Evaluating Aviation Information Systems: The Role of Information Priorities

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Several new systems apply modern technology to the processing and presentation of information in the cockpit. Many of these innovations have been available in large, complex aircraft for many years, but the continued development of information sources (e.g., GPS, Datalink) and the increasing power of small computers promise to offer the benefits of these technologies to more and more pilots in more and more different classes of aircraft. While these developments are to be applauded, for they offer the prospect of increased safety in the air, there are also reasons for concern over just how the increased information load is to be managed by pilots. The general issue revolves around insuring that Aviation Information Systems (AIS) meet clear criteria, including satisfying regulations, ensuring accuracy, and providing usability.

It is important to ensure that human factors are considered in determining what information to present, when to present it, how it is to be found, and how to present it. Various efforts in developing human factors guidelines and tools for this purpose have been underway for sometime, producing several documents and tools to assist in the evaluation of the quality of the human factors in information systems (Beringer & Ball, 2002; Dillard, 1999; FAA, 2002; Francis and Reardon, 1997; GAMA, 2000; Kaber, Riley, & Tan, 2002; Mejdal, McCauley, and Beringer, 2001; Seidler and Wickens, 1992; Semple, Heapy, Conway and Burnett, 1971). To date, the evaluation methods have not systematically considered the priority (or criticality) of various information factors in assessing the quality of AIS. The primary purpose of this report is to provide a methodology for evaluating AIS taking priorities into account. The starting point for this effort is found in recent studies addressing the priority of information factors in various phases of flight (Beringer & Schvaneveldt, 2002; Schvaneveldt, Beringer, Lamonica, Tucker, & Nance, 2000; Schvaneveldt, Beringer, & Lamonica, 2001).

The general plan of this report is to review some of the background for the present effort and then to discuss some issues surrounding the question of evaluating AIS. Then, the methodology used to assess accessibility of information relative to its priority is presented, and several examples of the application of the assessment methodology are discussed. Finally, a summary of the project and some suggestions for future directions are presented.

Priorities of Flight Information

It seems obvious that some information is more important than other information in executing a safe and successful flight. It is also clear that information priorities vary with the phase of flight (or preparation for a flight). For example, knowing about ground proximity is particularly important when near the ground, but it is usually of lesser importance when in an established cruise at altitude. These considerations led to a project devoted to gathering some data about information priorities (Schvaneveldt, et al., 2000; 2001). Subsequently, because weather information was underrepresented in the initial study, a second study was devoted to obtaining priority judgments about weather information (Beringer & Schvaneveldt, 2002). Table 1 shows the phases of flight included in these studies. The weather study added some additional phases to those included in the initial study. As the table shows the phases studied include planning and ground operations in addition to flying phases. The information factors included in the studies are shown in Tables 2 and 3 for Study 1 and Study 2, respectively. Study 1 was devoted to determining priorities for a broad range of information factors, and in the interest of keeping the number of factors to a manageable number, some of the factors actually consisted of categories (e.g., aircraft configuration, airport configuration). Study 2 included many weather factors at some level of detail.

In the present study we were concerned with applying the results of these earlier studies to the evaluation of aviation information systems. The primary goal was to include consideration of information priorities in the evaluation process. As work proceeded, it became clear that producing a useable tool for evaluating AIS required some revision in both the information factors included and in the phases of flight considered.

Table 1. Phases of Flight

Phases of Flight	General Information Study 1	Weather Information Study 2
Pre-Flight Planning	√	√
Just Before Departure		√
Taxi		√
Takeoff	√	√
Climb	√	√
Transition to Cruise	√	√
Cruise	√	√
In-Flight Planning	√	√
Descent	√	√
Approach	√	√
Landing	√	√

Table 2. Study 1 – Taxonomy of General Information Factors

Factor	Description
Aircraft configuration	Flaps, landing gear, cowl flaps, speed brakes, spoilers
Engine health	General health of engines
Fuel quantity	Fuel remaining
Fuel selection	Current selected source of fuel
RPM (power)	Power setting or desired power
Altitude - AGL	Altitude above ground level
Altitude - MSL	Altitude above Mean Sea Level
Distance	Distance to waypoint or airport
Bank	Bank
Pitch (attitude)	Pitch
Yaw	Yaw
Course	Desired track - Planned course
Heading	Nose direction
Track	Actual track over the ground
Waypoints	Location and type of enroute waypoints
Airspeed	Indicated airspeed
Ground speed	Actual speed over the ground
Vertical Velocity	Climb rate or descent rate
Time - ETA/ETE	Estimated time of arrival / Estimated time enroute
Airport configuration	Altitude, runways, approaches, notams, active runway
Runway aim point	Desired point of touchdown
Runway remaining	Length of remaining runway on takeoff or landing
ATC Comm	ATC instructions, clearances, etc.
Traffic / other Comm	Communication with traffic or other information source
Obstructions	Towers, trees, mountains, etc.
Traffic	Other aircraft
Airspace	Type of airspace A B C D, restricted, MOA etc.
General weather	General weather conditions
Wind	Wind direction and intensity

Table 3. Study 2 – Weather Information Factors

cloud ceiling	pressure - rate of change	wind - aloft direction
cloud coverage	pressure - static atmos	wind - aloft velocity
cloud thickness	sand/dust storms	wind - downdraft
cloud types	temperature - dewpoint	wind - ground direction
haze	temperature - geog gradient	wind - ground velocity
lightning	temperature - present	wind - gusts
precip - freezing rain/sleet	temperature - rate of change	wind - mountain rotors
precip - hail	temperature - vert gradient	wind - updraft
precip - rain	turbulence (clear air)	
precip - snow	visibility	

Why Three Categories of Operations?

The task of separately evaluating each of the 11 phases included in earlier studies of priorities appeared unnecessary. Most systems do not have as many modes as this so separate evaluation of all of these phases seemed superfluous and tedious. Further, examination of the priority ratings revealed that they could be grouped into three categories of operations without serious loss of detail. The categories are: 1. on the ground, 2. near the ground, and 3. in flight. We have labeled these Ground, Departure/ Arrival, and Inflight. The priorities for these three phases were obtained from the earlier priority data by taking the minimum priority rating (the highest priority) for the phases that went into those combined. Table 4 shows the grouping of the earlier phases into the three used in the present study. This set of 3 categories of operations provides a simpler scheme which should be easier to relate to various AIS.

Table 4. The Categories of Operations and Phases of Flight

Three Categories of Operations	Phases in Each Category	Comments
Ground	Preflight Planning Just Before Departure Taxi	None of the minimum priorities came from Taxi Study 1 only included Preflight Planning
Departure/Arrival	Takeoff Climb Approach Landing	
Inflight	Transition to Cruise Cruise Inflight Planning Descent	Inflight Planning produced the minimum priority for Waypoints, Distance, and Time

More Detailed Information Factors

Preliminary work in evaluating systems also revealed that some of the original information factors were too broad to be easily evaluated (e.g., aircraft configuration and airport configuration). It was decided to expand these into additional items (e.g., flaps, landing gear, airport elevation, nearest airports, and airport procedures). In addition, there were some omissions from our earlier lists that we added to ensure more complete coverage. The additions were largely concerned with communications and systems, and deviation from course was also added. Priorities for these new items were either taken from the coarser categories in the earlier studies or were determined by consultation with four pilots with varying amounts of flying experience. The more experienced pilots had heavier weight in assigning the new priorities.

The resulting information factors and the priorities are shown in Table 5. Note that the lower the priority rating, the higher the priority. Top priority is 1.0.

Table 5. Information and Operations Included in the Priorities Checksheet

Information Factor	Priority			Information Factor	Priority		
	Ground	Depart/ Arrive	Inflight		Ground	Depart/ Arrive	Inflight
AVIATE				**MANAGE SYSTEMS**			
airspeed	2.7	1.1	1.6	engine system status	2.3	1.1	1.5
altitude - AGL	2.6	1.2	1.8	electrical system status	1.0	1.0	1.0
altitude - MSL	1.9	1.3	1.4	fuel system status	1.1	2.0	1.7
engine - RPM (power)	2.0	1.0	1.4	hydraulic system status	2.0	2.0	2.0
vertical velocity	3.7	1.6	2.2	flaps	2.0	1.1	2.1
heading	1.0	1.6	1.8	landing gear	1.0	1.1	2.1
course (desired track)	1.0	1.7	1.6	checklists	3.0	3.0	3.0
bank	3.9	1.5	2.1	system modes	1.0	1.0	1.0
pitch (attitude)	3.8	1.4	1.8	**WEATHER**			
yaw	3.8	1.5	2.6	cloud ceiling	1.4	1.4	1.7
NAVIGATE				cloud coverage	1.6	1.8	1.8
track	3.4	1.6	1.8	cloud thickness	2.0	1.8	2.0
deviation from course (CDI)	1.5	1.5	1.5	cloud types	1.8	1.8	1.8
waypoints	1.0	2.9	1.7	haze	1.9	1.8	2.1
distance	2.3	2.4	1.6	lightning	1.3	1.2	1.3
time - ETA/ETE	1.5	3.2	1.4	precip - freezing rain/sleet	1.1	1.1	1.0
ground speed	2.5	2.4	1.9	precip - hail	1.0	1.1	1.1
airspace	1.9	1.7	1.9	precip - rain	1.8	1.8	1.9
airways	2.0	2.0	2.0	precip - snow	1.4	1.4	1.4
nearest airports	3.0	1.5	1.5	pressure - rate of change	2.2	2.4	2.3
airport elevation	1.6	1.3	1.8	pressure - static atmos	2.1	2.1	2.2
airport procedures	1.5	1.0	2.5	sand/dust storms	1.6	1.4	1.6
obstructions	1.9	1.6	2.1	temp - dewpoint	1.9	2.2	1.8
traffic	1.0	1.2	1.4	temp - geog gradient	2.5	2.8	2.6
moving maps	1.0	1.0	1.0	temp - present	2.1	2.0	1.9
fuel required	1.1	2.0	1.7	temp - rate of change	2.2	2.2	2.2
approach speed	3.5	1.5	2.5	temp - vert gradient	2.3	2.4	2.2
runway needed	2.6	1.1	3.7	turbulence (clear air)	1.6	1.7	1.6
runway lengths	2.0	1.5	3.0	visibility	1.0	1.0	2.0
runways available	3.5	1.5	2.5	wind - aloft direction	1.8	2.1	1.8
COMMUNICATE				wind - aloft velocity	1.8	2.2	1.9
COMM interface	1.0	1.0	1.0	wind - downdraft	1.7	1.4	1.7
terminal ATC radio frequencies	1.6	1.3	1.7	wind - ground direction	1.5	1.4	2.4
enroute ATC radio frequencies	2.4	1.3	1.7	wind - ground velocity	1.6	1.4	2.4
traffic / other frequencies	2.0	1.3	1.4	wind - gusts	1.9	1.4	2.1
VOR frequencies	2.0	1.0	1.0	wind - mountain rotors	1.5	1.9	1.5
				wind - updraft	1.8	1.6	1.8
				wind - windshear	1.3	1.2	1.4

Issues in Evaluating Aviation Information Systems

In the development of the evaluation methodology, several issues were considered and provisionally resolved, resulting in the final product. These issues should be revisited as work on developing effective evaluations proceeds because later developments may lead the effort down paths other than the one followed in this effort. It was necessary to make some decisions that allowed the project to be completed on time. As always, it would be helpful to have more time and more data to ensure adequate coverage of the relevant issues. In this section, some of these issues are discussed.

Coverage of Information Factors

Many systems are intended to provide only certain types of information, e.g., Navigation, Weather, Airport Data, etc. The question arises as to how to evaluate the extent to which AIS cover intended domains and how well the coverage meets the information needs of pilots. Consider a typical hand-held GPS unit. Aiding navigation is clearly a central function of such a unit, but it may also provide some information aiding aircraft control. For certification, there is a question of how well a system does what is intended to do, but it also seems relevant to consider just how much it is intended to do. Of course, the totality of information available in an aircraft must meet the Federal Aviation Regulations (FAR). Many systems provide information not required by regulations. Rather the information is intended to supplement the basic flight and engine instruments. Other systems attempt to integrate this basic information into a more comprehensive system that attempts to manage all of the information requirements. These different systems call for distinct methods of evaluation.

The approach adopted here is to provide separate evaluations for the familiar categories, Aviate, Navigate, Communicate, and Manage Systems. To these we add Weather which is a category of much needed information, but weather information is just beginning to appear in systems. In many cases, there is some provision for weather information, but it has not been entirely implemented. Presumably, the development of Datalink and other information sources will make timely weather information available to pilots so it would be wise to incorporate weather information into the evaluation process. With separate evaluation of information serving these various strategic and tactical activities, there will be an assessment of what a system is intended to do as well as an indication of what information must be obtained from other sources.

Availability and Access to Information

With multiple presentations available, how is the ease of access to be evaluated? For example, if the relevant screen is present, accessibility is more direct than when some other screen is present. Our evaluations attempted to optimize the evaluation for each category of operations by selecting the presentation that provided the most ready access for the most high priority information items for each category evaluated.

Irrelevant or low priority information

Should the evaluation reflect the extent to very low priority information gets in the way, i.e., information that is present when not needed? Such information adds clutter making accessing high priority information more difficult, but this seems less serious than not having ready access to the high-priority information. Users can learn where to locate information with some experience, mitigating the impact of excess information. We note

when excess information is present, and the presence of a lot of clutter is reflected in overall evaluations.

Alerts vs. Continuous Information

Another important issue concerns whether information should be displayed continuously or only under special conditions. For example, knowing AGL altitude may only be relevant when the aircraft is in some proximity to the ground. Also certain aircraft system information is of primary interest only when problems arise in the system. The evaluation performed here did not attempt to resolve this question, but credit was given for the presence of an information factor even if it was only available under certain conditions.

Complete Evaluation

It is becoming clearer that the evaluation of priorities should not be independent of other human factors evaluations. For example, a simple recording of the number of actions required to obtain a piece of information may not reflect how difficult or obscure or hard-to-remember those actions are.

There is also the issue of the quality of the information provided. One might expect information systems to improve on the information systems required by the FAR. Certainly, they should not degrade the information available from the standard instruments that have been available for decades.

Eventually, a complete human factors evaluation should include consideration of usability as well as priority. Unfortunately, the scope of the present project did not allow development of the complete package. The focus here was on developing the priority evaluation.

Relative Priority

For some purposes, it would be useful to have information about relative priority of the information factors to determine which should be presented in case of partial failure of the information system. For example, the loss of one screen in a multiple screen display system would require that critical information be presented on the available screen or screens. The priority data collected earlier does not directly address this issue, but the priorities can be used to determine what is most important. In addition, the category of information factors could be used to order the relative importance of the categories. Clearly Aviate is of paramount importance off the ground. Perhaps Navigate is next in importance, then Communicate and then Manage Systems. Where does the Weather fit in here?

Weather

Providing current weather information in the form of map displays and text is presently a very active area in the development of AIS. Manufacturers are rapidly deploying systems to display the NEXRAD and other sources of weather information provided by Datalink. The Priority Checksheet has provision for evaluating weather displays as evidenced by the extensive coverage of weather details in the information factors. Some of the systems evaluated in the present project have provision for displaying weather information, but the exact details of how it will be done was not available in the prototypes evaluated. It would be possible to evaluate the availability of information to the various systems, but without knowledge about whether and how a particular system will present each weather

factor, the priority evaluation cannot be completed. The present evaluations, therefore, concentrated on Aviate, Navigate, Communicate, and Manage Systems. It would be a simple matter to extend the evaluations once the design decisions have been settled. Perhaps even more importantly, the Checksheet information could be used to guide the design decisions.

Methodology

Most of the priority values on the Checksheet are derived from the priority ratings obtained earlier. In some cases priority rating values were obtained by consensus among the authors and other pilots. In any case, the Checksheet values were obtained by using ranges of the ratings to obtain a 5-step integer scale, 1 to 5. The ranges are shown in Table 6.

Table 6. Conversion of Ratings to Priority Values

Original Rating Range	Checksheet Priority Value	Priority
1.0 – 1.6	1	Highest
1.6 – 2.2	2	Next Highest
2.2 – 3.1	3	Etc.
3.1 – 3.6	4	Etc.
3.6 – 4.0	5	Lowest

Completing the Checksheet requires evaluating each of the 71 information factors in each of the three categories of operations (Ground, Departure/Arrival, or Inflight). The system being evaluated should be put into the mode most appropriate for the category of operation being evaluated and then each of the information factors should be checked. When checked so note by a check in the "Checked?" column (This allow keeping track of what has been completed.). If the information factor is available somewhere in the system, place a check mark in the "Present?" column. Then enter the accessibility measure in the "Access" column.

The accessibility measure is the number of steps required to reveal the information. If the information is available with no action other than perceiving it (including head turning), the accessibility score is 1. Otherwise, the accessibility is 1 plus the number of steps (actions) required to reveal the information factor.

The Checklist form is shown in Appendix A.

Once the accessibility measures are obtained, they are entered into an electronic spreadsheet, which performs several analyses providing evaluations at several levels of detail. First, each accessibility measure entered is compared to the priority to determine the appropriateness of the accessibility given the priority. A Priority x Access matrix is used to assign a symbol to each case, reflecting the appropriateness of the accessibility measure. This scheme allows easy modification for further evaluations by simply changing the matrix. The matrix used for the reported evaluations is shown in Table 7.

Table 7. Matrix for Assigning Appropriateness from Priority (P) and Access (A)

P \ A		1	2	3	4	5	6	7	8	9+
1		+	L	L	L	L	L	L	L	L
2		+	+	+	L	L	L	L	L	L
3		C	+	+	+	+	+	+	+	L
4		C	+	+	+	+	+	+	+	+
5		C	C	+	+	+	+	+	+	+

Note.

L	Access too low
C	Access too high (clutter)
+	Access appropriate
blank	not present in the system

Once the appropriateness assignments have been made, several analyses are conducted on the various categories of information factors (Aviate, Navigate, Communicate, Manage Systems, and Weather). By evaluating each category, it can be determined the extent to which the system under consideration supplies the information in each category. The decision rules used to evaluate each category of factors in each category of operations are shown in Table 8. The rules are checked in the order given. These rules can easily be modified by simply changing the cutoff values.

Table 8. Decision Rules for Evaluating Categories of Information Factors

1. if % Present < 50.0% decide **Not Covered**
2. if % Clutter > 50.0% decide **Clutter**
3. if % Low Access > 33.0% decide **Low Access**
4. if % Pass > 25.0% decide **Pass** (25% because % Present may not be 100%.)
5. else decide **Fail**

Some additional rules are used to evaluate each category of information factors across the three categories of operation giving an assessment of the system's performance in each of the categories: Aviate, Navigate, Communicate, Manage systems, and Weather. These rules use the results of the earlier decisions to get the assessment for each category of information factors. These rules are quite simple. There are 3 categories of operations. If a system shows 2 or more of "Clutter," "Low Access," or "Pass" in the 3 categories, the evaluation corresponds to the majority. Otherwise, the evaluation is "Fail."

The next section presents some applications of the Priority Checksheet.

Applications

The Priority Checklist was completed for several different systems to demonstrate its utility in evaluating systems. For comparison, the Checklist was completed assuming the presence of the instruments required by the FAR in Part 91 for both visual flight rules (VFR) and instrument flight rules (IFR). In addition the evaluation was completed for several different systems: (a) a **Portable GPS** system with a moving map display on a 1 ¾" x 2 ½" screen; (b) an **Electronic Flight Bag** system installed in the Civil Aerospace Medical Institute Human Factors Laboratory Simulator and displayed on a 12" touch sensitive screen; (c) a simulated display of a **Panel Mounted GPS/COMM/NAV** unit with a 3" x 4" display; and (d) a **Flight Management System** in a simulator with 4 screens, each one 13" x 10" (one Primary Flight Display for the pilot and one for the co-pilot plus two Multifunction Displays in the center, one above the other). Each system was evaluated in a mode most appropriate for the category of operation considered (Ground, Departure/Arrival, or Inflight).

Appendix A contains the detailed results of the Checklist analysis.

The analysis for VFR and IFR was based on Section 91.205 (US DOT, 2002) of the FAR identifies required instruments/equipment for aircraft. The instruments assumed for VFR and IFR flight are shown in Table 9.

Table 9. Information Instruments Required for VFR and IFR Flights

➢ **VFR:**
▪ Airspeed indicator.
▪ Altimeter.
▪ Magnetic direction indicator.
▪ Tachometer for each engine.
▪ Oil pressure gauge for each engine using pressure system.
▪ Temperature gauge for each liquid-cooled engine.
▪ Oil temperature gauge for each air-cooled engine.
▪ Manifold pressure gauge for each altitude engine.
▪ Fuel gauge indicating the quantity of fuel in each tank.
▪ Landing gear position indicator, if the aircraft has a retractable landing gear.
➢ **IFR – The above equipment plus:**
▪ Two-way radio communications system and navigational equipment appropriate to the ground facilities to be used.
▪ Gyroscopic rate-of-turn indicator except on aircraft with a third attitude instrument system usable through attitudes of 360 degrees of pitch and roll (rotorcraft: 80 degrees of pitch and 120 degrees of roll).
▪ Slip-skid indicator.
▪ Sensitive altimeter adjustable for barometric pressure.
▪ Clock displaying hours, minutes, and seconds with a sweep second-pointer or digital presentation.
▪ Gyroscopic pitch and bank indicator (artificial horizon.
▪ Gyroscopic direction indicator (directional gyro or equivalent).

The evaluation methods allow a summary of the percentage of information factors covered by systems as well as an evaluation of the appropriateness of the covered information. It is useful to report this separately for each category of information factors. The summary of the findings for all systems evaluated is presented in Table 10.

Table 10. Summary of Priority Checklist Evaluations

	AVIATE		NAVIGATE		COMMUN-ICATE		MANAGE SYSTEMS		All w/o Wx	All w/ Wx
System	**% Cover**	**Eval**	**% Cover**	**Eval**	**% Cover**	**Eval**	**% Cover**	**Eval**	**% Cover**	**% Cover**
FAR – VFR	40%	Not Covered	0%	Not Covered	0%	Not Covered	38%	Not Covered	17%	10%
FAR – IFR	80%	Pass	0%	Not Covered	20%	Not Covered	38%	Not Covered	29%	17%
Portable GPS w/ moving map	20%	Not Covered	63%	Pass	60%	Pass	0%	Not Covered	41%	24%
Electronic Flight Bag	40%	Not Covered	79%	Pass	60%	Low Access	0%	Not Covered	53%	31%
Panel Mount GPS/COMM/NAV	20%	Not Covered	79%	Pass	80%	Pass	25%	Not Covered	54%	32%
Flight Management System	100%	Pass	100%	Pass	100%	Pass	100%	Pass	100%	59%

It is interesting to observe that none of the categories of information factors (including Aviate!) is judged covered by the minimum instruments required for VFR flight. This makes it clear why these rules are for *visual* flight. A considerable amount of information needed for flight must be obtained in other ways. With no attitude instruments, even keeping an airplane straight and level relies on visual information. Instruments required for VFR flight account for 17% of the Information Factors evaluated (10% if Weather Factors are included).

Minimal IFR instruments at least provide a passing amount of information for Aviate Factors, but other aspects of flight require information from other sources. Minimal IFR instrumentation supplies 29% of the Information Factors (17% if Weather is included).

A basic handheld GPS unit (purchased in 1994) with a moving map display provides a reasonable amount of information in the Navigate and Communicate Categories. Obviously this unit is intended for use in aircraft with other instruments appropriate to the flight rules governing flights. The unit covered 41% of the evaluated Information Factors (24% if Weather is included, and this unit has no provision for presenting weather information).

The more sophisticated systems (the Electronic Flight Bag [EFB] and the Panel Mount unit) cover correspondingly more information, 53-54% of the Information Factors evaluated and 31-32% when weather is included. These units do have provision for weather information display so at least some part of the Weather Factors can be expected to be covered, but their accessibility cannot be assessed until the displays are available.

The scoring scheme did lead to the judgment of "Low Access" for the Communicate Factors in the EFB. This means that needed information is not as readily available as would be desired. Of course there are several individual Factors that do not show appropriate access. This information is available in the detailed evaluation sheets.

Finally, the flight management system (FMS) examined measured up extremely well in the evaluation. All of the individual factors were present, and passing scores were attained overall. There were several instances of Clutter and Low access in the individual factors, and some of the categories were deficient. Such factors should be considered in the design and evaluation of the system. Extensive Clutter was noted in Aviate Factors in Ground Operations. This evaluation may be a minor problem because the Aviate Factors are not generally relevant on the ground, and there is usually ample time to locate needed information. However, the presence of excessive clutter could also be taken to mean that there is some screen real estate that could be used for other functions more relevant to ground operations (such as displays of taxi ways and taxi procedures). Thus, noting clutter can be helpful in thinking about the way to design systems. There was also one instance in which a Low Access evaluation was reached in the FMS – in Communicate Factors in the Departure/Arrival Flight Operations. This evlauation suggests that needed communications information should be easier to get to than it is in these safety critical phases of flight.

Summary and Future Directions

The evaluation methodology appears to meet the goals established at the outset. It provides an analysis of what information is covered by an information system, what is missing, and the appropriateness of the accessibility of each information factor. The overall evaluations will likely need some fine-tuning with more experience evaluating systems, but the initial results are encouraging. It should be emphasized that several additional human factors considerations should be evaluated in addition to the priority evaluation developed here. It would be useful to integrate these various human factors aspects into a single evaluation instrument. This goal should be pursued in further research and development.

Although the purpose of this project was to develop a tool to assist in certification of information systems, it is clear that the tool should be of value in the design of such systems as well. Naturally, designing a system to pass as many information factors as possible should enhance the utility and usability of the system. Because the goal is to promote pilot performance, pilot awareness, and aviation safety, tools such as this one should be made available to designers early in the design process. With proper methods of feedback from system designers and users, the tool could be refined to produce accurate and comprehensive guidelines for establishing access to flight-related information. We hope this report facilitates such a development process.

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Appendix A. Checksheet and Detailed Applications

Appendix A can be found in file: AppendixA.xls