

Appendix 2 . Human Factors HWG Process

1. Overview of the Human Factors HWG Processes

The HWG went through several steps to identify deficiencies in the regulations and associated advisory material to determine what changes were needed. Figure A.2.1 shows these steps as well as the process adopted by the Working Group and its relationship with the Terms of Reference.

First, the HF HWG defined the material to be reviewed as instructed by the ARAC tasking. A subgroup (A) was tasked to provide the list of regulatory material to be reviewed.

Second, the HWG employed two different, but complementary, approaches to identifying deficiencies in the rules. The first approach (subgroup B) was a direct review of the regulatory material 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 (subgroup C) was experience based (based on data from accidents, incidents, in service experience and pilot/certification experience). This approach enabled the group to find data-driven evidence of gaps or deficiencies in the regulations.

A fourth subgroup (D) developed criteria to evaluate the safety benefit as well as the expected acceptance and efficiency of these recommendations and indicate priority of implementation.

After the deficiencies in the regulations and advisory material were identified, they were ranked by the HWG members and discussed to ensure that those that fell into the “top” or highest priority category were appropriate. Once the members were satisfied with the results, each of the top deficiencies were addressed by either recommending work be done in other ARAC groups or developing regulatory material to address them within the HF HWG. Two ARAC groups that were already tasked were given recommendations include deficiencies in their work. These two groups were the Avionics HWG and the Icing HWG. A Terms of Reference document was also prepared to be used for a future group tasking to address automation philosophy. The remaining 33 deficiencies were addressed within the HF HWG.

The HWG then organized the 33 deficiencies into a set of chapters, which are reflected in the current advisory material outline. All members contributed to authoring one or more chapters and had the opportunity to provide input into the development of the regulation. To ensure each member had input to sections beyond the ones they helped author, all members was tasked to review and provide comments on each section of each of the fifteen drafts that were distributed prior to finalizing the material submitted with this report. Members were also asked to coordinate within their organizations to get organizational feedback on the documents. Members reported out at various plenary sessions of the HWG meetings on the status of issues their organization identified per draft, in addition to documenting their concerns using a standard comment form. Thus, issues raised throughout the drafting process were documented in the official meeting notes and also in the comment forms.

Members were asked to provide proposed text to resolve any issues identified using a standard comment form which enabled group members to track issues associated with each paragraph, the proposed resolution by the comment author, and the disposition of each comment by the HWG. If a comment author or his/her organization did not feel that their concerns were adequately addressed, they had the opportunity to re-submit that comment on the next revision/version of the document. This process was used to ensure that each comment was systematically addressed to the satisfaction of the author and his/her organization. Thus, by the end of the fifteenth draft the group felt confident that all major concerns had been addressed.

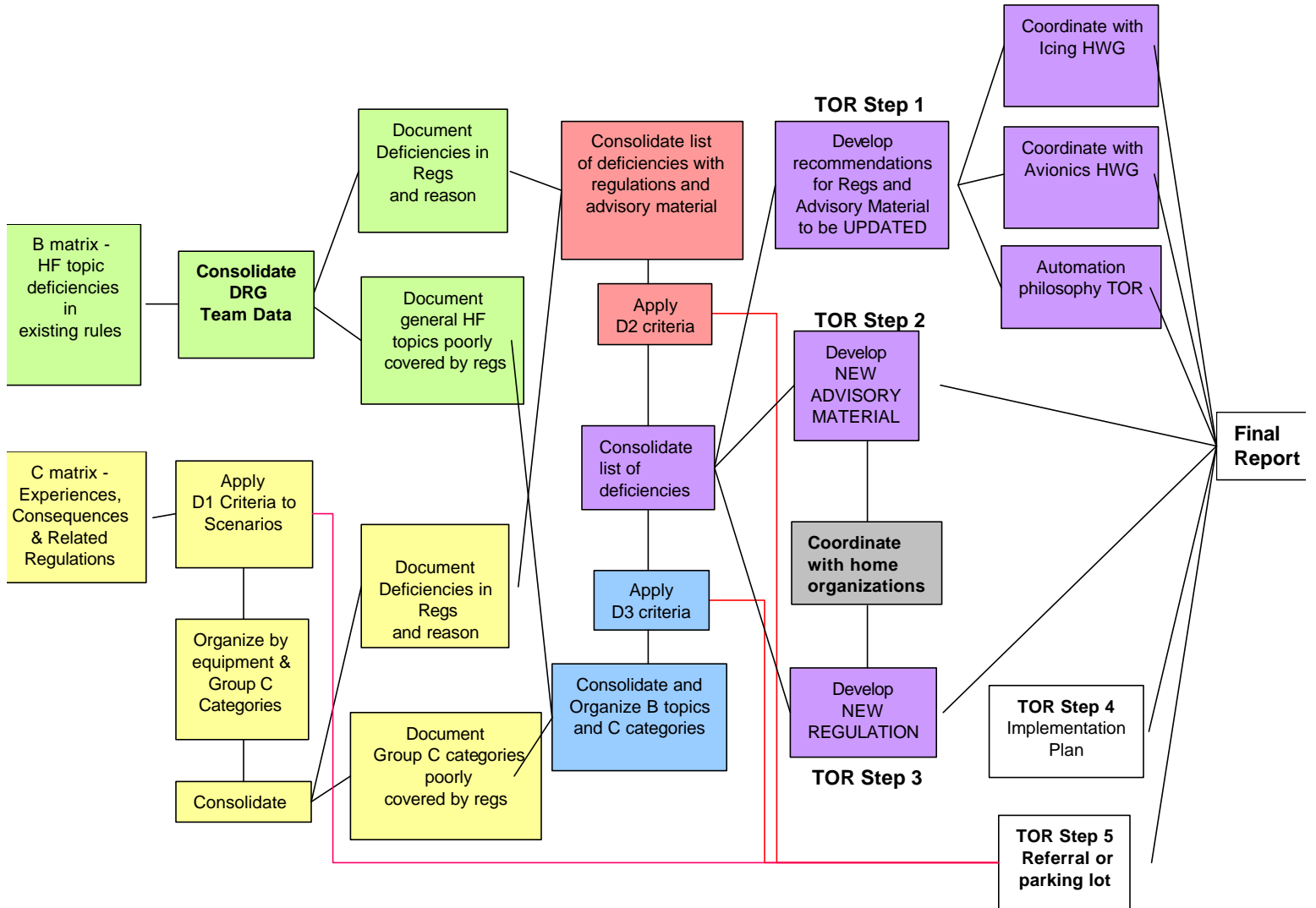


Figure A.2.1 Overview of the WG Process.

The text referred in the Figure can be expanded as follows:

B Matrix – HF topic deficiencies in existing rules:

This represents the analysis product (an Excel spreadsheet called a “matrix”) 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 represents the analysis product of Subgroup C (an excel spreadsheet called a “matrix”), 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 (Document Review Group) team data:

In this step, the various ratings and comments resulting from the Subgroup B analysis were consolidated and organized by small Document Review Groups. Different DRGs focused their reviews on particular sets of human factors topics or related regulations and advisory material. The purpose of these reviews

was to develop the analysis results into understandable statements of deficiencies regarding how the full set of documents addressed the human factors topics or how each of the regulations or advisory documents covered the human factors topics specific to their intent.

Apply D1 criteria to scenarios:

This represents the process wherein Subgroup C applied the Subgroup D criteria to individual items in order to determine whether each one should be kept for further consideration. (see 5.5.1 of this Appendix).

Organize by equipment and Group C categories:

In this step, Subgroup C filled four fields (columns) for mapping issues to rules or to human factors categories. These columns were used as follows:

Equipment type – Regulation and Other Equipment (columns 1 and 2)

The "equipment" columns in the matrix were intended to provide a means to associate each issue or deficiency identified with the type of aircraft equipment (e.g., flaps or Flight Management System), if it was associated with a specific type of equipment. This was done using a table of equipment names and related regulation paragraphs. For a given equipment reference, the table for the equipment name (such as "flaps") was searched. If the name was contained in either the "equipment name" or "aliases" columns of the table, related regulation paragraphs were given in the "FAR references" column. The texts of the related 14 CFR references were also provided to help speed the process of determining whether a given reference was relevant to the scenario in question. When the appropriate references, if any, were found, they were documented in the "Related FAR/JAR or advisory material" column of the spreadsheet. Identifying the related regulation and advisory material in this way enabled Subgroup C items to be combined directly with the Subgroup B items for the same material.

For any equipment involved in a scenario that was not referenced in the regulations, a regulatory deficiency could exist. This was most likely for new or emerging technologies, such as GPS.

Subgroup C category

The "Subgroup C category" column was intended to help consolidate items so redundancies could be identified, and to help identify deficiencies across the regulations.

Functions

The "Functions" column was 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. 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 was to identify and remove or combine redundant items in the Subgroup C matrix. This was done by organizing the items by equipment to identify redundant equipment and issue references, and by organizing the items by Subgroup C category. Consolidation was undertaken before continuing with analysis in order to reduce the number of items to be analyzed.

Document deficiencies in regulations and reasons (upper):

Subgroup B identified 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. (Example: lack of reference to pilot population for ergonomics, suitable forces, etc.)

Document deficiencies in regulations and reasons (lower):

Subgroup C identified 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 (Example: take off configuration warning doesn't segregate the different flap configurations).

Document general HF topics poorly covered by regulations:

In this step, Subgroup B Document Review Groups identified human factors topics that appeared to be inadequately treated by the regulations and advisory material by reviewing each of the topics (columns in the Subgroup B matrix) that had poor coverage across all of the regulatory documents that were analyzed (Example: rules address equipment in isolation: integration is not specifically addressed).

Document Subgroup C categories poorly covered by regulations:

In this step, Subgroup C carried out an analogous process to identify Subgroup C categories that were poorly covered by the regulations and advisory materials. This was 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 (Example: Crew error is only addressed in the context of reaction to a system failure).

Consolidate list of deficiencies with regulations and advisory material:

In this step, the deficiencies produced by Subgroups B and C were combined. For each regulation and advisory material paragraph, the relevant deficiencies identified by each of the subgroups were compiled (the intention was to add strength with each noted Subgroup B deficiency with factual evidence identified by Subgroup C).

Apply D2 criteria:

In this step, the Subgroup D criteria were applied to the set of deficiencies resulting from the prior step. The purpose of applying these criteria was to filter out the deficiencies that were outside the scope of the HWG's tasking (see 5.5.2 of this Appendix).

Consolidate and organize B topics and C categories:

In this step, the deficiencies of Subgroup B at the topic level and Subgroup C at the category level were combined and consolidated.

Apply D3 criteria:

In this step, the Subgroup D criteria were applied to the consolidated category and topics deficiencies to filter out those that were outside of the scope of the HWG's tasking (see 5.5.2 of this Appendix).

Consolidate list of deficiencies:

In this step, the filtered deficiencies addressing the documents and the category/topics were combined, consolidated, and prioritized. The top 33 deficiencies are listed in Appendix 3.

Develop recommendations for regulations and advisory material to be updated:

This represents the development of recommendations for updates based on examination of individual paragraphs and their associated deficiencies, per Step 1 in the original TORs.

Develop new advisory material:

This represents the development of new advisory material to address the broad deficiencies that exist across the regulations and advisory material, where particular human factors topics or issues were not adequately covered. This addresses Step 2 in the original TORs.

Develop new regulation:

This represents the development of new regulatory material to address the same broad deficiencies where required. This addresses Step 3 in the original TORs.

Coordinate with home organizations:

In this step, each member's home organization was consulted on the content of the regulation and advisory material and any objections identified. All organization representatives were asked to provide comments using the standard comment form and to verbally summarize the issue during the specified plenary discussion time.

TOR Step 4 - Implementation plan:

This was one of the overall technical products from the entire HWG, and addresses Step 4 in the original Terms of Reference. This TOR drifted to actual planning and writing of the material associated with recommendations resulting from tasks 2 and 3.

TOR Step 5 – Referral or parking lot:

In this step, hand-offs to other working groups were identified. This addresses step 5 in the original TORs.

2. Detailed Description of Sub-Group A Activity

2.1 Objective The task of Subgroup A was to identify, assemble, and make available to the entire HF HWG all the relevant 14/JAR 25 regulations, advisory material, policy, and related references from both the FAA and JAA for analysis by Subgroups B and C. Figure A.2.2. shows the interactions between the subgroups in detail.

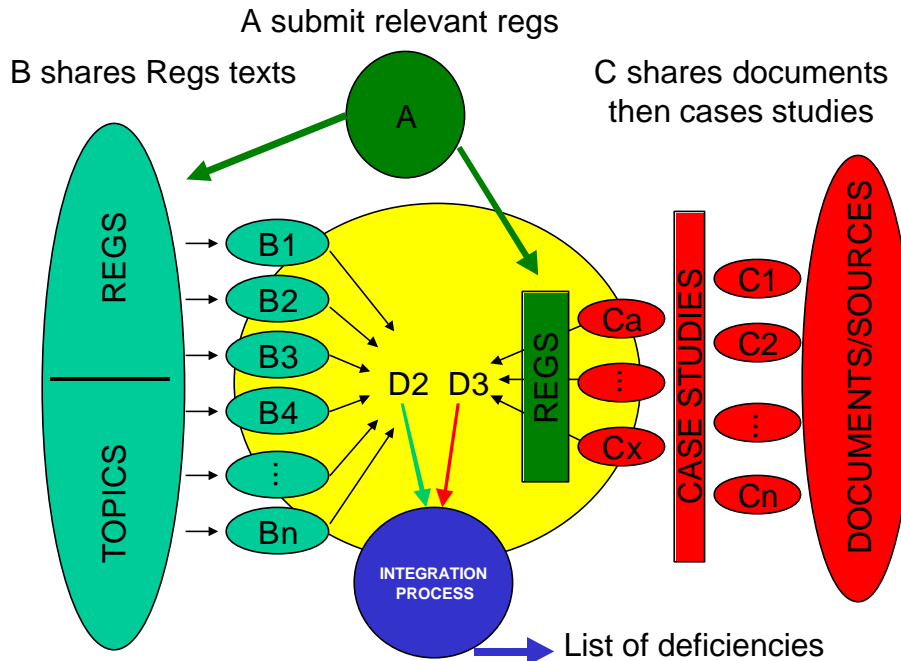


Figure A.2.2. Interactions between subgroups.

2.2 Assumptions. The material to be identified should be relevant to 14 CFR/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 had to be completed before Subgroups B and C could conduct their review of the documents.

2.3 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.

2.4 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.

2.4.1 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 to develop an Aircraft Certification Job Aid for Flight Deck Human Factors. As part of this project, a set of Human Performance Considerations (HPCs) was defined 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.

2.4.2 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.

2.5 Results. The following types of documents were identified as relevant to the HWG's task:

- 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)

3. Detailed Description of Subgroup B Activity

3.1 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.

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

3.2.1 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, shown in Figure A.2.3, 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
- External Environment

3.2.2 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 of 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. 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.

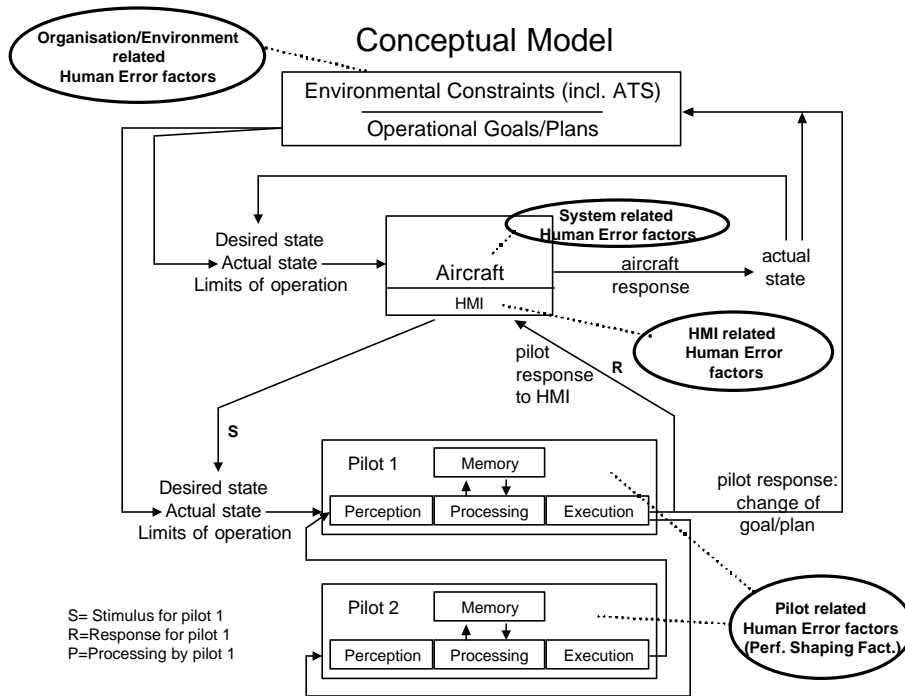


Figure A.2. 3. Conceptual Model of Human Behavior.

4. Detailed Description of Subgroup C Activity

4.1 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. 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 addressed issues that have been documented in the literature, experienced in the field and derived from research. Furthermore, it ensured the final recommendations were data driven.

4.2 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.

4.3 Background. The process used by Subgroup C was 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.

4.4 Process. The process included the following steps:

STEP 1: Identify the list of sources. A list of sources for obtaining relevant Part 25 human performance experience-based issues was identified. 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

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 or strong design linked 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 HWG's task was 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.

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. 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 were not adequately addressed across the body of the regulations and advisory material.

5. Detailed Description of Sub-Group D Activity

5.1 Objective. Subgroup D developed a series of critical questions and success criteria and then placed them into a decision flow-chart. This flow-chart was intended to enable the HWG to assess each subgroup's final product(s) and provide rationale for inclusion or rejection of HWG recommendations. The main objective was to focus the output on effective safety improvements. To help the HWG to focus its analytical effort on relevant issues, Subgroup D had to incorporate some of the criteria into the review processes being utilized by Subgroup C and by the whole HWG after Subgroup B and C integration.

5.2 Assumptions

- The primary goal of the HF HWG was to increase the level of safety of aircraft. Therefore, the criteria should reflect that priority.
- The recommendations were intended to 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.

5.3 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 were based on the expected safety

improvement which will result from the modifications introduced by the 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 were based on the methodology developed by the Safer Skies JSAT/JSIT/JSSI processes, which already used an accepted prioritization methodology for CAST regulation recommendations. This process uses expert judgment to evaluate recommendations against a set of rating scales, which are then combined partly through the use of a mathematical algorithm.

5.4 Process. The criteria were specified in three main categories and are adapted to the specifics of the Subgroup B and C requirements: Subgroup B was considered more concept oriented, and Subgroup C was considered more experience oriented. The criteria fell 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 were 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 were presented as a list of questions to be discussed, instead of a list of terms, or some other forms.

5.5 Results

5.5.1 The criteria (D1) related to Step 1 of the Tasking are:

Aviation Safety: These factors were 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)?

5.5.2 The criteria related to Steps 2(D2) and 3(D3) of the Tasking

Aviation Safety: These factors were 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?