

Investigation Organizer, NASA Ames Research Center

1. Overview of the Application

This section will familiarize the user with the safety issue being addressed and the objective of the use of the tool in the example application

The Investigation Organizer (IO) tool enables key elements of successful investigation through the fusion of accident investigation methodology with collaborative, information sharing technology,:

- gathering and sharing disparate types of information
- identifying the relationships between pieces of information
- understanding the significance of such relationships
- preserving the evidential chain

The tool enables the first element through a Web-based application that can be accessed by distributed teams to store and retrieve any type of digital investigation material in a secure environment. The second is accomplished by making the relationships between information explicit through the use of a semantic network—a structure that literally allows an investigator or team to “connect -the-dots.” The third element, the significance of the correlated information, is established through causality and consistency tests using a number of different methods embedded within the tool, including fault trees, event sequences, and other accident models. And finally, the evidence gathered and structured within the tool can be directly, electronically archived to preserve the evidence and investigative reasoning.

With investigations like SwissAir 111 consuming 4.5 years and \$40 million dollars and future investigation likely to increase in size and complexity, tools that can improve the effectiveness and efficiency of investigators and investigative teams are not only desirable but vital. The Investigation Organizer fills this need and has already demonstrated its usefulness and significance in real, complex investigations such as those of the Columbia accident and the CONTOUR mishap.

2. Input Data

This section will describe the data input to the tool in the example. Points to be addressed in this section include:

- Source of data analyzed
- Data preparation
- Any data formatting or cleansing required
- Interface between the tool and supporting databases or other analytical tools

Today, a wide variety of different media and different instruments are used to record evidence relating to mishaps and accidents, which may be collected and stored at remote locations. This evidence can include: handwritten notes, e-mail, text documents, taped or transcribed interviews with witnesses, and multi-formatted data files and images generated by software and/or by hardware. When a mishap or accident is investigated by a team that is geographically dispersed, these information management and coordination problems are particularly acute. Even more important than this management and coordination is the process of understanding the relevance of and relationships within this evidence—this is the heart of the investigation process itself.

The semantic network in IO allows users to create information items of different types, such as people, evidence, systems, action items, or causal models. It allows investigators to store important metadata with each information item, such as the address of a person, or the weight of a system. Investigators can also attach nearly any type of file to the information items, including text documents, images, digital audio or video files. Most importantly, the semantic network allows users to create meaningful links between these items. An example might be when an investigator collects a piece of evidence that supports a hypothesis (see Figure 1). These meaningful links allow users to explicitly share the reasoning as they conduct the investigation, "connecting the dots" from evidence, through analysis and modeling, and into findings and recommendations.

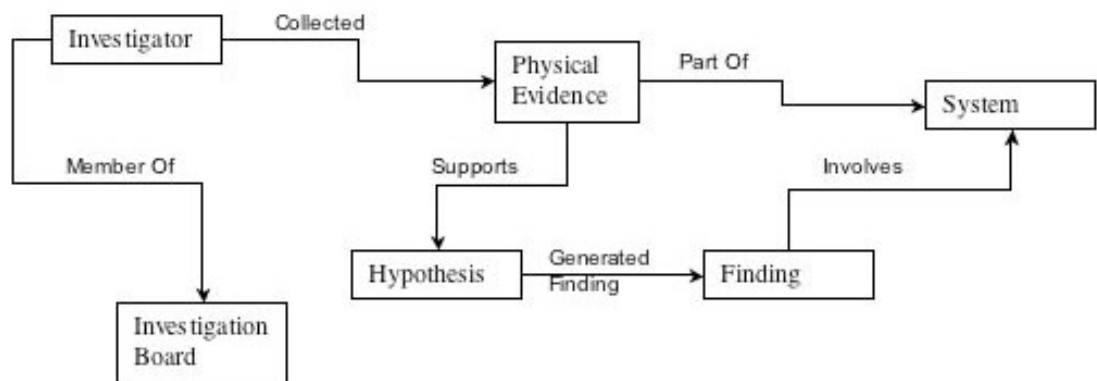


Figure 1. Semantic Network

Information items are entered into the IO ontology through a simple web form (Figure 2) which allows the investigator to upload a file and include any metadata they wish. The optional nature of the fields in the form means an investigator can upload information quickly and fill in the details later. Paper documents can either be scanned to electronic form using common tools or IO can be used as an index for the paper documents stored in an investigator's office.

Figure 2. Information Entry Form

To allow even faster entry of information into IO, investigators can zip numerous files together to be expanded in IO, or an API can be used to import data from other applications (for example the CAFTA fault tree tool). Development is ongoing to allow investigators to e-mail files and other standard forms directly to the system for faster integration and communication.

To assess and integrate the information gathered in the investigations, investigators link items together via standard link types (Figure 3). Each type of link can only apply to certain types of items, and when an investigator goes to make a link, IO's search function makes it easy to find the item to link to. In addition, a built-in inference engine allows

the system itself to help make basic links between information.

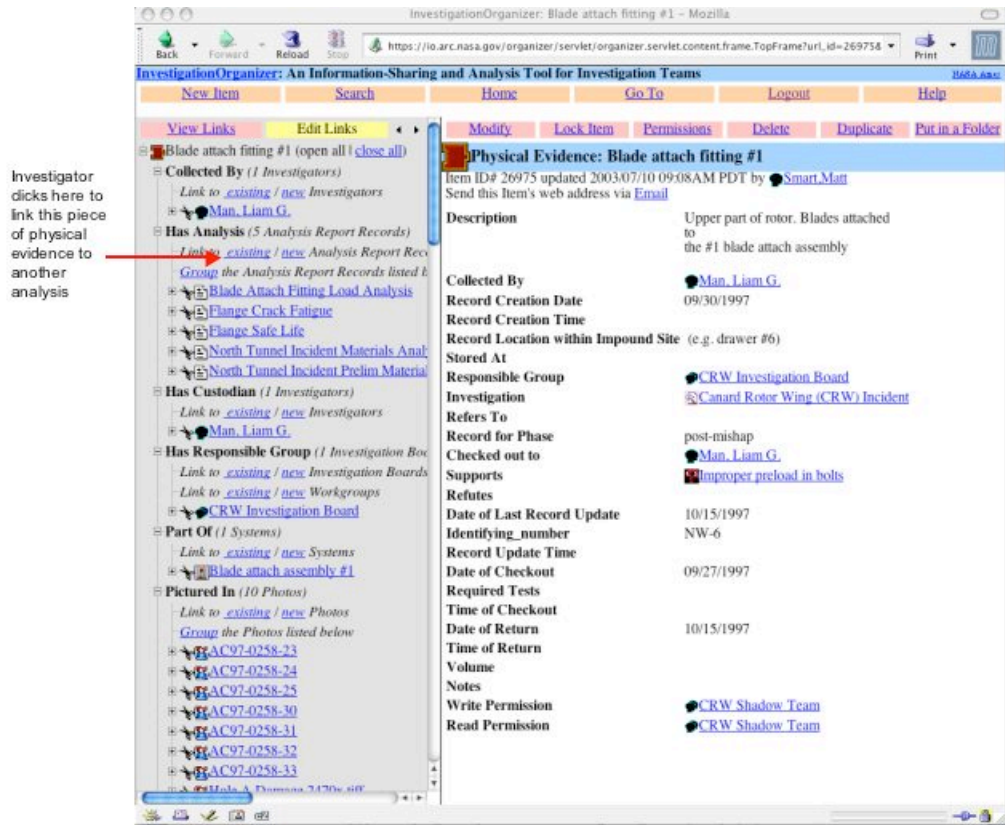


Figure 3. Linking Data

3. Analytical Process*

This section will describe how the tool transforms input data into output information. Points to be addressed in this section include:

- Process flow diagrams (ideally)
- Actions required by the user
- Automated processes performed by the tool
- Time required to run the analysis

Causality and consistency tests can be performed on the evidence gathered and entered into IO using a number of different methods embedded within the tool, including fault trees, event sequences, and other accident models. As investigators determine which evidence supports or refutes the hypothesized causes or elements of the causal model, they form explicit links between them, allowing the entire investigation team to see the reasoning as it develops (refer back to Figure 3). Investigators can also view and modify event sequences based

in a specialized viewer within their web browser (Figure 4). Investigators can re-order the sequence by clicking on the X in the link to break it, and clicking on the handles of two boxes to link them together. Investigators can also add new events and conditions to the sequence directly in the viewer.

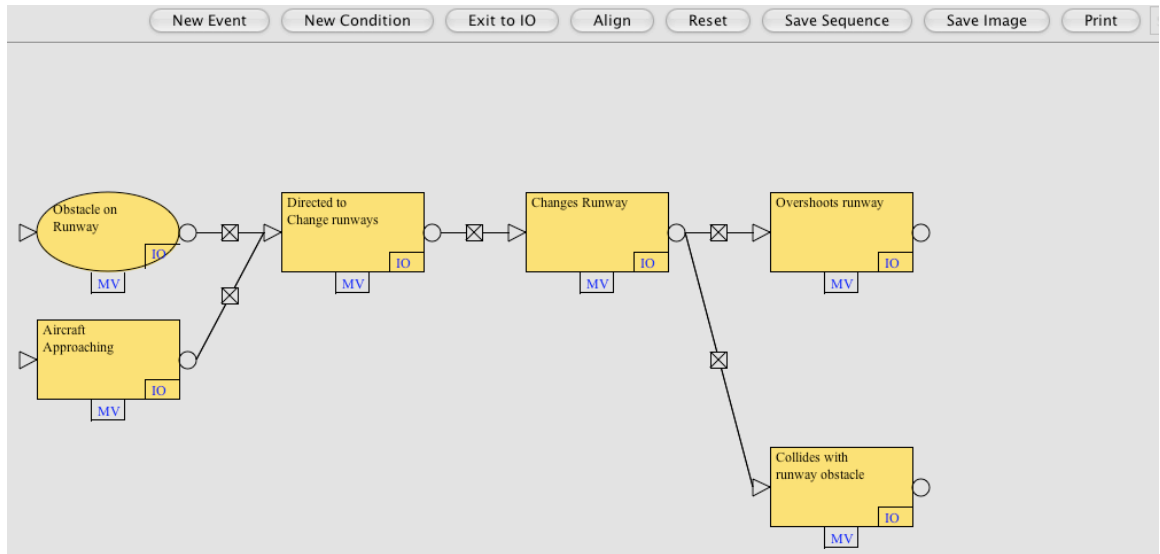


Figure 4. Event Sequence Viewer

Similarly, investigators can use a fault tree viewer (Figure 5). The fault tree viewer also allows investigators to manage and track the progress of the investigation. The colors show the status of each node in the fault tree, and the numbers (e.g. 6/0 on fatigue) show the number of pieces of evidence that support/refute that particular part of the fault tree. In both viewers, the MV tag on the boxes allows the investigators to move them around to better see what is there, and the IO button on the boxes allows the investigator to return to the standard view (Figure 2) at that particular node. Within the fault tree viewer, the user can also limit the view of the tree to a particular depth or a particular branch to make it easier to view, as some fault trees include hundreds of nodes.

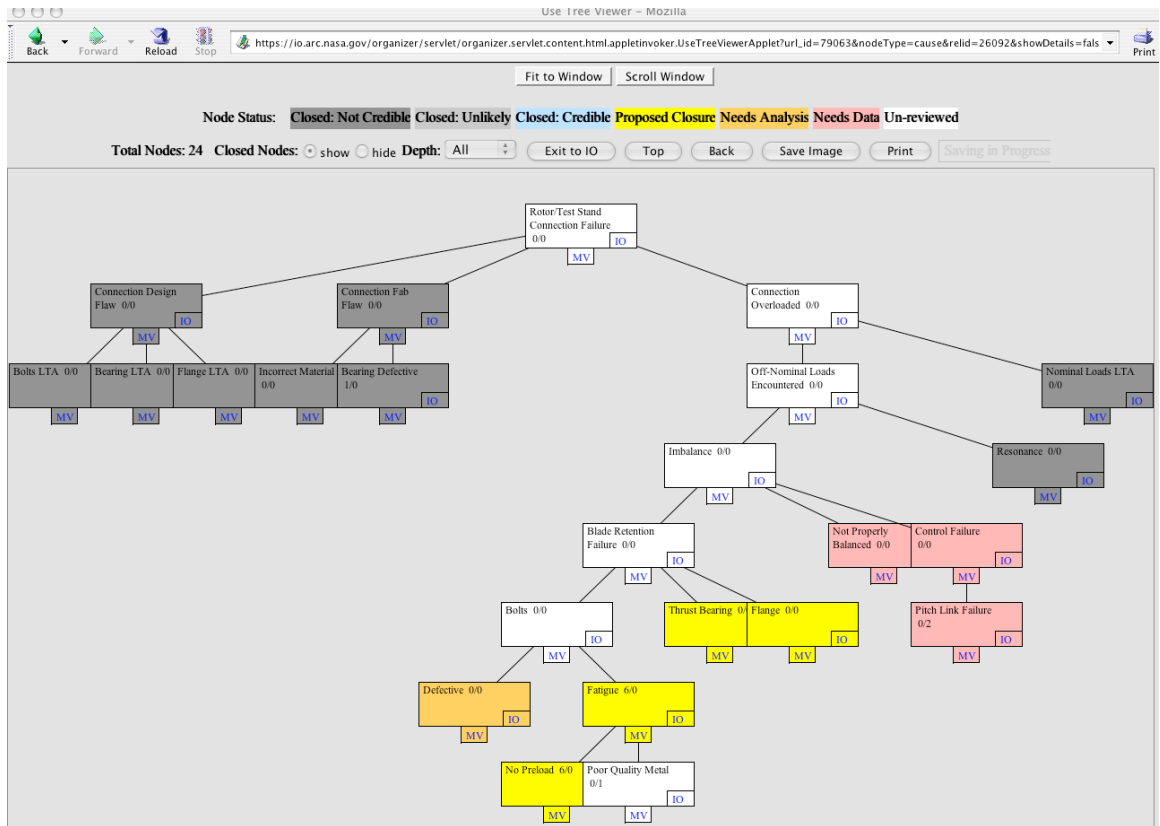


Figure 5. Fault Tree Viewer

4. Tool's Output*

This section will describe the output of the tool, that is, the result of the analysis process. This will familiarize the user of what the resulting information will look like, how it is arranged, etc.

The results of the analysis processes in IO are the integration of information, causality and consistency checks, and the preservation of the evidential chain and investigative reasoning. Further, work flow and logistical information are managed within IO for the investigation team. Finally, recommendations and corrective actions stemming from the investigation can be tracked and related back to the specific findings they address.

5. Application of the Results of the Analysis

This section will describe how the results of the analysis were or could be used, and the value of the information discovered. Actions taken based on the output from this example could be highlighted.

At the end of the investigation, the investigators have preserved the evidence, findings and recommendations generated in the investigation. These can then be implemented by various aircraft manufacturers and

operators to prevent this type of incident from occurring again. The preservation of the chain of evidence within IO allows those teams implementing the recommendations to trace them back to the source records so they can fully understand the history and extent of the changes. This may also allow those teams to realize that the recommendations should be more broadly applied. Finally, this full amount of information can allow safety review teams to review the changes made to the system and the full information behind the recommendations to ensure that nothing was overlooked. As more investigations occur, the history built up in IO will allow safety teams to begin to find larger trends in the problems that are being encountered with a particular type of system or operator. This can then assist in improving system-wide safety.