A NEW DECISION SUPPORT SYSTEM BASED ON A SERVICE-ORIENTED ARCHITECTURE

Neil Wheeler*, Tami Funk, Sean Raffuse, Stacy Drury, Paul Nuss, Kevin Unger, Liron Yahdav, Daniel Pryden, Alan Healy, Michael Haderman, and Lyle Chinkin
Sonoma Technology, Inc., 1455 N. McDowell Blvd., Suite D, Petaluma, CA 94954

John Cissel, Joint Fire Science Program, 3833 S. Development Ave., Boise, ID 83705

H. Michael Rauscher, Rauscher Enterprises LLC, 1733 Old NC 20, Leicester, NC 28748

1. INTRODUCTION

During the past decade, a proliferation of data, software systems, and analysis tools have emerged in various modeling communities. The heterogeneity of available data, data formats, software systems, and *ad-hoc* tools has fractured the awareness, access, and distribution of data and software tools. Consequently, analysts and decision makers are left with an assortment of analysis and modeling methods, as well as unconnected software systems in various stages of development.

In response to these issues, the Joint Fire Science Program (JFSP), acting in concert with the interagency Fuels Management Committee, initiated the Software Tools and Systems (STS) Study in 2007 to address the proliferation of unconnected and unmanaged modeling systems in the fire and fuels domain. A strategic assessment was performed (Palmquist, 2008) that led directly to development of a conceptual design and a software design for a service-oriented, framework architecture for fuels treatment planning (Funk et al., 2009). Under the guidance of an interagency team, these designs were developed into the Interagency Fuels Treatment Decision Support System (IFT-DSS). In 2009, JFSP funded development of a proof of-concept version of the IFT-DSS (Funk, 2010). A fully functional version of the IFT-DSS is now under development.

2. DESIGN ISSUES

Three major issues confounded the design of the IFT-DSS: multiple communities, implementation restriction, and overlapping process implementations.

**Corresponding author:* Neil Wheeler, Sonoma Technology, Inc., 1455 N. McDowell Blvd., Suite D, Petaluma, CA 94954; e-mail: neil@sonomatech.com

2.1 Multiple Communities

The STS Study identified five communities involved in fuels management whose needs had to be addressed by the IFT-DSS (**Figure 1**). Each of these communities has a different perspective on what is important.

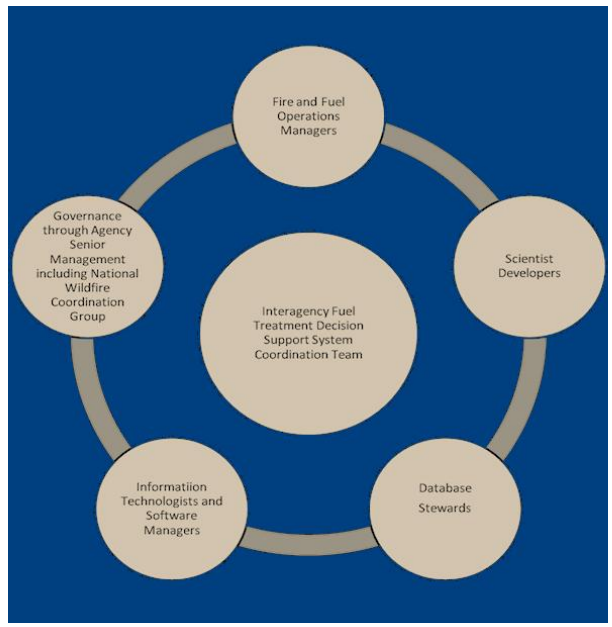

Fig. 1. The communities involved in the IFT-DSS.

2.2 Implementation Restrictions

Because of the multiple communities and agencies the IFT-DSS must support, several implementation issues exist. Individual agencies have their own information technology policies and restrictions, as well as security, training, and software installation requirements. In addition, the various user communities have varying levels of technical skill. The IFT-DSS design needed to address these varied issues.

2.3 Overlapping Process Implementations

The heterogeneity and proliferation of data and software systems in the fuels treatment community has resulted in overlapping science within different systems. For example, one system might only include science for one physical process, while another might link several processes and be unable to use the better science process from the first system. Further, the lack of modularity and clearly defined interface standards prevents changes in science being implemented across multiple systems.

3. DESIGN APPROACH

Our design approach consisted of five components: (1) community engagement; (2) workflows; (3) architectural approach; (4) separation of functions; and (5) process-level science.

3.1 Community Engagement

The literature of technology transition experiences clearly shows that it is rarely sufficient to engage only the end-user community (Moore 1991). Technology development teams allied with the early adopter end-users rarely have the resources or the staying power to move a new software technology from innovation to institutionalization on their own. The goal must be to design and deliver a "whole product," which is the technology introduced plus everything else needed for the technology to be accepted and used. That is, it is a complete solution to the set of requirements developed (Forrester, 2007). To deliver the IFT-DSS as a whole product, we needed the help and support of the stakeholder communities: Governance, Scientific Model Development, Database Stewardship, Information Technology & System Maintenance, and Fire & Fuel Management. In addition, an IFT-DSS Coordination Team was needed to monitor and guide the functioning of the software and the network of community stakeholders interacting with it.

3.2 Workflows

The design first focused on the most common workflows needed by the communities instead of the underlying models. Six workflows were identified that account for most of the work to be performed with the IFT-DSS.

1. **Data acquisition and preparation** involves collecting and preparing the vegetation data needed for input into fire behavior and fire effects models.
2. **Strategic planning** involves identification of high fire hazard areas within an area of interest. The focus is to identify where further treatment analysis may be warranted on the basis of potential fire hazard.
3. **Spatially explicit fuels treatment assignment** involves (1) simulating fuels treatment placement in areas of high fire hazard within an area of interest; and (2) simulating post-treatment influences on fire behavior and fire effects potentials. The spatially explicit fuels treatment assignment extends the strategic planning analysis to applying treatments on the landscape.
4. **Fuels treatment effectiveness over time** involves the evaluation of the temporal durability of fuels treatments; that is, how long, in years to decades, a treatment will continue to affect potential fire behavior and fire effects within an area of interest. This workflow scenario naturally follows the strategic analysis and fuels treatment assignment workflow scenario.
5. **Prescribed burn planning** involves preparing the information needed to plan, document, and conduct a proposed prescribed fire.
6. **Risk assessment** involves conducting a probabilistic risk assessment for fuels treatment planning.

3.3 Architectural Approach

Service Oriented Architecture (SOA) is a generic software architecture framework designed to support a collection of services such as databases and software applications. SOA has well-defined software and data interfaces, facilitates the integration of new and legacy software applications, and facilitates inter-operability with other systems.

3.4 Separation of Functions

To provide flexibility and extensibility to the system, we separated the system into three main functional parts.

1. User Interface
2. Scientific Modeling Framework
3. Models

This approach allows the scientist-developers to focus on the models and provides the flexibility to extend and customize the user interface for various types of users.

3.5 Process-Level Science

To facilitate the implementation of process-level science modules while allowing the legacy system to still operate with the IFT-DSS, a three-tier approach to science integration was used. This approach allows for new process-level science modules within the system, implementation of existing software in standardized interface wrapper, and access to external systems via web services.

4. ARCHITECTURE

Figure 2 shows the three main components of the IFT-DSS. The first component, the IFT-DSS Application (user interface), provides the user experience and includes (1) online help and documentation; (2) model selection, connection, and input (Action Graph selection); (3) spatial data visualization and editing; and (4) collaborative features. Action Graphs are graphic representations of models, data, and the connections between them. They are used to build linked modeling systems and control their execution. The second component, the Scientific Modeling Framework (SMF), includes (1) the SMF Executive, which manages the Action Graphs and connections between models; (2) data visualization services; and (3) scientific data storage. The third component, the models, consists of the various scientific models that are integrated into the IFT-DSS and their interfaces with the SMF.

Models can be integrated into the IFT-DSS by one of three methods: (1) direct integration into the system as a model subclass; (2) wrapping the model program using a custom interface; or (3) connecting to an external model service through a custom interface adapter (see **Figure 3**.) While the model subclass method is the most efficient and provides the best control over process-level science, the other two methods provide needed support for legacy models and system interoperability capabilities.

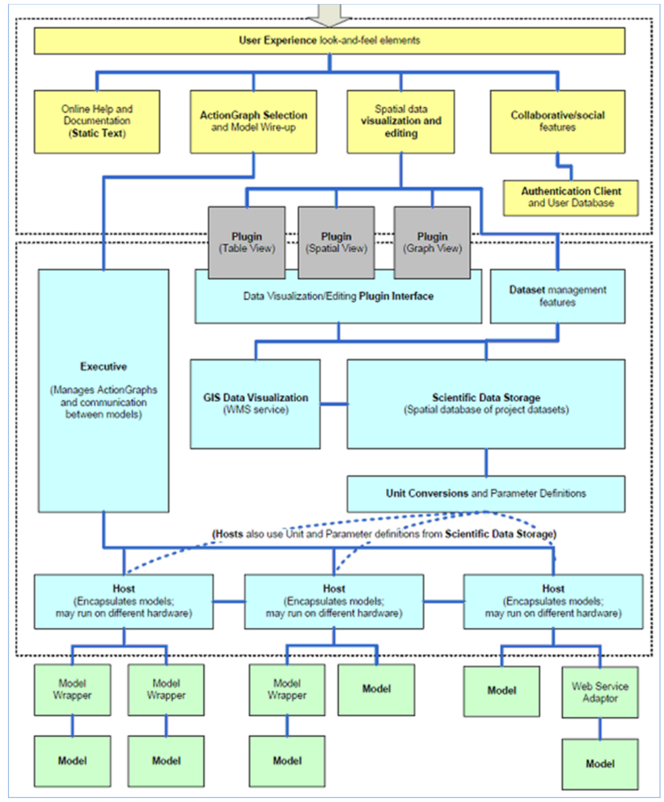

Fig. 2. IFT-DSS components and the separation of functions.

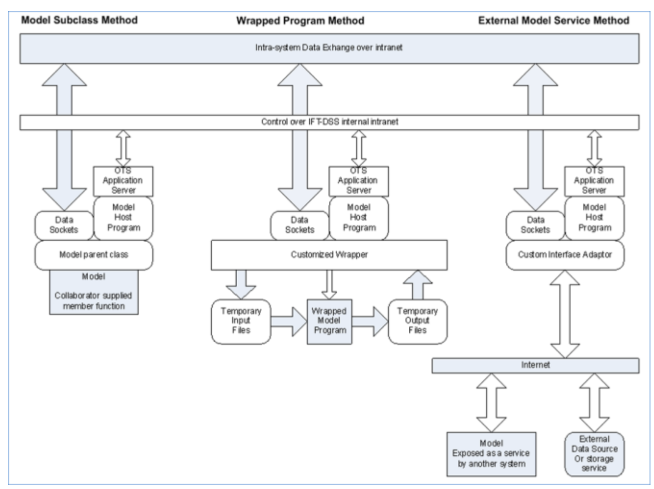

Fig. 3. IFT-DSS model integration methods

Figure 4 provides a summary of the IFT-DSS topology and the communications mechanisms between logical groups of system processes.

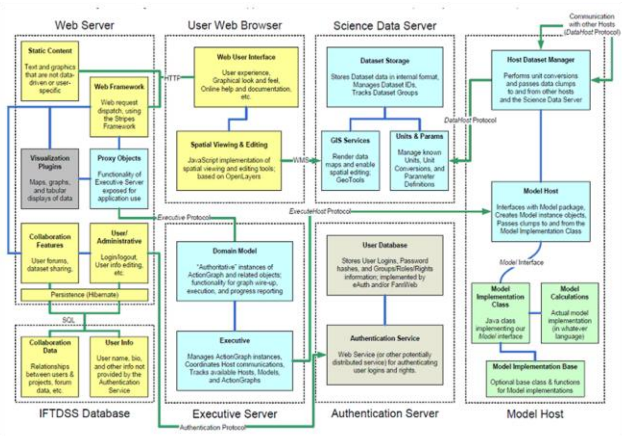

Fig. 4. IFT-DSS topology and the communication mechanisms.

5. IMPLEMENTATION

A functional prototype was completed in June 2010 (see **Figure 5**) and placed in service for the purpose of obtaining feedback from a test user group (see **Figure 6**.) The prototype included one workflow (prescribed burn planning) and limited GIS visualization capability, and demonstrated the use of all three model integration methods.

The fully functional version of the IFT-DSS is currently under development and Version 1.0 is scheduled to be deployed in June 2011. A final version (Version 2.0) is scheduled for deployment in June 2012. Full enterprise operations at a government data center is planned for the fall of 2012.

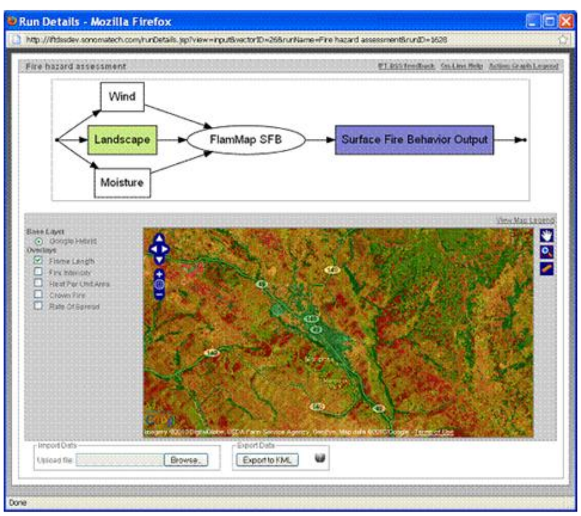

Fig. 5. Screenshot from the IFT-DSS prototype.

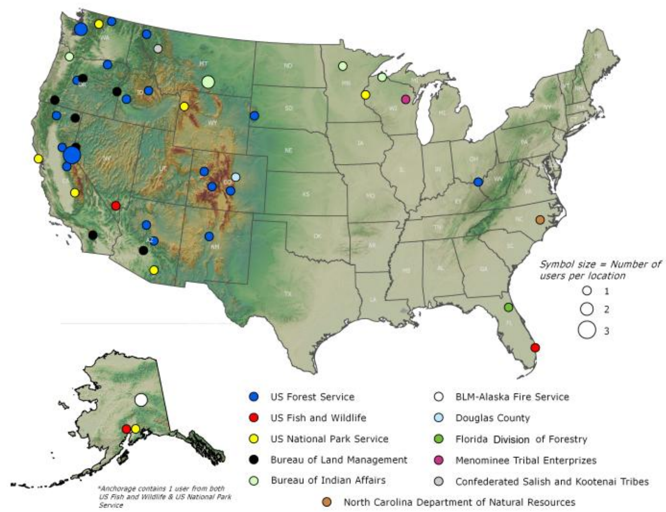

Fig. 6. Geographic distribution of the IFT-DSS test user group.

6. DISCUSSION

The JFSP's vision (**Figure 7**) for the IFT-DSS extends well beyond fuels treatment planning. There are many other areas of the fire sciences that could benefit from the IFT-DSS's design for model integration, visualization, and system interoperability. Therefore, the IFT-DSS SMF is being designed generically so it can be applicable to any scientific discipline, and the IFT-DSS Application, which is database driven, can be easily customized. Further, the IFT-DSS's SOA facilitates access to authoritative systems that are external to a DSS.

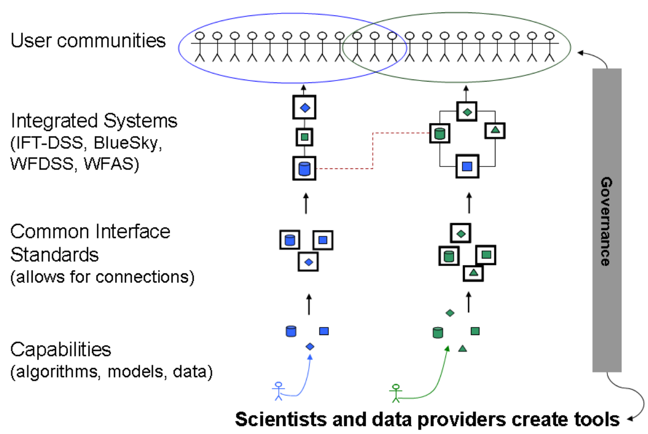

Fig. 7. The JFSP vision for the IFT-DSS.

In many ways the issues and challenges faced by the fuels treatment planning community parallel those of air quality research and planning communities. Therefore, some of the approaches to model integration and the tools used in the IFT-DSS may be transferable to the integration of process-level science in meteorological, emissions, and air quality modeling

7. CONCLUSIONS

Based on the STS Study and IFT-DSS design and development process, we have four main conclusions.

1. A DSS is more than a model. A model alone does not provide sufficient context to make decisions.
2. The development of an effective and sustainable DSS requires the participation of a community.
3. The STS Study and IFT-DSS attempt to address long-standing issues with modularity and model interactions in the fuels treatment community.
4. The atmospheric modeling community faces many of the same challenges as the fuels treatment community and might benefit from lessons learned and engineering practices employed as a result of the STS Study.

8. ACKNOWLEDGMENTS

The authors would like to thank the Joint Fire Science Program, the Fuels Management Committee, collaborating fire scientists, and our test user group for making this project possible.

9. REFERENCES

Moore G. (1991) Crossing the Chasm: Marketing and Selling Technology Products to Mainstream Customers. Harper Business.

Forrester E.C. (2007) Technology Transition. PowerPoint Presentation. Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA

Palmquist M.S. (2008) Working summary of the SEI's engagement with the Joint Fire Science Program. Report prepared for the U.S. Department of Defense by the Acquisition Support Program, Software Engineering Institute, Carnegie Mellon University, April.

Funk T.H., Corman R.G., Reed J.E., Raffuse S.M., and Wheeler N.J.M. (2009) The Interagency Fuels Treatment Decision Support System (IFT-DSS) software architecture. Software architecture design prepared for the Joint Fire Science Program, Boise, ID, by Sonoma Technology, Inc., Petaluma, CA, STI-908038.04-3565, March.

Funk T.H. (2010) Interagency Fuels Treatment-Decision Support System proof-of-concept system. Technical memorandum prepared for the Joint Fire Science Program, Boise, ID, by Sonoma Technology, Inc., Petaluma, CA, STI-909029-3876-TM, May.