

## **IMPROVING THE USABILITY OF AN AUTOMATED TOOL FOR THE RECORDING, COORDINATION, AND COMMUNICATION OF TRAFFIC MANAGEMENT INITIATIVES**

Bart Brickman

Northrop Grumman Information Technology, Dayton, OH, USA

Tanya Yuditsky, Ph.D.

Federal Aviation Administration, Atlantic City International Airport, NJ, USA

The current processes for recording, coordinating, and communicating traffic management initiatives in Air Traffic Control (ATC) are inefficient, workload intensive, and time consuming. The National Traffic Management Log (NTML) is an automated tool that will enhance and streamline these processes. We used an iterative design methodology with a multidisciplinary design team to develop solutions to existing design problems, and to design new system capabilities. The design team included Human Factors specialists, hardware and software engineers, and ATC domain experts. The design challenges faced by the team included addressing the unique needs of the various ATC domains while providing a usable human-computer interface. The application of the iterative design methodology and the benefits of using a multidisciplinary design team will be discussed.

### **INTRODUCTION**

Traffic Management Specialists within the Air Traffic Control (ATC) system strategically manage the flow of air traffic to minimize delays and congestion due to system stressors such as heavy volume, weather, and equipment outages. ATC facilities are required to record, or log, all traffic management initiatives. They are also required to coordinate the implementation of the initiatives with the Air Traffic Control System Command Center (ATCSCC), and to communicate the initiatives to controllers within their facility and to ATC specialists at all affected facilities.

The methods for accomplishing the three tasks of logging, communication, and coordination were, in the past, highly inefficient with work duplicated in a number of areas. Logging of traffic management initiatives varied from facility to facility. Some facilities relied on paper and pencil while others developed local automation. Coordination and communication was accomplished through verbal communications within the facility and through numerous telephone calls between the ATCSCC and other facilities. Every facility that was affected by an initiative was also required to log the information and communicate it to the controllers.

The National Traffic Management Log (NTML) was developed to provide a single system for automated logging, coordination, and dissemination of traffic management initiatives throughout the National Airspace System. An initial version of the NTML was deployed to a limited number of ATC operational facilities. This version had several problems with its user interface and the available functionality did not adequately meet the needs of field personnel. This paper describes the methods applied in redesigning the NTML to provide a more usable interface and developing designs for new NTML capabilities.

### **Design Approach**

To gain an understanding of the usability issues associated with the initial NTML, we evaluated the UI for compliance with established design principles and applicable Human Factors Standards (Ahlstrom & Longo, 2003). We then used a multidisciplinary design team approach to evaluate potential solutions to the issues, and address issues concerning the operational functionality of the NTML system design. The design team included Human Factors specialists, hardware and software engineers, and ATC domain experts. To ensure that the unique needs of the different types of ATC facilities were addressed in the design, we included specialists from each of the ATC operational domains: Terminal Radar Approach Control (TRACON), Air Route Traffic Control Center (ARTCC), and the ATCSCC.

One of the early and continuous benefits of the multidisciplinary design team was the opportunity for mutual education between team members. The ATC specialists provided information regarding field operations, aspects of the current system that are problematic, and opportunities for improvement. Hardware and software engineers provided information regarding the possibilities for NTML development in light of available technology. Human Factors specialists presented information regarding the capabilities and constraints of the human operator in light of the systems being discussed. In this manner the design team was able to entertain novel design concepts gauged against human limitations and real world technology constraints.

The design team participated in a rapid prototyping iterative design cycle. The process began with the statement of the problem, or need. When the team was in agreement on a high level approach to a solution, we created a prototype that implemented that solution. The prototypes were sometimes interactive and allowed the team members to conduct a structured walk-through.

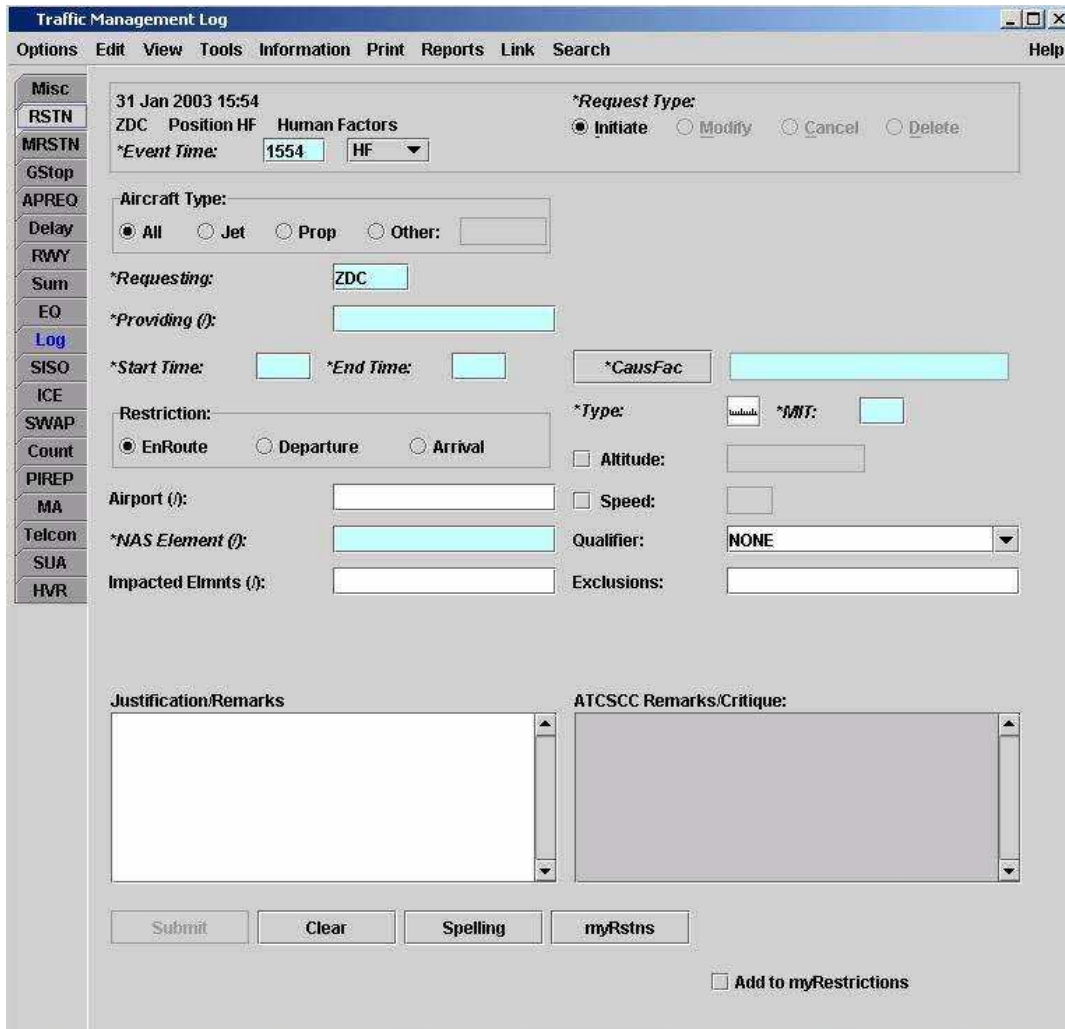


Figure 1. The Restriction template of the NTML as it appeared in the initial system.

The structured walk-through methodology was employed in order to better understand the effectiveness of the design in meeting operational needs. ATC specialists completed scripted test scenarios comprised of representative operational tasks using the design candidate under consideration. They were asked to act in a manner consistent with the operations of their home facility to accomplish the scenarios (e.g., establish a 10 mile-in-trail flight restriction over a given arrival fix). We observed their interactions with the prototype and solicited feedback on whether the design met their needs or whether further design work was needed.

In summary, the ATC specialists provided feedback on whether the prototype was successful at resolving the initial problem and whether the solution was acceptable given the operational requirements of the ATC environment. Based on their feedback, the prototype was either revised and evaluated again, or, when found to be satisfactory, used to generate system requirements. Because we were redesigning the NTML UI, we tried to maintain its' general look and feel, and consistency in interaction styles in our prototypes. This placed some constraints on the design concepts in that they

had to fit within the existing design scheme. The advantage of doing this, however, was that solutions were implemented into the system more quickly and at a lower cost.

The iterative design process allowed the team to explore different design options and to take part in the evolution of the final design solutions. Throughout the process, team members learned from each other and developed a better understanding of the operational requirements, human capabilities, and the technical aspects of the NTML.

## FINDINGS

### Existing design problems

During the Human Factors review of the initial version of the NTML we identified several design problems in the areas of information coding, consistency, and information layout. Figure 1 is an illustration of a template for entering restriction data as it appeared in the initial system. We will refer to this illustration as we describe several of these issues and the recommended solutions.

A screenshot of a software interface for a Restriction template. It features several sections:
 

- Aircraft Type:** Radio buttons for 'All' (selected), 'Jet', 'Prop', and 'Other', followed by an empty text box.
- \*Requesting:** A text box containing 'ZDC'.
- \*Providing (f):** An empty text box.
- \*Start Time:** and **\*End Time:** Empty text boxes.
- \*CausFac:** A wide empty text box.
- Restriction:** Radio buttons for 'EnRoute' (selected), 'Departure', and 'Arrival'.
- \*Type:** A ruler icon and a text box containing '\*MIT:'.
- Altitude:** and **Speed:** Empty text boxes.
- Airport (f):** An empty text box.
- \*NAS Element (f):** A text box with a blue background.
- Qualifier:** A dropdown menu showing 'NONE'.
- Impacted Elmnts (f):** An empty text box.
- Exclusions:** An empty text box.

 The labels for required fields are italicized and blue. There is significant spacing and misalignment between labels and their corresponding input fields.

Figure 2. A section of the NTML Restriction template as it appeared in the initial system.

*Redundant Coding of Required Fields.* Throughout the NTML software, required fields were identified using three coding schemes. As you can see in Figure 1, required fields were indicated by preceding the field label with an asterisk, presenting the labels in italic text, and color coding the data entry portion of the field in blue. Although it is generally a good idea to increase the salience of required fields, and to use redundant coding, all three schemes were not necessary. Furthermore, it may be necessary to use a coding scheme elsewhere in the system and it would be advantageous to have one of these schemes available. A recommendation was made to eliminate one of the redundant coding schemes.

*Template Layout and Spacing.* Many examples exist throughout the NTML interface in which there is too much space between field labels and their associated data entry areas. As you can see in Figure 1, the alignment of the field labels and the data entry areas creates many cases where there is a large amount of space between them. This organization

induces visual scanning and readability problems. The wide spacing between elements may also create confusion as to which data entry field is associated with a particular label. In Figure 2, an excerpt of the Restriction template from Figure 1, the label, "MIT" is physically closest to the ruler icon. However, the data field actually associated with the MIT label is the empty box to the right of the label.

We recommended placing the field labels adjacent to their associated data entry fields in order to enhance usability and avoid confusion. Figure 3 is an illustration of the template section presented in Figure 2, with the recommended layout and coding changes implemented. As you can see, it is easier to determine which label applies to which data entry area, and it is still easy to identify the required fields (coded with a blue data entry area and an italicized label).

*Inconsistent Terminology.* The use of abbreviations and acronyms was not consistent throughout the initial UI. Multiple variations were used for some abbreviations. For

A screenshot of the redesigned Restriction template. The layout is cleaner and more organized:
 

- Aircraft Type:** Radio buttons for 'All' (selected), 'Jet', 'Prop', and 'Other', followed by an empty text box.
- Requesting:** A text box containing 'ZDC'.
- Providing (f):** A text box with a blue background.
- Start Time:** and **End Time:** Text boxes with blue backgrounds.
- CausFac:** A text box with a blue background.
- Restriction:** Radio buttons for 'EnRoute' (selected), 'Departure', and 'Arrival'.
- Type:** A ruler icon and a text box containing 'MIT:'.
- Altitude:** and **Speed:** Text boxes with blue backgrounds.
- Airport (f):** A text box with a blue background.
- NAS Element (f):** A text box with a blue background.
- Qualifier:** A dropdown menu showing 'NONE'.
- Impacted Elmnts (f):** A text box with a blue background.
- Exclusions:** A text box with a blue background.

 The labels for required fields are italicized and blue. The spacing and alignment are improved, making the association between labels and input fields clearer.

Figure 3. An illustration of the redesigned Restriction template.

example, “Impacted Elements” was sometimes used in its full form, and other times abbreviated as “Impacted Elmnts” or “Impact Elmnts.” We recommended avoiding contractions, abbreviations, and acronyms in field labels. When their use is necessary due to space considerations, only standard acronyms, abbreviations, and contractions, as prescribed by the Federal Aviation Administration Contractions Standard (7340.1W), should be used.

Each of these existing design problems negatively impacted the ability of the NTML to satisfy the operational goals of recording, coordinating, and communicating traffic management information. The redesign of existing interface problems was geared toward solving the immediate issues of display readability, operational relevance, and lessening the potential for user confusion. The more usable interface then served as baselines for the design team to incorporate novel functionality into the NTML system.

### New Capabilities

In addition to addressing existing design problems, the team was also asked to develop designs for new capabilities. We will describe one of these capabilities, the motivation for including it in the system, and the design challenges the team faced in coming up with a design solution.

One thing we learned from the ATC specialists on the team was how diverse the field facilities are in the way they do business. The differences are large not only between domains, but also between individual facilities within a domain. For example, the New York TRACON has very different information requirements than Chicago TRACON. They perform similar functions but stress different aspects of traffic management information when making strategic decisions. Since the NTML was going to be used by all types of facilities throughout the NAS, it was important to provide a capability that allows each facility, or perhaps each user, to customize their view of the information contained within the system. The team developed the Status Information Area

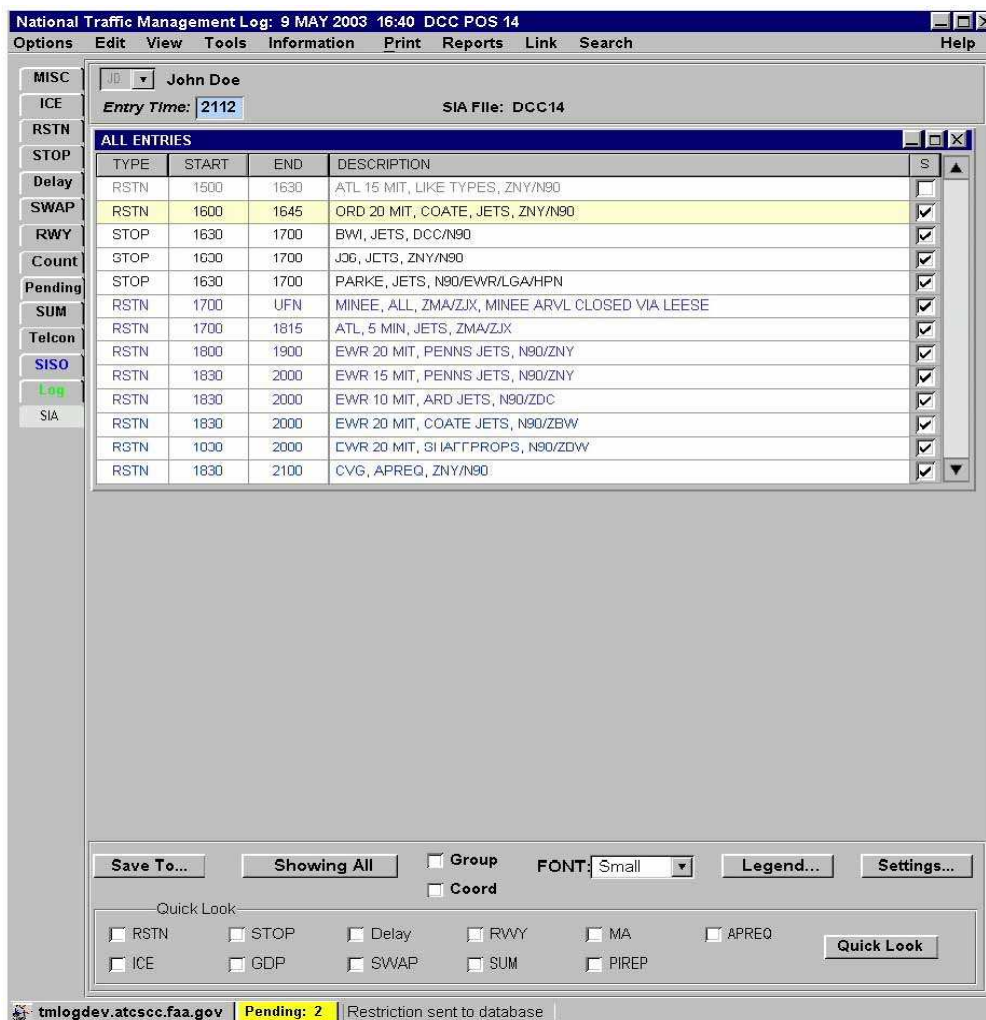


Figure 4. A prototype of the SIA for NTML.

(SIA) (Figure 4) to provide this capability.

The design concept for the SIA was to make it as customizable as possible and to allow an individual user to set up the display with only the information needed for their operational position. The team agreed to limit the customization of the look and feel of the SIA, but to allow great flexibility in selecting the events to be displayed, grouping them in panels, and selecting which information fields are displayed for each group. These capabilities were implemented in a prototype with commonly used tools such as pull-down pick lists for selecting a font size (small, medium, or large), check boxes for hiding or showing individual events, and sort boxes for determining the order of the information fields (see Figure 5).

Giving the users this much flexibility in setting up their display may lead to undesirable results. They may discover that they ended up with too much or too little information, or that the order they selected does not work for them. The team configured a default setup that the users can revert to quickly under those circumstances.

### Discussion

The logging, communication, and coordination of traffic management initiatives at ATC facilities were multi-step, inefficient processes. There was no standardized logging method and communication of the initiatives was primarily accomplished with a series of telephone calls. The NTML will streamline these processes by providing an automated tool for the recording and dissemination of traffic management information. An initial version of the NTML did not meet the operational needs of the field. A multidisciplinary team of Human Factors specialists, ATC specialists, and software engineers was formed to address the problems with the initial version, and to design additional capabilities.

The team used an iterative design approach to develop a human-computer interface that supported the

operational needs of the field while conforming to Human Factors design guidelines and best practices. This approach allowed us to address system requirements as expressed by the operational community while considering the capabilities and limitations of the human operator and available technology. The multidisciplinary design team approach is recommended for application to any complex dynamic domain in which system performance is dependent upon the interaction of multiple stakeholder groups.

After several iterations of the design-evaluate-design prototyping effort, the updated NTML software was deployed to several ATC field facilities. These facilities are providing initial feedback regarding the usability and operational effectiveness of the revised NTML software. The NTML will soon be deployed for operational use at Air Traffic Control facilities nationwide. Our future plans are for the design team to assess the operational effectiveness of the NTML once the system has been used in the field for some time. The team currently plans to visit representative facilities, including TRACONs, ARTCCs, Control Towers, and the ATCSCC to conduct post-deployment evaluations of the software. These field studies will focus on assessing how well NTML software meets operational requirements as well as identify areas of the system in need of further improvement. The lessons learned from these field studies will then be applied to refine the software requirements for future releases of the NTML system.

### References

- Ahlstrom, V., & Longo, K. (2003). *Human factors design standard: for acquisition of commercial-off-the-shelf subsystems, non-developmental items, and developmental systems.* (DOT/FAA/CT-03/05). Atlantic City International Airport, NJ: Federal Aviation Administration, William J. Hughes Technical Center.
- Federal Aviation Administration. (2003). *Contractions Order 7340.1W.* Washington, D.C.: Federal Aviation Administration.

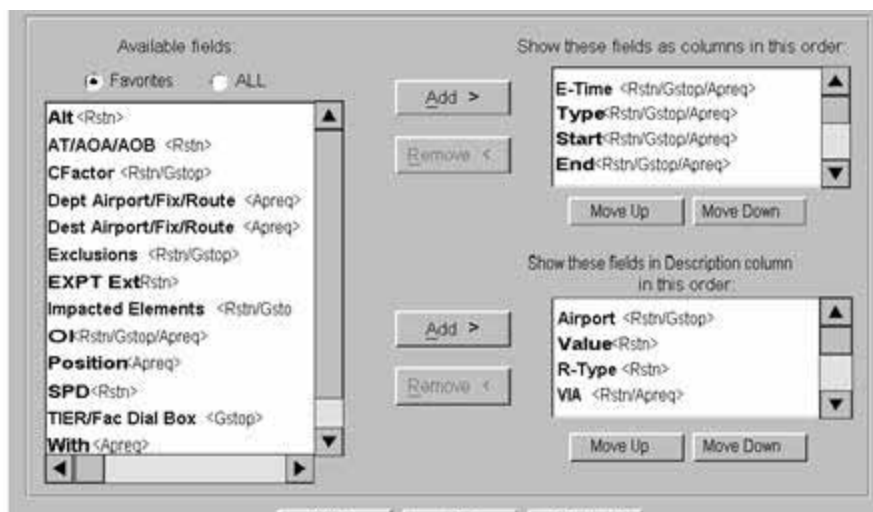


Figure 5. Customization window for selecting the information fields to be displayed in the SIA and their order.