Preface

This book presents a systematic, analytical approach to the design of advanced avionic systems. The analytical process proposed herein is not new, having been used on countless programs over many years. The Taguchi method is just one recent example of an analytic process that targets quality engineering. Another is Instructional System Design (ISD) that deals with curriculum development. Some of the unique aspects of this particular analytical approach will become evident and will provide the reader with a detailed explanation of the architecture, system, and method by which advanced adaptive flight-deck displays can be realized. The design of such operational systems as mission adaptive displays is not primarily informed by technology, but rather through a comprehensive understanding of the mission, the major mission objectives, and the many challenges one faces in the pursuit of mission success.

TARGET READERSHIP

While containing some research, a significant amount of material is operational-related to encourage any future design process—to engage in “operational engineering” instead of the more common but less useful “technology engineering.” The need for design teams to shift focus from technology engineering to operational engineering is now being considered the challenge of our age. This is because technology engineering inevitably results in the proliferation of technological silos across the technology landscape, so that individual technical components compete for human attention, producing what has been called a quagmire of complexity. (This term is now being used by software giant SAP as they seek solutions in the form of “Run Simple.”) Operational engineering, on the other hand, emphasizes convergent technology applications and higher order integration of heretofore discrete technical components leading to smart, user-friendly systems that optimize mission success while simultaneously reducing workload.
A target audience of this book is engineers and managers affiliated with high technology firms engaged in advanced system design and prototyping, especially advanced systems groups that examine futuristic design concepts. Such groups may be sponsored by manufacturers, universities, or government agencies. Lastly, but not least, the operational community is encouraged to join what could be called “The Smart Cockpit Initiative” and offer innovative solutions to some of the most pressing problems facing the aviation community today. This book offers a number of innovative ideas. Others are needed.

**DISPLAY TECHNOLOGY**

Flight deck displays that automatically adapt themselves to changing operational conditions are referred to as mission adaptive displays. Most of the enabling technology that permit such displays are already available within modern-day aircraft. This existing technology includes GPS navigation, terrain data, C band radar, aircraft communications, addressing and reporting system (ACARS), traffic collision avoidance system (TCAS), and integrated data buses. To be operationally effective, however, mission adaptive displays should be able to:

- Present mission critical information at the time and place in the mission that it is most urgently needed.
- Be capable of responding to all mission critical events including both single and multiple occurrences.
- Depict a rising risk profile based upon some coherent risk defining criteria.
- Be comprised of abstract clusters instead of individual, discrete units of information, so as to reduce workload in high stress situations.
- Contain, whenever appropriate, performance aids such that precise maneuver execution is assured. *This is singular in its importance and the major objective of this book.*

Mission Performance Aids (MPA) are defined as the real-time presentation of a set of informational packages that directly contribute to the precise execution of all known critical flight maneuvers. This display feature is considered of such importance that it should receive urgent status with respect to the industries’ operational and business plans. Moreover, mission adaptive displays should, as its number one priority, provide meaningful content concerning the accurate execution of all escape maneuvers. Escape maneuvers should be executed whenever extreme conditions exist.
TRIGGERS

An important technical component associated with automatically adaptive displays is the ability of its triggering device to detect the triggering event and thus retrieve the information needed for performance aid activation. This triggering device must be timely, accurate, and not prone to false alarms and must be able to operate with little or no exceptions. An example of such a trigger is given in the upset recovery section.

ODM

Many of the design aspects of mission adaptive displays (also referred to as the Smart Cockpit) are informed by the body of knowledge known as Operational Decision Making (ODM). The theoretical basis for the construct and application of Operational Decision Making is referred to as Operational Decision Theory.

An operational decision is singular among all classes of decisions and contains a number of unique components. These are: 1) decisions must often be performed under increased time compression, 2) decisions must be made in an environment where incomplete, conflicting, or unreliable information exists, and 3) decisions must be made where the consequences of poor judgment can be catastrophic.

Effective and timely decision making follows a mathematically sound analytical process that captures the ramifications of a rising risk profile such that operational risk can be effectively managed. The conceptual construct of ODM utilizes organized clusters of information instead of discrete informational units and correlates these informational clusters into convergent properties.

Non-linear problem solving in large-scale dynamic systems is the challenge facing all operational personnel. ODM can ease this burden by providing decision support concepts and methods tailored to the operational environment. Moreover, ODM is a viable alternative to the linear detection-response causal chain commonly in use, but often with disappointing results. In many operational situations, signal detection-crew response initiatives are not linear in nature and often require the exercise of good judgment, which includes the reinterpretation of discrete data into information packages representing reality as patterns and models instead of stand-alone phenomena. The important book The Logic of Failure by Dietrich Donner is instructive here.

Operational decision making is a clarified activity designed to improve decision making performance for operational personnel. The objective of this activity is to deal with the challenges faced when engaged in non-linear problem solving in large-scale dynamic systems under increased time compression. As expected, these
challenges directly affect mission performance. When engaging a decision activity, the operator must be able to assess the problem accurately and formulate solutions that will perform with a high degree of effectiveness. To this end, the decision making model presented in these chapters is oriented to work well within the operational environment and has the ability to respond to mission critical events.

Operational Decision Theory represents a body of knowledge that supports all operational decisions. The operational decision model in turn represents the major features of the algorithmic process by which a decision is executed. The theoretical construct of the operational decision model contains a number of key components that have the ability to activate a particular branch of the decision tree. These threshold conditions and triggering events are an important part of this detailed decision algorithm covered in the following chapters.

The theoretical basis of an operational decision must be clearly understood and explained. Two theoretical aspects are key. The first is that an operational decision must commence at the beginning of the decision making process. This point is at the problem definition stage. While conventional decision theory is useful, it does not begin at the problem definition stage, assuming instead that the problem has already been clarified. Its usefulness in the operational environment, where often the real problem is hidden from view, is limited. Furthermore, conventional decision theory does not address problem structuring and the creation of the problem space, ignores the volume of interest aspect of the “Big Picture,” and does nothing to clarify mission critical events.

ODM is event driven, thus it is immediately responsive to changing operational conditions. As an event driven model, ODM recognizes all mission critical event categories and their risk laden properties. The clarification of danger zone boundaries, with green, yellow, and red zones, is a good beginning. Importantly, employing ODM where a catastrophic event in which an escape maneuver must be executed needs to be a major part of the knowledge base of all modern flight decks.

The operational problem, its structural components, and its relationship to the extant operational environment must be clarified before attempting the formulation of a solution. To this end it is helpful in large-scale dynamic systems to recognize that physical movement, often referred to as kinematics, needs to be considered. Endsley’s Situation Awareness Model takes this into account, and is significant.

**MISSION PERFORMANCE AIDS**

Targeted MPA can be thought of as specialized informational packages of a short duration that aid in the execution of a specified maneuver contained within a phase-specific mission objective. The execution of such a maneuver will have a net positive
effect on the mission and may also enable a pilot to avoid catastrophe. Of particular 
interest is the built-in capability of modern flight decks to automatically respond 
to all known escape maneuvers. This initiative alone will be highly beneficial and 
is a key objective of this book.

MPA are not just a set of features that show up somehow on the flight decks of 
modern aircraft’s multi-function displays (MFD).

As we write this, Dr. Atul Gawande, a surgeon at St. Mary’s hospital in London, 
England, is talking and writing about an emerging phenomena he refers to as “The 
Century of the System.” By this he and others mean that all system components 
working together, for the first time, in modern industries and disciplines so that 
dramatic improvements in mission success occur. When incorporated, this systems 
approach, with respect to surgical procedures, has demonstrated in formal trials to 
improve survivability by an amazing 47%.

This begs the question: What is the organizing principle by which all system 
components can function together in such a way so as to optimize mission success? 
The first component of this organizing principle is that all players, technical and 
human, operate from the same set of informational packages. Often this requires 
specialized training for human operators, but in this century of the system, it also 
means that, for aviation, certain flight deck systems are trained as well. This intel-
ligent system training involves the instillation of appropriate knowledge bases and 
of reliable triggering devices.

The second component of the top level organizing principle is that the response 
protocol for each mission activity is the same. This means that the technology 
knows what the response protocol entails, when it should be evoked, and when it 
is completed. Flight crews then use this response protocol that is partly extracted 
from memory and learned from past training, but is reinforced by the support of the 
dependent system. Employing the organizing principles discussed above will usher 
in a new era where intelligent systems are communicating with intelligent systems, 
thereby optimizing mission success.

Figure 1. Aerodynamic feature

![Dihedral](image)
FLIGHT OPERATIONS

In aviation, certain problems have persistently resisted all attempts at effective solutions. Even those introduced with the highest expectations have been disappointments and achieved negligible results. A group of these problems have been the focus of various targeted initiatives over the last two to three decades. They fall under the category of aviation human factors. All of these efforts have been designed for schoolhouse applications with the view that flight crews can apply these skills in an operational environment.

To understand what these problems are, and to understand effective solutions, we should first cover briefly some important aspects of aviation history. Major milestones in aviation can be grouped under the following:

- Large four-engine aircraft with significant carrying capacity; first developed as bombers during World War II;
- Turbo-jet powered transport aircraft, such as the Boeing 707;
- High-bypass fan engines;
- Low-drag aerodynamics, exemplified by aircraft such as the Boeing 757, Boeing 767-300, Boeing 777, and Boeing 787;
- Digital avionics systems, including “glass” cockpits;
- GPS navigation and satellite communications.

Large four-engine aircraft with great carrying capacity were developed in World War II, and were the backbone of the strategic bombing of the Allied Forces. These included the B-24 Liberator and the Lancaster Bomber. Flight crew consisted of two pilots, a flight engineer, and other weapon specialists. Turbo-jet powered transport aircraft were first introduced in the 1950s, such as the Boeing 707, and represented a large milestone in aviation. Powered by four small diameter turbo-fan engines, this aircraft provided a serious and significant advancement in transport aviation—it was capable of flying long distances while carrying numerous passengers or cargo.
Because the 707 and its counterpart the DC-8 represented not only transcontinental capabilities, but also the ability to fly oceanic routes, much operational knowledge was developed at this time.

Automated navigation systems were an imperative addition to the avionics. Long-range, world-wide air transportation revealed, through a series of mishaps, the need to address important human-related issues of conducting such challenging operations. These included situation awareness, crew coordination, and decision making. The operational employment of swept-wing air transport aircraft received a wake-up call in the mid-1960s when a Boeing 727 crashed on landing at the Salt Lake City Airport. This accident revealed significant shortcomings and ushered in the need to define and emphasize what is referred to currently as “stabilized approaches.” Preparation, planning, and execution of approaches in swept-wing transport aircraft were greatly modified, and neophyte pilot training programs were implemented in most training organizations. This became a major aviation milestone.

Swept-wing high-speed aircraft, combined with high-bypass fan engines and low-drag aerodynamics, were all responsible for operational improvements and increased airline profitability. These, however, brought additional challenges with respect to pilot performance, air crew training, and pilot management procedures. Digital avionics, in the form of “glass” cockpits, world-wide GPS navigation, satellite communications, and terrain databases, are all recent and dramatic advances in avionics. This ushered in the ability to downsize the flight crew requirements and increase the number of international destinations available, thus increasing the size and scope of the airline operational footprint. Additional operator challenges became evident. Much more work was needed, particularly in the area of operational decision making (ODM), as well as planning and executing critical flight maneuvers. During this time, flight simulator capabilities and training program effectiveness improved, and most experts believed the long-term problem of controlled flight into terrain (CFIT) could be solved.

FLIGHT CREW ISSUES

CFIT is where an aircraft with no mechanical failures crashes. Lately this category of aircraft accidents has expanded to include all approach and landing accidents, runway excursions, loss of control, aircraft upsets, aircraft stalls, low-level wind shear encounters, microburst encounters, and encounters with rotor-clouds.

A partial list of accidents that have occurred over ten years will illustrate this problem. Most of these accidents are approach and landing accidents. They are listed using general terms without any carrier identification.
San Francisco: Impact with seawall on approach, aircraft destroyed, fatalities.
Jamaica: Ran off runway, aircraft destroyed.
Midway: Ran off runway, aircraft destroyed, fatalities.
Buffalo: Stalled on approach, fatalities.
Bali: Crashed on approach.
Burbank: Ran off runway, aircraft destroyed.
A Major Airport in India: Aircraft crashed on approach, fatalities.

This category of accident has been the most resistive to remediation and remains one of the most urgent problems facing aviation today.

CHALLENGES

In attempting to formulate an effective set of solutions to address the human-cause accident problem CFIT, this section will present some of the most pressing challenges. These are briefly listed below for convenience, and explained more in-depth later on:

• Understanding the complexity of the operational environment.
• Clarifying the non-technical flight crew skills essential for mission success.
• Overcoming the challenges of poorly designed training programs.
• Clarifying the definition of what constitutes “mission critical.”
• Modeling an effective response to all mission critical events.

The first challenge is comprehending the complex operational environment involving the modern air transport system. The design is one of the most intricate surroundings currently known and manifests itself in the large number of interacting components. It is imperative to know not only the details and specifications of each building block, but how they interact together. The aspects of two or more communicating components are difficult to understand without employing an analytical process to observe their interacting properties. For example, in aviation, airport visibility is a driving factor; visibility is so important that minimum parameters of this aspect are specified for all airports. However, in making a landing decision, pilots are required to factor in other airport conditions, such as wind. Currently, airport approach plates list visibility standards only, and pilots are left with the challenge of factoring in adverse wind conditions in order to execute a safe landing. All professional aviators do this as a matter of course. These factors—wind and visibility—could be listed formally, but as of today they are not.
The clarification of non-technical flight crew skills essential for mission success has eluded the aviation community for more than three decades. Many flight crew performance models, most commonly referred to as crew resource management (CRM), have been developed. Variations of these models have been developed over numerous years, however, there has been little attempt to integrate them into a superordinate model. Among all these non-technical, human-factor related skill packages, ODM is the most imperative skill a pilot should possess. Decision training, therefore, should become a key component in the training that all airline pilots receive. However, the aviation community needs to settle on a singular decision performance model, which has not occurred yet.

The majority of airline pilot training programs focus on the technical aspects of systems operation, standard operating procedures, and management of onboard emergencies and irregularities. Diminutive amounts of time have been spent in the classroom and the simulator in presenting complex operational problems, for which the flight crew is depended on to solve effectively and efficiently. This issue was formally addressed in the early 1990s as an advanced pilot training curriculum model and developed for the use of all United States’ and European carriers. This model is referred to as the advanced qualification program (AQP), and the important aspect of this is the use of line-oriented flight training scenarios (LOFT). The scenarios presented complex operational problems for which the flight crew was evaluated to sufficiently solve. However, the aviation community did not embrace this new training model—currently only eight carriers use it—because it was difficult and expensive to build and implement. Thus, what is left is the dilemma of how the aviation community can collectively come together to optimize ODM, which is key to mission success.

This challenge of understanding what constitutes “mission critical” may well be the most important challenge the aviation community faces to date. If one is to design a flight deck environment that is capable of responding to significant mission events, there must be a concise and comprehensive understanding of the most important events that should be addressed. The ultimate goal is to avoid mission catastrophe. Yet, the aviation community has yet to produce a “mission critical event document.” This is indeed a challenge that all designers face, and hopefully such a document can be developed. This book is a step in that direction.

**WORKING TOWARD A SOLUTION**

The centerpiece of the solution offered here is to implement mission adaptive displays in the flight deck environment. However, in order to employ such a system, certain preconditions are essential in order to realize effective performance, such
as understanding the aviation operational environment in sufficient detail to ensure that responsive systems are carried out. This understanding constitutes a clear idea of what is often called mission critical.

Another precondition is the role of the aviator. It is clear from a large number of operational studies that the central role of the aviator is to solve complex, non-linear problems in a time-compressed environment. This activity is also referred to as decision making and operational systems. For convenience, this has been shortened to operational decision making (ODM). The aviator is also termed “pilot as risk manager,” the key activity of the aviator. Since responding to mission critical events almost always involves decision making, it is proposed here that an effective decision aid to support such risk management will significantly improve mission performance. Making decisions, also known as risk management, should be aided and supported by two components. First is the schoolhouse-targeted training initiatives and ODM; second is an onboard decision aid to support the decision making process in real time. While targeted decision training has been addressed in a relatively limited sense, a useful, onboard decision aid has not been the focus of many coherent efforts until now. To design a robust decision-support system, mission adaptive display technologies are necessary. This consists of a number of databases and knowledge structures that can recognize and respond to all mission critical events. The apparatus systems logic and processing methods should also be specified—and are detailed—in this book. Major features of mission adaptive display technologies include components and functions that can respond to the following mission critical events:

- **Catastrophic:** A catastrophic occurrence is almost certain.
- **Parameters Exceeded:** Conditions in which operational safety parameters have been exceeded. A common pilot term for these events is “show stoppers.”
- **Deteriorated:** Conditions have significantly deteriorated.
- **Deteriorating:** Conditions are worsening and caution is advised.
- **Not Normal:** Conditions are abnormal, but as of now are not expected to worsen.

### MISSION CRITICAL EVENTS AND MISSION PERFORMANCE MODELS

In this section, we will briefly cover the corresponding responses to each mission critical event category, which evoke the appropriate mission performance model. A table listing these responses is also included. The overall concept of mission adaptive displays is that for each family of mission critical events, there is a corresponding set
of activities that can and must be employed to address important mission concerns. The activities can naturally be grouped into related categories. Once the response categories are identified within the construct of mission performance models, the details of their performance aspects can be made known. Performance aids can then be designed for each event.

In concert with these performance responses, more discussions are presented that address system details which involve the specification of the apparatus system and method by which an onboard risk management decision support system can be fully realized. The operational employment by such a performance support system promises to dramatically improve operational performance and safety within the air transport community.

Overall performance aspects of mission adaptive displays can be explained as follows. When a flight encounters a mission critical event, an initial determination is made as to whether certain aspects of this event represent significant operational concerns. If this is determined in the positive, then identification of the event category is made. Event categorization is one of the unique features of mission adaptive displays and it greatly simplifies the design process. Once this category selection is made, the appropriate signal path is selected. These signal paths have been presented in this section. Within each signal path resides a set of MPA that are designed to specifically address each class as well as each specific mission critical event.

A mission critical event that has been both detected and categorized enters its assigned signal path. This signal path contains a number of intelligent features that will activate. These features will first issue cockpit warnings in the form of aural and visual alerts. Then the presentation of targeted display features designed to optimize crew responses follows. These display features necessarily will have short dwell times, and will automatically adjust and alter depending on predetermined time-space conditions. Such display features will utilize most or all of the multifunction displays such as the primary flight display (PFD), navigation display (ND), and the engine indication and crew alert system (EICAS). Operationally valid performance aids are presented to the crew in such a way so as to be non-intrusive, natural, and effective.

Below is a brief description of each MPM.

- **Escape MPM:** This model is activated when an impending catastrophic event is detected. The escape maneuver package is then retrieved from the available database. This package contains cockpit warning features as well as the targeted performance aid. The performance depicts critical flight maneuver information in a way that supports the execution of one or more precision maneuvers without increasing the already high workload. All escape maneuvers will begin with the initial target pitch attitude. Experience has shown that if the pitch attitude is incorrect, the maneuver will fail.
• **Terminate MPM**: This model is activated when the operation must be terminated. This termination must occur as soon as possible. The termination response package will always contain a cockpit warning feature. It may also contain a targeted maneuver if appropriate to the situation.

• **Abandon MPM**: This model is activated when the current or original mission plan must be abandoned. This could involve proceeding to the destination alternate, takeoff alternate, or en route alternate. Appropriate diversion performance aids will be presented. These performance aids are especially important when conducting oceanic operations.

• **Prepare for Diversion MPM**: This model is activated when conditions are deteriorating and are expected to continue such that a diversion may be necessary.

• **Modify MPM**: This model is activated when an event is detected that may combine with other events, and represent (combined) risk levels that require modifications to the original mission plan. Appropriate performance aids are presented if appropriate. In all cases, however, the individual and combined risk factors are present.

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**MISSION PERFORMANCE AIDS**

For each mission performance model, a set of MPA correspond with the appropriate performance model. They provide the necessary detail, often in the form of targeted flight deck warnings and flight maneuver guidance, to aid flight crew activities. Important aspects of MPA are discussed below.

The primary focus and overall objective of MPA, which are the major feature of the mission adaptive display environment, is the presentation of the target pitch attitude to essentially guarantee that the aircraft’s flight path is optimized. Flight path optimization falls under the category of “trajectory management.” All performance aids that contain trajectory management elements will display the optimum pitch targets on the primary flight display (PFD) and, importantly, also on the upper engine indication and crew alert display. It must be emphasized that a large number of mission failures have been the result of improper flight path control (trajectory management).

The second primary objective of MPA is to improve dynamic situation awareness and optimize vehicle kinematics. This is accomplished through unique functional capabilities which continuously analyze the actual aircraft dynamics against the known optimum.

The third primary objective of MPA is to provide timely and effective management of a rising risk profile, particularly when multiple risk factors are in play. This
is called “cumulative effect.” This is accomplished by using a number of specifically designed databases and look-up tables as well as the application of recently advanced mathematical concepts.

**CHAPTER ORGANIZATION**

The organization of this book supports a number of different applications. The reader should consider first the preferred area of interest. For example, a reader with formal education in aerodynamics may not wish to read the section on aerodynamic essentials, preferring rather to just skim this material. Conversely, the section on approach energy management may be of such high interest that an electronic download of this chapter may be desirable for more in-depth study over a number of months.

This book begins with a brief overview of aviation history, which may prove to be of interest to those who are responsible for developing training materials as a way to capture the audience’s attention.

The section on aerodynamics and approach energy management will be of particular interest in the development of advanced kinematic display features supporting dynamic Situation Awareness. Consequently, many, if not most, working in the area of aeronautics will find this material of particular interest.

The section on escape maneuvers should be of interest to a large section of the aviation community, including research organizations, and is considered one of the main features of this book. The authors believe that this is the first time that all escape maneuvers have been identified under one roof and that a complete set of targeted escape performance aids have been specified. Hopefully this will spur the development of flight deck systems that contain all known escape maneuver triggers and mission performance aids as its knowledge base.

Three case studies are provided. This should prove of interest to many safety and flight managers throughout the aviation community. These case studies provide a rich source of information on such things as information overload, cases of poor judgment and choice, ineffective energy management, incomplete or inaccurate problem definition, and loss of the “big picture.”

The reader will almost certainly be surprised to learn that Mission Adaptive Displays have been considered before, in particular in the definition and design of a fifth-generation fighter. This particular performance aid was conceptualized as a way to reduce workload as well as provide a quicker response to the intercept problem while traveling above Mach One.

This book and the Smart Cockpit Initiative are a work in progress and thus additional innovations are, as always, encouraged.
SECTIONS AND CHAPTERS

Section 1 provides important information on flight operations. This is needed because the mission adaptive displays will ultimately address a large number of critical flight maneuvers. A thorough understanding of the operational environment is needed. Consequently, this section will discuss milestones in aviation, the air transport mission, and flying in adverse conditions. Various aspects of risk management and ODM are also introduced to the reader.

Section 2 introduces the reader to six MPMs. These models are used to assist planners and developers in understanding the essential elements of the air transport mission. These models are the escape, catastrophe, terminate, abandon, prepare, and modify.

Section 3 covers challenges and opportunities that confront all of us involved in the aviation industry. This section is especially important because it provides the reader with much vital information that cannot be easily obtained elsewhere. Included in this section is a comprehensive discussion of 1) operational visibility, 2) aerodynamic essentials, 3) approach energy management, 4) advanced thinking on certain aspects of risk management, and 5) important escape maneuvers.

Section 4 presents a number of solutions and recommendations that mostly involve the design and installation of onboard MPA. MPA are flight deck features that target specific maneuvers and automatically adjust themselves to display critical flight maneuver information for their safe and effective execution. MPA are grouped into three categories. They are mission performance evaluator (MPE), precision maneuver guidance (PMG), and operational decision making (ODM) (aid).

Section 5 presents conclusions and recommendations. An important feature of this section is the introduction and discussion of the triggering devices for all escape maneuvers. Providing the industry with escape maneuver triggers for all known escape maneuvers is arguably the most significant to flight safety in the last decade or more.

Section 6 provides the reader with additional material: two case studies and complementary discussions of risk management and decision making with emphasis on the operational envelope. Finally, an interesting discussion on critical thinking will no doubt prove popular.

Section 1. The Air Transport Mission

Chapter 1. Flight Operations

This chapter introduces the reader to flight operations, discusses important milestones in aviation, structures the mission, and covers operating in adverse conditions. The purpose of this information is to acquaint the interested parties to some important
aspects of flight operations, so that decisions regarding what to build and deliver can be optimized.

Chapter 2. Operational Decision Making in Aviation

Operational decision making is a defined process that provides for significant improvements in the ability to solve complex problems under increased time compression. This is especially important in the field of aviation, but also applies to other fields as well. Operational Decision Making is singular among all other classes of decisions and contains a number of unique components. The three that are often cited are 1) decisions must be made with incomplete, conflicting, or unreliable information; 2) decisions must be made under increased time compression; and 3) the consequences of poor decisions can be catastrophic. These and other important features will be discussed in this chapter, providing the reader with much useful material so as to understand this important subject. ODM represents the theoretical basis for the design and development of Mission Adaptive Displays.

Chapter 3. Mission Critical Events

With respect to the operational environment, that which is mission critical is central to mission success, such that a complete understanding of the consequences of this operational situation is vital. Within the operator’s volume of interest, the detection, assessment, and responses to all mission critical events are paramount to flight safety. This chapter will provide important information on the characterization of all mission critical events up to and including those that represent extreme risk. All mission critical events contain risk producing properties. The challenge for all of us in the design and research communities is to understand, from an operational perspective, what the implications are of these risk producing properties.

Section 2. Conceptual Models

Chapter 4. Mission Performance Models

The use of mission performance models are an emerging aspect of the advanced design process. They are introduced as supporting the conceptual design work. Mission performance models in aviation are surprisingly not new, having emerged from the 1987 “The Woods Hole Conference” sponsored by the U.S. Air Force. Utilizing mission performance models early in the design process reorients the design perspective in important ways. This perspective reorientation moves us away from conventional technology engineering to operational engineering, which results in the formulation of convergent super-functions horizontally situated.
Section 3. Challenges and Opportunities

Chapter 5. Essential Background Material

Essential material is presented in this chapter to aid in the research and design process. Important discussions concerning the complexity of operational visibility and how to manage such complex information and the difficulties surrounding the approach and landing safety problem will make for interesting reading. The approach and landing safety problem is the number one problem facing aviation today.

Chapter 6. Aerodynamic Essentials and Energy Management

Aerodynamic essentials and energy management are important aspects that contribute to mission success. This is considered an important knowledge base for all researchers and designers involved with advanced systems. Key behavioral characteristics of large-scale atmospheric and space systems and their kinematic properties are covered here.

Chapter 7. Case Study: Flight 214; Chapter 8. Case Study: Accident Analysis through ODM

Chapters 7 and 8 represent challenges we face as a community of professionals. These two case studies provide important insight into some persistent causes of catastrophic events and airline accidents. The perspective of both case studies is the human element, and the issues related in performing under conditions of high stress and extreme complexity. As a community, we need to do much more in the area of dynamic situation awareness, complexity reduction, and performance aiding. In particular, decision aiding should be given the highest priority.

Section 4. Solutions and Recommendations

Chapter 9. Escape Maneuvers

Recognizing the need and the timely execution of the escape maneuver is the most important responsibility of all operational personnel. Otherwise lives are held in the balance. The escape maneuver is defined as that which is required to avoid catastrophe. Recognizing that in large-scale dynamic systems, risk, once encountered, will inexorably rise unless decisive action is taken, up to a point beyond which catastrophe awaits. Such a point is called the “critical event horizon.” The escape maneuver, by definition, must be executed no later than the critical event horizon.
Chapter 10. Mission Performance Aids

MPA are the end-point manifestation of mission adaptive display technologies. Mission Adaptive Displays are defined as those display features that automatically adapt themselves to changing operational conditions. Mission performance aids are at once vital to the delivery of intelligent systems (the Smart Cockpit) and to ensure mission success. MPA cut through the quagmire of complexity, delivering to the operational environment onboard support systems that provide the right information at the right time.

Section 5. Conclusions and Recommendations

Chapter 11. Concept Evaluation

This chapter discusses some operational issues related to MPA. Operational, real-world concerns should be part of the design process. An emerging process that is receiving emphasis is what is often called storyboarding. Storyboarding has been used in the film industry for many years but is now being recognized as being valuable to test out new ideas, especially those ideas that involve kinematics.

Chapter 12. System Algorithm

The top level systems algorithm for mission adaptive displays (the Smart Cockpit) is presented here. This can be especially useful for designers and researchers. An algorithm such as the one presented in these pages is quite difficult to develop and thus many may find this representation a significant time saver. Furthermore, the algorithm can provide additional conceptual support and understanding for the theoretical basis of a whole range of intelligent display features.

Section 6. Additional Material

Chapter 13. Flying Adverse Conditions

Flying in adverse conditions presents many challenges, not least is the human performance concerns. These “systems level” concerns include the recognition of a rising risk profile due to the existence of certain adverse conditions and the response protocol associated with each adverse cluster. For the sake of consistency, these clusters are called event sets. Event sets are further classified in terms of being mission critical or not. In many cases, operating in adverse conditions will involve dealing with a number of mission critical events. A specified set of responses to
each type of event set can be clarified. Consequently response categories can be the design driver for any advanced system design and be the key to mission success.

Chapter 14. Operational Decision Making

Additional material on Operational Decision Making is provided. This will be helpful for advanced degree students as well as those engaged in advanced research.

Chapter 15. Mission Performance Aid for Air Combat

This rather fascinating chapter relates a research initiative that was undertaken to examine situation awareness and a workload reduction device for the Air Force’s Lockheed F-22 Aircraft. This effort resulted in the design of what is most certainly the first mission adaptive display (Smart Cockpit) within the aerospace community. A major feature of this air combat performance aid was its ability to calculate the utility of a particular set of intercept parameters thereby improving mission success as well as reducing complexity and excessively high workload.

Appendix: Procedures and Pilot Training

Additional material on procedures and pilot training is provided. This material may prove useful for those involved in developing advanced training products and simulation systems.