An Interactive Graphical Interface for an Expert Airload-Planning System

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ABSTRACT

An experimental expert system has been developed at SRI International to automate the planning of loading cargo onto aircraft. To allow for a visual display and last-minute adjustments of planned airloads, a two-dimensional interactive graphics system has been developed. This paper outlines the approach followed and introduces its essential features.

I. OVERVIEW

An expert system for automating the planning of aircraft loading has been developed. An interactive graphics system was thought to be appropriate for illustrating airloads planned by the system and for allowing their ad hoc modification. Such a two-dimensional system, using Quintus Prolog and the SunWindow Package on a Sun 3/75 with a high quality bit-mapped console, was then developed. Today the graphics system is fully integrated with the expert system (see Figure 1). Together they have been implemented and widely accepted by the military airload-planning community.

Figure 1. Schematic Diagram of the Airload-Planning System

The expert airload-planning system is rule-based. The airload-planning rules, such as how to intermix cargo and people on the aircraft, and the amount of tie-down clearance required for each type of cargo, are encoded in Quintus Prolog. As parameters to be entered into the expert system, the user can specify the airlift method to employ, as well as the types of cargoes and the number of people to be airlifted. The output of the expert system is a load plan expressed in Prolog facts. A load plan is typically a mix of airloads incorporating a typical selection of aircraft. This information can then be sent to the graphics system for display. The user can modify the airloads manually; any changes will be reflected in modified Prolog facts (see Figure 2).

Figure 2. Data Flow Between the Expert System and the Graphics System

A typical display of an airload consists of two sections. The top half is a picture of the aircraft, showing such features as the locations of ventilation units, ladders, and ramp hinges, the cargo on board, and seats occupied by people. The bottom half is an enumeration of the cargo and a summary of the principal measurements for the airload (see Figure 3).

Ia. Types of Users

This graphics system is intended for two types of users. One is represented by load planners with a great deal of experience and knowledge of aircraft loading. Their goal is to improve the load plan performance by modifying the loads interactively. The other users are load planners who have no or very little prior experience in aircraft loading, but who must acquire the necessary skills. These users need to be guided by the system through their learning curve and, when mistakes are made, be given instructive messages.

Ib. Logical Structure

The graphics system has three levels in its basic structure. All three are directly accessible by the user. The first level comprises tasks involving data manipulation. It includes such options as retrieving a load plan that has been created by the expert system. After plan retrieval, the user is automatically placed in the second level, where a number of analysis charts are available for evaluating
the performance of the load plan. These charts help determine which loads can be improved. The user can choose any one of these for examination, and, if desired, enter the third level of the system to manipulate and modify the selected load. The system also allows the user to create a load without going through the expert system. To do so, the user proceeds directly to the third level, where he creates a load on an empty aircraft template.

All three levels in the graphics system's structure are menu-driven. The menu options were determined by interviewing load planners and analyzing their essential functions. These functions were divided into three logical levels and, at each level, related options were grouped and put onto the menu stacks according to their frequency of use.

The following table summarizes the major functions at each level:

<table>
<thead>
<tr>
<th>Summary of Major Functions Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Level:</td>
</tr>
<tr>
<td>Retrieve a load plan</td>
</tr>
<tr>
<td>Create a load manually</td>
</tr>
<tr>
<td>Show aircraft constraint regions</td>
</tr>
<tr>
<td>Create cargo combination packages</td>
</tr>
<tr>
<td>Second Level:</td>
</tr>
<tr>
<td>Show summarized view of chosen load</td>
</tr>
<tr>
<td>Show detailed view of chosen load</td>
</tr>
<tr>
<td>Show scatter plot of overall load plan</td>
</tr>
<tr>
<td>Show histogram of departed/remaining aircraft</td>
</tr>
<tr>
<td>Enter aircraft departure schedule</td>
</tr>
<tr>
<td>Third Level:</td>
</tr>
<tr>
<td>Move cargo</td>
</tr>
<tr>
<td>Swap cargo</td>
</tr>
<tr>
<td>Modify cargo attributes</td>
</tr>
<tr>
<td>Add/delete cargo</td>
</tr>
<tr>
<td>Change airlift manifest information</td>
</tr>
</tbody>
</table>

Ic. Input and Output Scheme

The user interface of the graphics system was designed to be highly interactive. While all functions are triggered by mouse-sensitive menu options, the system uses both the mouse and the keyboard as input devices. The keyboard is used primarily for entering such textual information as aircraft departure locations and dates. The system uses a cursor icon or prompt message to signal its readiness to receive keyboard input. The mouse is used primarily for pointing to and dragging moveable objects, such as cargo and people on the aircraft. The system provides information as to which mouse actions are expected in a message area. Other relevant information, such as system status, wait mode entered, and various actions undertaken by the system that could cause delays in its response time, is also communicated by means of messages displayed in this area.

II. DESIGN CONSIDERATIONS

Three principal criteria influenced the design of the graphics system. The first was the need for accurate representation of knowledge. Airloads generated by the system must be safe, that is, the center of balance of the overall load, the pallet positions, the seat configurations, etc., must be measured and displayed accurately; otherwise human lives (everyone on board the aircraft in flight) could be at risk. Any airload that has been adjusted manually must be checked according to the rules prescribed by the aircraft manufacturers. Any violations incurred must be flagged by the system to alert planners, so that such infractions may be dealt with.

A large number of the system's users are experienced load planners. They are highly trained professionals who are very familiar with the structural limitations of the aircraft. In representing an airload and flagging its violations, the system must take into consid-
eration the load planner's conceptual model of the aircraft and its
load, then project this model succinctly onto a 2-D graphic repre-
sentation.

The second criterion concerns the system's flexibility. One of
our goals was to provide a friendly tool that would enable load plann-
ers to assemble or adjust airloads manually. In the world of air-
craft loading, many factors could cause planned airloads to be
changed. These changes, ranging anywhere from minor last-minute
adjustments to a complete revision of the cargo list, usually occur
just before flight time. Hence the graphics system must be designed
with the utmost flexibility to accommodate these alternations. The
set of commands the system provides the load planner for customiz-
ing his airloads must be adequate in both functionality and reliabil-
ity. Furthermore, because load changes are usually made in an
ad hoc fashion, the system must be equipped to check for potential
violations under all kinds of conditions and cargo arrangements.

The third criterion is that the system should be easy to use by
someone with no or very little prior experience in airload planning.
Since personnel changes occur frequently in the airload-planning
community, the system needs to be as self explanatory as possible.
Errors must be flagged and clarified to aid the user's learning
process. Cross-checking between aircraft limitations and cargo at-
tributes should be available to provide an audit trail that will allow
violations detected by the system to be explained.

III. SELECTED KEY FEATURES

The system is based on the concept of display files. Airloads
planned by the expert system are stored in display files for retriev-
als, when needed, in the graphics system. Performance statistics of
planned airloads are gathered automatically by the graphics system
when the display file is read in. These statistics are updated in real
time when airloads are modified by the user.

The system is linked to a cargo data base where all the attribute
information of standard cargo is kept. When a user asks for a
standard cargo to be added to a given load, the attributes of the
cargo are automatically retrieved from the cargo data base. This
information is then used to illustrate the cargo and to compare with
the aircraft attribute information when violation checks are per-
formed. The following section explains these key features in
greater detail.

IIIA. Airload Performance Evaluation Tools

The optimality of an airload can be determined in terms of its Air-
craft Load (ACL or total load weight) and/or space (total load vol-
ume) utilization. High optimality is a 100% utilization of either
parameter or a high utilization of both parameters. To help load
planners evaluate the overall performance of a load plan, a scatter
plot using these two measurements is available in the graphics sys-
tem (see Figure 4).

A listing showing the percentages of ACL and space utilization for
each planned airload is available to guide the load planner in
choosing individual loads to improve. A particular airload can be
viewed in either a summarized or a detailed mode. The summa-
rized mode offers a terse outline of the airload and a few basic
measurements, while the detailed mode offers a full-scale view of
the airload that provides data on footprints, nomenclature of each
cargo, a break down of the airload's weight by both cargo and peo-
ple, and so on.

IIIb. Aircraft Movement Statistics

One of the useful features of the graphics system is its ability to
manipulate aircraft movement data. Histograms are available for
illustrating the number of aircraft departed as compared with the
number of aircraft still remaining on the ground (see Figure 5).
This movement data is generated automatically by the system from
the departure data the user enters for each aircraft. Also available
are histograms showing the relative figures for departed and remain-
ing cargo, as well as those for departed and remaining personnel.

Figure 4. Sample Scatter Plot

Figure 5. Sample Histogram of Departed Aircraft Versus Remain-
ing Aircraft

IIIC. Cargo Addition/Deletion

Standard cargo from the system's cargo data base can be added to
a load. When a cargo is added, all the relevant attributes needed
for violation checks are retrieved automatically. If a special-pur-
pose cargo that is not part of the standard cargo data base is to be
added, the user can first call up a generic-cargo icon that resembles
the special-purpose cargo closely, then modify its attributes by
means of the system's modification feature.

When deleting a cargo, the user can choose to discard it from the
list of cargo to be transported or put it aside temporarily and load it
back later. This latter alternative allows for flexibility in rearranging
individual loads without having to change the content of the overall load plan or exchange cargo between loads within the same load plan.

III. Modification of Cargo Attributes

In the world of airload planning, there are often discrepancies between planning data and execution data. These discrepancies are frequently caused by differences between the data available to the expert system during the planning phase and the types of cargoes actually available for the execution of the plan. It can also be caused by plan adjustments that must be made to reflect last-minute changes in the nature of an airlift mission. Such adjustments of planned airloads make it necessary to find a quick and reliable way to modify cargo attributes in the graphics system. The graphics system now offers an easy-to-use function so that the load planner can adjust attributes of any cargo. Its modify command uses a block mode input format (see Figure 8) and, using the modified cargo attribute data, triggers violation checks automatically.

III. People Loading

The graphics system allows people to be loaded or unloaded by allowing aircraft seats to be toggled on and off. Two kinds of seats are considered by the system, namely, those that are permanently located on the sides and those that are assembled as needed in the center of the aircraft. Seat outlines are provided when they are being filled. The system provides the capability of erasing these outlines and determining the support stanchions needed for the filled-in seats in the center (see Figure 9).

IV. CONCLUSIONS AND PROSPECTIVE FUTURE WORK

We have designed and implemented a graphics system as an adjunct to an expert airload-planning system. Today this system is fully integrated with the expert system to illustrate its planned airloads and to allow modifications made to these loads interactively. The graphics system has been deployed successfully and now widely accepted as a useful tool for airload planning and execution, though there are still certain aspects of the system that could be improved.

As a front end to an expert system, the graphics system flags all cargo violations. These violation notices are all accompanied by explanations, but not by suggested remedies. Once the violations are flagged, the user is left to correct the situation on his own. An obvious improvement of the graphics system, therefore, is to provide recommendations on correcting these violations. This will entail examining the airload, computing a permutation of the cargo that is non-violating, and presenting this permutation as a helpful suggestion to the user.

At present, the graphics system displays the same help message to all users, regardless of their respective levels of expertise. While the same message may be very precise and meaningful to an experienced load planner, it could actually be too simple to be helpful to a novice. Likewise, some messages that are helpful to new users might be burdensome for more experienced planners. Therefore, it would be potentially beneficial to model the type of person using the graphics system and to display help messages in accordance with each user’s experience level. This would require gathering user statistics, building user profiles, extracting from the latter information a given user’s level of airloading expertise, and then ascertaining what kind of help would be most appropriate for him.

Acknowledgment

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Axle violation

Wheel violation

Axle and wheel violation

Figure 7a. Axle and Wheel Violation Flags

Figure 7b. Cargo with Axle and Wheel Violations

References:


Figure 8. Modification Screen of The Graphics System

Figure 9. Airload with Filled-In Side Seats and Center Seats