was cleared "on to hold." The captain did not visually clear the final approach path to Runway 17R until the nose of the aircraft entered onto the runway. Another aircraft was then observed to be on a one-mile final.

As the aircraft crossed the hold-short line, the first officer was not certain that they had been cleared for takeoff and started to confirm the clearance with air traffic control, but was overridden by a tower transmission directing the landing aircraft to execute a go-around.

Although the before-takeoff checklist was complete before the aircraft taxied across the hold-short line, the first and second officers were surprised when the B-727 continued onto the runway. Both expected to be asked to confirm that all checklists were complete and to stand by for takeoff clearance.

A company review of the incident concluded that because the first and second officers were busy completing routine tasks, they did not realize immediately that the aircraft was headed for the runway. "Both the first and second officer[s] lost situational awareness while attempting to complete routine tasks," the company incident report said. "Neither flight officer continued a visual ‘outside scan’ while completing these tasks, and both were surprised when the aircraft continued past the hold-short line.”

The report concluded: “It appears that effective task management and task prioritization broke down during a critical phase of taxi.”

Air Taxi Commuter

Tug Bashes Fuselage After Start-up

ATR-42. Substantial damage. One minor injury.

After the No. 2 engine was started, the ground attendant disconnected the ground power unit and began driving away from the aircraft. The tug then made a sharp left turn and struck the left side of the aircraft in the cockpit area.

A flight attendant was injured during the impact when she struck a folded-down galley table. The aircraft was substantially damaged. None of the 10 passengers or two flight crew members were injured. Meteorological conditions at the time of the accident were reported as night visual meteorological conditions with moonlight.

Unserviceable ILS Leads Commuter Crew Astray

De Havilland DHC-8. No damage. No injuries.

The twin-turboprop DHC-8 was executing an instrument landing system (ILS) approach to a Canadian airport. Unknown to the crew, flight checks were being conducted on the ILS.

The test signal caused the aircraft to be 9.7 kilometers (six miles) east of the runway centerline, but the ILS receiver in the aircraft indicated that the aircraft was on the centerline. The ILS had been listed unserviceable by a notice to airman (NOTAM), but the crew did not have this information, according to the Canadian incident report.

The crew had noted a discrepancy between the ILS and indications of the automatic direction finder (ADF). After breaking out of the clouds at 4,000 feet (1,220 meters), the crew terminated the instrument approach and continued to the destination under visual flight rules (VFR). The operator has since changed its NOTAM distribution procedures to ensure that NOTAMS for all destinations are provided to flight crews.

Corporate Executive

Hot Approach Runs out of Runway

Cessna Citation II. Substantial damage. No injuries.

The aircraft landed long and fast and overran the end of the runway. Because of the excessive airspeed on final approach, the aircraft touched down 703 meters (2,304 feet) from the approach end of the 1,200-meter (4,000-foot) long runway.

Accident investigators determined that if the aircraft had been traveling at the correct final approach speed of 108 knots (200 kilometers per hour), it would have been able to stop in 808 meters (2,650 feet). No one was injured in the accident, but the aircraft was substantially damaged. Weather at the time of the daylight accident was reported as visual meteorological conditions.

Mountain Shortens Long Final

Cessna 421. Aircraft destroyed. Four fatalities.

The twin-engine aircraft was on a long final approach to a German airport when the crew canceled its instrument flight rules (IFR) flight plan at 5,000 feet (1,525 meters).

During a normal descent for the night landing, the aircraft struck a mountain and caught fire. The two pilots and two passengers were killed, and the aircraft was destroyed. Weather at the time of the accident was reported as instrument meteorological conditions (IMC).

Other General Aviation

Trees Snag Scud-running Twin

Beech 55 Baron. Substantial damage. No injuries.

While the Baron cruised in mountainous terrain, the weather deteriorated, and the pilot encountered low clouds. The pilot initiated a climb, but the aircraft struck tree tops.

The aircraft was flown to a nearby airport, where the left-main gear collapsed on landing. The pilot and two passengers were not injured. Weather at the time of the accident was reported as daylight visual meteorological conditions.

Engine Fire Fails to Alarm Pilot

Piper PA-31 Navajo. Substantial damage. No injuries.

The twin-engine PA-31 was about 32 kilometers (20 miles) from its destination, a rural Canadian airport, when the turbocharger on the right engine failed. The pilot continued the flight inbound and the landing was uneventful.

While the aircraft was taxiing to the ramp, a flight service specialist saw smoke billowing from the right engine and alerted the pilot. The pilot acknowledged the transmission and replied that he would continue to taxi to the ramp parking area, which was at the end of a steep taxiway and required significant engine power to traverse. After the aircraft was parked, flames were visible beneath the engine nacelle and the lower wing.

Available fire extinguishers were not able to extinguish the fire and fire fighters from a nearby town were called. After a high-speed drive from town, they arrived a few minutes later and extinguished the fire. The source of the fire was traced to oil leaking from the failed turbocharger. Insulation around the turbocharger had contained most of the fire and prevented major damage to the aircraft.

Rotorcraft

Power Lines Snare Low-level Flight

Bell BH-47G. Aircraft destroyed. Two minor injuries.

The helicopter was flying at low level along a canal when the passenger spotted looming power lines along the route of flight and alerted the pilot.

The pilot executed a quick stop maneuver to avoid the power lines, but the tail rotor assembly impacted the ground. The helicopter was destroyed in the impact. The pilot and the passenger received minor injuries. Weather at the time of the daylight accident was reported as visual meteorological conditions with 458 meters (1,500 feet) scattered, 3,660 meters (12,000 feet) broken and visibility 16 kilometers (10 miles).

Pilot Killed in Logging Operation Accident

Sikorsky CH-54A. Aircraft destroyed. One fatality and one serious injury.

The helicopter was removing logs using a 61-meter (200-foot) external cable in a narrow canyon at 1,400 feet (427 meters) above mean sea level. Ground personnel heard a popping sound, and the pilot released the load of logs.

Witnesses said the helicopter then began to spin and the tail rotor was observed to slow down. The helicopter descended to the ground and collided with the steeply sloped terrain. The pilot received serious injuries and the copilot was killed. Weather at the time of the daylight accident was reported as visual meteorological conditions, clear skies and visibility 97.5 kilometers (60 miles).

Passenger Ignores Safety Briefing, Walks into Rotor

Bell BH-206B. Minor damage. One fatality.

The helicopter was transporting four workers to a remote Canadian site. Before beginning the flight, the pilot briefed the passengers about the danger posed by the main rotor and the tail rotor and showed them how to approach the helicopter while the rotors were turning.

The pilot returned later in the day to transport the group back to their base camp. Two of the workers approached the helicopter from the front and boarded without incident. The third worker, who was wearing a hat, approached the helicopter with his head and body bent forward. Although the fourth worker, who was nearby, attempted to warn him, the third worker walked into the tail rotor and was critically injured.

The injured worker was transported to a nearby camp, where he was pronounced dead.

Mountain Pass Offers No Escape

Bell BH-206B. Aircraft destroyed. One serious injury.

The helicopter was on a cross-country flight in mountainous terrain when the commercially rated pilot flew toward a mountain pass. The pilot encountered low ceilings and began a turn to exit the pass. During the turn, the helicopter collided with terrain.

The pilot and two passengers were not injured. A third passenger received serious injuries. Weather at the time of the accident was reported as instrument meteorological conditions, 305 meters (1,000 feet) overcast and 3.2 kilometers (two miles) visibility.♦

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