

# Human Factors-HWG Interim Report

## 1 April 2001



**HF-HWG**  
Human Factors-Harmonization Working Group  
Flight Crew Error / Flight Crew Performance  
Considerations in the  
Flight Deck Certification Process  
Federal Aviation Administration – USA  
Joint Aviation Authorities – Europe



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*The Human Factors HWG dedicates this report to the memory of Eric Fiore, a Bombardier Aerospace test pilot and dedicated member of this Group who died as the result of a tragic flight test accident in November 2000. Eric's extensive knowledge, professional commitment and enthusiasm helped us to focus on those human factors issues that will improve safety for all pilots, as well as passengers, in the future. He will be greatly missed both as a colleague and a much-appreciated friend.*

## Executive Summary

The Human Factors Harmonization Working Group (HF HWG) was created in August 1999 per the tasking published in Federal Register, July 22, 1999.

The tasking can be summarized as follows:

- Review the relevant existing FAA/JAA 25 rules and regulatory material applicable to flight deck design, to determine their adequacy to consistently address design-related flight crew performance vulnerabilities and the prevention and management of flight crew errors.
- Based on this review, recommend the updating of existing rules and advisory material or development of new rules, new advisory materials and the associated implementation plan.
- As work progresses, identify implications for qualifications and operations to be communicated to and addressed by other appropriate groups.

The group first met in October 1999. It was constituted in such a way as to intentionally balance the various types of expertise needed by the group (human factors, piloting, aircraft design, certification, rulemaking...) as well as the national and organizational (North America vs. JAA nations, authorities vs. industry) ties of the members. Today the group consists of 40 members who meet on a quarterly basis, usually alternating between North American and European locations. To date, six meetings have been held.

After developing the work plan and having it approved by TAIEG, the group defined its working method:

1. First, the HF HWG needed to define the material to be reviewed as instructed by the Aviation Rulemaking Advisory Committee (ARAC) tasking. A subgroup (A) was tasked to provide the list of regulatory material to be reviewed.
2. Second, the HF HWG decided to employ two different but complementary approaches to identify deficiencies in the rules.
  - The first approach consisted of a direct review of the regulatory material by using a carefully constructed list of human factors topics to examine each component of the rules and associated advisory documents to determine if the topics were consistently addressed or not, and why (or why not).
  - The second approach was experience based. It started from a collection of data describing either human performance problems (e.g., accidents or incident reports, experience of airline pilots or test pilots) or actual instances in which certification experts could not find regulatory material with which to address an obvious human factors design issue. This approach enabled the group to find data driven evidence of "holes in the regulations."
3. Third, starting from an integrated list of the deficiencies identified by both approaches, the Group will use predefined criteria to derive recommendations for developing or updating relevant Part 25 rules and advisory material. These criteria will evaluate the safety benefit as well as the expected acceptance and efficiency of these recommendations and will indicate priority of implementation.

If needed, the Group will also issue recommendations for additional work that should be carried out on non-Part 25 rules.

Contacts with other HWGs have been made to coordinate major human factors concerns and results relevant to their assigned activities.

The HF HWG believes that it will have thoroughly and extensively analyzed both current regulations and the operational record within the scope of its tasking, while taking into account the latest scientific knowledge about human performance. The current progress of the Group is such that the scope is defined, the criteria to apply to the identified deficiencies are prepared, and the two complementary analyses are almost completed. These results should be integrated into a common product by summer 2001 thus enabling the Group to begin developing recommendations in time to meet the schedule as prescribed in the TORs.

The nature and extent of such recommendations may require additional time beyond the 3-year charter depending on the level of detail which the TAEIG and the HF HWG decide to pursue.

## Definition of terms and abbreviations

AC	Advisory Circular
ACJ	Advisory Circular Joint
AMJ	Advisory Material Joint
ARAC	Aviation Rulemaking Advisory Committee
CAST	Commercial Aviation Safety Team
DRG	Document Review Group
FAA	Federal Aviation Administration
HF HWG	Human Factors Harmonization Working Group
HPC	Human Performance Considerations
JAA	Joint Aviation Authorities – Europe
JSAT	Joint Safety Advisory Team
JSIT	Joint Safety Implementation Team
JSSI	Joint Safety Strategy Initiative
STC	Supplemental Type Certificate
TAEIG	Transport Airplane and Engine Issues Group
TOR	Terms of Reference

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# 1 Introduction

**The aim of this interim report is to communicate the progress, the challenges and the initial findings of the Human Factors Harmonization Working Group to the TAEIG.**

Accident statistics cite flight crew error as a primary contributor in over 60 percent of accidents involving transport category airplanes. These statistics remain consistent across accident categories that have been recently examined, such as controlled flight into terrain, loss of control, etc. The vulnerability of the aviation system to flight crew performance, especially flight crew error, is expected to increase due to a number of factors, including increased traffic and the growing diversity of cultures operating aircraft worldwide. However, it is important to look behind the label of flight crew error to find the contributing factors that may have led the flight crew to make errors, miss the detection of errors, or recover late from errors that have safety consequences. Contributing factors can often be -- and have been -- identified from design, qualification, operations (e.g., procedures, maintenance), or other areas. The work described in this document primarily addresses the factors related to flight deck design.

## 1.1 Tasking

This ARAC tasking was initiated because the FARs or JARs that currently address this safety issue through design certification may be inadequate or out of date.

In the Terms of Reference from the TAEIG the Human Factors Harmonization Working Group (HF HWG) has been tasked with the following:

**Step 1.** Review relevant existing material (FAR/JAR 25 regulations, advisory material, policy, and related references) and make recommendations about what regulatory standards and/or advisory material should be updated or developed to consistently address design-related flight crew performance vulnerabilities, and prevention and management (detection, tolerance, and recovery) of flight crew error. This review should be accomplished in the context of both the Type Certification and Supplemental Type Certification processes.

**Step 2.** Based on results of the Task 1 review, recommend new advisory material to address design-related vulnerabilities of flight crew performance and the management of flight crew error.

**Step 3.** Recommend (or plan for the development of) new regulatory material to address design-related vulnerabilities of flight crew performance and the management of flight crew error. If rulemaking is not recommended, provide reasons and propose non-rulemaking alternatives.

**Step 4.** Recommend an implementation plan for products of Steps 1–3, and develop Terms of Reference for fulfilling the plan.

**Step 5.** During accomplishment of these tasks, identify implications for qualification and operations for communication to appropriate groups.

## 1.2 Criteria for group composition

The HF HWG is composed of technical experts having an interest in the assigned task. The co-chairs and FAA & JAA focal points have taken special care to ensure that a balance is

maintained among members. Every effort possible was made to balance the membership with respect to the following:

- Industry and Regulatory Authorities
- Human Factors expertise
- Pilots
- Aircraft certification expertise
- Flight deck design expertise
- N. American and European and other representatives

As explained below, the same care was taken when constituting working subgroups. The HF HWG members are listed in Appendix A.

## 2 History of Meetings

Six meetings have been held to date. Following is a short description of the meeting results.

Meeting 1 was held October 1999. The HF HWG processes were established, and the ARAC TORs were reviewed and discussed for clarity of meaning. Relevant issues for each task were documented.

Meeting 2 was held January 2000. There were detailed discussions of the HF HWG tasking with respect to the Statement of Work. Temporary subgroups were formed to define the processes to be used to perform Step 1 and to recommend the scope of the review. As a result, four subgroups were formed to discuss and provide proposals for the following subject areas:

- Subgroup A: Identify FAA/JAA regulatory/guidance materials to be reviewed
- Subgroup B: Develop and test (validate) a set of theory-based processes and topics to use in reviewing the materials defined by Subgroup A.
- Subgroup C: Develop and test (validate) a set of experience-based processes and topics to use in reviewing a collection of actual cases or experience-based documents.
- Subgroup D: Develop a set of criteria that will guarantee the adequacy and efficiency of our final recommendations.

Meeting 3 was held April 2000. Most of the meeting was spent in subgroup working sessions and presentation of their reports. The following agreements were reached:

- Subgroup A would be dissolved when the review list is complete (prior to next meeting)
- Subgroup D would be dissolved when the process and criteria details are completed (prior to next meeting), but would reconvene to deal with any subsequent process or criteria issues.
- The concept-based and experience-based processes (from Subgroups B and C) would be run in parallel. The differences in the approaches are likely to yield different but complementary insights and will assure that our review is comprehensive and complete. Subgroup A and D members will be reassigned to B and C.

The 4<sup>th</sup> meeting was held June 2000, and the 5<sup>th</sup> meeting was held October 2000. Most of the meetings were spent in subgroup working sessions enabling the subgroups to conduct detailed reviews. At the 5<sup>th</sup> meeting an integration team was tasked to facilitate the process of integrating the outputs from Subgroups B and C in preparation for making the team recommendations.

Meeting 6 was held Jan 2001. Most of the meeting was spent in subgroup working sessions. The goal of the meeting was to complete the regulatory review and experience-based compilation of information and to obtain HF HWG agreement on the integration process. The

Integration Group further defined how the results of the two subgroups would be combined so that the criteria process could be applied to make recommendations for the final HF-HWG report. The HF HWG agreed that the proposed integration process was ready for "beta" testing; a "beta" test team was formed and tasked.

## **3 Working Method**

### **3.1 Communication Process**

The HF HWG has made use of a resource web site to document its work. Research Integrations, Inc. (Tempe, AZ, USA) hosts and administers this site. There is an area for public information on the site, e.g.:

- Quarterly status reports
- Names of members
- Publicly available information about our tasks (Federal Register Announcement)
- Points of contact information

The remainder of the website is password protected for use by the HF HWG members.

The HF HWG meets approximately every three months, alternately between Europe and the North America to the greatest extent practicable (2 meetings in the N. America, and 2 meetings in Europe each year).

### **3.2 Compliance with ARAC Procedures**

The HF HWG is in compliance with the procedures adopted by ARAC Operating Procedures for the Aviation Rulemaking Advisory Committee, October 1997 Revision and the harmonization procedures adopted by the JAA and FAA. As part of the procedures, the working group is expected to:

1. Recommend a work plan for completion of the task, including the rationale supporting such a plan, for consideration at the meeting of ARAC held following publication of Federal Register notice.
2. Give a detailed conceptual presentation of the proposed recommendations, prior to proceeding with the work stated in task 3.
3. Draft recommendations for appropriate regulatory action with supporting economic and other required analyses, and/or any other related guidance material or collateral documents the working group determines to be appropriate; or, if new or revised requirements or compliance methods are not recommended, a draft report stating the rationale for not making such recommendations. If the resulting recommendation is one or more notices of proposed rulemaking (NPRM) published by the FAA, the FAA may ask ARAC to recommend disposition of any substantive comments the FAA receives.
4. Provide a status report at each meeting of ARAC held to consider transport airplane and engine issues.

### **3.3 Development of Subgroups**

Through the end of the 1<sup>st</sup> quarter of 2000, the HF HWG focused on:

- Organizing the working group
- Familiarizing members with the task and processes (including communication plan and the web site)
- Developing a work plan.

- With respect to the work plan (through the end of the 1<sup>st</sup> quarter of 2000) the HF HWG has focused on Step 1<sup>1</sup> and the development of a process for reviewing the regulatory material. To work effectively, the HF HWG was split into 4 subgroups (A, B, C and D) to address the various aspects of task 1 (see Figure1) :
- Subgroup A: Materials to be reviewed
- Subgroup B: Top-down/Concept-based process for reviewing the regulatory material
- Subgroup C: Bottom-up/Case-based process for reviewing the regulatory material
- Subgroup D: Criteria for assessing the expected success of the product(s) of the working group

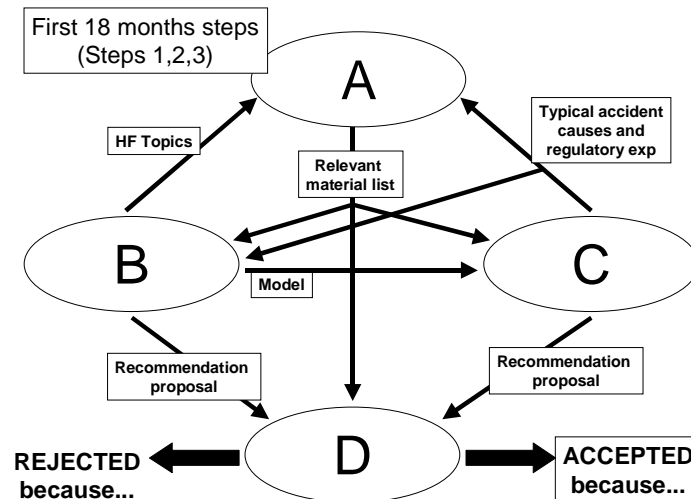


Figure 1: Initial model of Steps 1, 2 and 3 and the four processes developed by subgroup A, B, C and D.

Because the two approaches taken by Subgroup B and Subgroup C had to stay independent to remain effectively as exhaustive and complementary as possible, a need to create a process to integrate their outcomes arose. An Integration team was created for this purpose.

In conclusion the efforts of the HF HWG have been focused on:

- Setting-up the working group
- Familiarization with the task and processes (including communication plan and the web-site)
- Development of the work plan.
- Selecting the material to be reviewed
- Reviewing the regulations for "generic" inadequacies in the regulations and advisory material.
- Reviewing accidents, incidents and certification practice for "evidenced" holes or inadequacies in the regulations and advisory material.
- Integrating the results of these two reviews.
- Developing an analytic approach for processing the outcomes of the reviews.

<sup>1</sup> Review relevant existing material (FAR/JAR 25 regulations, advisory material, policy, and related references) and make recommendations about what regulatory standards and/or advisory material should be updated to consistently address design-related flight crew performance vulnerabilities, and prevention and management (detection, tolerance, and recovery) of flight crew error.

## 4 Subgroup A Activities

### 4.1 Objective

The task of Subgroup A was to identify, assemble, and make available to the entire HF HWG all the relevant FAR/JAR 25 regulations, advisory material, policy, and related references from both the FAA and JAA for analysis by Subgroups B and C.

### 4.2 Assumptions

- The material to be identified shall be relevant to FAR/JAR 25 and should be accomplished in the context of both the Type Certification and Supplemental Type Certification processes.
- When identifying material to be included in the review, Subgroup A should err on the side of being more inclusive. The review conducted by Subgroups B and C will be more detailed and better able to determine which documents are applicable to their specific tasks.
- The bulk of Subgroup A's task must be completed before Subgroups B and C will be able to conduct their review of the documents.
- Due to the international nature of the group, an effective means of communicating among the subgroup is e-mail and an effective means for the subgroup to communicate with the entire working group is via the HF HWG web site.

### 4.3 Background

Subgroup A was comprised of members who were familiar either with the regulations and guidance material of the FAA, with the regulations and guidance material of the JAA, or previous work identifying regulation and advisory material related to human factors issues.

### 4.4 Process

Subgroup A responded to the task of identifying, assembling, and making available to the entire working group all the relevant regulations and guidance documents from both the FAA and JAA for analysis by Subgroups B and C. The regulations that were considered were FAR Part 25 and JAR25 at Change 15. The guidance material considered were FAA Advisory Circulars of the 20, 25, and 120/121 Series, and JAA Advisory Circulars of the 25 Series. Subgroup A accomplished this by performing the following tasks:

- Identify FAA regulations and guidance material
- Identify JAA regulations and guidance material
- Make the recommended material available to entire working group

These steps are described in the subsequent paragraphs.

#### 4.4.1 *Identify FAA Regulations and Guidance Material*

To identify potentially relevant FAA regulations and guidance for the HF HWG's review task, Subgroup A built upon work performed as part of an ongoing FAA funded research project. The FAA funded research project is developing the FAA Aircraft Certification Job Aid for Flight Deck Human Factors. As part of this project, a set of Human Performance Considerations (HPCs) was developed to categorize Part 25 FARs and related Advisory Circulars (ACs) based on human factors and human performance literature. Part 25 FAR sections and related ACs were then reviewed thoroughly to identify excerpts that relate to the HPCs. Each excerpt and the associated HPC(s) were then recorded in a database. One result of this effort was a list of Part 25 FARs and related ACs that were identified as potentially addressing human

performance. Subgroup A recommended that the Part 25 FARs and ACs included on this listing be included in the HF HWG's review.

To supplement the list of potentially relevant ACs generated as part of the previously described process, each of the subgroup members reviewed a list of all the ACs of the 20, 25, and 120/121 Series and came to a consensus about which additional ACs should be recommended.

#### **4.4.2 Identify JAA Regulations and Guidance Material**

To identify potentially relevant JAA regulations and guidance for the HF HWG's review task, the JAA members of the subgroup conducted a review to select potentially relevant material. The process used for selection was to read the text of each of the JAR-25 regulations, ACJs and AMJs and to categorize them as rejected or candidate (i.e., not rejected) according to the following criteria:

Material was categorized as "rejected" if it dealt only with the following:

- System concern (e.g., component, performance, mechanical and flight tests, ...)
- Structure
- Weight
- Flight tests techniques
- Training
- Maintenance
- Cabin issues
- Manual (except AFM)
- Operation
- General aviation
- Not JAR25 (applicable for ACJs only)

Other material was categorized as "candidate".

This categorization method allowed the subgroup to provide justification for the rejection or selection of each of the JAR-25 regulations, ACJs and AMJs. The material classified as "candidate" was then recommended by Subgroup A for review by the HF HWG.

#### **4.4.3 Make recommended material available to entire working group**

As the regulations and guidance material to be reviewed were identified, they were converted into an appropriate electronic format and posted on the HF HWG's web site.

## **4.5 Results**

The following types of documents were identified as relevant to the working group's task and were made available on the HF HWG web site:

- Part 25 FARs (133 regulations and 3 appendices) at amendment 87
- FAA Advisory Circulars (AC) - 20 series (19 ACs)
- FAA Advisory Circulars (AC) - 25 series (22 ACs)
- FAA Advisory Circulars (AC) - 120/121 series (10 ACs)
- JAR-25 (136 regulations) at change 15
- JAA Advisory Circulars (ACJ) 25 series (108 ACJs)
- Temporary Guidance Leaflets (TGL) 25 series (10 TGLs)

## **4.6 Conclusion**

Subgroup A has successfully completed its task, and the members have been absorbed into Subgroups B and C to continue the work of the HF HWG.

## 5 Subgroup B Activities

### 5.1 Objective

The objective of Subgroup B was to assess the adequacy of the Part 25 regulations and advisory material with regard to established human factors knowledge (i.e. topics).

The tasks of the subgroup were to:

- Develop the human factors topics to use for the review,
- Develop the process for reviewing the documents for deficiencies,
- Review the documents using the process,
- Analyze the review data and define subgroup results of deficiencies in specific documents and general deficiencies across the documents, and
- Communicate the subgroup results to the rest of the HF HWG.

### 5.2 Process

This section describes how Subgroup B accomplished each of the five tasks.

#### 5.2.1 Human Factors Topics

The human factors topics to use in the review process were developed by the full subgroup. The development was guided by a conceptual model of human/system interaction (see Appendix B) to ensure that the group of topics was inclusive of all known human factors considerations related to flight deck design. The topics each describe some type of information that may be useful to include in regulations and advisory material documents. The topics are organized into seven categories: Information, Controls, Means to Communicate, Human/Machine Integration, Pilot Characteristics, Flight Deck Environment, and External Environment. A table presenting all the topics, their definitions, and review questions is included in Appendix C.

#### 5.2.2 Review Process for Regulations and Advisory Material

The review process was developed to produce:

- A systematic review of the regulations and guidance material determined to be appropriate (based on the suggestions of Subgroup A) and
- A determination of the human factors related deficiencies of the regulations and guidance material based on the human factors topics.

The process was developed to review the large volume of documents (regulation and advisory material) as efficiently as possible. The subgroup selected a Process Coordinator to oversee the process and decided to conduct the detailed review work using five document review groups (DRGs). Each DRG was made up of a DRG coordinator and three other members. Membership to the DRGs was assigned by balancing expertise (regulator, human factors, flight operations, and industry design). Each DRG was assigned a set of regulations and advisory material to review.

The regulations under a Subpart were assigned to a group so that the review could be done for the inadequacies in the set if necessary rather than in a specific section or paragraph. The advisory material related to each of the regulation subparts was assigned to the same DRGs. The regulations and advisory material reviewed by each DRG is included in Appendix D. For each set of regulations the DRG determined how adequately each of the HF Topics are addressed by entering a mark and comments in the appropriate cell of a matrix in an Microsoft Excel file. The DRG members were encouraged to include comments related to all of their adequacy assessments. After the DRGs completed their reviews the results were reviewed by the full subgroup and integrated into a set of subgroup findings about the

deficiencies in specific regulations and general deficiencies for particular human factors topics.

### 5.3 Results

Subgroup B is finishing the extensive review of the material and no preliminary result or finding is available at this time. The results from subgroup B will be ready after the April 3-5, 2001 Brighton meeting to be integrated with the results of Subgroup C.

## 6 Subgroup C Activities

### 6.1 Objective

The objective of Subgroup C was to take a data driven, experienced based approach at identifying human performance design related deficiencies within and across the Part 25 regulatory material. The subgroup was tasked with reviewing a set of published reports that document analyses of accidents, incidents, and safety related events and research studies (See Appendix E). To supplement this literature, the subgroup was also tasked with reviewing experience-based items from the manufacturers' databases; in-flight operational experience collected from airline pilots and test pilots; and regulatory experience compiled from various certification projects. The list of issues compiled from these published and unpublished sources was used to identify deficiencies of the regulatory material. This approach ensures that the resulting list of deficiencies addresses issues that have been documented in the literature, experienced in the field and derived from research. Furthermore, it ensures the final recommendations are data driven.

### 6.2 Assumptions

The review was intended to be representative rather than exhaustive. Additionally, since some reports presented an analysis of accidents and incidents and summarized their findings, the subgroup used these summaries. The subgroup assumed it was not necessary to duplicate the analysis of the accidents or incidents.

### 6.3 Background

The process used by Subgroup C is based on the philosophy that any new endeavor should build upon the previously documented work and lessons learned. Thus, Subgroup C started out by reviewing the literature and gathering experience-based data from industry and regulatory experts. This approach was taken in order to ensure that any deficiencies identified would be data driven and objective. Additionally, this method served as a check against the approach taken by Subgroup B, since it is possible that an individual line-by-line review of the regulatory material may overlook elements that are missing rather than inadequate.

### 6.4 Process

The process included the following steps:

**STEP 1: Identify the list of sources.**

Identify a list of sources for obtaining relevant Part 25 human performance experience-based issues. Forty-five sources were reviewed including documents which summarized accident and incident data, research literature, experience-based items from the

manufacturers' databases, in-flight operational experience collected from airline pilots, test pilots and regulatory experience compiled from various certification projects (see Appendix E for a list of all sources reviewed).

**STEP 2: The Matrix.**

Relevant issues were entered into a spreadsheet, referred to as "the matrix." Data collected included, but were not limited to, a description of each human performance issue or scenario, potential consequences, related regulatory material, and the regulatory issue raised.

**STEP 3: The Filter.**

Issues that did not have a FAR/JAR 25 component were not entered into the matrix. The group was conservative and inclusive in its approach by keeping issues which could have a design solution to guard against the risk of not considering potentially useful data just because one solution could be training. All issues not related to human performance were screened out.

**STEP 4: Linking to the specific regulatory paragraphs.**

Since the ARAC working group task is to identify deficiencies within and across the FAR/JAR 25 regulatory material, issues were linked to the associated individual regulatory paragraphs.

**STEP 5: Linking to equipment types.**

A second methodology had to be used to link other types of experienced-based issues that were not easily linked to the equipment type-FARs; for example, issues associated with new technologies not specifically called out in the FARs, such as Global Positioning Systems (GPS).

**STEP 6: Identify Issue Categories.**

The matrix items were also classified by category. These categories are more general in nature, such as issues with a flight crew lack of situation awareness (see Appendix F). These general issues were linked, where possible, to specific regulations. Alternatively, some categories of issues could not be mapped back to specific regulatory material, and were flagged as a general deficiency across the regulatory material.

**STEP 7: Consolidation.**

Once the matrix data was complete, the next step in the Subgroup C process was organizing and consolidating the issues. This was critical since Subgroup C identified over 400 individual issues.

This step was necessary in order to attain the two key goals, to:

1. develop a list of deficiencies related to any given regulation or advisory document, section, or paragraph;
2. develop a list of particular human factors concerns that are not adequately addressed across the body of the regulations and advisory material.

## 6.5 Results

The working group has not yet developed major findings because the data in the matrix are still being analyzed. The results from Subgroup C will be ready to be integrated with the results of Subgroup B during the June meeting.

## 7 Subgroup D Activities

### 7.1 Objective

Subgroup D has developed a series of critical questions and success criteria and then placed them into a decision flow-chart. This flow chart is intended to enable the HF HWG to assess each subgroup's final product(s) and provide rationale for inclusion or rejection of HF HWG recommendations. The main objective is to focus the HF HWG output on effective safety improvements.

To help the HF HWG to focus its analytical effort on relevant issues, Subgroup D has to incorporate some of the criteria into the review processes being utilized by Subgroup C and by the whole HF HWG group after Subgroup B and C integration.

### 7.2 Assumptions

- The primary goal of the HF HWG is to increase the level of safety of aircraft. Therefore, the criteria should reflect that priority.
- The recommendations should focus on those changes that would be incorporated into FAR/JAR 25. However, other potential regulatory changes that would affect other FAR/JAR parts will be retained and provided as recommendations for other groups.
- In addition to having an effect on safety, recommendations should be feasible to implement and cost-effective. Therefore, the criteria should also reflect these considerations.
- Recommendations should be prioritized based on a combination of the factors listed above.

### 7.3 Background

The method used to define the best criteria was based on the review of the literature and expertise of the Subgroup D members. The evaluation criteria are based on the expected safety improvement which will result from the modifications introduced by the HF HWG, as well as the feasibility of the recommendations, based on technical issues, cost-effectiveness, and the expected level of acceptance by both the regulatory authorities and industry. The prioritization of the recommendations will be based on the methodology developed by the Safer Skies JSAT/JSIT/JSSI processes, which already use an accepted prioritization methodology for CAST regulation recommendations. This process, which will be modified as needed to fit the HF HWG task, uses expert judgment to evaluate recommendations against a set of rating scales, which are then combined partly through the use of a mathematical algorithm. This process will be presented to the HF HWG at the April 2001 meeting for comment and approval.

### 7.4 Process

The criteria are presented in a flow chart (Figure 2) to help the analyst address them. The criteria are specified in three main categories and are adapted to the specifics of the Subgroup B and C requirements: Subgroup B is considered more concept oriented, and Subgroup C is considered more experience oriented. The criteria fall into three main categories:

1. Safety aspects (related to Steps 1, 2, 3 of the Tasking and considered the most important criteria)
2. Effects on industry (related to Steps 2 and 3)
3. Industry/authority Acceptance (related to Steps 2 and 3)

The criteria will be applied in three different and sequential steps within the HF HWG activity.

- **First step (during task1):**  
Apply the *filter function*, to the integrated Subgroup C matrix. This filter was applied during the collection and collation of the data. The purpose was to identify the relevant (and consolidated) data, retaining an audit trail of the data that were eliminated.
- **Second step (during task 1):**  
Apply the *filter function to the regulation-based and topic-based findings*, after integration of Subgroup B and Subgroup C data.
- **Third step (during tasks 2 & 3) :**  
Apply a *prioritization function* to the recommendations. This would be based on the ratio between the amount of effort necessary to implement a recommendation and the expected effectiveness of that recommendation if it could be achieved.

In order to help the analyst(s) to use the criteria, the criteria are presented as a list of questions to be discussed, instead of a list of terms, or some other forms.

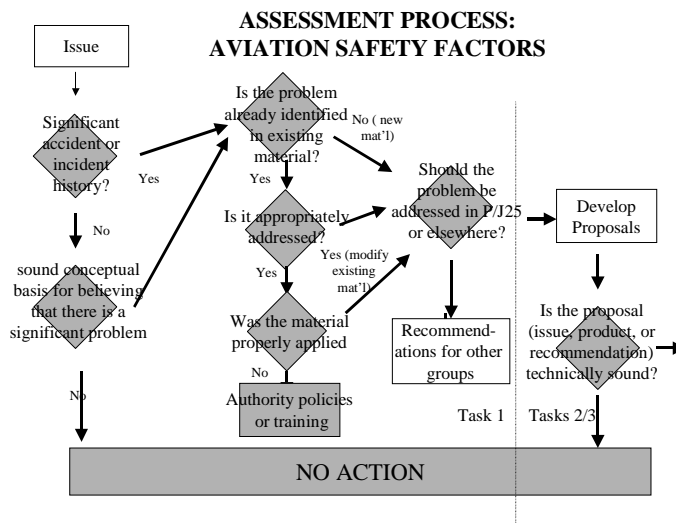


Figure 2: Initial version of the flow-chart developed by Subgroup D

## 7.5 Results

### 7.5.1 The criteria related to Step 1 of the Tasking are:

**Aviation Safety:** These factors are to be considered during Task 1 to assess the significance of any deficiencies in the rules and/or advisory material.

- **Concept-based criteria:**
  - Is the deficiency associated with current designs, or just older designs that are no longer in production? (utility for current design including retrofit STCs)
  - Is the regulatory deficiency associated with known future technology or operational concepts? (utility for future design)
  - Does the deficiency represent a significant gap, from a safety perspective? In other words, do we believe that the identified lack of coverage would allow realistic but hazardous designs to be approved? (impact for safety)

- *Experience-based criteria:*
  - Were flight deck design, pilot interaction, or flight crew performance a potential causal or contributing factor in the accident or incident? (human- flight deck design problem)
  - Is the accident or incident data well supported? (sound data)
  - Has the problem been evident in more than one incident? (coverage of the problem)
  - How severe were the incidents - how “close” were they to an accident? (impact for safety)

### 7.5.2 The criteria related to Steps 2 and 3 of the Tasking

**Aviation Safety:** These factors are to be considered during Tasks 2 and 3 to assess the expected effectiveness of any proposed changes to the rules and/or advisory material.

- *Concept-based criteria:*
  - Will the change significantly affect safety or just close a “conceptual gap” in the regulatory or guidance material?
  - Do we have reason to believe that unacceptable designs will be proposed unless this change is made?
- *Experience-based criteria:*
  - Does this change directly address the design-related problems identified from the accident/incident data?
  - If this change had been in place and enforced (with the resultant design changes), is it likely that the relevant accidents/incidents would still have happened?
- *General criteria:*
  - Are there any potential negative safety impacts of the proposed change (does it solve one problem but create another)? What is the expected overall safety impact?
  - Is the proposed change compatible with other proposed changes?

#### Effects on industry:

- Is the expected cost of compliance appropriate for the expected gain in safety?
- Is compliance technically reasonable?
- Will the proposed change significantly increase the time needed to develop and certify the airplanes?
- Is the proposal consistent with realistic assumptions about the aviation environment?
- Is the recommendation a performance standard, or is it a design specification that will interfere with desirable innovation or will prohibit acceptable alternative solutions?

#### Authority/industry acceptance:

- Can we reasonably expect the various certification authorities (airworthiness and operations) to agree upon this change?
- Can we expect strong resistance from manufacturers, due to cost, schedule, aircraft performance, design philosophy, or other competitive issues?
- Can we expect support from the pilot community?
- Can we expect strong resistance from airlines, due to cost, fleet commonality issues, operational philosophies, or competitive issues?

## 7.6 Conclusion

It has been acknowledged that the criteria and decision flow-chart may need to be updated by the overall HF HWG. As a consequence, Subgroup D will remain in place, while members can also take part in the FAR/JAR review process itself (e.g., Subgroups B or C).

## 8 Subgroup "Integration Team" Activities

### 8.1 Objective

Develop a process for integrating Subgroup B and C results into a form that can be used by the entire HF HWG to produce a single, comprehensive set of recommendations.

1. Recommend a scheme for organizing data into an integrated format.
2. Recommend an analysis process to apply Subgroup D criteria.
3. Propose how the HF HWG can best be organized to implement the scheme and conduct the final analysis.

### 8.2 Assumptions

- The technical products of Subgroups B and C have independent value; the purpose of the integration effort should be to add mutually supported value in the combination of products.
- The large number of individual items, particularly in the Subgroup C matrix, requires an efficient means of collecting similar items for consolidation, and for treating classes of items in analysis rather than individual items.
- The Subgroup D process will be used to evaluate items, classes of items, conclusions, and recommendations for relevance and validity.

### 8.3 Background

Subgroup B is in the process of completing a paragraph-by-paragraph analysis of the FARs, JARs, and advisory material. These data are organized by section and paragraph, where possible deficiencies with each paragraph are identified by associating them with human factors topics; where a topic is deemed relevant but insufficiently treated by the paragraph, a deficiency is noted. Potential broad deficiencies that exist across the regulations and advisory material may be discovered by assessing how well each human factors topic is treated overall. The paragraph-by-paragraph deficiencies are identified by reading across the rows of the matrix used by Subgroup B, and the broad deficiencies will be identified by reading down the columns.

Subgroup C is in the process of documenting a broad range of experience-based data, including incidents, accidents, and regulatory experiences. These data are contained in a matrix associating each experience item, described in a scenario, to potential consequences (in order to assess importance), pass/fail judgments, and related regulations and advisory material.

Given the disparate natures of the two subgroup products, the Integration Team task was to recommend a process for combining them into a manageable whole, in order to:

- Identify and remove redundant items;
- Consolidate items with similar focus to enable analytic treatment of classes of items rather than individual items;
- Develop a comprehensive view of deficiencies related to any given regulation or advisory document, section, or paragraph;
- Develop a comprehensive view of how well particular human factors concerns are treated across the body of the regulations and advisory material;
- Identify classes of items that may be more appropriately addressed by other Harmonization Working Groups;
- Determine whether items derived from subjective judgment or subjective conclusions based on experience have supporting basis in fact (determined by whether a class or collection of items contains both opinions and documented incidents or accidents supporting the opinions).

The recommended integration process is shown in Figure 3. Appendix G describes the intent of each box and the actions prescribed. The recommended process lays out a roadmap for the remainder of the HF HWG Activities, including specific technical steps to be taken and the internal organization and grouping required to support those steps.

## 8.4 Conclusion

It is believed that the recommended plan will help us organize the products coming out of Subgroups B and C to:

- Show a path to get to the tasks assigned in the TOR
- Consolidate items with similar focus to enable analytic treatment of classes of items rather than individual items; identify and remove redundant items;
- Develop a comprehensive view of deficiencies related to any given regulation or advisory document, section, or paragraph;
- Develop a comprehensive view of how well particular human factors concerns are treated across the body of the regulations and advisory material;
- Identify classes of items that may be more appropriately addressed by other HWGs;
- Determine whether items derived from subjective judgment or subjective conclusions based on experience have supporting basis in fact (determined by whether a class or collection of items contains both opinions and documented incidents or accidents supporting the opinions).

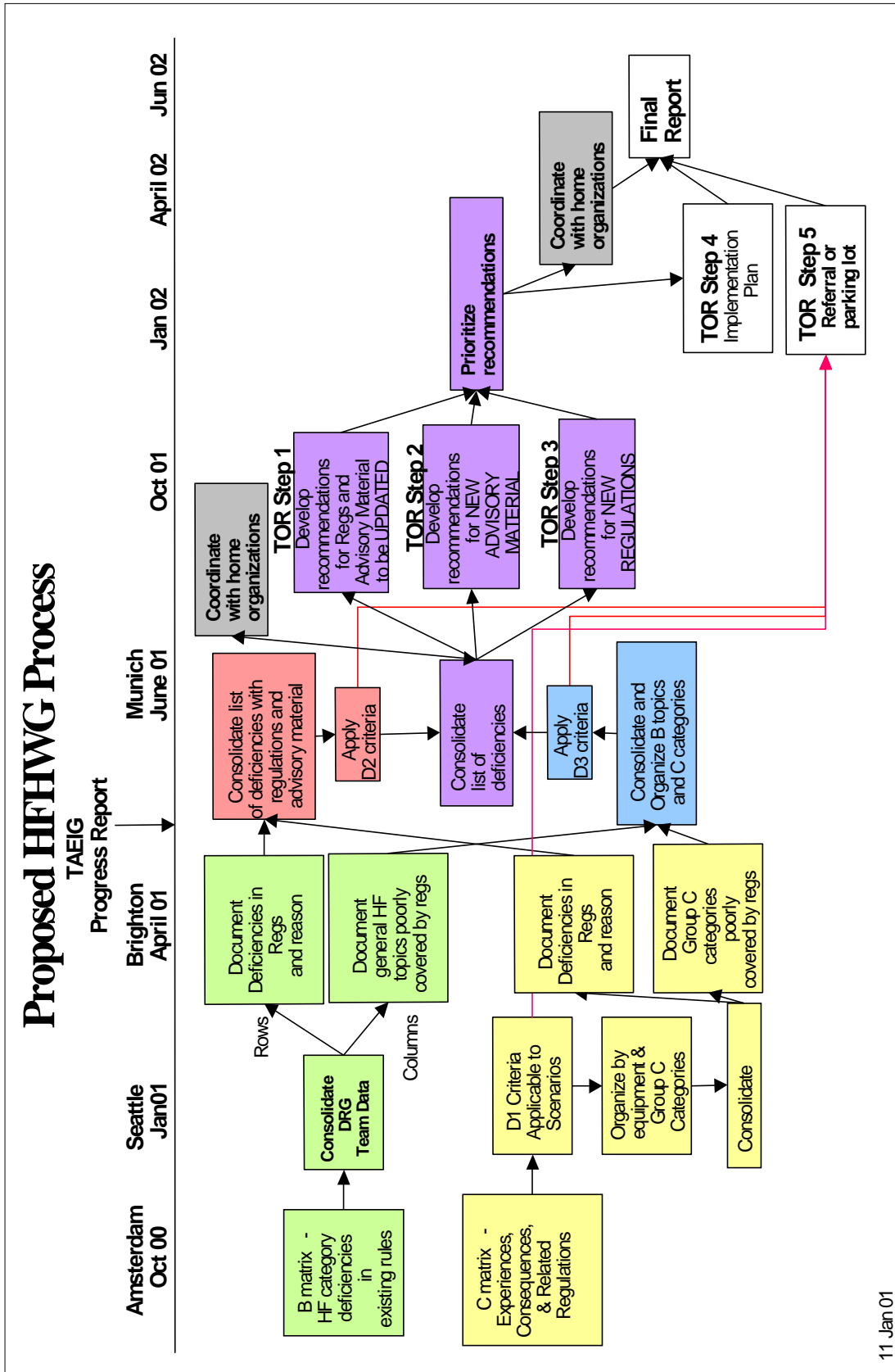


Figure 3: Recommended integration process

## 9 Lessons Learned

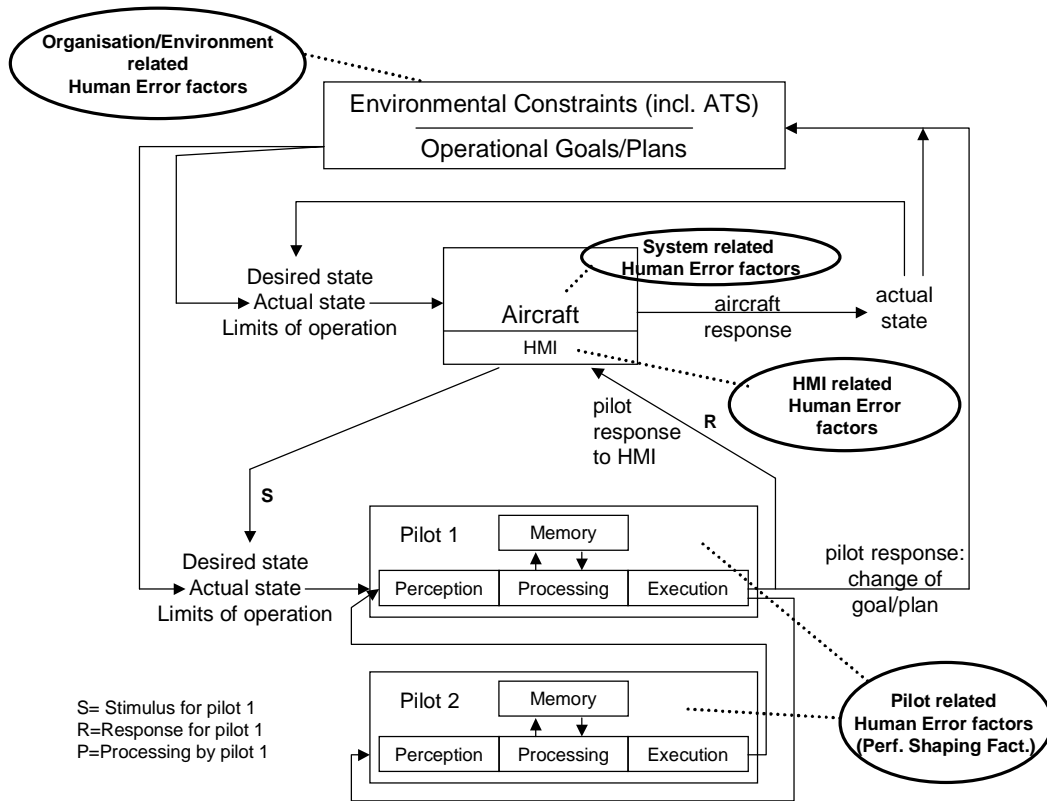
Addressing regulatory requirements for human factors issues requires multidisciplinary and cross-cultural expertise. The HF HWG's tasking is unique and much broader than usual for a HWG TOR and therefore required development of an innovative analytic process. The dual approach used by the HF HWG was required in order to be comprehensive, but was more challenging and time-consuming than originally anticipated. Crew error related to automated systems in Part 25 regulations cannot be readily addressed separately within current regulations due to their organization by equipment categories. It is very difficult to separate out "design induced" factors from "operational" factors (including training) in assessing accident/incident experience and developing effective remedies. Considerable effort is required from HF HWG members outside the quarterly meetings. The HF HWG web site has been helpful, but not sufficient, for assuring close communication and coordination among members. E-mailing of draft documents and analyses and telecons have compensated for this.

## Appendix A - Membership of Human Factors Harmonization Working Group

Name	Company
Abbott, Kathy FAA	
Armstrong, Don (alternate: Guy Thiel)	FAA, Flight test
Beaujard, Florence	EADS AIRBUS FRANCE
Birowo, Imam	Dornier
Bousquié, Jean-François	Airbus Industrie
Boyd, Stephen	FAA Transport Directorate
Bresley, Bill (alternate: Ann Berner)	Universal Avionics Aero Engineering
Carr, Tom	Raytheon Flight Test
Courteney, Hazel	CAA Safety reg grp
Deharvengt, Stéphane (alternate: Rémi Jouty)	SFACT
Donovan, Colleen	FAA AIR-130
Fabre, François	CEV/N.AT
Gagnon, Pierre	Bombardier Aerospace
Garloch, Julie	Rockwell Collins
Glover, Howard (alternate: Daryal Kuntmann)	Honeywell
Graeber, Curt	Boeing
Harris, Don	Cranfield University
Hecht, Sharon	FAA Transport Directorate
Hicks, Mark	SEA
Hollop, Christine	Boeing
Imrich, Tom	FAA, NRS Flt Ops
Jorna, Peter	NLR
Kelly, Brian (alternate: Jean Crane)	Boeing
Kimball, Ken	Cessna
Lawrence, Simon (alternate: Bill Best)	ALPA, US Air Capt.
Leard, Tom (alternate: Dave Pepitone)	Honeywell Inc.
Lyll, Beth	Research Integrations, Inc.
May, Doug (alternate: Eric Fiore)	Bombardier Aerospace
Newman, Terry	CAA Safety reg grp

Nibbelke, Rene	BAE Sow. Res. Ctr.
Proust, Jean-Michel	Air France
Reinhold, Svenja	Dornier
Reuzeau, Florence	EADS AIRBUS FRANCE
Riley, Vic	Honeywell
Ronceray, Didier	Airbus Industrie
Singer, Gideon (alternate: Dan Gurney)	SAAB →Dornier (British Aerospace)
Starr, Alison	Smiths Industries
Stephen, Don	Transport Canada
Strilesky, Paula	Capt. IFALPA

## Appendix B - Conceptual model of crew-system interaction



## Appendix C - Subgroup B topics list

Category	Topic	Definition	Review Question
Information	Tasks that require information	A description of the tasks that the pilots must perform that require information to be presented to them.	Does the document inadequately describe the tasks for which the pilots need the display of information?
	Information required for tasks	A description of the specific information required to be presented for each of the pilot tasks.	Does the document inadequately describe the information required to be displayed for each task?
	How information is to be presented	A description of any requirements for how the information is to be presented.	Does the document inadequately describe the requirements for the methods to be used for information presentation?
	When information is to be presented	A description of any requirements for when the information is to be presented.	Does the document inadequately describe the requirements for when information is to be presented?
	Accessibility requirements	A description of any requirements for access to the information.	Does the document inadequately describe requirements about how accessible the information is to be to the pilots?
	Attention capturing requirements	A description of any requirements for the information to capture the pilot's attention when it is presented.	Does the document inadequately describe the requirements for the information display to capture the attention of the pilot?
	Requirements for consistency with other displays	A description of any requirements for the information or display design to be consistent with other information or displays presented in the flight deck or other flight decks.	Does the document inadequately describe requirements that the display of information be consistent with other displays?
	Requirements for distinguishability from other displays	A description of any requirements for the information or display design to be distinguishable from the background of the display or from other information or displays presented in the flight deck.	Does the document inadequately describe requirements that the display of information be distinguishable from other displays?
	Required relationships with other displays	A description of any relationships between the information or display being addressed and any other information or displays in the flight deck that must be considered in the design.	Does the document inadequately describe requirements that the display has particular relationships with other displays?

Category	Topic	Definition	Review Question
Controls	Tasks that require controls	A description of the tasks that the pilots must perform that require controls to be available to them.	Does the document inadequately describe the tasks for which the pilots need the control to be available?
	When control must be available	A description of any requirements for when the control is to be available to the pilots.	Does the document inadequately describe the requirements for when the control is to be available?
	Accessibility requirements	A description of any requirements for access to the controls.	Does the document inadequately describe requirements about how accessible the control is to be to the pilots?
	Operability requirements	A description of any requirements for specific operability of the controls.	Does the document inadequately describe the operability requirements of the control?
	Consistency with other controls	A description of any requirements for the control design to be consistent with other controls available in the flight deck or other flight decks.	Does the document inadequately describe requirements that the control be consistent with other controls?
	Distinguishability from other controls	A description of any requirements for the control to be distinguishable from the background of the flight deck or from other controls available in the flight deck.	Does the document inadequately describe requirements that the control be distinguishable from other controls?
	Workload constraints	A description of any constraints on the pilot workload that may be induced in the use of the control that must be considered when designing the control.	Does the document inadequately describe requirements for the workload constraints associated with the design of the control?
	Error tolerances	A description of the error tolerances for the use of the control that must be considered when designing the control.	Does the document inadequately describe the requirements for the error tolerances associated with the design of the control?
	Relationships with other controls	A description of any relationships between control being addressed and any other controls in the flight deck that must be considered in the design.	Does the document inadequately describe requirements that the control has particular relationships with other controls?
Means to Communicate	Tasks that require means to communicate	A description of the tasks that the pilots must perform that require means to communicate to be available to them.	Does the document inadequately describe the tasks for which the pilots need the means to communicate to be available?

Category	Topic	Definition	Review Question
	When means to communicate must be available	A description of any requirements for when the means to communicate is to be available to the pilots.	Does the document inadequately describe the requirements for when the means to communicate is to be available?
Human/Machine Integration	Feedback information requirements	A description of any requirements for information to be presented to provide feedback when a control is activated or used by the pilots.	Does the document inadequately describe the information required to be displayed for feedback?
	When feedback is to be presented	A description of any requirements for when the feedback is to be available to the pilots.	Does the document inadequately describe the requirements for when feedback is to be presented?
	Display/control compatibility requirements	A description of any relationships between the displays or controls being addressed and any other controls or displays in the flight deck that must be considered in the design.	Does the document inadequately describe the requirements for compatibility between displays and controls?
Pilot Characteristics	Consistency with pilot expectations	A description of any requirements for the design to be consistent with pilot expectations of the population for which the design is targeted.	Does the document inadequately describe requirements for the design to be consistent with pilot expectations?
	Consistency with cultural expectations	A description of any requirements for the design to be consistent with pilot cultural expectations of the population for which the design is targeted.	Does the document inadequately describe requirements for the design to be consistent with cultural expectations?
	Pilot population characteristics that apply	A description of any requirements for considering applicable pilot characteristics of the population for which the design is targeted.	Does the document inadequately describe the pilot population characteristics that should be considered for the design?
	Pilot conditions that apply	A description of any requirements for considering possible pilot conditions (i.e. fatigue, high workload) during the design.	Does the document inadequately describe the pilot physical conditions that should be considered for the design?
Flight Deck Environment	Lighting requirements	A description of any requirements for the flight deck lighting that must be available when using the design and the effects of the ambient lighting conditions that are expected to be present during use.	Does the document inadequately describe the requirements for lighting conditions that should be considered for the design?

Category	Topic	Definition	Review Question
	Vibration limitations	A description of the requirements for considering the effects of vibration on the use of the design and the limitations of the extent to which vibration can be present.	Does the document inadequately describe the requirements for vibration conditions that should be considered for the design?
	Temperature limitations	A description of the requirements for considering the effects of the expected temperature range on the use of the design and the limitations of the extent to which extreme temperatures can be present.	Does the document inadequately describe the requirements for flight deck temperature conditions that should be considered for the design?
	Noise limitations	A description of the requirements for considering the effects of the expected noise range on the use of the design and the limitations of the extent to which noise can be present.	Does the document inadequately describe the requirements for noise conditions that should be considered for the design?
External Environment	Operational conditions that apply	A description of any requirements for considering expected operational conditions during the design.	Does the document inadequately describe the operational conditions that should be considered for the design?
	Environmental conditions that apply	A description of any requirements for considering expected environmental conditions during the design.	Does the document inadequately describe the environmental conditions that should be considered for the design?

**Appendix D - Documents reviewed by each DRG (Subgroup B)****DRG 1**

FAR/JAR 25 Subpart B – Flight  
FAR/JAR 25 Subpart C – Structure  
AC 20-133  
AC 25-13  
AC 25-15  
AC 25.253.1A

**DRG 2**

FAR/JAR 25 Subpart D – Design and  
Construction  
AC 20-34D  
AC 20-42C  
AC 20-99  
AC 25-7A  
AC 25-9A  
AC 25-14  
AC 25-16  
AC 25-20  
AC 25.672-1  
AC 25.703-1  
AC 25.773-1  
AC 25.783-1  
ACJ 25-777  
ACJ 25-785  
ACJ 25-851G

**DRG 3**

FAR/JAR 25 Subpart E – Powerplant  
AC 20-111  
AC 20-120  
AC 20-121A  
AC 20-129  
AC 20-138

**DRG 4**

FAR/JAR 25 Subpart F – Equipment  
AC 20-69  
AC 20-73  
AC 20-94  
AC 20-117  
AC 20-131A  
AC 20-134  
AC 20-141  
AC 25-11  
AC 25-12  
AC 25.1309-1A  
AC 25.1329-1A  
AC 25.1357-1  
AC 25.1419-1  
AC 25.1457-1A

**DRG 5**

FAR/JAR 25 Subpart G – Operating  
Limitations and Information  
FAR/JAR 25 Appendices  
AC 20-88A  
AC 20-130A  
AC 20-140  
AC 25-15  
AC 25.1523-1  
AC 25.1581-1

## Appendix E - Sources reviewed by Subgroup C

The following is a list of documents reviewed by Subgroup C.

Document Name or Source Type	Description of Information Content
1. Commercial Joint Safety Analysis Team Master Collector Document	Document produced by a team of Federal Aviation Administration and industry representatives tasked as part of the Safer Skies program to review incidents and accidents in specific areas. At the time the document was reviewed it included commercial aviation issues from the following JSATs: 1) CFIT and 2) Approach and Landing. It did not include data from the Turbulence JSAT, Loss of Control JSAT, or any General Aviation JSATS.
2. Federal Aviation Administration Human Factors Team Report on: The Interfaces Between Flight Crews and Modern Flight Deck Systems	Result of a study of the interfaces between flightcrew and the automated systems on highly automated airplanes produced by FAA and the European Joint Aviation Authorities, assisted by technical advisors from three universities.
3. Regulatory & Certification Experience	Issues that have come up during various certification and operational approval projects as reported by industry representatives or the aviation authorities.
4. In service experience (pilot experience & issues-regulatory & company pilots)	Issues collected from test pilots operational, in service experience.
5. Civil Aviation Publication (CAP) document 681: Global Fatal Accident Review 1980-1996	This document, published by the Civil Aviation Authority in March of 1998, summarises an analysis of 621 global fatal accidents to jet and turboprop aeroplanes above 5,700kg between 1980 and 1996 inclusive, which resulted in 16,849 fatalities. It highlights significant causal and circumstantial factors.
6. Final Report of RTCA Task Force 4 Certification (Feb. 26, 1999)	Report includes recommendations to the FAA and industry on issues typically experienced during certification and operational approvals as well as recommendations to help streamline the certification process to make it faster, cheaper, and better.
7. Airbus database	<ul style="list-style-type: none"> <li>• ISO: In Service Occurrence. Data base of Airbus In Service incidents.</li> <li>• Other Airbus incidents came from the Airbus web site.</li> <li>• The articles were Airbus Fast #23 (FAST is an AIRBUS magazine published by the Customers Support Department) Page 18-22 for Rain Repellent article. Page 10 for the elevator vibration article. Articles date 9/17/1998.</li> </ul>
8. Hangar Flying: Airbus Flight Safety Digest	This is a document (magazine) issued by the Airbus Flight Safety Department. It aims at enhancing flight safety through increased knowledge and improved communications and experience sharing.
9. Air France events + significant topics	
10. Killers in Aviation: Flight Safety Foundation (FSF) Task Force presents facts about Approach and Landing (ALAR) and Controlled Flight Into Terrain (CFIT) Accidents	This report was published by Flight Safety Foundation and presents facts about Approach and Landing (ALAR) and Controlled Flight Into Terrain Accidents (CFIT). Published Feb. 1999. Reports on commercial airplane accidents for Jet and Turboprop airplanes above 12,500 lbs. occurring between 1980-1996.

11. Aviation Safety Reporting System (ASRS) NASA Report Sets	Databases providing the 50 most recent relevant ASRS reports grouped by topic (i.e. TCAS Incidents, CRM Issues, Checklist Incidents and EGPWS Incidents). Review of selected topics relevant to Human Factors was conducted.
12. Joint Safety Strategy Initiative (JSSI) Future Hazards	Interim document produced by a team of international civil aviation authorities and industry representative as part of the JAA JSSI program. The Future Hazards method is being developed to provide solutions to hazards resulting from changes affecting the aviation system. Examples of such changes include Very Large Aeroplanes, 'virtual companies', new responsibilities for crew and privatization of tasks traditionally done by governments.
13. Research	ECOTTRIS (European Collaboration on transition training research for improved safety – EU DGVII 12.11.98) : Research centered around the transitions of pilots from conventional to more advanced cockpits. The main objective is to improve existing transition training procedures.
14. ICAO Circular 240-AN/144: Human Factors Digest #7 Investigation Of Human Factors Accidents And Incidents (1993)	This circular discusses the background and introduces a protocol for the investigation of human factors issues in accidents and incidents.
15. ICAO Circular 234-AN/142. Human Factors Digest # 5 Operational Implications of Automation in Advanced Technology Flight Decks (1992)	This digest introduces basic human factors considerations in the operations and training of advanced-technology flight deck aircraft.
16. ICAO Circular 276-AN/162: Accident/Incident Reporting (ADREP) Annual Statistics- 1998 -1999	This document contains detailed information for accident/incident reporting for the year 1998, preliminary data for the year 1999, and ten year trends from 1990 to 1999.
17. ICAO Circular 249-AN/149: Human Factors Digest #11 Human Factors in CNS/ATM Systems (1994): The development of human-centered automation and advanced technology in future aviation systems	This document includes analysis from experts contacted by the ICAO secretariat who reviewed recent and ongoing studies to identify Human Factors issues of relevance to ICAO CNS/ATM systems. It includes issues and concerns in CNS/ATM automation.
18. Advanced Technology Aircraft Safety Survey Report (Bureau of Air Safety Investigation (BASI) Report)	Report analyzing incidents, accidents, and the human factors literature published by the Department of Transport and Regional Development Bureau of Air Safety Investigation. Released by the Secretary of the Department of Transportation and Regional Development. Report produced by Bureau of Air Safety Investigation (BASI). June 1998 ISBN 0642 27456 8.
19. Boeing Accident Analysis	<ul style="list-style-type: none"> <li>• Includes data from a Boeing database.</li> <li>• Boeing articles were from the Boeing website called AERO. <ul style="list-style-type: none"> <li>• Erroneous instrument issue from #8. Date year 1999.</li> <li>• Erroneous takeoff ref speeds. Date 2000. Issue # 11.</li> </ul> </li> </ul>
20. Cultural issues (including Russian Reports)	No data in the matrix under this category. The Russian reports were not available.
21. FAA Administrator's Daily Bulletin	Typically a one to four page document produced for and by the FAA that comes out every day reporting aviation

	incidents and accidents
22. Air Transport Association Task Force: Flight Management System/Area Navigation (FMS/RNAV) Charts Database and Avionics Harmonization (CDAH) Working Group Report	Report produced by the ATA FMS/RNAV task force CDAH working group that contains a list of issues where there is a lack of harmonization between the paper charts and the avionics as well as recommendations to resolve those issues.
23. Manufacturers Newsletters (ex. Honeywell newsletter)	Flight Guidance document A320 Flight Management Guidance System (FMGS) was #97-3. Date 1997 alert # 3. This document identified an anomaly with the FMGS turning the wrong way in the holding pattern.
24. National Transportation Safety Board (NTSB) Summary Reports Recommendations	<ul style="list-style-type: none"> <li>• NTSB Accident Synopses from the NTSB database – by month. Used Database only. One reviewer (Don Stephen) used 1990 through 1994.</li> <li>• NTSB report entitled: WE ARE ALL SAFER: NTSB-Inspired Improvements in Transportation Safety.</li> </ul>
25. Airline Pilots Association (ALPA) Alert Bulletins	<p>ALPA Safety Alerts are issued from time to time by ALPA staff for all the pilot groups under ALPA. They are internal to ALPA.</p> <p>Ice accumulation items in the matrix were #94-5. Date was 1994 alert #5.</p> <p>ALPA Alert bulletin #97-3, dated 1997 was number 3 of that year and was an internal alert for all ALPA pilots.</p>
26. Propulsion System Malfunction + Inappropriate Crew Response (PSM & ICR) Report	AIA/AECMA Task Force Report 1999
27. Australian Reports	
28. Embraer data	Data from Embraer internal database de-sensitized and provided by Embraer representative.

## Appendix F - List of categories defined by Subgroup C

### Introduction

The categories described in this document were generated by members of the HF HWG Group C. The categories are used to classify the data base of accidents, incidents, regulator experience etc. generated by the Group C. These categories were generated by the process described below.

An initial set of categories was generated at the HF HWG held in Oct 2000 (Amsterdam). This was done by subgroups of Group C members reviewing and categorizing subsets of the draft Group C matrix of data. The category items generated were then combined and grouped into one list. This list (see B Summary List below) was then used to classify the items in the entire draft Group C matrix. The data was then subdivided into sub-matrices, one for each category or sub-category.

At the HF HWG meeting held in Seattle, in Jan 2001, sub-groups of members of Group C were formed. These sub-groups checked the categorization of the items. Where necessary items were allocated to different categories, or (where multiple factors were considered to arise from an item) the item was assigned to additional categories. Definitions of the categorization of sub-matrix items and route issues were identified for each categorization. These definitions are given below.

### Summary List

The list of categories used is presented below.

#### 1. Awareness

- 1.1 *Mode Awareness*
- 1.2 *Awareness of Traffic*
- 1.3 *Awareness of System Status*
- 1.4 *Position and Terrain Awareness*
- 1.5 *Energy State Awareness*
- 1.6 *Awareness of Aircraft Configuration and States*
- 1.7 *Awareness of what automation is doing*

#### 2. Failure Situations

- 2.1 *Diagnosis*

#### 3. Design

- 3.2 *Consistency Across the Flight Deck*
- 3.3 *Inconsistent with Task*
- 3.4 *Crew Expectations*
- 3.5 *Information Presentation*
- 3.6 *Feedback*
- 3.7 *Control Design*
- 3.8 *Procedures*
- 3.9 *Design Issues Relating to Over Reliance on Automation*

#### 5. Airworthiness Certification

- 5.1 *Supplementary Systems*
- 5.2 *Operations or design organization approval*
- 5.3 *New Technology*

#### 6. Operational Issues

- 6.3 *Weather*
- 6.5 *Air Ground Incompatibilities*

**7. Alerting**

**8. Human**

*8.1 Decision making*

*8.2 Overload and Underload*

*8.3 Human Error*

## Appendix G - Integration process

The following describes the proposed integration process illustrated in Figure 3. The order of discussion is generally from top to bottom, left to right, with the diagram viewed in the correct orientation.

### **B Matrix – HF category deficiencies in existing rules:**

This describes the current analysis product of Subgroup B, with regulation and advisory material paragraphs down the rows and human factors topics across the columns.

### **C matrix – experiences, consequences, and related regulations:**

This describes the current analysis product of Subgroup C, with incidents, accidents, and other experience listed down the rows and other documentation, including places to cite related regulations and advisory material, listed across the columns.

### **Consolidate DRG Team Data:**

In this step, the various ratings and comments made by the Subgroup B Document Review Groups are consolidated and organized.

### **D1 criteria applicable to scenarios:**

This represents the process already being followed by Subgroup C of applying the Subgroup D criteria to individual items in order to determine whether each one should be kept for further consideration.

### **Organize by equipment and Subgroup C categories:**

In this step, Subgroup C will fill four fields that will be used for mapping issues to rules or to categories:

- equipment type – FAR;
- other equipment;
- Subgroup C category;
- functions.

These columns are used as follows:

#### ***Equipment type – FAR and Other Equipment***

The "equipment" columns in the matrix are intended to enable pointers to the relevant FAR material. If a scenario description refers explicitly or implicitly to a particular piece of equipment involved in the scenario, references to the same equipment in the FARs may be used to help identify relevant FAR paragraphs. This can be done using a table of equipment names and related FAR paragraphs (to be provided). For a given equipment reference, the table for the equipment name (such as "flaps") is searched. If the name is contained in either the "equipment name" or "aliases" columns of the table, related FAR paragraphs will be given in the "FAR references" column. The texts of the related FAR references are also provided to help speed the process of determining whether a given reference may be relevant to the scenario in question. When the appropriate references, if any, are found, they are documented in the "Related FAR/JAR or advisory material" column of the spreadsheet. Identifying the related regulation and advisory material in this way will enable Subgroup C items to be combined directly with the Subgroup B items for the same material.

For any equipment involved in a scenario that are not referenced in the FARs, a FAR deficiency may exist. This is most likely for new or emerging technologies, such as GPS.

It is also possible that an item will not have any equipment reference at all. For these items, links to the regulations and advisory material will be found through the Subgroup C categories, if any such links exist at all. If there are no appropriate links for an item, a potential deficiency may exist.

### **Subgroup C category**

The "Subgroup C category" column is intended to help consolidate items so redundancies can be identified, and to help identify deficiencies across the regulations. It is possible that Subgroup C categories may be mapped to Subgroup B topics for consolidation between the groups, but such consolidation is not the primary purpose of these categories. It is also possible that classes of items in a particular Subgroup C Category should be referred to another Harmonization Working Group for treatment. Once these categories have been identified, the Subgroup C data can be sorted by category, enabling analysis of classes of items as a group, identification of possible support relationships between fact-based and opinion-based items, and combination with the Subgroup B (further to the right on the process chart) topics to identify broad deficiencies that may exist across the regulation and advisory materials.

Requirements for the Subgroup C categories include:

- non-homogeneous – the categories should be driven bottom-up by the data rather than top-down according to an imposed structure. This will allow better identification of categories that may be appropriate for assignment to another working group, and the appropriate treatments for the remaining categories will be more appropriate than if force-fit into an imposed structure.
- useful resolution – the categories should collect enough items to promote efficiency, but not so many that they become too general ("human error" would be too general to be useful, but "human error reading a display" may be useful).

### **Functions**

The "Functions" column is intended to enable later analysis of Subgroup C data by relevant functions. This may be useful because future regulations may have to move toward more of a function-based organization than an equipment-based organization, as more functionality is assigned to software residing on generic architectures. For example, the Primary Flight Display is a widely recognized display format that integrates many of the parameters used for aviating. The Navigation Display is the primary display for navigating. Yet neither of these formats is referred to as such in the regulations. Instead, the regulations refer to specific components of each. If the function(s) related to a scenario are defined, in terms of aviation, navigation, communication, manage equipment, and manage tasks, or some other broad set of functional categories, it may be easier to reconcile Subgroup C data with a future, more functional organization of classification of regulations.

### **Consolidate:**

The purpose of this step is to identify and remove or combine redundant items in the Subgroup C matrix. This can be done by organizing the items by equipment to identify redundant equipment and issue references, and by organizing the items by Subgroup C category. We recommend consolidation before continuing with analysis in order to reduce the number of items to be analyzed.

### **Document deficiencies in regulations and reasons (upper):**

Subgroup B will identify potential deficiencies with individual regulations and advisory material on a paragraph-by-paragraph basis, based on associations between the paragraphs and the human factors topics. This will be one of the technical products of Subgroup B

**Document deficiencies in regulations and reasons (lower):**

Subgroup C will identify potential deficiencies with individual regulations and advisory material by associating scenario items with regulations and advisory material through the equipment column of the Subgroup C matrix. This will be one of the technical products of Subgroup C.

**Document general HF topics poorly covered by regulations:**

In this step, Subgroup B will identify human factors topics that appear to be inadequately treated by the regulations and advisory material by looking for topics (columns in the Subgroup B matrix) that have poor coverage overall. This will be the other primary product of Subgroup B.

**Document Subgroup C categories poorly covered by regulations:**

In this step, Subgroup C will carry out an analogous process to identify Subgroup C categories that are poorly covered by the regulations and advisory materials. This will be done by assessing the adequacy of coverage of regulatory and advisory material references that exist for each category. Categories with little or no coverage may suggest broad deficiencies in the materials.

**Consolidate list of deficiencies with regulations and advisory material:**

In this step, the first products of Subgroups B and C are combined. For each regulation and advisory material paragraph, the relevant deficiencies identified by each of the subgroups are compiled. We are considering that two new groups be formed at this point, combining personnel from Subgroups B and C into each: one group would be tasked with analyzing the deficiency data related to each individual regulation and advisory material paragraph (this box), while the other would be tasked with analyzing the broad deficiencies existing across the materials (see "Consolidate and organize B topics and C categories" below).

**Apply D2 criteria:**

In this step, the Subgroup D criteria will be applied to the results of the step above. One outstanding issue is the extent to which these criteria exhibit inter-rater reliability. A small experiment may be necessary, with many people applying the same criteria to the same items, in order to assess this level of reliability. Based on the results, the analysis may proceed, or instructions may have to be developed to ensure more consistent application of the criteria by different people.

**Consolidate list of deficiencies:**

In this step, the filtered, the consolidated results of the individual deficiencies analyses and the category/topics analyses are combined and, again, consolidated.

**Coordinate with home organizations:**

In this step, each member's home organization will be consulted on the list of deficiencies and any objections identified.

**Apply D3 criteria:**

In this step, the Subgroup D criteria will be applied to the consolidated category and topics analyses results.

**Consolidate and organize B topics and C categories:**

In this step, the results of B at the topic level and C at the category level are combined and consolidated.

**Develop recommendations for regulations and advisory material to be updated:**

This will be specific recommendations for updates based on examination of individual paragraphs and their associated deficiencies. This addresses Step 1 in the original Terms of Reference.

**Develop recommendations for new advisory material:**

This will be recommendations for new advisory material to address the broad deficiencies that may exist across the regulations and advisory material, where particular human factors topics or issues are not adequately covered. This addresses Step 2 in the original Terms of Reference.

**Develop recommendations for new regulations:**

This will be recommendations for new regulatory material to address the same broad deficiencies. This addresses Step 3 in the original Terms of Reference.

**Prioritize recommendations:**

In this step, the three products will be consolidated, prioritized, and organized for documentation and presentation.

**Coordinate with home organizations:**

In this step, each member's home organization will be consulted on the Group's results and any objections identified.

**TOR Step 4 - Implementation plan:**

This will be one of the overall technical products from the entire HWG, and addresses Step 4 in the original Terms of Reference

**TOR Step 5 – Referral or parking lot:**

In this step, items relating to other working groups will be assigned to them. This addresses Step 5 in the original Terms of Reference.