

Final Report of the Interagency Fuels Treatment Decision Support System (IFTDSS) Evaluation Study

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Table of Contents

Acknowledgments	viii
Executive Summary	x
Abstract	xii
1 Background	1
1.1 Software Tools and Systems (STS) Study (2007-2012)	1
1.1.1 STS Study Phase I	1
1.1.2 STS Study Phase II	2
1.1.3 STS Study Phase III	3
1.1.4 STS Study Phase IV	3
1.2 IFTDSS Evaluation Study (2012-2013)	3
2 The Strategic Environment	4
2.1 Summary	7
3 IFTDSS Evaluation Study	9
3.1 Interagency Fuels Treatment Decision Support System (IFTDSS)	9
3.2 IFTDSS Evaluation Study	9
4 Task 1a: IFTDSS and Its Relationship to WFI&T (IFTDSS Looking Outward)	11
4.1 Findings and Observations	11
4.1.1 Federal CIO 25 Point Plan	14
4.2 Challenges	15
4.3 Recommendations	16
4.3.1 Service Oriented Modular Capabilities	16
4.3.2 Integrated Security Posture	16
4.3.3 Connected Wildland Fire Community	16
4.3.4 Cloud Hosted Infrastructure	16
4.3.5 Data Governance Recommendations	17
4.3.6 Enhanced Innovation Recommendations	17
5 Task 1b: IFTDSS As a Software Tool (i.e., IFTDSS Looking Inward)	18
5.1 IFTDSS Architecture	18
5.2 IFTDSS Architecture Analysis Findings and Observations	20
5.2.1 Architecture Risk Themes	21
5.3 Challenges	24
5.4 Recommendations	24
6 Task 2: IFTDSS and Software Lifecycle Management	26
6.1 Findings and Observations	26
6.1.1 Operational Efficiency and Quality	26
6.1.2 Governance	27
6.1.3 Innovation	27
6.2 Challenges	27
6.2.1 Core Problems	27
6.2.2 Challenges	27
6.3 Recommendations	28
6.3.1 Clarify Development Responsibilities	28
6.3.2 Ensure any Solution Addresses the Overall Fuels Management Problem Space	29
6.3.3 Implement Portfolio Governance	30

7	Task 3: IFDTS User Evaluation	31
7.1	Findings and Observations	32
7.1.1	Data	33
7.1.2	Project	33
7.1.3	Analytical Models	34
7.1.4	Workflows	35
7.1.5	IFDTS and Wildland Fire Community Business Problems	36
7.1.6	Comparison to Other Systems in Use	38
7.2	Conclusions	38
8	Task 4: IFDTS and User Training	40
8.1	Findings and Observations	40
8.2	Challenges	42
8.2.1	Supporting Training in Desired Workflow(s)	42
8.2.2	Support for Fuels Treatment Workforce Development	43
8.2.3	Support for Education	44
8.2.4	Support for Training	45
8.2.5	Support for Experience	46
8.2.6	Support for Existing NWCG Training	46
8.2.7	Context of Broader Technology or Practice Adoption	47
8.3	Recommendations	48
8.3.1	Promote IFDTS to a System of Record	48
8.3.2	Define and Support a Curriculum of Required Training for Fuels Treatment Specialists	48
8.3.3	Prototype Use of IFDTS' Tutorial Environment for Robust Fire Science Concept Online Courses	48
9	Main Challenges Facing the Wildland Fire Community	49
9.1	Challenge: Meeting the Promise to Congress that Sound Risk Management (will be) the Foundation for all Management Activities	49
9.2	Challenge: There is no Agreed-Upon Strategy or Vision to Guide New Investments, or to Evaluate the Efficacy of Current Investments	49
9.3	Challenge: There is no Agreed-Upon, Consistent End-to-End fuels Treatment Planning Process in use Across the Community	50
9.4	Challenge: There is no Consistent, Coherent Support for the Training Needed to Accelerate Workforce Development for Fuels Treatment Planning and Management	50
9.5	Challenge: There is no Enterprise-Wide Policy and Transition Mechanism to Move From Research to Operations	51
9.6	Challenge: There is no Consistent, Enterprise-Wide System Hosting Strategy	52
9.7	Challenge: Software Chaos Is Still an Issue	52
10	Conclusions and Recommendations	54
Appendix A	Task 1A Approach and Previous Response	61
Appendix B	Task 1B Approach and Additional Information	88
Appendix C	Task 2 Approach	95
Appendix D	Task 3 Approach	97
Appendix E	Task 4 Approach	114
Appendix F	Work Plan Questions	116
	Bibliography	123

List of Figures

Figure 1:	Factors and Performance Measures, National Cohesive Wildland Fire Management Strategy	6
Figure 2:	IFTDSS Architecture	19
Figure 3:	Physical Architecture of Beta Production System	20
Figure 4:	Overall User Survey Results	32
Figure 5:	User Survey Results: Data Capabilities	33
Figure 6:	User Survey Results: Importance of Factors Related to Data Capabilities	33
Figure 7:	User Survey Results: Project Capabilities	34
Figure 8:	Importance of Factors Related to Project Capabilities	34
Figure 9:	User Survey Results: Access to Analytical Models	34
Figure 10:	User Survey Results: Importance of Factors Related to Analytical Model Access	35
Figure 11:	User Survey Results: Workflows	35
Figure 12:	User Survey Results: Acceptability of Each Workflow	36
Figure 13:	User Survey Results: Important Workflow Characteristics	36
Figure 14:	Notional Risk Assessment and Fuels Treatment Workflow	43
Figure 15:	IFTDSS Strategic Drivers and User Needs	55
Figure 16:	Key Stakeholder Groups	56
Figure 17:	Principal Short-Term Recommendations	58
Figure 18:	Logical Depiction of Comprehensive Federal Identity as a Service Offering	72
Figure 19:	Evaluation Workshop Locations and Dates	97
Figure 20:	Experience of Respondents	107
Figure 21:	Organization of Respondents	107
Figure 22:	Previous Positions of Respondents	108
Figure 23:	Reason for Attending Workshop	109
Figure 24:	Experience Using Fire Models	109
Figure 25:	Baseline Business Process for Fuels Treatment	110
Figure 26:	Tailored Workflow for Comparative Analysis Interviews	111

List of Tables

Table 1:	Six Strategic Elements of the Technical Architecture and How IFTDSS Supports Them	13
Table 2:	Observations About Business Problems Based on User Feedback	37
Table 3:	Quality and Efficiency Characteristics of IFTDSS	38
Table 4:	Business Problems Addresses by IFTDSS	39
Table 5:	Training Findings and Observations	40
Table 6:	Current Positions of Respondents, Other	108
Table 7:	Previous Positions of Respondents, Other	108

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Executive Summary

This report presents the findings and recommendations from the Software Engineering Institute's (SEI's) independent evaluation of the Interagency Fuels Treatment Decision Support System (IFTDSS).

We recommend the wildland fire community adopt IFTDSS and make it a funded program to support both managers and scientists performing fuels treatment. Overall, IFTDSS:

- Demonstrates key principles of the Wildland Fire Information & Technology (WFI&T) Plan.
- Provides an enterprise solution for the strategic goal of risk-based fuels management.
- Provides an enterprise solution for the strategic goal of improved (standardized, risk-based) fuels management planning.
- Demonstrates how standard guidance and processes can be implemented via IFTDSS's work-flow-based navigation.
- Demonstrates a framework that could support end-to-end training.
- Demonstrates a framework for improved software development management.
- Addresses numerous user issues and concerns.
- Allows for improving the management of fuels treatment thru its data management and its incorporation of scientific models.
- Offers the opportunity to make significant improvements in the science of fuels treatment.
- Can be extended beyond fuels treatment to other domains.

Unlike many of the development efforts the SEI evaluates, IFTDSS was also an exemplar as a program:

- The program “looked up” to meet agency and department strategic mission goals
- The program “investigated across” to conform to agency and department IT governance (as it existed)
- The program “listened down” by actively soliciting user feedback, and acted on that feedback
- The program had achievable scope and schedule
- The development approach was appropriate for the program and within the skill-set of the contractor
- The government and the contractor had a good, professional working relationship

Near-Term Recommendations

While there are some technical concerns regarding IFTDSS, the greatest challenge for IFTDSS – or any similar effort – is the lack of the governance and policy needed for the wildland fire community to achieve its stated strategic and information technology goals. We recommend these actions be taken within the near-term:

From a Business and Governance Perspective:

- Select the IFTDSS Managing Partner, establish IFTDSS as a system-of-record, and fund continued development.
- Approve a consistent, multi-agency risk analysis process for fuels management planning .
- Determine and implement the IFTDSS hosting strategy.
- Determine the enterprise security requirements for IFTDSS and other enterprise SOA systems.
- Determine the performance and scalability requirements for IFTDSS.
- Establish the governance needed for researchers to integrate new or enhanced tools and models into IFTDSS.

From a Technical and Transition Perspective:

- Educate users about IFTDSS through formal and informal means.
- Create the documentation needed for the government or a third-party to maintain and evolve IFTDSS.
- Create an IFTDSS software development kit (SDK).
- Create a fuels management curriculum with an emphasis on risk and hazard analysis.
- Validate that IFTDSS meets performance and scalability requirements (once they are determined).
- Validate that IFTDSS conforms to security requirements (once they are determined).
- Align IFTDSS's existing workflows with the approved risk analysis process for fuels management (tailored as necessary for legitimate agency and regional need).
- Align IFTDSS's existing workflows with the approved fuels management curriculum.

Report Background

ITDSS was developed by the Joint Fire Sciences Program (JFSP) as part of a multi-phase Software Tools and Systems (STS) Study.

- STS Phase I studied the problem of “software chaos” that had been identified by the fire and fuels user community.
- Phase II designed IFTDSS under JFSP's vision of an interconnected “system-of-systems” to provide common workflows and a single point of access to the data, models, and tools used most by the fuels management community.
- Phase III was the IFTDSS proof of concept
- Phase IV was a limited release and prototyping.

The SEI conducted the IFTDSS Evaluation Study using document reviews, demonstrations and examinations, individual and group stakeholder interviews, a software architecture assessment workshop, and a series of user workshops.

Abstract

The Joint Fire Sciences Program (JFSP) is a multi-federal agency group that brings together a diverse set of stakeholders that need to understand fire behavior with scientists who study fire behavior. The program's doctrine, training, and tool products help the wildland fire community respond to threats from fire, plan and execute actions to prevent catastrophic fires, and appropriately manage ecosystems that both depend on and are threatened by fire.

In the course of its mission, the JFSP sponsored the Software Tools Study that produced a prototype decision support tool as one phase of its work. The goal of the tool is to bring together many of the fire science models used for performing hazard assessment, risk assessment, fuels treatment analysis, and fuels treatment planning through a single web interface.

This decision support tool, called the Interagency Fuels Treatment Decision Support System (IFTDSS), uses workflows to guide fuels treatment planners in performing the main tasks of fuels treatment planning and management. In creating this tool, JFSP had the foresight to direct the solution providers to support emerging governance and policy trends resulting from legislation such as the Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009.

In 2012, JFSP chartered the Software Engineering Institute (SEI) of Carnegie Mellon University to independently evaluate the IFTDSS prototype along multiple dimensions. JFSP was interested determining the following:

- tool's conformance to the technical and governance requirements provided by JFSP
- reaction of the intended user population to the prototype
- potential effects of the solution on the overall research, development, and application lifecycle for fire science
- implications for training and other adoption mechanisms

This report provides the SEI's observations, recommendations, and rationale for those recommendations and is for use by JFSP and those with whom JFSP chooses to share the report.

1 Background

1.1 Software Tools and Systems (STS) Study (2007-2012)

In 2007, the Joint Fire Science Program (JFSP), working in conjunction with the National Wild-fire Coordinating Group (NWCG) Fuels Management Committee, initiated the Software Tools and Systems (STS) study.

Phase I (2007-2008) studied the problem of “software chaos” that had been identified by the fire and fuels user community. In Phase II (2008-2009), JFSP designed a collaborative system architecture and the software lifecycle process to address the challenges cited in Phase I.

In Phase III of the Study (2009-2010), JFSP focused on Interagency Fuels Treatment Decision Support System (IFTDSS) proof-of-concept demonstrations. In Phase IV (2010-2012), JFSP released a series of IFTDSS versions that demonstrated growing functionality. These versions were made available to a large body of test users in an active program to gather user feedback.

The most current version of IFTDSS (version 2.0) was released in October 2012.

1.1.1 STS Study Phase I

JFSP engaged the SEI for Phase I, the independent evaluation phase of the Study. As the nation’s Federally Funded Research and Development Center (FFRDC) focused on software engineering, the SEI had broad experience helping federal agencies facing these and similar issues. The SEI delivered its working summary of the engagement in April 2008.

In its Phase I summary, the SEI cited these four themes. The scope of our STS Study Phase I work extended beyond fuels management, so elements of these themes go beyond IFTDSS. However, the core of these themes remains applicable.

The wildland fire and fuels management community needs a shift in the science focus

The science program needs to extend its focus in a way that parallels the shift to distributed collaboration. Currently, the wildland fire community focuses on tools, systems, and data sets in a predominantly fire-behavior framework. This needs to extend to the challenges associated with developing systemic understanding of fuel growth and ecosystem dynamics within a changing wildland urban interface (WUI) context. In particular, there needs to be particular emphasis on a methodological approach to simulation methods and data fusion across varying scales of ecosystems and scope of observations. This approach will rely heavily on cooperative action research or situated research methods.

The wildland fire and fuels management community needs a shift in the investment focus

Currently, the wildland fire community views tools, systems, and data sets as independent entities, and justifies investments in terms of their independent use. However, these tools, systems, and data sets need to be viewed in a net-centric fashion where they are combined into composite capabilities supporting the full range of ecosystem management activities. This requires investments be driven from the perspective of the user situations being supported, rather than the particular functionality being supplied.

The wildland fire and fuels management community needs a platform and approach that supports distributed collaboration

As the operational users described to us, fuels management and risk mitigation have an on-going need for data fusion and require a distributed approach to collaboration. Because of the variety of operational contexts, it is impossible to centrally predict or resource the exact sets of models, tools, or data sets needed for each situation. This requires collaborative tools supporting net-enabled methods of analysis. This flexible and extendable integration framework (what we call framework architectures) will allow tool developers or sophisticated users to rapidly configure, calibrate, or extend web-enabled capabilities to meet needs of a specific operational situation (commonly called situational applications or mashups).

The wildland fire and fuels management community needs methods for creating, publishing, and managing appropriate web-based services

If these services are driven by the suppliers (a supply-side approach), the merits of the individual services will be emphasized, within the particular interests of the supplier. In contrast, if these services are driven by the users (a demand-side approach), developing processes of user validation and supporting the emergence of new forms of user collaboration will be emphasized, within the presumption of a multi-sided market. A demand-side approach uses standards and infrastructures supporting publication to focus on developing communities of use, which enable the widest possible population of suppliers to meet the user needs.

1.1.2 STS Study Phase II

The primary objective of Phase II was to design a collaborative system software architecture that could be used to test the effectiveness of the strategic elements identified above. This phase resulted in the IFTDSS conceptual design and software architecture design.

The SEI was not involved in Phase II.

1.1.3 STS Study Phase III

STS Study Phase III focused on an IFTDSS proof-of-concept using an interagency test group. This phase resulted in provisional acceptance of IFTDSS Version 0.3 by the NWCG as well as the designation of the Forest Service as the interim managing partner.

The SEI was not involved in Phase III.

1.1.4 STS Study Phase IV

STS Phase IV focused on continuous field testing of IFTDSS versions with steadily growing capabilities. This phase resulted in IFTDSS Version 2.0 and the designation as the Department of Interior Office of Wildland Fire (OWF) as the managing partner.

The SEI was not involved in Phase IV.

1.2 IFTDSS Evaluation Study (2012-2013)

In April 2012, an interagency group led by Jim Douglas (USDOJ) and John Phipps (USDA FS) directed the JFSP to conduct an independent evaluation of IFTDSS. During the summer of 2012, JFSP again engaged the SEI to perform the independent evaluation. JFSP and the SEI held discussions to ensure there was not a conflict of interest, as IFTDSS was in part based on the SEI's Phase I recommendations.

However, as the SEI had not had played a role nor had any involvement in the subsequent phases of the study where IFTDSS was designed and prototyped, JFSP and the SEI agreed the SEI could serve as an independent evaluator. The SEI's status as an FFRDC and an independent, expert advisor for the federal government also contributed to and supported this decision.

The SEI began the IFTDSS Evaluation Study in October 2012.

2 The Strategic Environment

During the four-year period from the end of the SEI's involvement in Phase I of the STS Study in 2008 until the start of the SEI's involvement in the IFTDSS Evaluation Study in 2012, several significant events occurred:

- In 2008, The Department of Agriculture (USDA) and the Department of the Interior (DOI) released the *Interagency Prescribed Fire Planning and Implementation Procedures Guide* (the 2008 Prescribed Fire Guide)
- Congress passed *The Federal Land Assistance, Management, and Enhancement Act (The FLAME Act) of 2009*
- In 2011 and in response to the FLAME Act, the Wildland Fire Leadership Council (WFLC), an intergovernmental committee of fire program leaders representing federal, state, tribal, county and municipal interests, completed *A National Cohesive Wildland Fire Management Strategy* and its companion document *The Federal Land Assistance, Management and Enhancement Act of 2009 Report to Congress*
- In 2012, the Department of the Interior and the USDA Forest Service signed the *Wildland Fire Information and Technology (WFI&T) Plan*

The Interagency Prescribed Fire Planning and Implementation Procedures Guide (2008 Guide)

The 2008 Guide provides standardized procedures for planning and implementing prescribed fires. It provides unified direction and guidance for prescribed fire planning and implementation for the Department of the Interior's Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), the National Park Service (NPS), the United States Fish and Wildlife Service (USFWS) and the United States Department of Agriculture Forest Service (USDA FS) as well as National Wildfire Coordinating Group (NWCG) partners the National Association of State Foresters (NASF) and the United States Fire Administration (USFA).

In his paper "*A New Era of Federal Prescribed Fire: Defining Terminology and Properly Applying the Discretionary Function Exception*," Robert H. Palmer III discusses the legal precedents related to the federal government's liability regarding wildfire and prescribed fires and the government's discretionary and non-discretionary actions. This is a critical distinction because of the legal and financial implications of a *discretionary* versus a *non-discretionary* prescribed fire:

"Because all federal prescribed fires are strictly regulated by the prescribed fire plan created pursuant to the 2008 Prescribed Fire Guide¹ and because all of the federal land agencies have adopted and agreed that the 2008 Prescribed Fire Guide provides mandatory direction, the first prong of the Berkovitz test

¹ [Interagency Prescribed Fire Planning and Implementation Procedures Guide \(2008 Guide\)](#)

will always be answered in the negative: prescribed fire planning or implementation is not discretionary.

Thus, a federal land agency employee does not have the choice whether to follow the 2008 Prescribed Fire Guide's planning and implementation requirements for any prescribed fire, large or small.

Even if a federal land agency asserts that it had discretion in formulating the prescribed fire plan, the 2008 Prescribed Fire Guide also requires that the federal land agency employee implement the prescribed fire pursuant to the prescribed fire plan."

The important point is the legal opinion that all federal land agency employees must use the processes described in the *2008 Prescribed Fire Guide* when preparing a prescribed fire plan.

The Federal Land Assistance, Management, and Enhancement (FLAME) Act

The Federal Land Assistance, Management, and Enhancement Act (the FLAME Act) required the Interior and Agricultural Secretaries to submit a "cohesive, national strategy" addressing seven specific topic areas ranging from how best to allocate fire budgets at the federal level to assessing risk to communities, and prioritizing hazardous fuels project funds.

The National Cohesive Wildland Fire Management Strategy

The National Cohesive Wildland Fire Management Strategy was required by the Federal Land Assistance, Management, and Enhancement Act of 2009 (the FLAME Act).

The strategy has three overarching, broad goals:

- Restore and maintain resilient landscapes
 - *Landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives*
- Fire-adapted communities
 - *Human populations and infrastructure can withstand a wildfire without loss of life and property*
- Wildfire Response
 - *All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions.*

These factors and their associated performance measures are shown in Figure 1.

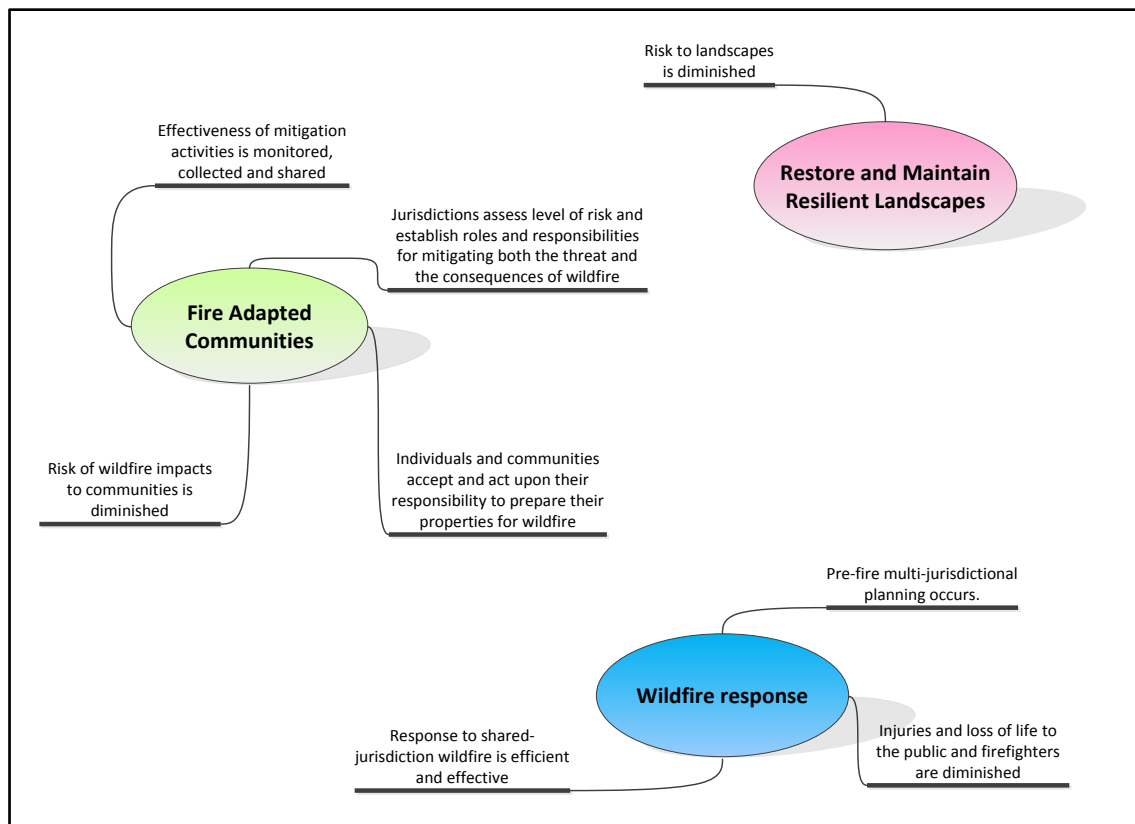


Figure 1: Factors and Performance Measures, National Cohesive Wildland Fire Management Strategy

The main point for our work is that the *Cohesive Strategy* also emphasizes risk. In discussing performance measures, the strategy states that “*measurement of risk will be the common thread.*” “Sound risk management is the foundation for all management activities” is the second highest guiding principle and core value, second only reducing risk to firefighters and the public.

Risk is such an important part of the strategy that the Appendix describing comparative risk assessments is the longest single part of the document, and at 20 pages comprises half the document.

The Federal Land Assistance, Management, and Enhancement (FLAME) Act Report to Congress

This was a companion document to the *National Cohesive Wildland Fire Management Strategy*.

In its Recommended Management Strategies section, the FLAME Act Report to Congress emphasizes regionalized trade-off analyses using a common analysis approach ... conducted by an inter-agency/intergovernmental science team using common tools.

Wildland Fire Information and Technology Strategy, Governance, and Investments (WFIT Plan)

(This section was adapted from the Executive Summary portion of the Wildland Fire Information and Technology Strategy, Governance, and Investments)

The 1996 *Information Resource Management (IRM) Strategy Project and Wildland Fire Business Model* report identified the need for an enterprise architecture program to help the interagency wildland fire community modernize its IT support. In 2004 an effort to create a modernization blueprint was chartered, and in 2010 the Department of the Interior (DOI) Investment Review Board (IRB) approved the *National Wildland Fire Enterprise Architecture (NWFEA) Modernization Blueprint* with conditions.

The report *Implementing the National Wildland Fire Enterprise Architecture Blueprint* was completed in 2011 and resulted in these two tasks:

- developing a single, executive level governance body and structure for wildland fire information and technology investments and activities
- developing a common wildland fire information and technology vision and strategy for use in evaluating current and new investments

Wildland fire was selected as one of the six pilot efforts to develop "roadmaps" to manage investments within specific lines of business (LOB).

The Wildland Fire Information & Technology (WFI&T) Plan is the product of this pilot and is built on four principal concepts:

- Mission requirements drive integrated, modular based applications and tools.
- Authoritative data are readily available for all uses and users.
- Interconnection and accessibility regardless of organization affiliation or user location.
- Technology, research, and innovation enable and enhance mission accomplishment.
- As this report is written in June 2013, the WFI&T is undergoing update and implementation.

2.1 Summary

Drawing from these and other relevant references, we consider the following to be the key strategic drivers for the wildland fire community that relate to IFTDSS:

- In response to the FLAME Act, DOI and the FS stated they would develop a common analysis approach to be used by an interagency/intergovernmental science team using common tools; this has two significant implications:
 - a common process (or workflow) using common tools
 - an emphasis on interagency and intergovernmental collaboration

- Also in response to the FLAME Act, DOI and the FS reported back to Congress that sound risk management will be the foundation for all of their management activities, second in importance only to reducing risk to firefighters and the public.
- All federal land agency employees must use the processes described in the 2008 Prescribed Fire Guide when preparing a prescribed fire plan (i.e., they must follow a consistent process or workflow).
- DOI and the FS agreed to an information technology plan that emphasized integrated, modular-based applications, authoritative data, availability for all uses and users regardless of agency or location, and that technology, research, and innovation will enable and enhance missions.

3 IFTDSS Evaluation Study

3.1 Interagency Fuels Treatment Decision Support System (IFTDSS)

(This section was adapted from <http://www.frames.gov/iftdss>)

The Interagency Fuels Treatment Decision Support System (IFTDSS) focuses on the interagency hazardous fuels reduction (HFR) program. The IFTDSS software integration framework provides a demonstrated technical solution to create a standard and effective process for organizing currently stand-alone scientific software tools so that data management inefficiencies are eliminated, and project management and functional application support is enhanced.

IFTDSS is a web-based software integration framework designed to manage pre-existing and future software models and their required data needs to support fuels management analysis and decision making. Previously, the software tools available to field users to assist in hazardous fuels reduction planning were stand-alone tools that supported only part of the planning process and could not easily share data.

Interviews with users highlighted the need to automate this sequencing of isolated software tools into a workflow that takes them from beginning to end of a specified task. In IFTDSS, this “beginning to end” sequence is called a workflow. At present, IFTDSS contains four workflows:

- hazard analysis
- risk assessment
- fuels treatment
- prescribed burn planning

IFTDSS also allows users to access individual software tools FOFEM, FlamMap, FCCS, Consume, etc. without following a workflow. In this usage scenario, IFTDSS provides a single user interface and a coordinated data management processes for these tools, simplifying their use and providing access to these tools in one location.

3.2 IFTDSS Evaluation Study

The IFTDSS Evaluation Study has four main tasks. Quoting from a September 2012 press release from the JFSP, the high-level description of the tasks were:

Task 1: Relationship to the Wildland Fire Information and Technology (WFI&T) Plan

This task focuses on how well IFTDSS meets the vision and strategy outlined in the WFI&T plan. JFSP is particularly interested in an evaluation of the IFTDSS as an interconnected system-of-systems architecture in the context of current wildland fire

business practices and available software systems, and its potential extensibility for use in other business domains.

Does IFTDSS provide a significantly improved platform for the integration of computational models and data?

Task 1 was broken into two tasks to better manage the work. Task 1a was focused on the relationship between IFTDSS and the WFI&T. Task 1b was the IFTDSS architecture assessment.

Task 2: Software Lifecycle Management

This task focuses on the potential impact IFTDSS could have on the lifecycle development and maintenance of current fuel treatment models and software systems, including functions currently performed by research organizations.

Can IFTDSS improve the efficiency and effectiveness of model and software development and maintenance process as compared to existing procedures?

Task 3: Fuels Treatment Planning User Evaluation

This task will evaluate the potential for IFTDSS to improve the quality and efficiency of fuels treatment planning in the field, including a comparison with current methods and major software systems used for this purpose. A series of user evaluation workshops will be held across the country to gather the data needed to independently and creditably assess user feedback. This work will be coordinated with the NWCG Fuels Management Committee, and supported logistically by the JFSP Knowledge Exchange Network.

Does IFTDSS measurably improve the quality and efficiency of fuels treatment planning?

Task 4: IFDTSS and User Training

This task will assess whether the IFTDSS has the potential to support a more effective and efficient training framework and/or training delivery methods for fuels treatment planning.

By focusing on user defined workflows to solve business needs rather than specific models and interfaces, does IFTDSS encourage and improve critical thinking and problem solving skills needed for fuels treatment planning?

Each of these tasks is discussed in subsequent chapters.

4 Task 1a: IFTDSS and Its Relationship to WFI&T (IFTDSS Looking Outward)

Task 1: Relationship to the Wildland Fire Information and Technology (WFI&T) Plan

This task focuses on how well IFTDSS meets the vision and strategy outlined in the WFI&T plan. JFSP is particularly interested in an evaluation of the IFTDSS as an interconnected system-of-systems architecture in the context of current wildland fire business practices and available software systems, and its potential extensibility for use in other business domains.

Does IFTDSS provide a significantly improved platform for the integration of computational models and data?

After the IFTDSS Evaluation began, it became apparent that Task 1 had two distinct views. With the concurrence of JFSP, Task 1 was broken into two tasks to better manage the work.

Task 1a—characterized as IFTDSS looking outward—addressed how well IFTDSS complied with the WDI&T and other enterprise governance. Even this characterization morphed over the course of the work, as it soon became apparent that the enterprise governance was not sufficiently formed during IFTDSS’s development to provide concrete guidance.

Therefore, Task 1a emphasized what was needed in the WFI&T and other enterprise governance documents to support IFTDSS (or other SOA-based systems).

Task 1b—characterized as IFTDSS looking inward—was an assessment of the architectural viability of IFTDSS as a software tool; this task characterization remained constant during the course of our work.

4.1 Findings and Observations

Note: This material is drawn from the white paper that was originally delivered to JFSP in January 2013; the full text of the white paper is in Appendix A.

The wildland fire community consists of a diverse set of federal, state, local, and nongovernmental organizations, involves many personnel with varying skill sets and backgrounds, and spans a broad range of technical and materiel capabilities. However, effective wildland fire planning and response requires a comprehensive picture of current and potential future conditions (through scientific models), understanding of environmental and property risks, and knowledge of and access to available resources. The need for coordinated action in the face of organizational, geographic, and mission diversity challenges traditional information and technology management methodologies.

The current wildland fire technology landscape consists of scores of independently developed applications, scientific models, and data sets. This fragmentation impedes the development of efficient operational planning and undermines the effectiveness of wildland fire response. Traditional architectural approaches to address technology fragmentation depend on tight centralized control and hierarchical structures. This strategy often results in bloated mission systems that are expensive to develop, limited in impact, slow to adapt, and difficult to maintain.

The broad constituency and diverse interests of the wildland fire community requires an architectural approach that accounts for the decentralized nature of management and operations. A “system-of-systems” architectural approach is characterized by an independence of operations and management, meaning that the individual constituents of the system are able to act with relative independence.

Effective management in this construct requires greater emphasis on strategic elements (e.g. core enabling services, data and interface standards, and coalition governance). These elements should encourage conformance while placing minimum constraints on the mission solution space - empowering technologists and operational elements to quickly incorporate and adapt preferred capabilities that meet diverse mission needs. In a decentralized environment, a system-of-systems architectural approach can yield greater agility, enhanced situational awareness and mission effectiveness, improved security posture, and reduced development and lifecycle costs.

A system-of-systems approach explicitly recognizes and enables independent, evolutionary development of constituent capabilities. This co-evolution is necessary given the wide range of continuously improving capabilities associated with wildland fire. Independence of change in individual constituents adds to the complexity of the interactions among constituents and of management and operations. Thus, in a system-of-systems, evolution must be explicitly recognized and managed. By facilitating change, systems can more readily integrate innovation resulting in greater mission impact.²

In March 2012, the Department of Agriculture Forestry Service and the Department of Interior jointly signed the Wildland Fire Information and Technology (WFI&T) Strategic Plan. This plan articulates a vision to enable an interagency, integrated approach to wildland fire information and technology management in support of mission activities. The plan establishes four concepts that guide wildland fire technology implementation:

- Mission requirements drive integrated, modular based applications and tools.
- Authoritative data are readily available for all uses and users.
- Interconnection and accessibility regardless of organization affiliation or user location.
- Technology, research, and innovation enable and enhance mission.

² Fisher, David; *An Emergent Perspective on Interoperation in Systems of Systems* (CMU/SEI-2006-TR-003). Software Engineering Institute, Carnegie Mellon University, 2006.
<http://www.sei.cmu.edu/library/abstracts/reports/06tr003.cfm>

To achieve the WFI&T vision, wildland fire management must establish a technical architecture consistent with these concepts. The architecture will enable coordinated wildland fire planning and response while accounting for the decentralized nature of the wildland fire community.

To support the four WFI&T strategic concepts, the technical architecture requires six strategic elements. These are listed below, along with highlights of how IFTDSS can help the community reach these elements:

- service oriented modular capabilities
- integrated security posture
- connected wildland fire community
- cloud hosted infrastructure
- data services and governance
- open innovation platform

While each of these elements is discussed in greater detail in Appendix A, Table 1 provides a summary description of how IFTDSS supports them.

Table 1: Six Strategic Elements of the Technical Architecture and How IFTDSS Supports Them

Strategic Element	IFTDSS Support
Service Oriented Modular Capabilities	<ul style="list-style-type: none"> • IFTDSS decomposes application functions into logical modules • IFTDSS provides a single integration platform for the scientific models, providing a step toward a system of systems vision • The SMF component within IFTDSS can be extended to support scientific models in other domains • IFTDSS can, with relative ease, be extended to interact with other wildland fire systems
Integrated Security Posture	<p><i>NOTE: while IFTDSS has a minimal security posture (user id/password), no security requirements were levied against it during development and there were no published security policies to which it could conform. This will be discussed more in Section 5.</i></p> <ul style="list-style-type: none"> • Like nearly all wildland fire tools, success requires specific gaps be closed <ul style="list-style-type: none"> – Most of the gaps reflect lack of governing guidance (e.g. security) • IFTDSS security model is “all or nothing” • Demonstrates a “single sign-on” for included scientific models

Connected Wildland Fire Community	<ul style="list-style-type: none"> • IFTDSS provides users from any agency or location with web-based access the scientific models <ul style="list-style-type: none"> – This eliminates the need to execute scientific models on local machines – IFTDSS could be made downloadable to laptop or desktops but doing so will risk recreation of the software chaos identified in 2007 • IFTDSS provides a consistent user interface through a single portal to reduce barriers to accessing and using included scientific models
Cloud Hosted Infrastructure	<ul style="list-style-type: none"> • IFTDSS extracts relevant scientific models from the multiplicity of systems for use within a single user interface • IFTDSS is capable of hosting many scientific models • IFTDSS can be hosted in the cloud
Data Services and Governance	<ul style="list-style-type: none"> • IFTDSS is well positioned to consume data from other systems • IFTDSS allows sharing of project outputs • IFTDSS has data formatting and reformatting capability • IFTDSS can be used to limit access to data sources • IFTDSS can be extended to become a contributor to an enterprise-wide data strategy
Open Innovation Platform	<ul style="list-style-type: none"> • An IFTDSS design goal was to create a platform to help streamline the integration of new scientific models <ul style="list-style-type: none"> – By encapsulating scientific models, researchers can focus on improved or new science vs. interface design, data access, handling and mediation, etc. – To be most effective, IFTDSS needs to be an extended with an SDK to enable self-service use by the scientific community

4.1.1 Federal CIO 25 Point Plan

In general, IFTDSS is aligned with those parts of the U.S. Chief Information Officer's December 2010 *25 Point Implementation Plan to Reform Federal Information Technology Management* that are applicable to a tool like IFTDSS. While many of the 25 points are well outside the scope of a tool such as IFTDSS, there are a number that will either affect IFTDSS, or to which IFTDSS should comply.

- *Point 1: Complete detailed implementation plans to consolidate at least 800 data centers by 2015 and Point 2: Create a government-wide marketplace for data center availability*
 - Data center consolidation and a government-wide marketplace for data center availability could affect where IFTDSS is hosted, but we did not explore this topic.
- *Point 3: Shift to a “Cloud First” policy and Point 4: Stand-up contract vehicles for secure Infrastructure-as-a-Service (IaaS) solutions*
 - As discussed in other sections of this report, IFTDSS is capable of being hosted in the cloud.
- *Point 6: Develop a strategy for shared services*
 - The May 2012 *Federal Information Technology Shared Services Strategy* defines an IT shared service as an information technology function that is provided for consumption by multiple organizations within or between federal agencies. There are three general categories of IT shared services:
 - commodity
 - support
 - mission
 - The services are delivered through cloud-based or legacy infrastructures. Inter-agency IT shared services are called lines of business (LOBs) and are operated by a managing partner within a federal agency.
 - If adopted, IFTDSS could be a shared service, and as such should be listed in the online catalog of approved inter-agency IT shared services.
- *Point 9: Require integrated program teams*
 - IFTDSS was developed using an integrated team of business process owners who understood the problem they were solving and IT professionals who understood the range of technical solutions.
- *Point 10: Launch a best practices collaboration platform*
 - If deployed, we recommend that IFTDSS be considered as a case study.
- *Point 16: Reduce barriers to entry for small innovative technology companies*
 - While this point is primarily directed at encouraging small businesses to work with the federal government, our take was that IFTDSS is designed to reduce the barriers for entry for small innovators (researchers, etc.). The further development of the software development kit (SDK) as well as the necessary governance to promote a model from research status to production status is needed to achieve the goal of reduced barriers.

4.2 Challenges

The primary challenge will be to make progress. The goals of WFI&T need to be operationalized in the form of a detailed technical architecture, including: specifications of security and interoperability standards; a determination of enterprise-wide services (e.g., security and data services) that wildland fire systems will be expected to use; a schedule for migrating existing systems to comply with the specified standards and consume the enterprise services. Detailed recommendations with

respect to this challenge follow though we consider that progress toward implementation of an integrated security posture is a vital and important area to start. While IFTDSS could be the system that hosts such an enterprise wide security service, IFTDSS is currently better suited to be a consumer and not the provider of that service.

4.3 Recommendations

These are summary points from the longer discussion in Appendix A; for further detail please see that Appendix.

4.3.1 Service Oriented Modular Capabilities

- Create and enforce enterprise SOA guidelines and governance.
- Inventory existing wildland fire applications and data for services that can be exposed for reuse consistent with SOA guidelines. Set budget priorities to replace or phase out systems that do not expose or consume modular capabilities.
- Encourage modular system development through budget incentives that reward component reuse and compensate service providers through cost recovery mechanisms.

4.3.2 Integrated Security Posture

- Coordinate with agency CIOs to establish a wildland fire identity management policy that includes agency and non-agency users.
- Investigate IDaaS providers to identify if cost-effective solution exists that meets the needs of the wildland fire enterprise.
- Establish a centrally managed wildland fire IdAM infrastructure.
- Ensure cloud strategy consistent with integrated security posture.
- Integrate mission and back office systems as technology refresh cycles permit by replacing tool-specific authentication.

4.3.3 Connected Wildland Fire Community

- Establish a WebUI Policy phasing out applications with client dependencies.
- Encourage technologies to support mobile devices and use HTML 5 including offline capabilities.
- Develop and enforce common user interface standards for a consistent user experience.
- Establish enterprise collaboration capabilities and services.

4.3.4 Cloud Hosted Infrastructure

- Select one or more cloud providers from the FEDRAMP list of vendors.
- Ensure cloud provider is consistent with integrated security posture (Part 2).
- Research cloud service brokers to simplify cloud management and migration.
- Establish cloud integrated IT asset management (ITAM) to prevent VM sprawl.

4.3.5 Data Governance Recommendations

- Survey wildland fire systems for business functions and data. Identify systems of record, expose data and functionality for reuse, and eliminate redundancies.
- Create derived data manipulation and storage capabilities to facilitate group and community sharing as well as third-party system reuse.
- Create enterprise processes for establishing the authoritativeness of derived data.
- Establish wildland fire data formatting and exchange standards (e.g. NIEM, KML).

4.3.6 Enhanced Innovation Recommendations

- Establish a cloud-hosted open innovation environment for the wildland fire community that hosts integration versions of mission systems and forums for idea exchange.
- Create Simple Rules governance structure and associated conformance endpoints for technology compliance.
- Enhance IFTDSS to facilitate third-party reuse and support “self-service integration” of wildland fire scientific models.

5 Task 1b: IFTDSS As a Software Tool (i.e., IFTDSS Looking Inward)

Task 1: Relationship to the Wildland Fire Information and Technology (WFI&T) Plan

This task focuses on how well IFTDSS meets the vision and strategy outlined in the WFI&T plan. JFSP is particularly interested in an evaluation of the IFTDSS as an interconnected system-of-systems architecture in the context of current wildland fire business practices and available software systems, and its potential extensibility for use in other business domains.

Does IFTDSS provide a significantly improved platform for the integration of computational models and data?

5.1 IFTDSS Architecture

IFTDSS can be loosely³ characterized as a service oriented architecture system (SOA) that encapsulates scientific models extracted from the existing tools. As such, it provides a framework called the scientific modeling framework (SMF), with various capabilities (including a workflow engine, a data storage manager, a data acquirer, and a scientific model manager) provided as part of the framework, an application that contains the business logic specific to fuels treatment, and a collection of new and existing scientific models that are made available to the application.

³ IFTDSS exhibits many of the characteristics of an SOA system but cannot, as we understand the term be considered an SOA. In particular, models such as the OASIS SOA Reference Model. That model states that an SOA must provide three basic operations: discovery, composition, and invocation. While SMF supports composition and invocation it has no support for discovery.

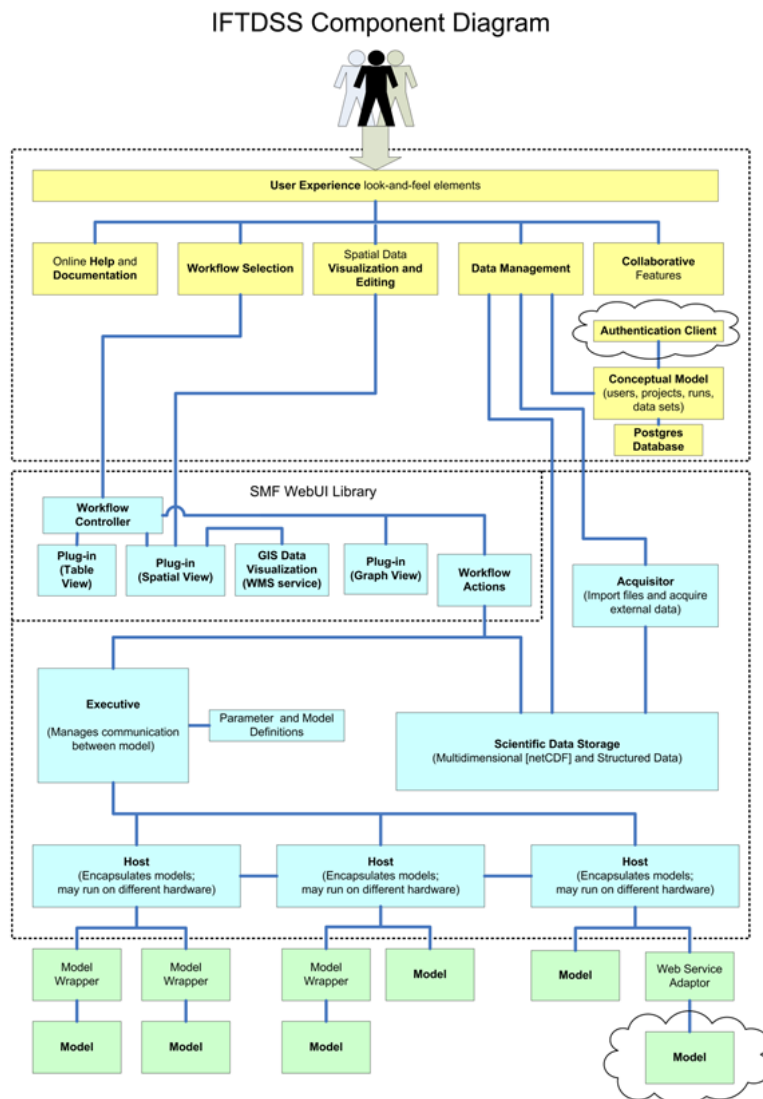


Figure 2: IFTDSS Architecture

The diagram in Figure 2 (courtesy of STI), provides some detail with respect to the three layers of IFTDSS. The top layer is the web application that contains the business logic with respect to fuels treatment and is the component that should best be labeled as IFTDSS even though that name more usually applies to the composition of all three layers. The middle layer is the scientific modeling framework which contains a generic set of capabilities that could, with the addition of a new web application, be used in domains⁴ other than fuels treatment. The third layer comprises the scientific models (either new models or residing within or extracted from existing tools) and the software necessary for those models to communicate with the SMF.

⁴ For example, the SMF could be used to support models in other aspects of wildland fire management, but a testament to its flexibility is that it is currently being considered with respect to analysis of road safety.

In terms of physical architecture, the three components may reside on one or more physical systems. For example, for development, all three components reside on a single server. However, the environment for the beta production systems is arranged on three servers as seen in Figure 3.

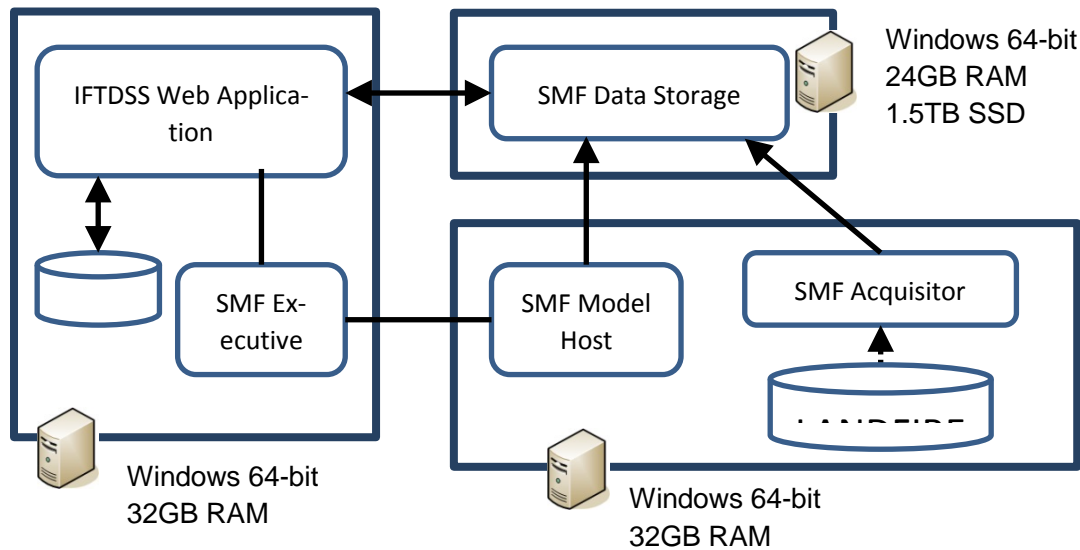


Figure 3: Physical Architecture of Beta Production System

The model host servers could easily be duplicated with not all servers hosting all models permitting some tuning, at the hardware level, for performance. Similarly, the data storage server could be duplicated, reducing the communications load on the storage server though this will likely require greater coordination with respect to where the different projects would reside. Finally, the web application server can be duplicated using traditional techniques for enhancing performance in web applications. From the physical perspective, the IFTDSS architecture is scalable.

5.2 IFTDSS Architecture Analysis Findings and Observations

A crucial question that has to be answered is whether or not the IFTDSS software is good enough to be fielded. A key component of this question is whether or not the IFTDSS architecture is robust enough for operational use. We used a variant of the Architecture Tradeoff Assessment Method (ATAM) to investigate the IFTDSS architecture. ATAM is a proven technique that delves into the architectural drivers for a system and operationalizes those drivers in the form of quality attribute scenarios and then determines how well the architecture performs in the situations defined by the scenarios. The variation shortened the period over which the architectural analysis was performed and involved fewer stakeholders than usually found in an ATAM. We augmented the analysis team with members of the user workshop team in order to add other stakeholder viewpoints.

From an architectural perspective, IFTDSS is sound and responds well to the key architectural drivers. It could be fielded now, but this is not without risk; the following sections detail the archi-

tectural risks. We have collated the risks into the following themes: Security, Performance, Extensibility, Documentation, Interoperability, and Usability. The analysis is summarized hereafter with the detailed analysis found in Appendix B.

5.2.1 Architecture Risk Themes

Security

IFTDSS, as a system developed by the research community, was developed without significant investment in security. Specifically, the IFTDSS web application has a module which authenticates users and also maintains the links between users and the data projects for which they are responsible.

A strength of IFTDSS is that the current architecture makes it easy to adhere to an enterprise wide security policy since changes are localized to a small part of the web application. However, if SMF is to be exposed as a service to other applications then a notion of identity and, even, data confidentiality, will need to be implemented in both SMF and the model hosts.

We should stress that the lack of a security model in IFTDSS is not a show-stopper but is, rather, a caution on operational use.

Performance Risks

On the development server and, also, the beta distribution server, IFTDSS performs well enough⁵ though users occasionally complained of unexpected delays. By performance, we're referring to perception of speed in reasonable load, disk space consumption, and bandwidth consumption.

The structure of IFTDSS is such that additional hardware can be added to the IFTDSS hardware suite in order to support as many users as the wildland fire community desires. Adding a new data server should require no more than adding the appropriate SMF Data Storage software onto an appropriately configured machine. Similarly, adding a new model host means determining which models should be resident on the hardware; installing the underlying models and the SMF model host software on the machine. In both cases, the IFTDSS web application will need to be restarted in order for the new hardware to register.

A secondary component of the performance theme is that there is little current data on the resource requirements for the different scientific models. The developers have some rules of thumb with respect to the time it takes a model to execute and use these rules to limit overall execution time in order to halt models that are diverging and will never terminate. As more model hosts are added, the SMF model scheduler will need to take into account current loads and a model's resource requirements to perform load balancing. We note, though, that IFTDSS lacks a monitoring capability and this, too, will be necessary in order to provide load balancing.

⁵ The lack of hard requirements with respect to performance means that only subjective measures such as "well enough" can be applied.

Before being deployed community-wide, performance and scalability must be shown to be adequate, and that cannot be done until performance and scalability requirements are determined.

We stress that the inability to validate IFTDSS performance and scalability (because there are no requirements to validate against) is not a show-stopper at present but it should be addressed prior to full deployment.

Extensibility

IFTDSS is extensible in two different ways: first, it can be extended by adding new scientific models, thus enriching the choices available to the fuels treatment community and second, it can be extended to other domains within the wildland fire community.

The architecture of IFTDSS is well suited to adding new scientific models. These can be registered, incorporated into existing pathways or form the basis of new pathways. A deficiency of IFTDSS is that models are integrated on a one-by-one basis using model specific integration. This problem is exacerbated where IFTDSS is being used to host the scientific models residing in existing tools where the integration methods vary from invoking a shell script to integrating with DLLs that are part of the tool. Models, such as the risk model can be directly integrated into the java model host software.

The current approach to integration is labor intensive and dependent on knowledge of internals of the tools and also knowledge of the SMF. A future goal for IFTDSS should be the creation of a software development kit (SDK) that provides the interface to which scientific models can be developed. For new models, developing to this interface would be all that is needed. For existing models, some effort will be required to adapt their tools to use the API. A documented API offers the opportunity for self-service integration where model developers can perform all the steps necessary to integrate their models into the framework.

Making it easier to extend IFTDSS by adding new models will place additional burdens on the governance processes. Models integrated into IFTDSS will, at present, be available to all users; this means that a governance process is required in order to qualify models for deployment and, as importantly, to stop models from being deployed.

The second way in which IFTDSS can be extended is by deploying the SMF as the modeling framework in other domains. One concern is that IFTDSS invokes the scientific models as if they were essentially “batch” models. That is to say, data is prepared, the model is initiated and executes until it has completed, and then the results are made available to the user. While such usage is typical and even desirable for services in an SOA, if the models in other domains cannot be extracted and operated in this batch mode, then IFTDSS extensibility will be reduced.

A second concern is that the separation between the IFTDSS web application and the SMF is not as clean as depicted and that the extension will require some refactoring of the architecture. Obviously, extending the SMF to a new domain will entail the creation of a new web application.

Documentation

IFTDSS software documentation at present appears to be inadequate should the government decide to pursue third-party maintenance, self-service integration of scientific models, or future capability evolution. Currently, there is no architecture documentation available to the government that goes into significantly more depth than used in this report. No risk arises as long as STI is providing support, however, that contract is coming to an end. Even if the internals of IFTDSS were not documented, some areas **must** be documented if the wildland fire community is to go forward with IFTDSS.

Pathways are a key feature of IFTDSS; they provide the mechanisms to create business processes that cross the boundaries of multiple underlying scientific models and will form the basis of standardized business processes across the community. There is no documentation describing how to define a pathway. The lack of such documentation isn't a barrier as enterprising individuals will copy an existing pathway and modify it to suit their purposes, but such an approach leads to inefficiencies and inaccuracies.

We've discussed the need for an SDK that enables new scientific models to be incorporated; clearly this SDK needs to be documented.

The knowledge needed to construct appropriate documentation content exists within the IFTDSS development team. This is the time to capture that information before members of the team disperse and this critical knowledge is lost.

Interoperability

The IFTDSS architecture allows for more interoperation with other systems than is currently being achieved. The two areas immediately available for interoperation are the security module in the IFTDSS web application and data sharing. As stated above, the IFTDSS web application contains a single module responsible for security; federating identities with other applications will be localized to this module.

Similarly, the SMF contains a component known as the data acquirer that is responsible for obtaining data from other sources; addition of new data sources means that only that module needs to be altered. However, IFTDSS currently has no data export capability, limiting full interoperation.

It is unlikely that the structures used for internal IFTDSS communication will be the precise structures needed for communication with other wildland fire systems; on the other hand, in the absence of enterprise-wide standards, the internal structures form the basis of discussion. An interface could be created to the data storage component that would then serve project data to other systems in much the same way as projects are shared internally. However, such interoperation is dependent on enterprise-wide standards or the community will create a network of point-to-point connections and fail to meet the WFI&T policy goals.

Usability

From an architectural perspective, the usability of IFTDSS will be affected by inconsistent user experiences. The extent of resource throttling within IFTDSS is to terminate a model should it overrun a fixed bound. However, the execution time for a model will depend on variable factors, such as server load. Our concern is that models will be erroneously terminated leaving users with no option other than to restart a model in the hope that it will execute within its time limits.

This issue is far from critical as execution times can be set deliberately high in the monitor, however, a better approach will be to use load monitoring to provide a more realistic calculation of the appropriate execution limits.

A particular strength of IFTDSS is that scientific models are executed using background tasks. This means that users don't have to wait for model execution to complete before they can proceed. The immediate return to the user interface means that users can perform other tasks until such time as their workflow has completed.

Another usability strength of IFTDSS is the pathway concept; this helps users understand "what to do next" by leading them through standardized processes. From an architectural perspective, it is not clear why an open source solution could not have been used as the workflow engine.

5.3 Challenges

The risks above can be described as a challenge to both the wildland fire community and, also, IFTDSS, we discuss each of these challenges.

For IFTDSS to implement a security policy, the wildland fire community has to have such a policy. We've previously discussed recommendations in this area so, simply, repeat here the need for the community to develop a policy.

With changing emphasis on fuels treatment, developing a model of IFTDSS usage patterns will be problematic; further, because IFTDSS offers opportunities to do more science, IFTDSS will likely be used more than expected.

The wildland fire community needs to make a decision with respect to the framework they wish to use for modeling. IFTDSS presents an ideal opportunity to support fuels treatment and to be extended to other domains. At the same time, STI and the modeling community must reach agreement on the nature of an SDK so that model integration becomes easier and benefits the lifecycle.

We are aware of the iIRWIn project and its goals to help identify data; however, until the goals of iIRWIn are realized, the community still needs to develop data interchange standards at an enterprise level and migrate systems to using those standards.

5.4 Recommendations

For the enterprise:

- Use IFTDSS as an opportunity to experiment with a security policy – choose an initial policy and determine whether or not that is manageable by the community.
- Create realistic usage patterns and review these periodically to determine current needs in comparison to expected needs. Use these usage patterns to drive the manner in which IFTDSS is scaled.
- Fund and deploy IFTDSS for the fuels treatment community; subsequently determine whether to extend IFTDSS to other domains or, at a minimum, link it to other frameworks.
- Develop enterprise-wide data standards for communication; these should account for the use of the needs of transmitting large data sets and not necessarily employ a pure XML model.
- For IFTDSS: Extend the SMF with better support for security. As a minimum, a data access management mechanism needs to be introduced. This could be localized to the data storage component where data would be tagged with its confidentiality and access provided to that data depending on the requestor's identity.
- Perform better analysis of the resource requirements for each model and extend the scheduler to perform appropriate load balancing.
- Run experiments to ensure that IFTDSS scales to multiple data storage, scientific model, and application hosts as expected.
- Add a scientific model monitoring capability that provides the scheduler with detail to enable load balancing.
- Develop an SDK for model integration and migrate the current STI custom code to use that SDK
- Document the SDK and pathway mechanisms so that developers other than STI can integrate new models and create new pathways
- Document Both IFTDSS and SMF with, at least,
 - Module views
 - Class hierarchies
 - Interface specifications
 - Runtime views showing concurrency
- Create a data export service that, if nothing else can be used to share data between IFTDSS instances.

6 Task 2: IFDTSS and Software Lifecycle Management

Task 2: Software Lifecycle Management

This task focuses on the potential impact IFDTSS could have on the lifecycle development and maintenance of current fuel treatment models and software systems, including functions currently performed by research organizations.

Can IFDTSS improve the efficiency and effectiveness of model and software development and maintenance process as compared to existing procedures?

Beginning approximately in the late 1970s researchers within the fire science community started developing personal computer (PC)-based applications to implement models of fire behavior, originally based upon the equations and nomographs of R.C. Rothermel. Over time these PC applications have proliferated, and the algorithms and data models upon which the applications are based have been enhanced.

As these applications were adopted by the wildland fire community, the development and support burden required to maintain them has increased. As a result, what were initially research projects have largely (if not predominantly) transformed into software enhancement and support activities.

An additional complication lies in the fact that the money to fund applications work is derived from a variety of sources. These include JFSP; NSF; DoD; NASA; Regional Forest Service Management; Local Forest Service Management; one-off grants from stimulus funding, etc. Each of these agencies has different priorities and agendas relative to model development.

6.1 Findings and Observations

6.1.1 Operational Efficiency and Quality

We found widely divergent practices and quality standards for lifecycle activities such as coding, test, configuration management, release management, change management, requirements, and architecture. In particular:

- Development and release practices and quality standards are not held to production level disciplines.
- There is no robust, unified hosting strategy.
- Staffing for application development and support is highly opportunistic; frequently development is done by whoever is available and willing, not necessarily by who has the most relevant skill sets.
- The usage model for applications is blurred; the applications are utilized both as turn-key end user programs and as tools used by researchers to model more complex applications.

- There is a proliferation of support mechanisms for users; i.e., there are different support mechanisms for different tools.

6.1.2 Governance

Governance (or more accurately, the lack of governance) was the greatest issue we found; there is no authoritative, cohesive development agenda and roadmap for fuels management software. There are also no incentives or organizational support structures for the achievement of common architectures, integrated workflows, common user interfaces (UIs) and common data models across applications.

There is no coherent governance and review process for model approval and acceptance or for the consolidating of redundant models, nor is there a coherent long-term vision on the role of new paradigms in fire behavior modeling (e.g., physics-based models).

6.1.3 Innovation

We found innovation to be a strength of the community; researchers are highly engaged and dedicated to their teams, their user base, and their projects. There are close interactions between researchers and fire management personnel, and these spur some model enhancements. Other innovations result from researcher-to-researcher collaboration, and in some cases researchers may anticipate needs in advance of users.

It also appears that the use of open source is increasing, as is the reliance on university collaborators.

However, we also found that the considerable amount of researcher capacity that is dedicated to development and support activities hampers innovation.

6.2 Challenges

6.2.1 Core Problems

From these observations we have identified three core underlying problems:

- There are no standardized policies and mechanisms for the transition of research projects into operational production; many key operational applications are supported out of research environments.
- There is no consistent lifecycle management model.
- There is no coherent portfolio management process for fuels management applications.

6.2.2 Challenges

The key challenge for the wildland fire community regarding the software development lifecycle may be summarized as:

Increasing operational efficiency and governance for model development, deployment, and support while

- *fostering innovation in fire science and technology,*
- *respecting legitimate requirements for agency independence, and*
- *ensuring that mission-critical needs are met with high integrity and quality across the spectrum of the fuels management planning problem space*

IFTDSS can certainly play an important role in meeting this challenge. In particular, IFTDSS provides a framework in which:

- Unconnected, fragmented, and overlapping software systems can be consolidated and rationalized.
- An integrated data environment offering authoritative data sources can be established.
- Availability to software systems and data can be provided across agencies and locations.

However, in order to completely address the software development lifecycle challenge, IFTDSS must exist as part of a wider ecosystem that includes organizational design and process and technology governance. Further it should be recognized the design of this ecosystem may in turn impose further requirements on the design of the IFTDSS framework.

6.3 Recommendations

It takes *organizations*, *technology*, and *processes* to make up an ecosystem, and each of these elements depend on the other two. Consequently, a decision made in any one of these areas affects the other two. While IFTDSS represents a step forward from a technology perspective, it cannot fully address the software development lifecycle challenge without corresponding action in the arenas of organization and process.

6.3.1 Clarify Development Responsibilities

The wildland community needs to determine which of the following activities are assigned to a research organization or a centralized development organization:

- “product ownership”—setting the vision for the application and determining development priorities in accordance with user requests and evolving science
- design and implementation of model extensions and enhancements
- design and implementation of model bug fixes
- maintenance activities (i.e.—technology upgrades, refactoring)
- qualification, test, and acceptance activities
- user support (e.g., the help desk)
- user training
- release and deployment
- hosting

IFTDSS would lend itself most naturally to the use of a centralized organization for software release and deployment and hosting support. However, IFTDSS is essentially neutral with respect to allocation of the other above-listed development activities.

Centralized vs. Distributed Development

Greater centralization of development activities facilitates the achievement of certain benefits related to efficiency and quality by:

- locating development activities within an organization that has a singular focus on technology and operational excellence
- facilitating a consistent development lifecycle across development activities
- simplifying the implementation of governance related to architectural convergence and module reuse

However, if not carefully managed, centralization can have the effect of introducing increased bureaucracy and of distancing the researchers from the realities and needs of frontline fire managers.

As previously mentioned, the allocation of organizational responsibilities will in turn have an impact on IFTDSS requirements. For example, if the decision is made that development and implementation of model enhancements will reside within the research organizations, IFTDSS will require stronger discovery mechanisms as well as a robust SDK (Software Developers' Kit).

6.3.2 Ensure any Solution Addresses the Overall Fuels Management Problem Space

IFTDSS was designed primarily as a tool to guide and facilitate fuels management planning by front-line forest managers. To accomplish this, it “hides” certain complexities of the fuels management models which are not required to accomplish standard fuels management planning scenarios.

A consistent concern raised by researchers regarding IFTDSS was that it could lead to a naïve, “black-box” approach to running and interpreting model results. Researchers believe that their current involvement in operational support activities provides some safeguards against this risk, both because they can educate users on model assumptions, and can themselves step in and conduct modeling for complex high-risk scenarios.

Any organizational adoption and transition to IFTDSS must ensure adequate training on model assumptions as well as thorough explanations of the default parameters that were selected for incorporation into IFTDSS. In addition, consultation services for modeling complex high-risk scenarios will still be required. Training should be provided both on how to recognize these high-risk scenarios and the mechanisms by which to escalate them for evaluation by those with enhanced expertise.

In addition, the “expert” tools should be identified and plans should be made for their support and enhancement. One potential route is that the expert tools will reside within the IFTDSS framework and will be the same ones used by front line managers. The only difference would be that experts would have access to a full and robust set of model parameters. Another potential path is that IFTDSS itself would contain only user level modeling capabilities and a different tool set would be supported and maintained for expert usage.

6.3.3 Implement Portfolio Governance

The WFI&T calls for “*Development of, and adherence to, a five-year rolling investment plan to ensure that investments support the business with the best value.*” The design and implementation of a coherent portfolio management system for fuels management software is perhaps the most difficult change management problem to undertake, given the multitude of funding sources and priorities to be considered.

The investment management model must address governance of the following types of activities:

- platform design—technology selection and design of the underlying architecture to satisfy system quality requirements (e.g., performance, security, usability)
- operational enhancements and support—implement, qualify, release and distribute feature and platform enhancements and bug fixes
- pipeline model extensions and enhancements—research and codify (in text, spreadsheets or in computer code) extensions and enhancements to existing operationally-deployed models
- research-driven model development—research and codify new paradigms in fire behavior modeling (e.g., physics-based models)

In addition to serving operational needs by allocating funding and setting priorities, the portfolio management process should also serve to:

- address model proliferation, enhance model integrity and address research concerns by implementing a consistent peer-review process for the acceptance of new models and significant model enhancements
- work with research organizations to create a unified vision of a long-term fuels management roadmap that could inform future research efforts.

In the words of the WFI&T, the design of the portfolio governance process must “...*respect agency organizations while efficiently organizing and managing the work.*” In addition, portfolio governance must address the needs and perspectives of operational managers and the research community.

Also, establishing line funding for key operational activities versus using “soft money” funding of research and enhancement proposals must be addressed as well as joint cross-agency funding mechanisms.

7 Task 3: IFDTSS User Evaluation

From the SEI work plan, JFSP asked SEI to examine the following:

Task 3: Fuels Treatment Planning User Evaluation

This task will evaluate the potential for IFTDSS to improve the quality and efficiency of fuels treatment planning in the field, including a comparison with current methods and major software systems used for this purpose. A series of user evaluation workshops will be held across the country to gather the data needed to independently and creditably assess user feedback. This work will be coordinated with the NWCG Fuels Management Committee, and supported logistically by the JFSP Knowledge Exchange Network.

Does IFTDSS measurably improve the quality and efficiency of fuels treatment planning?

The SEI worked with JFSP and its contractor, STI, to develop and conduct user workshops in order to demonstrate functionality and gather user feedback. User feedback was solicited via an on-line survey that was constructed to capture feedback on four specific topics as well as overall impressions in order to gauge the usefulness and acceptability of IFTDSS throughout the user community.

The SEI also interviewed expert users in order to gather information for determining the value of IFTDSS in comparison to other products currently in use in the field.

Each of the capabilities, as well as an overall assessment of IFTDSS, received a score based on the table below. Using the Qualtrics software tool, each question in the survey calculated a mean score. A scale of 1-5 was used to indicate satisfaction of each capability. The mean score is represented in the capability tables.

Score	Description
5	Very Satisfied
4	Satisfied
3	Neutral
2	Dissatisfied
1	Very Dissatisfied

Users were asked to indicate factors that influenced their score for each capability; the options were:

- Reliable
- Efficient
- Quality
- Ease of Use
- Data Sharing

Values for these charts are the number of users that indicated it was a factor in scoring the capability. As such, these values are comparative in nature. They indicate the factor(s) that was most important to the user audience when scoring the capability. They should not be construed as a value of goodness.

7.1 Findings and Observations

Overwhelmingly, users rated IFTDSS as very satisfactory and satisfactory in all categories of assessment. The overall mean score is just under 3.9 out of a maximum score of 5. Workflows, which are new to the user community, were rated the lowest while capabilities the users are much more familiar with were rated much higher. Users rated data capabilities slightly less than project and analytical models due to the inability to upload shape files. However, data capabilities are still highly rated by the workshop audience.

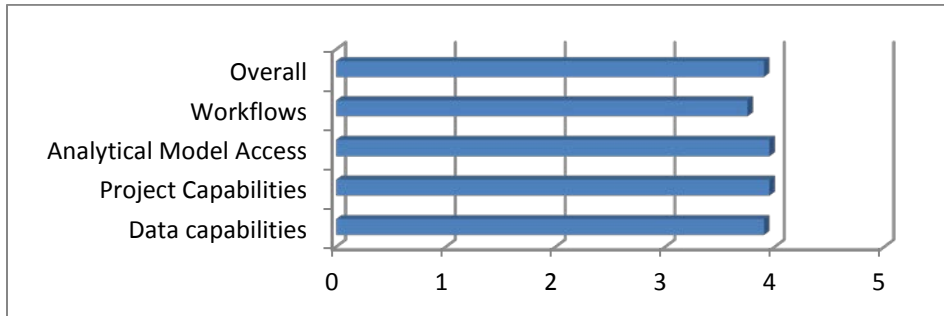


Figure 4: Overall User Survey Results

7.1.1 Data

Data capabilities include the ability to format, edit and use data in IFTDSS. These capabilities scored positively by the workshop attendees. Overall, users rated the data capabilities at 3.9 out of a possible 5. The efficient design of the data features was rated the highest while the data sharing and reliability/predictability was rated lowest, while still reasonably high.

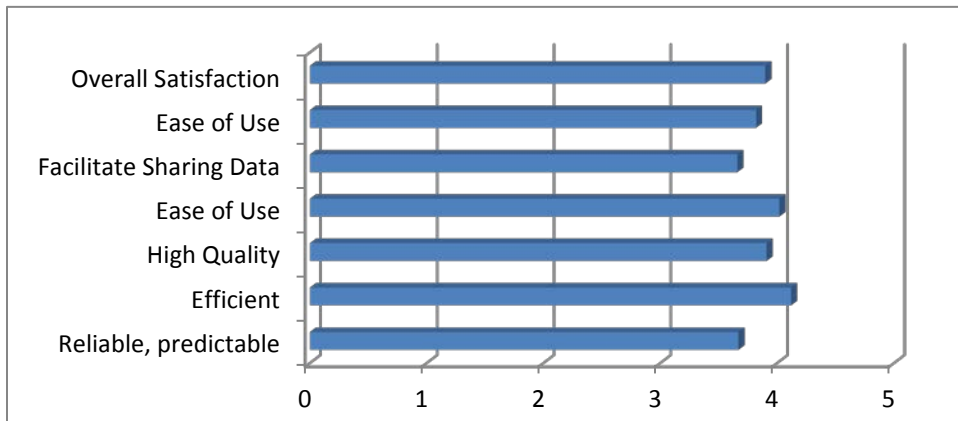


Figure 5: User Survey Results: Data Capabilities

Users considered the efficient use of the product to be the most important factor in assessing the acceptability of the data features. While none of the features were deemed unimportant, of least importance were ability to share data and the reliability/predictability of the features.

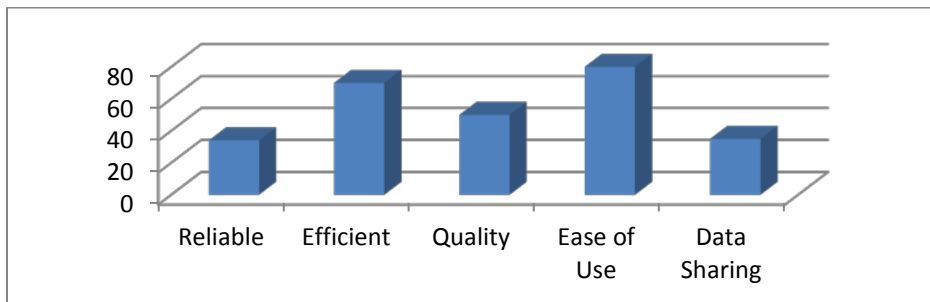


Figure 6: User Survey Results: Importance of Factors Related to Data Capabilities

7.1.2 Project

Users rated the overall project capability and the ability to create, modify and save projects very positively. The features related to sharing data and reliability/predictability were rated lower than the others while efficiency and ease of use rated the highest.

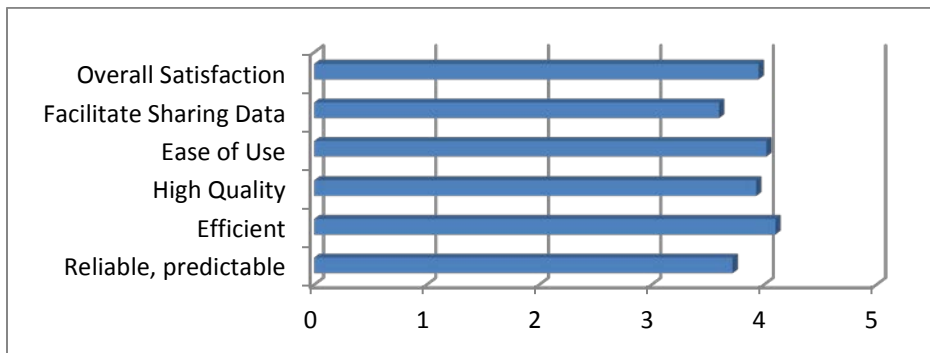


Figure 7: User Survey Results: Project Capabilities

Users indicated that ease of use and efficiency were the primary drivers of their overall rating for project capability.

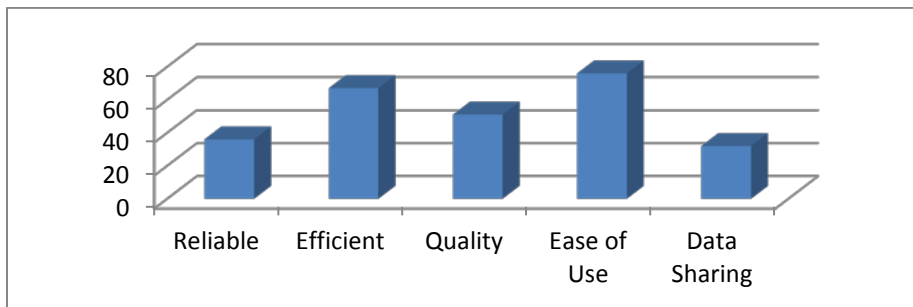


Figure 8: Importance of Factors Related to Project Capabilities

7.1.3 Analytical Models

User feedback was sought regarding the integration and availability of scientific models. Users rated the analytical model capability positively, with a very positive view of the impact on efficiency, ease of use, and overall satisfaction.

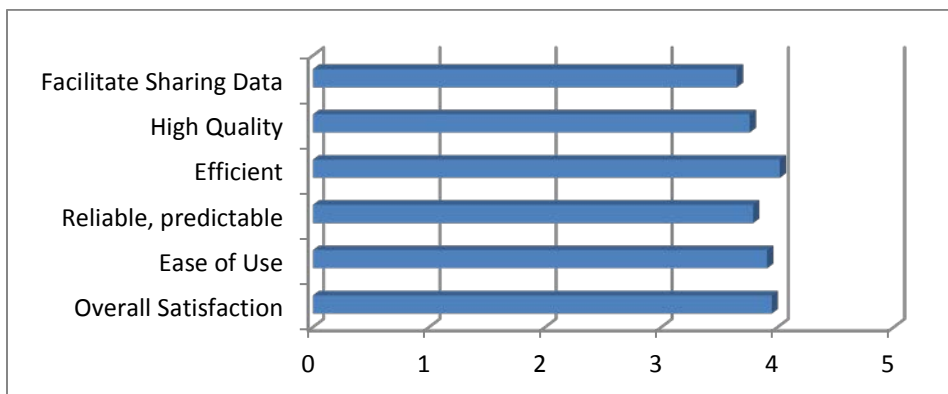


Figure 9: User Survey Results: Access to Analytical Models

Users indicated that efficiency and ease of use impacted the overall rating more than reliability, data sharing and quality.

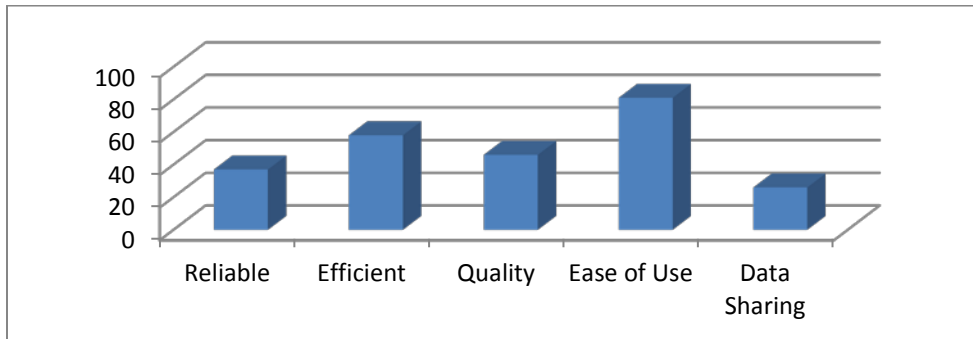


Figure 10: User Survey Results: Importance of Factors Related to Analytical Model Access

7.1.4 Workflows

IFTDSS workflows are a set of business-oriented modeling pathways intended to capture the problem-solving needs of the fuels treatment analysis and planning community. They provide access to scientific models in a stepwise, intuitive pattern, reducing the emphasis of individual models. These workflows were developed based on direct user input from JFSP-sponsored fuels treatment working group and other test user groups.

IFTDSS currently has four workflows. Two of these support current work processes: prescribed burn and fuels treatment. The other two represent new work processes: hazard analysis and risk analysis.

Users were asked to rate each of the four IFTDSS workflows. All workflows were rated positively. Workflows that provide structure to new processes were more positively rated than those workflows that represent processes that have been in place.

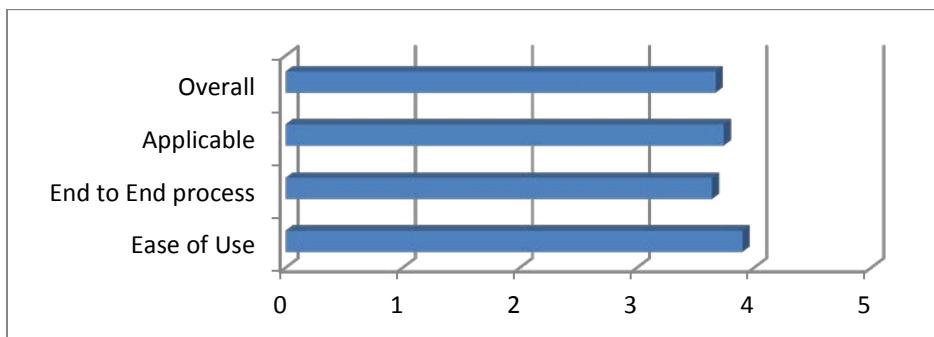


Figure 11: User Survey Results: Workflows

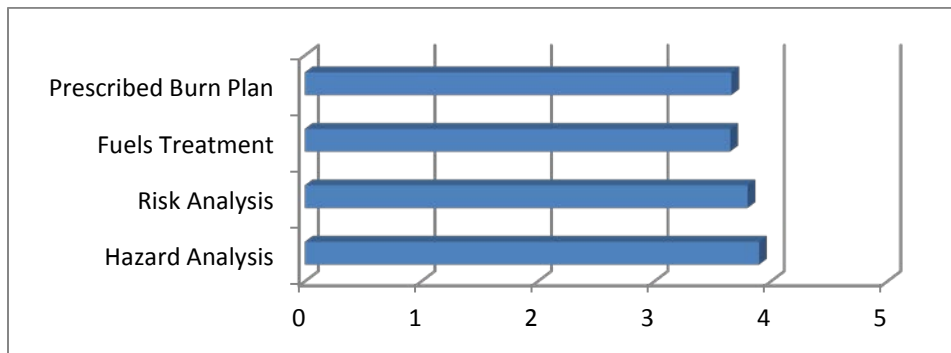


Figure 12: User Survey Results: Acceptability of Each Workflow

For each workflow, users were asked to indicate characteristics that were most important when rating the satisfaction of the workflows. As in the previous capability areas, efficiency and ease of use were identified most often. Quality of the workflow and its outcomes along with efficiency rated nearly the same for the prescribed burn plan workflow.

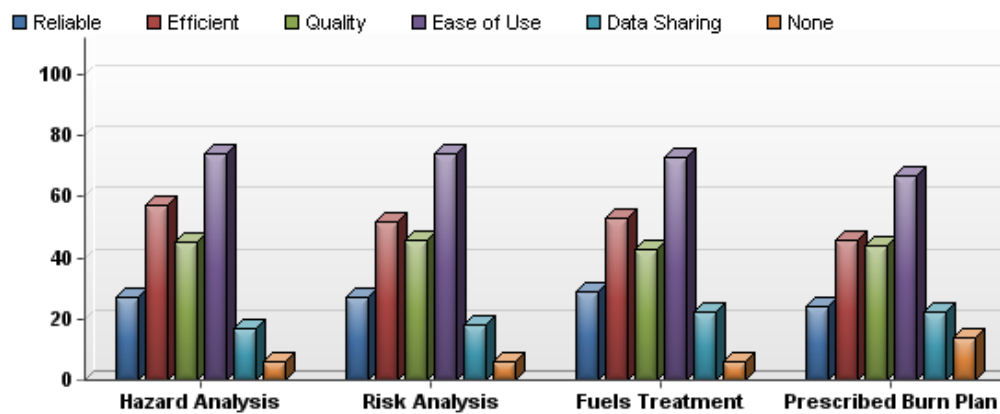


Figure 13: User Survey Results: Important Workflow Characteristics

7.1.5 IFTDSS and Wildland Fire Community Business Problems

We applied the overall body of user feedback to a subset of the specified business problems and made the following observations.

Table 2: Observations About Business Problems Based on User Feedback

Business Problem	Findings/Observation
Data acquisition	<p>Most user workshop attendees found acquiring data using IFTDSS to be easy or very easy. Several interviewees and user workshop attendees cautioned that the scale of acquisition (down to the stand level, up to an entire state) was an important aspect of any standard fuels treatment tool solution. Participants indicated that acquiring LANDFIRE data using IFTDSS was faster than acquiring data through other systems, by a factor of hours.</p> <p>Potential Challenges: Users were concerned with the file size limitation imposed during the workshops. This limitation was to ensure all participants could stay on pace during the workshop. However, file size limitations should be considered a critical aspect during national deployment.</p>
Data (re)formatting	<p>Users agreed or strongly agreed that IFTDSS' capabilities for data (re)formatting were efficient, reliable, and easy to use. IFTDSS removes the need to format and reformat data for multiple systems, creating efficiency in the process as well as removing opportunity for error. Some expert user interviewees had suggestions for improvements in data formatting/reformatting but were generally positive toward IFTDSS' data capabilities.</p> <p>Potential Challenges: Users expressed the need to be able to upload shape files/polygons. It is our impression that this capability is essential to usability of the system.</p>
Complicated hazard or risk analyses	<p>A standard or template workflow for hazard and risk analysis enabled users unfamiliar with the processes to perform the analysis without the need to investigate and obtain scientific models. However, the need to understand the underlying science in the model remained necessary.</p> <p>Potential Challenge: Users expressed the need to use the native scientific models in order to access more complicated features of the models. We interpreted this as an exception condition for expert users or uniquely complicated analysis and not necessary for the large majority of potential users that are the target audience for IFTDSS.</p>
Sharing and collaboration	<p>User workshop attendees found the limited sharing features provided by IFTDSS to be easy or very easy to use, consistent with interviewees.</p> <p>Potential Challenge: In order to leverage any enhanced collaboration capability, there needs to be a framework for collaboration and an understanding of how the field would like to collaborate. Sharing and collaboration are highly dependent on the security capabilities.</p>
End-to-end workflow support	<p>Most user workshop attendees agreed that IFTDSS' support for workflow pathways was comprehensive and supportive of improved risk and hazard analysis. Interviewees generally agreed, although several cautioned that the workflows promoted via IFTDSS had no official "approval" from authoritative agency entities.</p> <p>Potential Challenge: With numerous agencies identified as the intended audience for IFTDSS, it should be expected that numerous versions of workflows will be necessary. Consideration for enhancing the workflow capability will be critical for large scale deployment. Consider automatic routing capability for workflows in order to impose reviews and approvals throughout the process. Robust workflow capability will require a supporting security capability.</p>

7.1.6 Comparison to Other Systems in Use

SEI conducted a limited comparison of numerous products through a comparative analysis. Using a common baseline process that captured steps from data acquisition through prescribed burn plan creation, we interviewed a number of field experts that represented numerous products currently in use. Products represented by expert users included FsVeg, ArcFuels, WFDSS and Behave +. Without exception, from the user perspective, we observed the following when one or more of these products was in use:

- Data management, the (re)formatting of data, managing data files, upload and downloading of data files, was an arduous task. Data tasks were made all the more problematic by the need to use multiple scientific models for any one portion of the process, thus increasing the number of times a user must reformat data, save and store files, and ultimately upload files.
- Interviewees all had to use more than one system to perform the baseline process. There was not a single scientific model that performed the end-to-end process.
- Sharing and collaboration is via email of data, map files and outputs.

7.2 Conclusions

User feedback indicates that users feel IFTDSS improves the quality and efficiency of the fuels treatment planning process for the majority of user needs.

Table 3: Quality and Efficiency Characteristics of IFTDSS

Quality	Efficiency
Quality of the actual analysis is not affected by IFTDSS	Workflows guide users through common activities thus removing the need to determine the next step or navigate between tools
Quality through predictability of the analytical steps performed is enabled through IFTDSS workflows	Moving data between modules within IFTDSS is nearly seamless
Complex analysis that requires more than the subset of capability integrated into IFTDSS will need to be performed outside of IFTDSS at this time	

User feedback indicates that IFTDSS does improve the efficiency of the fuels treatment planning process. The improvement of the quality of the process is spread across the completeness of the analysis through a standard process and the knowledge of the science, field experience, and knowledge of the scientific models. IFTDSS does contribute positively to quality by standardizing the process, providing a workflow of linked steps for performing the process. IFTDSS does not improve the field experience or the knowledge of scientific models.

In comparison to other solutions currently in use today, IFTDSS addresses a number of business problems that are not or cannot be addressed by the current systems, such as WFDSS, Behave+, ArcFuels or FsVeg. These are listed in Table 4.

Table 4: Business Problems Addresses by IFTDSS

Business Problem	Observation
Too much time spent in acquiring and preparing data for an analysis	IFTDSS acquires LANDFIRE data more quickly than current systems
Too much time spent formatting and reformatting data for different software systems	Once a user has created an updated, current landscape in IFTDSS, no additional data formatting is needed to run multiple models
Hazard and risk analyses are too complicated for most fuels treatment planners to do	IFTDSS workflows guide users through the hazard and risk assessment processes. While this may make the process more predictable and standard, it does not alleviate the need for field experience and scientific knowledge to perform the workflow process successfully
Users cannot easily share work, compare notes, teach each other across agency and location	IFTDSS has limited ability to share data, such as project data and map outputs. Enhanced security architecture can enable a more robust sharing capability
Available software systems do not typically support the entire mission critical fuels treatment planning process	IFTDSS workflows link together scientific models in order to perform an entire mission critical fuels treatment planning process. The user is not required to investigate or evaluate the scientific models to use; the relevant models are already presented to the user (though the user remains free to use alternative workflows if desired)

8 Task 4: IFDTSS and User Training

Task 4: IFDTSS and User Training

This task will assess whether the IFDTSS has the potential to support a more effective and efficient training framework and/or training delivery methods for fuels treatment planning.

By focusing on user defined workflows to solve business needs rather than specific models and interfaces, does IFDTSS encourage and improve critical thinking and problem solving skills needed for fuels treatment planning?

8.1 Findings and Observations

Table 5 summarizes findings and observations related to the training aspects of the nine topics cited above. Following the table, subsections provide further discussion on each topic. Data sources for the table included user workshop surveys, informal discussion with workshop attendees, interviews with trainers, intended users, and intended governance entities, as well as evaluator hands-on interaction with IFDTSS.

Table 5: Training Findings and Observations

Training Topic	Finding or Observation	Notes
Learning Time	User survey indicated that the majority of attendees believed that IFDTSS would reduce learning time for typical models in use, consistent with interviewees. Reduced learning time for addressing the mechanics of model use means that more training time (in a traditional or online classroom situation) can be devoted to conceptual and critical thinking aspects of fuels treatment competency.	The consistent spatial interface of IFDTSS is a likely contributor to reduction in learning time. One opportunity for improving the reach of IFDTSS is to analyze models that are currently not able to be represented spatially to see what, if any, advantages IFDTSS' spatial representation could provide.
Retraining	Interviewees indicated that the consistent, web-based user interface of IFDTSS applied to multiple models that normally have differing user interfaces would reduce retraining needed when using multiple models to perform a fuels treatment task. From a training viewpoint, a single user interface reduces the need to dedicate additional training time on mechanics each time a new models' capabilities are introduced.	IFDTSS' consistent user interface does reduce the training burden for accessing multiple models, but it alone cannot be expected to substitute for understanding the constraints and conceptual limitations of different models that are accessible.

Training Topic	Finding or Observation	Notes
Fuels Treatment Analysis Framework	Interviewees indicated that the inclusion of a standard workflow with specific model suggestions for different steps could move the agencies toward a consistent fuels treatment analysis framework. From a training viewpoint, a consistent fuels treatment analysis framework would provide the foundation for fuels treatment courses that focus on different workflow tasks and different workforce competencies needed to effectively perform fuels treatment planning, execution, and management.	Caveats on IFTDSS' ability to contribute to a consistent fuels treatment analysis framework included the need to ensure the models in the SMF remain current, and the need to allow inclusion of models more specific to regional needs, not just national level.
Data Acquisition	Most user workshop attendees found acquiring data using IFTDSS to be easy or very easy, consistent with interviewees. Several interviewees and user workshop attendees cautioned that the scale of acquisition (down to the stand level, up to an entire state) was an important aspect of any standard fuels treatment tool solution.	User workshop attendees were limited to a 20,000 square acre data acquisition to keep the load on the training server reasonable. This restriction does not apply normally.
Data (re)formatting	A majority of user workshop attendees agreed or strongly agreed that IFTDSS' capabilities for data (re)formatting were efficient, reliable, and easy to use. Some expert user interviewees had suggestions for improvements in data formatting/reformatting but were generally positive toward IFTDSS' data capabilities.	Several users were interested in the ability to spatially represent FVS data, which is technically feasible within IFTDSS' Scientific Modeling Framework, if the proper governance agreements are in place for access to relevant data.
Complicated hazard or risk analyses	User survey indicated that majority of attendees believed that less training for performing analyses would be needed using IFTDSS, consistent with interviewees	Comments in survey cautioned that fire science concepts are still a prerequisite, consistent with interviews
Sharing and collaboration	A majority of user workshop attendees found the sharing features provided by IFTDSS to be easy or very easy to use, consistent with interviewees. This will reduce the training burden for encouraging collaboration	Interviewees and user workshop attendees cautioned that the "all or nothing" project sharing approach to data would not be useful in all collaboration situations.

Training Topic	Finding or Observation	Notes
End-to-end Workflow Support	IFTDSS supports training the MECHANICS of supporting end to end fuels treatment workflows. Most user workshop attendees agreed that IFTDSS' support for workflow pathways was comprehensive and supportive of improved risk and hazard analysis. Interviewees generally agreed, although several cautioned that the workflows promoted via IFTDSS had no official "approval" from authoritative agency entities. From a training perspective, having an agreed-upon workflow to map to concept and critical thinking training is an important element contributing to accelerating workforce competencies in fuels treatment.	Neither IFTDSS NOR ANY OTHER TOOL can directly train fuels treatment specialists in the critical thinking skills needed to produce <i>relevant</i> artifacts for a particular fuels treatment situation.
Integrating new science	The training aspects of integrating new science into fuels treatment workflows go beyond IFTDSS as a tool. The Scientific Modeling Framework has the capability to include any model that is deemed appropriate for presentation in a fuels treatment workflow. However, the choice of which models are presented in each workflow should be a governance body decision, rather than the tool developer's decision.	Incorporation of new models approved for inclusion in IFTDSS would be greatly facilitated by the publication of a SW Developer's Kit, described elsewhere in this report.

8.2 Challenges

8.2.1 Supporting Training in Desired Workflow(s)

Figure 14 below shows a notional risk assessment and fuels treatment (including burn plan production) workflow that the SEI created as a support for communicating about the scope of IFTDSS to interviewees. This is not meant to be an authoritative source for fuels treatment workflows.

The diagram highlights places where

- IFTDSS supports the mechanics of a particular task
- IFTDSS' tutorials section has concept guidance for all or part of a task
- IFTDSS can be used to generate all or part of the needed content for a particular task.

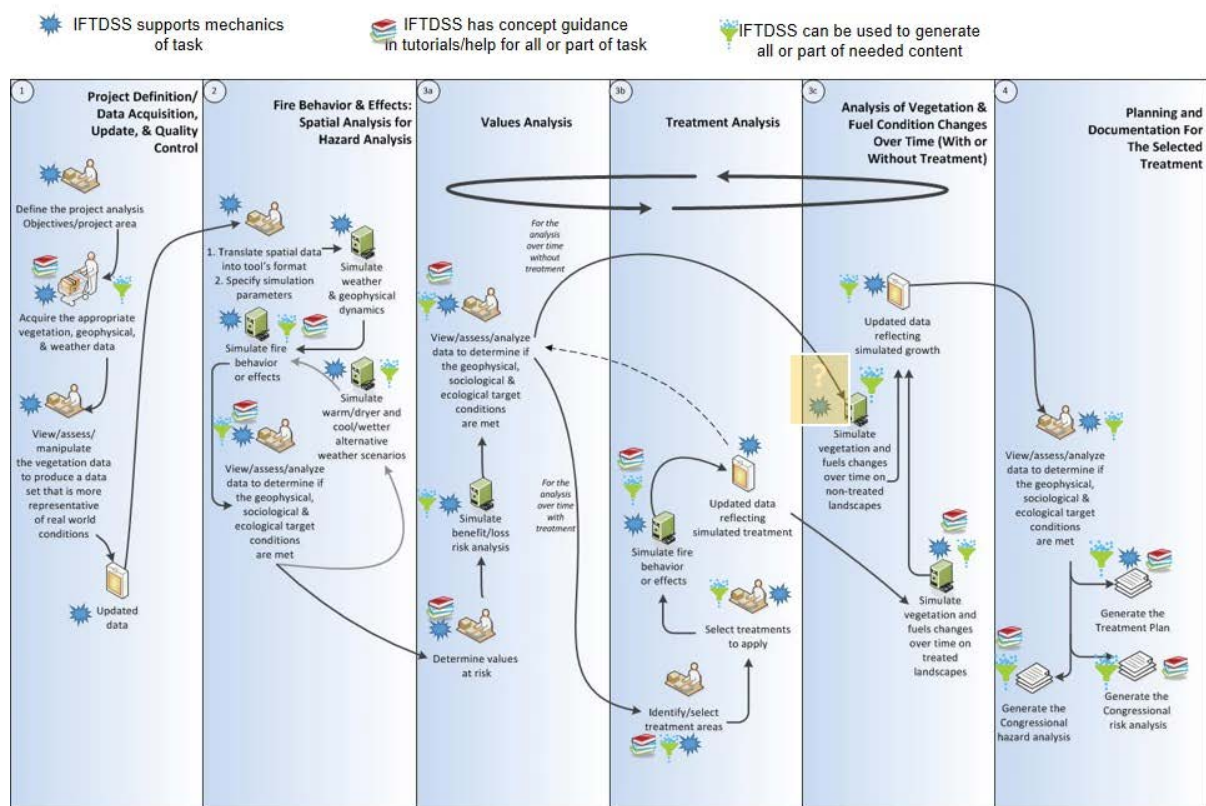


Figure 14: Notional Risk Assessment and Fuels Treatment Workflow

A version of IFTSS was one of the sources for this workflow diagram, so it isn't surprising that mechanically, IFTDSS supports almost all of the tasks in the workflow. What is more encouraging is that IFTDSS also contains, in its tutorial section, at least some of the conceptual material that would be needed by a fuel treatment specialist in performing the task, and it contains reports or templates that make producing artifacts required by a particular step easier than creating them outside the IFTDSS environment.

8.2.2 Support for Fuels Treatment Workforce Development

A brief survey of recent wildland fire community literature shows a consistently perceived need for accelerated workforce development for the fuels treatment specialist portion of the wildland fire workforce, as well as an increasing focus (mandated by legislation such as the FLAME Act) on risk assessment and non-prescribed burn treatment options for fuels management specialists.

In 2005, the National Interagency Fuels Group issued a report that performed a detailed analysis of the competencies (knowledge, skills, and abilities) needed to explicitly support evolving fuels treatment planning and management practices. This was followed by an NWCG report in 2008 analyzing the evolution of the fuels treatment specialist workforce and calling for acceleration in workforce development, as well as a 2010 report sponsored by JFSP on user perspectives on fire science research (including analysis from the viewpoint of fuels treatment). Also of note is an ar-

ticle from the Education Committee of the Association of Fire Ecology from 2009 that reviews the state of fire science education across a broad set of parameters, including fuels treatment planning and management.

Common threads in the above cited works, as well as those that they cite from earlier workforce analysis activities include:

- ongoing recognition that training can only assist workforce development in the context of experience and education
- robust risk assessment practices that withstand auditing by outside parties require, at minimum,
 - an understanding of fire science,
 - ability to accurately discern risk parameters,
 - competency in critically evaluating modeling results, and
 - facility communicating the rationale for decisions resulting from risk assessment. Within the community, we frequently heard the summary term “critical thinking skills” that encompass many of these.
- this community benefits from certification requirements as an incentive for extremely busy fire professionals to increase their skill in areas deemed necessary by their agencies.
- There are multiple paths for becoming a fuels treatment specialist. Understanding the gaps (education, training, experience) and addressing them is more complex than for other roles that are more straightforward.

IFTDSS’ has interesting potential for supporting many of the goals and addressing several of the issues in the published literature on fuels treatment workforce development. Many of those goals and issues were reinforced via our interviews of various training roles in the wildland fire community. We will use the education-training-experience triangle as the frame for discussing IFTDSS achievements and potential.

8.2.3 Support for Education

From a competency viewpoint, education is the essential building block for increasing knowledge. IFTDSS increases knowledge about fuels treatment in three specific ways:

- IFTDSS’ tutorial environment (one of the richest this evaluator has ever seen in terms of knowledge-related content) not only provides guidance on use of workflows, selection of models, and use of results; it also includes the canonical fire science theoretical reference papers that the models included in IFTDSS draw on for their parameters.
- Within IFTDSS’ workflows, IFTDSS’ pre-selection of different models for particular tasks in risk assessment workflow, for example, increases the knowledge of fuels treatment users on valid models to consider for the task (*valid* is not always *relevant*; IFTDSS’ tutorial material provides first-level knowledge to help frame model choices).

- IFTDSS' inclusion of a case study with a worked example allows fuels treatment specialists to follow a path instance to a commonly required fuels treatment artifact—a Prescribed Burn Plan—and increase their knowledge by comparing that example with their own situation.

IFTDSS also has the potential to increase fire science knowledge within fire science course settings. Instructors could design projects within IFTDSS that include both examples and non-examples of different model use that highlight known issues in how different models can and should be used. Having a “sandbox” to try different strategies (e.g. using different models than the student is accustomed to) provides a safe environment for knowledge acquisition.

In addition, the IFTDSS tutorial environment could be explicitly tied to KSAs for fuels specialists and maps could be created that help a fuels specialist understand which parts of IFTDSS' tutorial material support different KSA objectives.

8.2.4 Support for Training

From the competency viewpoint, training is the essential building block for increasing skill, the application of knowledge to a problem in the domain. IFTDSS supports training for fuels treatment specialists in at least the following ways:

- The workflows presented in IFTDSS provide guidance on applying fire science model knowledge in a consistent, systematic way to common tasks fuels specialists encounter in their role: risk assessment, hazard assessment, fuels treatment selection, fuels treatment planning, prescribed burn planning, fuels treatment reporting and approvals, among others.
- IFTDSS' ability to save “projects” and associate multiple runs of one or models to a project can increase the skills of a fuels treatment specialist who is learning to apply models to fuels treatment tasks. Not only can they include their expected values prior to a planned event, they can create a separate run with actual values and compare results to the prior runs so they can see how different models represent results in comparison to the reality observed by the fuels specialist.
- IFTDSS' tutorial environment provides robust information about performing workflow tasks and interpreting various model results for different purposes (not all cases are included, but the examples seem to be quite relevant to the kinds of tasking fuels specialists are expected to undertake).

There are enhancements to IFTDSS that would further improve its support for fuels treatment training. For example, providing direct ability to compare different models' results (sort of like the “compare” feature on a product web site) could highlight relevant differences in how different models process inputs of various types. Providing “caution” messages when an input parameter for a particular model is considered outside of “normal” could alert users as to boundary conditions that constrain a model.

8.2.5 Support for Experience

From a competency viewpoint, experience is the building block that, along with knowledge and training, increases overall ability to efficiently and effectively perform tasks in the problem domain. IFTDSS supports learning from experience in at least the following ways:

- One of the uses of the projects feature of IFTDSS would be to collect sets of model runs that reflect “actual” input values rather than estimated values. Reviewing the model results against the known results (which could be included in notes) would provide a set of case studies that fuels specialists within a region or a particular interest area could share and discuss. This would improve their understanding of how reality differs from model outputs, and may help them to productively frame their experiences in a way that can be shared and made useful to others in similar situations.
- The ability within IFTDSS to perform and save multiple runs provides a simulation environment for users to test strategies in a “safe” environment and provide data for discussion with more expert fuels specialists on results from particular simulations. This vicarious experience doesn’t substitute for “walking the forest,” but it may actually incentivize obtaining real environment data to improve the fidelity of particular simulations of interest.

There are enhancements to IFTDSS that would further improve its support for fuels treatment experience. For example, a potential use for the IFTDSS tutorial environment would be to include an “Experience Report” or similar section that includes templates for users to fill out that connect predicted results from a fuel treatment action with actual results. These could be treated as a special kind of project, to permit additional simulation, or could be static reports, depending on the resources available for implementation.

8.2.6 Support for Existing NWCG Training

NWCG supports the instructional design and training delivery for a specific set of courses that include foundational fire science education, as well as skill building in the use of various fire science models used to support specific tasks covered in a course. Although this study did not perform a detailed analysis of the mapping between IFTDSS capabilities and individual courses, interviewees that were involved in curriculum development, instructional design, and/or training delivery were unanimous in their support for IFTDSS to be included in their courseware once it becomes a system of record. This is considered a pre-requisite for inclusion by them to minimize the risk of IFTDSS access being removed for wildland community users.

Some of the ways in which these instructors saw IFTDSS supporting them were:

- providing a simulation environment for hands-on reinforcement for different educational or training objectives in a course—This is important in courses targeted at professionals who are mostly hands-on in terms of their daily fire-related activities
- using the IFTDSS workflows (once agreed upon by the governance bodies for the fuels treatment community) as a frame for specific courses on fuels treatment planning and management

- using IFTDSS as a repository of self-learning materials associated with fire science topics that either are too detailed to include in NWCG courses or are topics known to need reinforcement once students are in the field

8.2.7 Context of Broader Technology or Practice Adoption

JFSP Project Report 04-4-2-01 *Influences to the Success of Fire Science Delivery: Perspectives of Potential Fire/Fuels Science Users*, cites six particular influences to the use of research by fire and fuels professionals:

- beliefs about research usefulness and ease of use
- individual willingness to try new approaches
- education, history with scientists
- public values, acceptance
- position responsibilities
- organization culture: support, time for reflection, experimentation, communication, appreciation of alternate viewpoints. [JFSP 04-4-2-01]

IFTDSS could play a role in influencing accelerated research use if it is positioned to explicitly support some of these influences. For example:

- IFTDSS' ease of use could improve fuels specialists beliefs about research usefulness, since it is now more accessible to them.
- Although IFTDSS itself won't change an individual's innate willingness to try new approaches, its ability to allow individuals a "safe" environment for trying out new approaches can reduce individual barriers to new approaches.
- IFTDSS' rich tutorial environment provides knowledge about individual scientists and their theories that can improve users' knowledge of underlying fire science and its application to their problem.
- If IFTDSS becomes a system of record, it increases in acceptance at the policy level.
- IFTDSS' workflows are explicitly meant to support position responsibilities of fuels treatment specialists.
- IFTDSS' ability to share projects address some of the organizational culture elements, including experimentation, communication, and appreciation of alternate viewpoints.

The potential benefits cited above for IFTDSS use depend on IFTDSS being available to use and supported, both in terms of doctrine and in terms of accessibility.

8.3 Recommendations

8.3.1 Promote IFTDSS to a System of Record

IFTDSS, in its current state, will be helpful to a subset of fuels specialists who are ready to take advantage of its features. Making IFTDSS a system of record and providing it with an organizational home would be a clear signal to the training community that IFTDSS is here to stay. This will incentivize its inclusion in existing courseware and will encourage the creation of courses that explicitly leverage IFTDSS.

8.3.2 Define and Support a Curriculum of Required Training for Fuels Treatment Specialists

As we completed our work, we understood there was a new working group reviewing the 2005 fuels specialist workforce study, including analyzing the proposed KSAs for current relevance and identifying current gaps. We applaud this effort and encourage the wildland fire community to go beyond work that has been done in the past. We recommend the community define and support a curriculum of required training for fuels treatment specialists. This is an important step in facilitating the use of risk assessment as a basis for fuels treatment decision-making, as promised to Congress in response to the FLAME Act.

8.3.3 Prototype Use of IFTDSS' Tutorial Environment for Robust Fire Science Concept Online Courses

IFTDSS' tutorial environment is already impressive, but it was created without the benefit of an accepted set of knowledge, skills, and abilities to guide it. If recommendation (2) is adopted, the current tutorial area of IFTDSS could be mapped to the defined curriculum and gaps that need to be filled, in terms of material suitable for online delivery, could be identified and prioritized. We recommend prototyping this use of IFTDSS with fuels management specialists at multiple points in their career path to determine the optimal use of online modules to support fuels specialist workforce development.

9 Main Challenges Facing the Wildland Fire Community

Drawing from the challenges cited under the four tasks as well our observations about other issues facing the wildland fire community, we have summarized below what we feel are the most important.

While we believe IFTDSS can help meet many of these challenges, IFTDSS alone cannot resolve them; IFTDSS can be part of a cohesive strategy to meet these challenges.

9.1 Challenge: Meeting the Promise to Congress that Sound Risk Management (will be) the Foundation for all Management Activities

The most significant aspect of this challenge is that the wildland fire community does not have an agreed-upon, consistent risk and/or hazard assessment framework. To reach one will require an inter-agency agreement on a high level risk workflow that also allows for agency and region specific tailoring.

Two other factors compound this challenge. First, users consistently stated risk and/or hazard assessments were difficult to do and were inherently complex. Second, none of the software tools used for this type of analysis were originally conceived to do an end-to-end process, which is what risk management requires.

IFTDSS demonstrated a key element needed by the community to meet this challenge. IFTDSS demonstrates candidate end-to-end hazard and risk assessment workflows. These workflows support a consistent analysis framework to guide users through the scientific models needed to complete hazard and risk assessments.

Once the community formally adopts one or more risk analysis methodologies and processes, IFTDSS workflows can be tailored to reflect that process to help reinforce/enforce them. The workflows can also be tailored to meet approved specific-agency or region-specific needs.

9.2 Challenge: There is no Agreed-Upon Strategy or Vision to Guide New Investments, or to Evaluate the Efficacy of Current Investments

Currently, there is no authoritative, cohesive development agenda and roadmap for fire management software (including IFTDSS). Neither is there consistent support for ongoing platform enhancements and technical debt reduction.

IFTDSS helps address this challenge by making gaps or redundancies in scientific modeling support visible through the workflows. IFTDSS also provides a framework and environment in which model efficacy could be explored.⁶ Information regarding gaps, redundancies, or underperforming tools are critical to establishing an ongoing investment and development roadmap.

⁶ This is presently a mostly manual capability, but could be enhanced in future versions of IFTDSS.

Also, if IFTDSS (or any other system) became the single release point for new scientific modeling or related applications, this would help establish a governed gateway for release which can be tied to funding governance.

Last, the continuing maturation of WFIT is also critical to addressing this challenge.

9.3 Challenge: There is no Agreed-Upon, Consistent End-to-End fuels Treatment Planning Process in use Across the Community

This challenge is drawn primarily from the user community. We also noted that one fuels treatment planning process—prescribed burn planning—must follow the *Interagency Prescribed Fire Planning and Implementation Procedures Guide (2008 Prescribed Fire Guide)* for any prescribed fire, large or small.

With the *2008 Guide* five years old and a legally required process, we expected to see prescribed burn planning as an exemplar of a consistent, community-wide but tailored process, but this was not the case.

The IFTDSS workflows help meet this challenge by supporting a consistent view of the fuels treatment planning mission. The workflows support a consistent analysis framework, and IFTDSS's web accessibility supports cross-agency, cross-location access.

From our perspective, IFTDSS could be an enterprise solution for fuels treatment planning functions. As we have stated before, if a federal land agency needed a tailored process, additional or agency-specific workflows can be supported in IFTDSS.⁷

9.4 Challenge: There is no Consistent, Coherent Support for the Training Needed to Accelerate Workforce Development for Fuels Treatment Planning and Management

This challenge is drawn primarily from our observations as well as from several years of reports and white papers addressing various aspects of fuels specialist workforce development.

This challenge is manifested by the lack of an approved, cohesive curriculum for fuels treatment planning. There are also no agreed-upon criteria to guide material inclusion or exclusion in a fuels treatment planning curricula.

A consistent theme from users was that experienced planners self-selected themselves and then took it upon themselves to construct their own curriculum; they sought out training opportunities and drew on multiple and varied funding sources.

Interviewees also stated that the training currently provided for fire suppression is insufficient to prepare for increasingly complex fuels planning demands.

⁷ However, if an agency chose to limit access to particular models, IFTDSS as it stands does not support access limitations of that type.

We believe that once training needs and curricula are agreed upon, the IFTDSS workflows can be made consistent with them (if they were not already). The use of IFTDSS and the workflows will then help reinforce/enforce them. IFTDSS workflows can also be used to encourage and improve critical thinking and problem solving skills needed for fuels treatment planning as the workflows can highlight those areas where critical thinking needs to occur.

IFTDSS already has a rich tutorial and references environment that goes beyond “how to do this step in the tool” and could be a strong leverage point for future fuels management planning curriculum elements.

In addition, the IFTDSS workflows—built with extensive user involvement—can help the community by serving as “prototypes” from which governing bodies could start to create the approved versions.

However, IFTDSS—as with any tool—is not a complete solution to fuels management training needs. Most importantly, IFTDSS cannot substitute for fire behavior understanding as well as knowledge of the use and limitations of the underlying tools. The underlying assumptions contained within the tools and the relationship of these assumptions to underlying fire concepts must be an integral part of any IFTDSS-based training curriculum.

9.5 Challenge: There is no Enterprise-Wide Policy and Transition Mechanism to Move From Research to Operations

This challenge is drawn primarily from observation, but has its roots in several issues cited in *Implementing the National Wildland Fire Enterprise Architecture Blueprint*:

- There is no agreed-upon strategy or vision to evaluate the efficacy of current investments.
- Enterprise approaches to data, infrastructure, security, and the like are lacking.
- Inefficiencies exist in data sharing, project management, and application support.
- Management responsibility is diffused between and among organizations, hampering cooperation and coordination.

This challenge is manifested by:

- Divergent software lifecycle practices and quality standards.
- A proliferation of software lifecycle tools and development technologies.
- A proliferation of support mechanisms for users (i.e., different support mechanisms for different tools).
- Development and release practices and quality standards are not held to consistent production level disciplines.

Making a software development kit (SDK) available for researchers and developers is a crucial step to enable IFTDSS to help address this challenge. In conjunction with appropriate governance, this could clarify the distinction between research-only models and models used for operational

purposes. Additionally, once the enterprise-wide transition policies are defined, IFTDSS and the IFTDSS SDK can be aligned with them to help reinforce/enforce them.

A common gateway for release, which would include testing, configuration management and release criteria, would also be important to meeting this challenge.

9.6 Challenge: There is no Consistent, Enterprise-Wide System Hosting Strategy

At present, the hosting strategy throughout the wildland fire community is piecemeal. While meeting this challenge is beyond IFTDSS and this report, IFTDSS can support multiple hosting strategies, including the cloud. IFTDSS itself is capable of hosting any provided scientific model.

9.7 Challenge: Software Chaos Is Still an Issue

Users are still dealing with model proliferation—the multiple, overlapping models created by different researchers. This is an aspect of the chaos problem that IFTDSS does not explicitly address but by bringing the models under a single framework, it is a step towards unified governance which could eventually start to resolve the proliferation issue.

Another aspect of chaos might be lack of unified guidance as to how to string the tools together to solve a problem. The IFTDSS workflows help with this.

Users also continue to deal with the lack of consistency in the software available to them. Specifically, the tools available at any one location or agency were dependent on past history and available hardware/software platforms. Even when the same software was available at different locations (or even on two different computers at the same location) there was no guarantee that the software would be at the same revision level.

Additionally, because all work is location specific, the data necessary to execute the scientific models had to be transferred from authoritative data sources to the local sites and then prepared according to the individual operator's understanding of the realities of the environment. This chaos has resulted in the following issues:

- The skew between different tool versions on different platforms could result in different results, even when presented the same data and options.
- The site and system autonomy means that, even should the enterprise standardize on a given version of a tool, there will be no guarantee that each instance will be at that version.
- Each site/system requires time and effort to install and upgrade the locally available tools.
- There is no enforcement of consistency with respect to the source of data.
- There will be duplication of effort in preparing data for subsequent use by the tools.
- The data format differences between the different tools means that a significant amount of effort is spent transforming data from one format to another.

Because IFTDSS is web-based with no software required on a user's system, many of the negative implications outlined above are solved. Issues with respect to version skew in the scientific

models are resolved due to there being fewer instances of the software at sites that are within the IFTDSS governance perspective. Thus, if the enterprise determines that it is appropriate to upgrade a specific tool, all users will have access to the new tool as soon as all IFTDSS model servers are appropriately updated—which can be done by a single organization.

Data selection and transmission problems are minimized as IFTDSS can be used to limit the data sources to authoritative data sources only. Further, data that has been prepared can be shared with other IFTDSS users cutting down on duplication of effort. Finally, IFTDSS contains data transformations that are applied automatically as part of workflow processing.

However, IFTDSS does more than simply resolve the issues we cited above. It offers an opportunity for the wildland fire community to improve the way it does both its business and, also, its science.

Specifically, the tools that a given fuels manager will choose to use is highly dependent upon availability, past history, and perceptions of prior success.. The workflow concept of IFTDSS will lead to greater commonality of business processes to the extent that such commonality makes sense. Workflows can be created for various situations and regions as needed but, then, can be standardized in those situations and regions leading to optimal results based on past assessments.

Further, with the IFTDSS project concept it is conceivable that (and we would encourage this) after a burn plan has been created, approved, and executed, that scientists rerun the various models to determine how close the model predictions come to the reality of the burn. In this way, factual data can be used to determine which models are the best predictors in different situations or locations. Such data can be used to improve both the models and decision support on which models should be used.

10 Conclusions and Recommendations

We believe JFSP has succeeded with IFTDSS. If fielded as part of a cohesive governance strategy, we believe that IFTDSS will be a major step to bringing order to the software chaos. IFTDSS demonstrates that it meets the goals of WFI&T and is near-ready for operational use, exceeding our expectations for a prototype.

Overall, we feel that IFTDSS is a strong candidate to support an enterprise-wide solution for risk-based fuels management strategic goals. IFTDSS:

- enables standardized, risk-based fuels management planning for a large part of the fuels specialist community
- demonstrates a consistent, common set of analysis processes that use common tools, and makes these available regardless of agency or location
- demonstrates a prescribed burn plan workflow that is designed around the *2008 Guide* and was also significantly influenced by users
- demonstrates a workflow for risk assessments that is accessible for the majority of users

IFTDSS also demonstrates a vision of the WFIT's principal concepts:

- mission requirements drive integrated, modular-based applications and tools
- authoritative data are readily available for all uses and users
- interconnection and accessibility regardless of organizational affiliation or user location
- technology, research, and innovation enable and enhance mission accomplishment

Further, IFTDSS:

- contains a rich set of tutorial material that goes beyond mechanics into a knowledge management system that could serve as a framework for fuels management self-study and training support
- demonstrates a single-sign on for a host of currently stand-alone systems
- facilitates data entry and formatting
- allows a user to create a landscape that most reflects their current, local knowledge of that landscape and then to run multiple tools across that landscape without the need for data reformatting
- can be used to share both the data and the analysis
- uses workflow-based navigation to demonstrate how end-to-end guidance and processes can be implemented when these processes are adopted across the wildland fire community
- provides the ability for agency-specific needs via tailored workflows

- provides spatial constructs for some non-spatial foundational models that allow a more-complete visualization of fire behavior
- provides a consistent user interface and data formatting approach

These are shown in Figure 15.

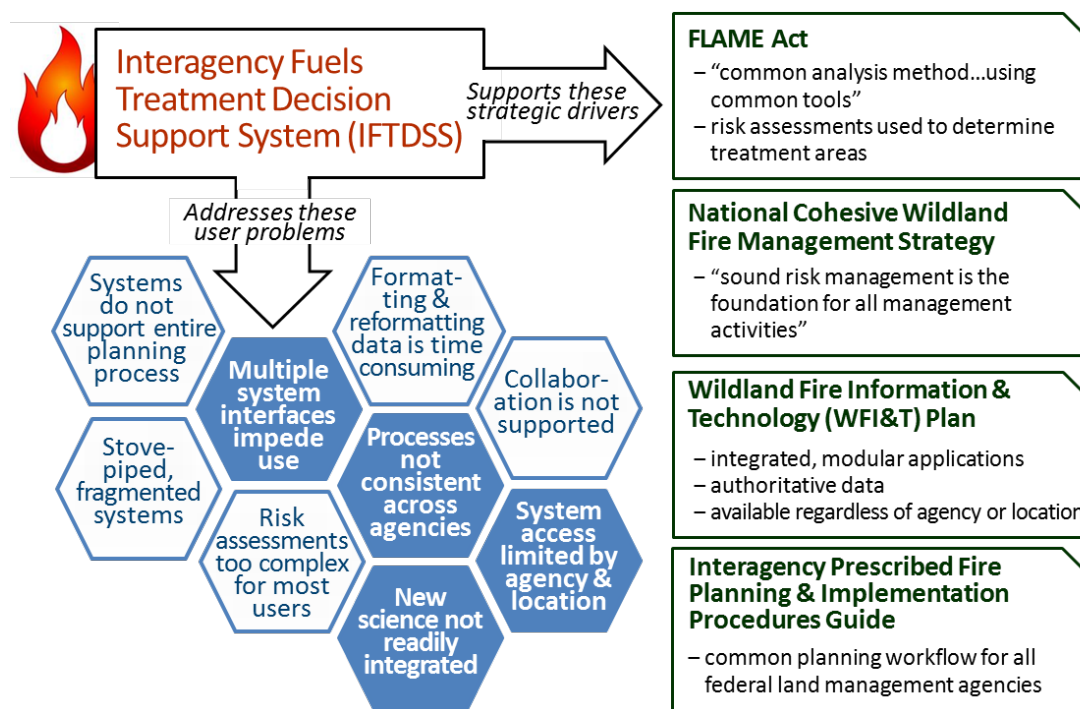


Figure 15: IFTDSS Strategic Drivers and User Needs

Can IFTDSS Be Used Today?

While not without some concerns (performance and scalability, for example), IFTDSS has demonstrated its value, and its functionality accommodates a large portion of the fuels specialist user audience. We believe the wildland fire community would benefit from continued exposure to IFTDSS in a controlled prototype effort as it is currently configured. This would allow for continued user feedback while governance, hosting, training and other issues are addressed.

However, during this period expectations for its performance must be managed. Users must be aware that IFTDSS will still be a work in progress, and until performance measures are set and validated, the numbers of users and the file size should be limited. Additionally, the minimal security posture (application log-on only) must be acknowledged and managed.

Most importantly, the DOI and the FS must understand the goals for this continued prototype, and must have realistic measures to track both the maturation of IFTDSS as a tool as well as the desired improvements in fuels management planning overall.

IFTDSS Deployment as a Robust, National Product

In our 2008 report, we stated that successful programs ensure that the needs of four key stakeholder groups are considered and balanced, as shown in Figure 16.

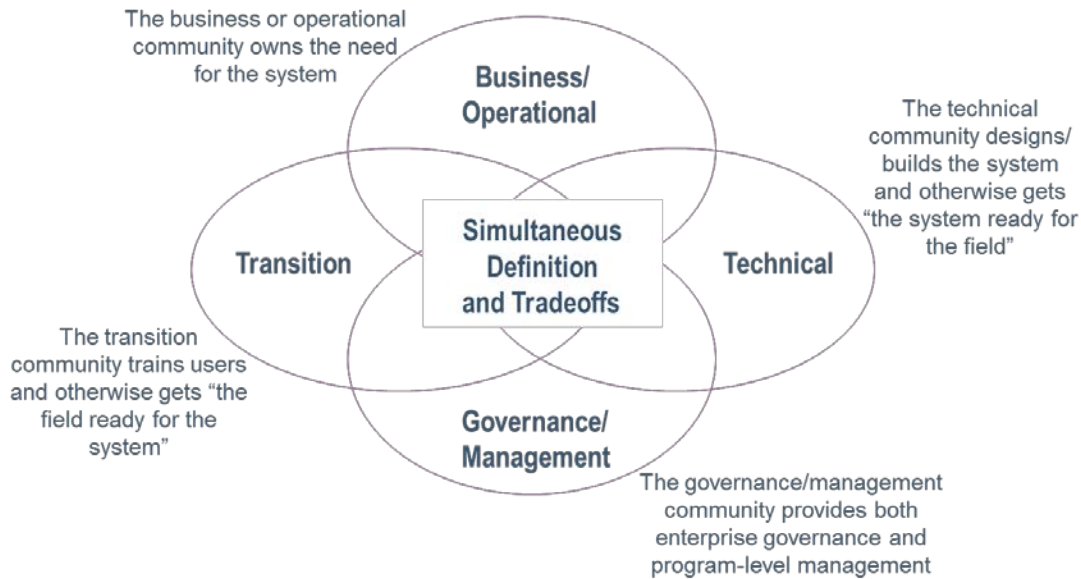


Figure 16: Key Stakeholder Groups

These four communities roughly align with our four tasks, and the four perspectives provided us with excellent insight into IFTDSS and the wildland fire community. As can be seen, there is considerable overlap between the communities, so the allocation of these recommendations into a "community" is not intended to be hard-and-fast.

Near-Term

Success will require effort in each area; emphasizing one at the expense of another will result in sub-optimization or failure.

Governance/Management

- select the IFTDSS Managing Partner and establish IFTDSS as a system-of-record
- determine and implement the IFTDSS hosting strategy
- determine the enterprise security requirements for IFTDSS and other enterprise SOA systems
- establish the governance needed for researchers to integrate new or enhanced tools and models into IFTDSS

Business/Operational

- support the continued development of IFTDSS
- determine what performance and scalability is required for IFTDSS
- approve a consistent, multi-agency risk analysis process for fuels management planning

Transition

- educate users about IFTDSS thru formal and informal means
- create an approved fuels management curriculum with an emphasis on risk and hazard analysis

Technical

- create the documentation needed for the government or a third-party to maintain and evolve IFTDSS
- validate the IFTDSS performance and scalability requirements
- validate that IFTDSS meets the security requirements
- create an IFTDSS software developer's toolkit (SDK)
- align IFTDSS's existing workflows with the approved risk analysis process for fuels management (tailored as necessary for legitimate agency and regional need)
- align IFTDSS's existing workflows with the approved fuels management curriculum

These are shown in Figure 17.

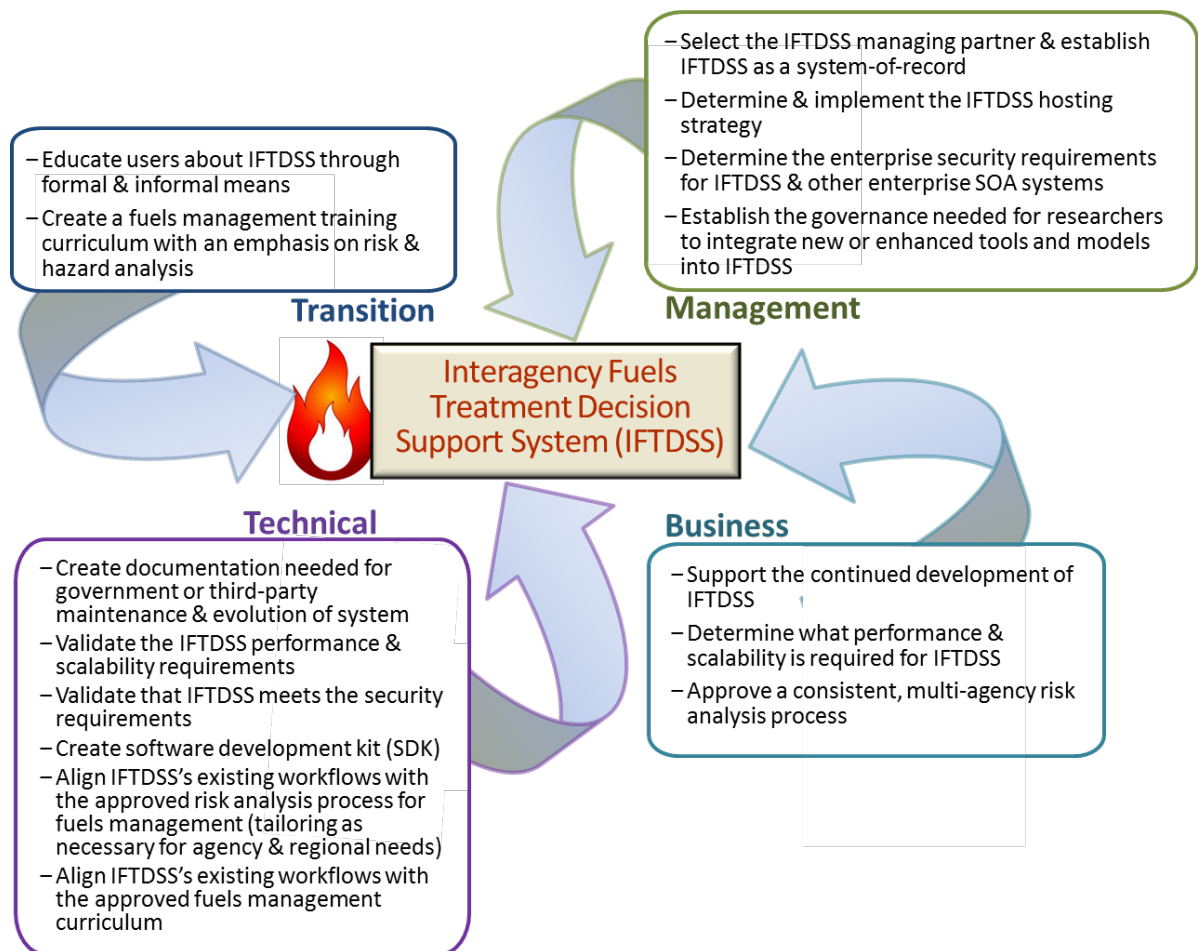


Figure 17: Principal Short-Term Recommendations

Mid-Term

Governance/Management

- define procedures and governance for the process to migrate or promote models in IFTDSS from the research community to operational use (will also apply to other models and tools)
- create enterprise processes for establishing the authoritativeness of IFTDSS (and other tool) derived data
- establish wildland fire data formatting and exchange standards, and modify IFTDSS to comply (if needed)

Business/Operational

- establish a fuels treatment planner development path with an agreed upon curriculum for knowledge and skills acquisition and application

Technical

- create a simple-but-robust “IFTDSS playground” and software development kit (SDK)

- enable IFTDSS and the SMF to provide agencies with the ability to manage access for specific models
- enable IFTDSS to export data in conjunction with the enterprise's selection of an appropriate data formatting and exchange standards
- address IFTDSS security, extensibility, performance, documentation, interoperability, usability issues

Transition

- enhance fuels treatment planner workforce development path
- create formal IFTDSS user training
- use the Fuels Working Group work on fuels management competency to prioritize enhancements to IFTDSS' tutorial framework and formally map IFTDSS capabilities to the defined competencies

Long-Term

Governance/Management

- establish how IFTDSS could be used to evaluate scientific model efficacy

Business/Operational

- evolve workflows, tools, and data to stay current with changing mission needs
- if emphasis on fuels treatment workforce development continues, consider adding certification requirements into the fuels specialist career designations

Technical

- expand IFTDSS's workflow capability to include the ability to create, access and manage the workflows at multiple levels
- expose SMF capabilities as services for reuse by other wildland fire systems
- enable IFTDSS and the SMF to do self-service integration
- add features that allow direct model-to-model comparison within the IFTDSS environment.

Transition

- evolve training and transition mechanisms to stay current with changing mission needs
- Define and enable appropriate IFTDSS use in the required basic fire behavior courses

Final Thoughts

The feasibility of IFTDSS as a software tool is no longer a question. We recommend IFTDSS be deployed in a limited manner (similar to its current use) while bringing IFTDSS to a "production level" state and preparing field users to more-effectively use IFTDSS in the course of executing their missions.

We believe that IFTDSS will affirm the sense of "community" within the fuels management community. Among users by the ability to share data and workflows and burns plans, etc. Among researchers by the ability to integrate models and emphasize a data driven approach to

evaluating model efficacy (by comparing model projections to actual results). We believe that both of these could foster a collaborative scientific environment.

For long-term success IFTDSS must be supported by appropriate policies and governance to enable its workflows and integration capability to have a meaningful impact on the wildland fire community's business needs.

The wildland fire community will need to adopt a comprehensive national strategy in order for it to leverage IFTDSS as an ongoing operational capability. This multi-dimensional, organizational change management project will need a significant emphasis on a stronger definition of the skills, knowledge, and process abilities needed to successfully perform fuels treatment planning, analysis, and management functions.

Appendix A Task 1A Approach and Previous Response

Approach

Shortly after beginning out work, we realized that the WFI&T Plan was still early enough in its development that the question “Is the IFTDSS consistent with the key concepts of the WFI&T Plan” was perhaps premature. Instead, the focus of this task shifted to “What should be in the WFI&T Plan to support IFTDSS or similar, SOA-based systems?”

Task 1a was executed thru document review and discussions with key stakeholders.

At the request of JFSP, we accelerated the delivery of this section of the report from July 1, 2013 to late January 2013. The entire text of our January delivery is below, and for continuity it repeats the opening paragraphs which were included in the body of the report.

Task 1a Executive Summary

The wildland fire community consists of a diverse set of federal, state, local, and nongovernmental organizations, involves many personnel with varying skill sets and backgrounds, and spans a broad range of technical and materiel capabilities. However, effective wildland fire planning and response requires a comprehensive picture of current and potential future conditions (through scientific models), understanding of environmental and property risks, and knowledge of and access to available resources. The need for coordinated action in the face of organizational, geographic, and mission diversity challenges traditional information and technology management methodologies.

The current wildland fire technology landscape consists of scores of independently developed applications, scientific models, and data sets. This fragmentation impedes the development of efficient operational planning and undermines the effectiveness of wildland fire response. Traditional architectural approaches to address technology fragmentation depend on tight centralized control and hierarchical structures. This strategy often results in bloated mission systems that are expensive to develop, limited in impact, slow to adapt, and difficult to maintain.

The broad constituency and diverse interests of the wildland fire community requires an architectural approach that accounts for the decentralized nature of management and operations. A system-of-systems architectural approach is characterized by an independence of operations and management, meaning that the individual constituents of the system are able to act with relative independence. Effective management in this construct requires greater emphasis on strategic elements (e.g. core enabling services, data and interface standards, and coalition governance). These elements should encourage conformance while placing minimum constraints on the mission solution space - empowering technologists and operational elements to quickly incorporate and adapt preferred capabilities that meet diverse mission needs. In a decentralized environment, a system-of-systems architectural approach can yield greater agility, enhanced situational awareness and mission effectiveness, improved security posture, and reduced development and lifecycle costs.

A system-of-systems approach explicitly recognizes and enables independent, evolutionary development of constituent capabilities. This co-evolution is necessary given the wide range of continuously improving capabilities associated with wildland fire. Independence of change in individual constituents adds to the complexity of the interactions among constituents and of management and operations. Thus, in a system-of-systems, evolution must be explicitly recognized and managed. By facilitating change, systems can more readily integrate innovation resulting in greater mission impact⁸.

In March 2012, the Department of Agriculture Forestry Service and the Department of Interior jointly signed the Wildland Fire Information and Technology (WFI&T) Strategic Plan. This plan articulates a vision to enable an interagency, integrated approach to wildland fire information and technology management in support of mission activities. The plan establishes 4 concepts that guide wildland fire technology implementation:

- Mission requirements drive integrated, modular based applications and tools
- Authoritative data are readily available for all uses and users
- Interconnection and accessibility regardless of organization affiliation or user location
- Technology, research, and innovation enable and enhance mission

To achieve the WFI&T vision, wildland fire management must establish a technical architecture consistent with these concepts. The architecture will enable coordinated wildland fire planning and response while accounting for the decentralized nature of the wildland fire community.

A technical architecture that supports the WFI&T strategic concepts (i.e. Integrated Modular Applications, Authoritative Data, Accessible Applications, and Streamlined Technology Transition) requires the establishment of a set of 6 strategic elements:

- Service Oriented Modular Capabilities
- Integrated Security Posture
- Connected Wildland Fire Community
- Cloud Hosted Infrastructure
- Data Services and Governance
- Open Innovation Platform

Each of these elements are articulated in the content that follows.

Implementation Approach

Many agencies have attempted to implement enterprise architecture guidance only to be frustrated when the guidance fails to achieve desired results, or worse, is completely ignored. To avoid re-

⁸ Fisher, David; An Emergent Perspective on Interoperation in Systems of Systems (CMU/SEI-2006-TR-003). Software Engineering Institute, Carnegie Mellon University, 2006.
<http://www.sei.cmu.edu/library/abstracts/reports/06tr003.cfm>

peating these mistakes, a number of principles guide the strategic elements and implementation guidance that will follow.

First, it is important to recognize explicitly the budgetary and mission climate that affect the wildland fire community. In the face of budget austerity and increasing mission demands, the technical architecture must support efficient operations. It is important to “start small, scale fast, and if necessary fail cheap.” This suggests pilot initiatives (even for elements of the technical architecture) that are designed with an eye towards scalability but deliver testable results quickly and require only a small up-front investment until value is affirmed. Failing cheap requires the vision to set clear performance goals up front and the discipline to pull the plug on initiatives that do not meet the goals.

To maximize benefit, it is important to tie into existing initiatives in the broader DOI and USDA agency context. The technical architecture must leverage existing wildland fire investments and support piecemeal implementation allowing systems to join when opportunity avails—not all at once. Any approach that demands full compliance to yield any benefit will not work.

Strategic elements and standards should be developed with particular attention to mission impact—excessive guidance can slow the adoption of needed technologies and impede innovation. However, guidance can be developed quickly—without letting the perfect be the enemy of the good—as long as mechanisms are in place to continuously evolve the guidance. Standards developers should communicate directly with affected implementers to ensure guidance is practical. The greater the obstacle a standard creates to implementers, the lower the probability that it is applied. Resources should be set aside to help implementers conform.

Clear policy, verifiable standards, and loosely coupled systems will help to avoid locking in to a single vendor once the government has engaged with a provider. Without enforceable definitions of standard interfaces and other requirements, vendors will develop their own solutions in accord with their internal financial, technical, logistical, and other requirements. The result will be a set of proprietary service offerings that make it difficult for the government to transfer services from one vendor to another. Before such a “vendor lock” situation occurs, it is advantageous to work now to establish the necessary policies, governance structure, and conformance validation procedures that will shape how the vendor community structures solutions in response to the wildland fire community’s needs.

Policy compliance is verified through conformance validation—alignment with a set of “Simple Rules”. Simple Rules are the codification of guidance established in the implementation of the wildland fire technical architecture, specifically guidelines stemming from the first 5 strategic elements of this document. They must be easy to understand, readily available to system developers, practical to implement, objectively verified, limited in number, and should constrain the solution space as little as possible. Excessive rules dampen the value of any one rule and encourage providers and mission buyers to circumvent the system – resulting in reduced awareness and increased non-compliance. The Simple Rules do not specify WHAT technologies will meet mission needs but rather HOW technologies (existing and future) should behave to meet enterprise goals without sacrificing mission impact. They provide the substrate by which many tools can work

together in a new environment for sharing/linking/layering of content consistent with the WFI&T vision.

Simple Rule Conformance is measured through a set of conformance endpoints, i.e. web services that emulate characteristics of the mission environment, facilitate integration, and objectively measure compliance. The endpoints instantiate technical architecture guidelines ensuring that new technologies can be distributed across the enterprise, have consistent security mechanisms, and adhere to standards necessary to meet enterprise information sharing goals. By developing against these endpoints, technologists can leverage mission services while receiving assurance that systems will work as expected in mission settings.

Benefits of Simple Rules Governance Structure:

Rapid transition of capabilities - Establishing the rules up front through accessible web service conformance endpoints provides technology providers guidance on how to create capabilities that are more easily integrated into existing community environments. Web service enabled capabilities in conformant tools are more accessible—providing an environment that supports new combinations of capabilities after stand-up. The Simple Rules reduce the cost of transition to the government and the risk associated with development to the technology provider.

Enhanced security - The Simple Rules provide for a more secure environment through common authentication, access aware applications, and auditing of analytic activity in a common format—that can be mined to identify malicious behavior.

Enhanced sharing - Pulling group associations, communities of interest (COI), social network data out of individual applications to use collectively across applications enhances the utility of these groupings—since they may be expressed once and used frequently for trusted sharing of insight. Having a common service for exposing attributes connects dynamic groupings with formally established affiliations enabling deeper awareness and sharing.

Broader availability of tools - Different mission needs result in a wide variety of IT infrastructures and desktop configurations. These differences limit the distribution of tools, increase accreditation costs, result in uneven capabilities, prevent usage convergence towards best of breed technologies, and add to the fragmentation of insight. The Simple Rules distill integration requirements to the essential components to give compliant applications the broadest distributability. The rule which requires web user interfaces is an example. One of the few enterprise wide similarities is the availability of web browsers. Recent advances in the richness, speed, and interactivity of information presented in a browser have closed the gap in functionality between web and desktop applications. As a result, there is a growing list of capabilities presented via a web interface that have near enterprise wide reach. There are very few desktop applications (Microsoft Office excepted) that can make this claim.

Context shared across tool boundaries - One tool can leverage the fact that an analyst has expressed interest in a specific target/topic in a different tool—without directly integrating with that tool. Through Simple Rule compliant applications, context can be shared across tool boundaries

(without expensive app to app integration) alleviating the need for an analyst to restate needs, priorities, and interests repeatedly for each application required to do his/her job.

More powerful technologies - *Since Simple Rule compliant technologies can be more readily combined, technology providers can focus on extending core competencies while leveraging the strengths of other services. This results in quicker development cycles and lighter weight applications that combine best of breed components.*

The Simple Rules enable more effective operations by alleviating technology barriers: Fragmented Insight, Limited Discovery, Prohibitive Integration Costs, Bloated Tools, and Reactive Security.

Part 1: Service Oriented Modular Capabilities

Due to the diverse and distributed nature of the wildland fire mission, the WFI&T strategy calls for “integrated, modular-based applications and tools.” The current wildland fire technology environment is highly fragmented with many standalone tools and data sources. According to the WFI&T Strategy:

The target applications environment leverages the principles and concepts of service oriented architecture and uses components to build suites of interoperable tools or "system-of-systems" rather than focusing monolithic, stove-piped applications. In this environment, use of web based systems, support for mobile technologies and uses, and support for cross platform integration are preferred. The target application environment minimizes the number of unique systems or applications in favor of a framework of modules that allow flexibility and agility in meeting dynamic wildland fire mission requirements.

Tool and data fragmentation makes it difficult to obtain comprehensive situational awareness and to conduct operational risk assessments. Additionally, the wide variety of tools makes it difficult to integrate new cross cutting capabilities or to broadly distribute advances in scientific modeling. Since tools are not designed for use beyond the original context, related tools must rebuild the capability resulting in added complexity and potential variability in results.

Since integration with existing tools is impractical, scientists and technologists desiring to deliver new capabilities to mission elements choose to “go it alone”. The resulting end to end solutions are disconnected from existing tools and models causing further fragmentation of the wildland fire information and technology landscape. Significant development efforts are dedicated to tool scaffolding rather than core model development. As standalone solutions, these applications do not take advantage of existing interfaces and familiar workflows resulting in greater training demands. Furthermore, these capabilities are seldom developed as enterprise grade tools, exacerbating information sharing challenges and increasing information assurance risk.

The implementation of a Service Oriented Architecture (SOA) is central to the goal of achieving integrated modular applications in a system-of-systems framework.

*“Service Oriented Architecture is a **paradigm** for organizing and utilizing **distributed capabilities** that may be under the **control of different ownership** domains. It provides a **uniform** means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations.”*

*“A **service** is the means by which the **needs** of a consumer are brought together with the **capabilities** of a provider.”⁹*

The wildland fire community should require all mission applications to expose central functions via a SOA framework for reuse in other systems. Applications that do not support practical third party reuse (including burdensome licensing restrictions) should be phased out. Systems should be designed to separate presentation, business logic (e.g. scientific models), and data thereby facilitating collaboration and enhancing innovation through novel combinations of capabilities.

To realize the full benefits of an SOA framework, wildland fire management must establish and enforce guidelines that codify the following principles¹⁰:

- *Standardized service contract*: Services adhere to a communications agreement, as defined collectively by one or more service-description documents.
- *Service loose coupling*: Services maintain a relationship that minimizes dependencies and only requires that they maintain an awareness of each other.
- *Service abstraction*: Beyond descriptions in the service contract, services hide logic from the outside world.
- *Service reusability*: Logic is divided into services with the intention of promoting reuse.
- *Service autonomy*: Services have control over the logic they encapsulate.
- *Service statelessness*: Services minimize resource consumption by deferring the management of state information when necessary
- *Service discoverability*: Services are supplemented with communicative metadata by which they can be effectively discovered and interpreted.
- *Service composability*: Services are effective composition participants, regardless of the size and complexity of the composition.

As applications become increasingly interdependent, special emphasis on governance is required. This is especially true in multi-organizational SOA environments. While SOA simplifies the interaction between service consumer and provider, it can necessitate an interaction between fellow service consumers when upgrades to services are required to support mission needs. For example, a new operational need may drive a service consumer to request an upgrade of a consumed ser-

⁹ OASIS SOA Reference Model (SOA-RM). Version 1.0 . October 2006. <http://www.oasis-open.org/specs/index.php#soa-rmv1.0>

¹⁰ <http://serviceorientation.com/index.php/serviceorientation/p3>

vice. But this upgrade may impact other consumers who may not have the resources to adapt to changes in the underlying service. Cross consumer dependencies can be mitigated through careful planning, standardization of the structure of interfaces, and an emphasis on loose coupling. Where these interdependencies cannot be avoided, release schedules must be coordinated and sufficient resources set aside to update all affected consumers.

An SOA reduces overall environment complexity by separating the service consumer from concerns about specific implementation details. For mission applications, the relationship between service consumer and service provider should be governed by a service level agreement (SLA) to ensure that the delivered service meets the needs and expectations of the service consumer. Typically availability, reliability, capacity, and other factors are specifically called out in the agreement. SLAs should include maintenance and upgrade expectations as well as recourse procedures if the agreement is not met.¹¹ Where possible, SLA parameters should be written into contract language. Doing so requires advance planning and tight coordination between IT leadership and agency acquisition components. SLA development should be a formal step in all acquisitions of major information and technology systems.

To create the proper incentives for service reuse, cost recovery mechanisms must be established. Without cost recovery mechanisms, service hosts foot the bill for use outside the original mission context resulting in a disincentive for sharing. The result may be degraded mission performance, greater maintenance and support costs, and increased liability. Cost recovery should be tied to service use to avoid scenarios where a consumer can overrun provider capabilities without consequence. Without cost recovery mechanisms, hosts have little incentive to provide quality service and will often slow roll initiatives intended to increase service reuse. However, cost recovery mechanisms can be challenging in a government acquisition environment due to the uncertainty in outlays, slow acquisition response, and difficulties with interagency transfers. Agencies have addressed this challenge by issuing credits to service consumers that can be exchanged services as demand arises. These credits reflect costs associated with service delivery and can be tied to budget allocations but are more fungible to meet unanticipated changes in demand.

In a multi-organizational SOA environment, it is important to align help desk functions to properly respond to defects or outages. Since dependencies may cross organizational boundaries, mechanisms for issue isolation and mechanisms for organizational handoff need to be established to ensure proper service to consumers.

A robust SOA environment requires the fielding of development and test service interfaces for key services to facilitate development and integration of applications that consume these services.

Information assurance considerations require mutual authentication between service provider and consumer. Service to service authentication is typically done through a PKI framework. Mutual authentication reduces the possibility of denial of service and man-in-the-middle attacks.

¹¹ <http://www.gartner.com/id=314581>

Wildland fire management should establish data and API standards to simplify system integration. However, when establishing interoperability standards, it is important to avoid making the perfect the enemy of the good. Rigid guidelines will discourage participation especially when compliance significantly impacts mission goals.

When the number of systems in the SOA are relatively small (as is the case with the wildland fire community), participants should coordinate directly on API design. In this case, central coordination is only required for general practices (mutual authentication, data standards, etc.) and for services that have enterprise scope.

Though specific circumstances may dictate otherwise, the wildland fire community should favor the use of REpresentational State Transfer (REST) interfaces over Simple Object Access Protocols (SOAP) interfaces, since in general, REST interfaces simplify reuse by reducing coupling between systems.

Cross cutting infrastructure services are key enablers for SOA environments. One cross cutting service essential to unlock SOA potential is identity and access management (IdAM). Without a common IdAM infrastructure, it is very difficult to transfer information securely between applications. When users are represented differently in each system, security context is lost for actions that take place across applications. At a small scale this is manageable. But as environment complexity grows, the administrative burden can be overwhelming. IdAM requirements are discussed in detail in Part 2.

By decomposing application functions into logical modules (presentation layer, Scientific Modeling Framework, models, and data), the Interagency Fuels Treatment Decision Support System (IFTDSS) provides a design pattern that should be emulated throughout the wildland fire enterprise. IFTDSS was designed to facilitate the development and deployment of scientific models to the wildland fire community. The centerpiece of the system is the Scientific Modeling Framework (SMF), a forward leaning approach to modular integration particularly valuable in integrating independently developed scientific models—crucial elements in the execution of the wildland fire mission. Before IFTDSS, scientific models were often tightly coupled with standalone tools. Users were required to install and train on a variety of different tools to execute their mission. Additionally, many wildland fire workflows require a combination of models. Without IFTDSS, users were forced to integrate various tools manually by moving files and restructuring data. The SMF simplifies this integration by decoupling presentation and integration functions from the underlying models. The SMF masks technical details of model execution through an abstraction layer. This simplifies interface development and unburdens the user from integration and data formatting considerations. As a result, models can be accessed through a single interface individually or in combination using a workflow engine that executes a variety of models in succession. Details of gathering and managing the underlying input and output data are handled by the SMF. This approach simplifies model development by freeing scientists to focus on algorithm development while isolating them from interface design, data management and transformation, and enterprise infrastructure requirements and standards. While the SMF provides a model for modular applications, additional work must be done (e.g. web service enablement) to facilitate reuse by other wildland fire systems.

Service Oriented Modular Capabilities Recommendations

- Create and enforce enterprise SOA guidelines and governance.
- Inventory existing wildland fire applications and data for services that can be exposed for reuse consistent with SOA guidelines. Set budget priorities to replace or phase out systems that do not expose or consume modular capabilities.
- Encourage modular system development through budget incentives that reward component reuse and compensate service providers through cost recovery mechanisms.
- Extend the Scientific Modeling Framework (SMF) to simplify scientific model integration and third party reuse.

Part 2: Integrated Security Posture

Wildland fire planning and response involves a geographically and organizationally diverse set of participants. Response scenarios may involve a rapidly formed coalition of federal multi-agency, state, local, commercial, NGO, environmental, and private participants. To execute operations efficiently, participants must be provided secure, attributable access to shared tools and data. From the WFI&T strategy:

The target security environment ensures an integrated approach to protecting the integrity of data and systems through a combination of application design, data standards, infrastructure design, and management of credentials and access. The target security environment must explicitly weigh and manage the risks of security measures with the ability of business functions to operate effectively. The ideal security environment is an integrated approach of automating security requirements that were once accomplished through a manual process. Security will continue to focus efforts towards confidentiality, integrity and availability through a balanced security in depth approach that meets all Federal requirements.

Wildland fire systems must limit access to authorized users whose identity can be established with assurance. A unified approach to identity management, where each and every participant has one and only one universally recognized identity, is probably the most fundamental requirement to an effective information sharing environment. Yet, this remains as one of the biggest stumbling blocks in many federal information technology environments.

Many participants in the wildland fire mission are geographically distributed are not directly affiliated with federal agencies. As a result, they do not (and cannot practically) possess a federally issued identity token such as an HSPD-12 compliant Personal Identity Verification (PIV) card. Therefore, establishing a unified approach to wildland fire identity management has unique challenges and will require a forward leaning approach.

A robust identity and access management (IdAM) solution is critically important to secure universal access to applications and data. To unlock the potential of service oriented architectures, an IdAM strategy must be coordinated at the enterprise level. As the foundation for information assurance, an enterprise IdAM strategy may be the single most important enabling service. Since

every application is affected, implementation of the strategy requires dedicated leadership. An enterprise IdAM solution requires all applications to respect common credentials for access and authorization decisions. Additionally, application-specific credentials are not permitted since they limit the ability to distribute data across application boundaries. All credentials must be traceable to a specific user or device.

The wildland fire IdAM strategy must be coordinated with, if not led by, DOI and USDA CIO offices. But, the wildland fire mission requires an IdAM solution that can enable collaboration beyond the DOI and USDA enterprise among rapidly formed coalitions of federal multi-agency, state, local, commercial, NGO, environmental, and private participants. Wildland fire leadership must ensure that the proffered IdAM solution is in sync with agency IdAM solutions but also permits strong authentication of the broader wildland fire community.

Traditional enterprise IdAM solutions have an onboarding process that can take days or weeks, often involve face to face verification, and frequently require the issuance of a physical token such as a PIV card. There are security and sharing benefits to this approach but administrative burden for a distributed organization can be cost and manpower prohibitive. Just as confounding, external participants may not receive credentials until AFTER a crises is resolved, limiting the benefits of wildland fire information and technology systems.

The enhanced security requirements and distributed client base of online banking, has driven the emergence of identity service providers and IDentity as a Service (IDaaS) solutions. IDaaS gains the security and sharing benefits of a traditional approach while, at low cost, addressing the distributed nature of the wildland fire community, the need to respect enterprise role assignments and authorities, and during response, the requirement for rapid onboarding and dynamic role management of participants.

Due to the increased demand for citizen facing and mobile applications, government agencies have begun to leverage IDaaS for enhanced interactions with users inside, across, and outside government. Since IDaaS providers specialize in enabling high assurance transactions, these methods are (if implemented properly) more cost effective, flexible, and secure than traditional agency IdAM methods. Additionally, through a properly worded service level agreement, the government can transfer security and privacy risk associated with distributed environment identity management to service providers with the expertise to manage it.

To meet the needs of the wildland fire mission, an IDaaS solution must exhibit the following characteristics:

- Ability to integrate with HSPD-12 compliant PIV cards for credentialing
- Ability to issue identities to wildland fire community members and first responders outside the DOI and USDA FS enterprise via identity proofing with dynamic knowledge based authentication
- Ability to leverage enterprise DOI and USDA FS security tokens and attribute stores such as LDAP or Active Directory

- Support for common standards based models for authorization and credential management (e.g. OAuth, SAML2.0, web service based management functions)
- Support for risk based authentication capable of NIST Level 3 assurance or above
- Support for intergovernmental attribute exchanges and stakeholder managed authorization

IDaaS with PIV integrated identities

Homeland Security Presidential Directive 12 (HSPD-12) was enacted to enhance security and information sharing among government agencies by providing high assurance identification of government employees, contractors and assets (applications, servers, routers, etc.) engaged in transactions on federal government networks. Increasingly, federal government users authenticate to information systems through the use of PIV cards. For many Federal Agencies, deployment of these cards in the enterprise has been met with challenges. While PIV cards are an important piece of the puzzle they do not meet the full scope of the need for user authentication. PIV-only methods force a “one size fits all” approach to sharing that disenfranchises less sophisticated Agencies, make it difficult to support teleworking or to tie mobile devices to the Enterprise, and all but eliminate important sharing scenarios such as citizen facing applications, or disaster response coordination between non-government organizations (NGOs) and Federal, State, and local authorities.

Many IDaaS providers can and do integrate with the PIV infrastructure to further extend assurance. This integration provides a higher level of assurance than PIV alone through a broader spectrum of assured authentication. This spectrum enables users to engage with government systems, working in settings and using devices that most naturally support their workflow, while still providing a means to engage in high assurance transactions. This approach strengthens and extends the existing HSPD-12 model.

As a practical matter, it has been difficult to roll out PIV-centric solutions in government settings for a number of reasons. Initially, the rollout creates a divide as some users benefit while others are isolated. The cost and time lag associated with issuing compliant cards and integrating card readers with workstations have proven to take years. Often, technology advancements or shifting requirements necessitate upgrades to the PIV infrastructure before it is completely deployed. This is evidenced by the ubiquity of mobile devices and the challenges in securing them and integrating PIV, while there have been advances in encryption chipsets that can securely hold certificates and PIV credentials (end point and user), allowing for the deployment of these technologies on desktops, laptops and in the very near future mobile devices. The high cost and protracted deployment continues to place a strain on IT departments (cost, schedule, capabilities), and during the extended timeline other mission priorities begin to take precedence. Conversely, IDaaS solutions that integrate with PIV can be implemented more quickly, and provide immediate benefits to all users. These benefits are strengthened as the PIV rollout “catches up” and evolves.

Third party issued identities (such as an identity established through a cloud provider) are flexible since they can be issued as needed through streamlined processes. But, if the identity is not linked to internal enterprise attribute stores, the end result is more, not less, administrative overhead. For example, security considerations may dictate that certain system functions be made available only

to Forestry Service government employees. If the third party identity is not linked to the internal Forestry Service identity, organizational role and affiliation would need to be maintained separately and with the same level of assurance – the immense administrative burden that follows easily outweighs the flexibility of an externally issued identity. The need for coordinated action in the distributed wildland fire community requires an IdAM solution that combines the flexibility of third party issued identities with the assurance benefits of integration with internal attribute stores.

Integrating PIV-based identities with enterprise attribute stores, such as Active Directory, to provide/remove user access can involve significant and disruptive infrastructure changes. IDaaS solutions that naturally integrate authentication standards such as SAML offer an open interface to simplify the integration of existing identity and authentication stores. Cost reductions can be achieved by hosting IDaaS solutions off premises, integrated with on premises attribute stores via a common PKI root. This flexibility makes IDaaS solutions ideal to serve as the authentication backbone for hybrid and public cloud offerings. Figure [18] below presents a high-level logical depiction of a comprehensive IDaaS offering and how the various elements could be integrated with existing infrastructure to provide such a service.

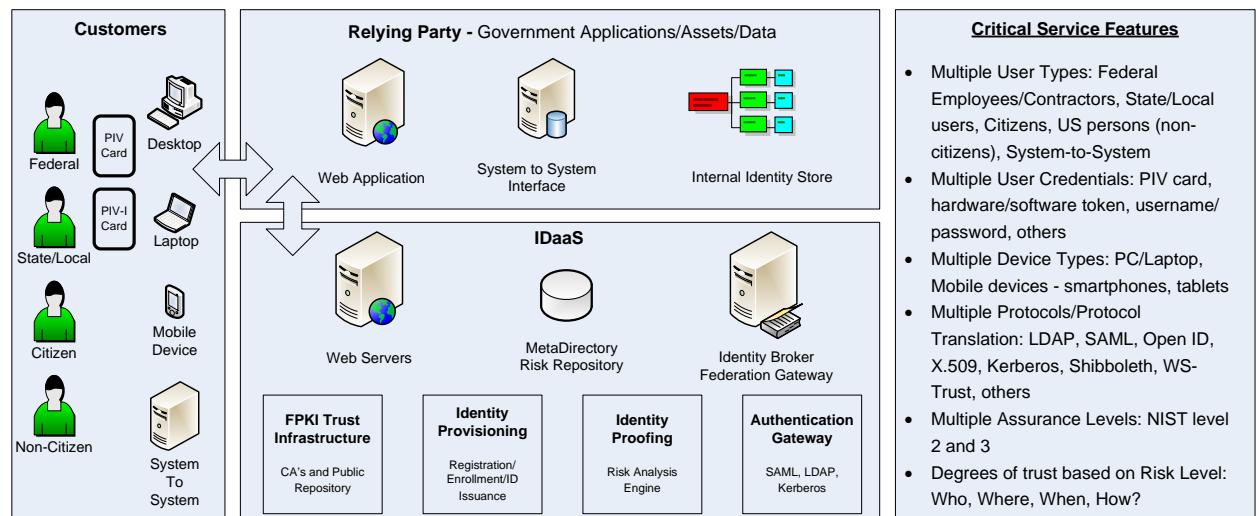


Figure 18: Logical Depiction of Comprehensive Federal Identity as a Service Offering

Identity Proofing (IdP) through dynamic knowledge based authentication (dKBA)

Identity proofing (IdP) is the verification that a user is who they claim to be. Proofing is an essential element in the issuing of an identity lest the whole security framework be undermined by users who have received valid credentials under a false context. In legacy infrastructures, identities are tied to physical credential (PIV card) usually issued by an authority via face to face verification. On issue, measures are taken to ensure the user is who they claim. In this manner, it can take years to issue credentials to all users and a robust infrastructure is needed to maintain them and deal with lost or stolen cards. Physical credentialing may be possible for federal wildland fire constituents but, by itself, precludes the broader wildland fire community from participating in a common identity framework.

Knowledge-based authentication (KBA) is the default identity proofing technique in many government systems where face to face proofing is impractical. The problem with KBA is that the answers are generally easily guessed by social engineering or an insider (especially system administrators). The result is that KBA is probably not a good choice for stronger authentication systems that contain sensitive data.

Private sector enterprises (financial, health care, etc.) have needed to conduct transactions involving high value data with a diverse user base at low cost. This need has given rise to a more flexible proofing mechanism that can offer greater assurance than traditional means. Dynamic KBA proofs the identity of an ad hoc user by pulling questions and answers from information sources like public records, credit reports, internal data, or even the employee's last pay stub. The answers are generally much harder to guess and unknown by system administrators. According to the user's responses, questions are sequenced to provide a high level of certainty to the user's identity. dKBA is the only mechanism that can be used to proof users with no previous engagement with the enterprise (frequently the case for local first responders or private interests that may be involved in wildland fire response). It can also be used to authenticate users who have lost, damaged, or misplaced physical credentials or who are attempting to access wildland fire systems through mobile devices. dKBA can be used in conjunction with, or in lieu of, other forms of authentication to provide a robust, flexible IdAM solution.

Risk Based Authentication (RBA)

Many identity management as a service (IDaaS) providers offer solutions with broad capabilities centered on risk based authentication methods. RBA methods establish a user's identity with high (NIST Level 3) assurance through combinations of username/password, out of band second (or more) factors, and challenge identity proofing. RBA permits systems to dynamically adjust authentication assurance based on the source device and context, usability factors, and the level of assurance required for requested actions. For example, username/password authentication may be sufficient to enable a user to run a scientific model but additional assurance of identity (e.g. PIV card, multiple factors via out-of-band channels, or proofing) may be required to update a model or alter a dataset. RBA methods have matured through the evolution and use of similar services in commercial settings to secure financial transactions, and are now highly reliable and have flexible cost models based on service and usage types.

An example of a government IDaaS solution that combines these features is the US Citizenship and Immigration Services (USCIS) SelfCheck system (<http://www.uscis.gov/selfcheck>). SelfCheck enables a distributed user base (any US Person) to access government held PII data (eVerify employment eligibility status) with high (NIST Level 3) assurance and at low cost. This solution won a 2012 Excellence in Government award honoring the most effective, efficient, and innovative solutions in government. This model is now being emulated by other agencies looking to interact securely with a distributed workforce.

Attribute Based Authorization with Stakeholder Managed Attributes

The utility of a comprehensive authentication model is only fully realized once a complementary authorization framework is established. Access to any enterprise asset, virtual or physical, and the authorization to perform actions with and on the asset are a function of the roles, responsibilities, and interests (i.e. attributes) of the actor. A central characteristic of ANY organization is an authorization structure that guides [and often mandates] *who* can do *what* in a particular context. Examples include: Who can speak authoritatively for the agency? Who can modify an algorithm or delete data? Who can provision a resource? Who can issue a command and to whom during an emergency response? Who should receive an emergency update? Information systems are expected to enforce authorization rules which are often contextual and depend on roles and characteristics of participants which may change over time. For example, during disaster response participation, roles, and authority may change by the hour.

To make authorization decisions, systems rely on attributes that span the spectrum from enterprise scope (civilian/contractor, agency affiliation) to those assigned and maintained by the individual information or system owner (administrator/end user). Role definitions often vary across agencies undermining their application. Many agencies are hamstrung by authorization models that rely on attributes maintained in centralized repositories, or are forced to implement authorization models that have only local context (built within the system itself), limiting re-use and extensibility.

In many cases, authorization decisions are contextual. Scene coordinator, responding asset, affected landowner are all transient attributes best managed by stakeholders (active participants or asset owners). But traditional authorization models force stakeholders to cede some measure of control to IT departments responsible for maintaining the attributes and the authorization controls. Further, these models don't scale to match the complex environments of government enterprises and their missions limiting the ability to support inter-agency or inter-organization information sharing.

The wildland fire mission requires a robust, flexible, decentralized attribute management framework that accounts for frequently changing roles, authorities, and data distribution channels. This framework includes enterprise standards for attribute distribution (SAML 2.0 & XACML), a mechanism to exchange centrally managed attributes (official roles and authorities) between entities, and a service to permit stakeholders to manage cross application attributes.

The Department of Homeland Security, in coordination with the Department of Defense, has established an attribute sharing framework, called the Backend Attribute Exchange (BAE). The BAE has been used in a pilot program to demonstrate the ability to make interagency authorization decisions (access to DoD held imagery in support of disaster response) based on cross agency attributes (DHS held "first responder" attribute)¹².

The fluidity of the wildland fire mission requires a means for information sharing boundaries to be set by stakeholders without limits of artificial constructs such as registered users of an applica-

¹² http://www.idmanagement.gov/documents/BAE_v2_Overview_Document_Final_v1.0.0.pdf

tion or systems within a specific network. Through decentralized attribute management, information can flow safely across organizational boundaries, along contours defined by stakeholders, and in accordance with mission needs. While some user attributes are best maintained centrally, many attributes are fluid and are best maintained by stakeholders – those who are directly responsible for data or who are directly involved in planning and response. Decentralization requires the ability to delegate attribute management authority, empowering stakeholders rather than IT personnel to create and assign roles and authorities for managed assets. This delegation is critical to the scalability, adaptability, and security of distributed systems.

DHS has developed a decentralized cross-application authorization framework to complement existing enterprise attribute stores. This framework translates a user's identity, established by a common authentication model, into a collection of stakeholder managed attributes tailored to the context of the application, system, and the specific transaction request. Stakeholders are empowered to manage user roles, responsibilities, access rights, and interests relevant to the physical and virtual information assets they control through a secure, intuitive interface. Decentralizing authorization management in this way follows a security best practice to place authority and responsibility for safeguarding information assets directly in the hands of those most closely tied to and responsible for those assets.

Since permissions are not bound to a specific application in this framework, data can be reused in other contexts and in other applications without losing the intended security context. This is crucial to unlock the promise of SOA and business intelligence (BI) applications. Until such a model is in place broadly, the impact of SOA and BI applications will be limited and cross-agency information sharing will be difficult to manage.

The need for a distributed management model continues to grow with the accelerating migration of applications to the cloud. IT departments and to an even greater degree, Cloud Service Providers, are further isolated from the tenant customers of these cloud environments, necessitating a model that empowers stakeholders to manage their own access and authorization.

Application Level Auditing as a Service

A common identity framework makes it possible to get an integrated, comprehensive view of user activity. Situational awareness through an integrated picture of activity is a crucial component to information assurance. Unfortunately, the focus on lower level auditing (network, firewall, server, database), coupled with the lack of a consistent auditing model, has made the development of a comprehensive picture very difficult. Instead of being proactive, security officers and organizations are forced to react by piecing together the impact of an incident after the fact, and with limited context of the event and the nature of the information compromised or impacted, rather than understanding the context and even being able to take action as the incident is occurring.

Current auditing techniques piece together a picture of user activity based on network activity, data that crosses network boundaries, and limited application logs. The data to be audited comes in a wide range of formats, occurs under varying identities, and is stored in distributed locations across the network. A number of organizations aggregate and consolidate audit information in

Security Operations Centers. Through “big data” analysis, Security Event and Information Management systems are able to piece together events generated in different systems. But, the context of events and the nature of the information involved often do not exist. Since a great deal of event context is internal to an application, security organizations cannot fully know the nature of the threat and compromise. Simply viewing audit artifacts gives little indication of why a user engaged in a transaction. A vibrant information sharing ecosystem relies on a “trust but verify” security model, but without a comprehensive user activity auditing framework security remains reactive not proactive.

A cross-application auditing service can be used to deliver an enterprise view of user activity. This service captures system level events, exceptions, and user activity in an easy to read, expressive format. Through this service, application owners can get a comprehensive view of the health of their system, react in real time to issues, and improve delivery through information on how users engage with the system, and with each other. Events can be aggregated across systems to provide a comprehensive cross application view of activity.

Logging of user activity enhances: security (insider threat detection), best practice detection and tradecraft improvement, tool value assessments (pay per use, not huge license fees up front), expertise finding and insight sharing (finding others with related interest), and cross tool context (enabling one tool to understand what a user is doing in another tool).

Integrated Security Posture Recommendations

- Coordinate with agency CIOs to establish a wildland fire identity management policy that includes agency and non-agency users.
- Investigate IDaaS providers to identify if cost effective solution exists that meets the needs of the wildland fire enterprise.
- Establish a centrally managed wildland fire IdAM infrastructure.
- Ensure cloud strategy consistent with integrated security posture.
- Integrate mission and back office systems as technology refresh cycles permit by replacing tool specific authentication.

Part 3: Connected Wildland Fire Community

The diverse mission and distributed nature of the wildland fire community requires a strategic approach to collaboration and information sharing. As described in the WFI&T strategy:

The target infrastructure and technology environment provides secure, integrated, and accessible capabilities for all users and applications to be able to collect, analyze, share, and disseminate information regardless of function, agency, or location. The target environment includes both data and voice infrastructure.

A central function in this strategy is to ensure that wildland fire systems and data are broadly accessible. The community consists of participants with widely varying IT resources, needs, and access to support. Users will access wildland fire systems through a wide variety of platforms, operating systems, browsers, devices, locations, and network connectivity. This diversity makes it

difficult to develop, distribute, and maintain “thick” client solutions (systems that depend on client installations and licensing). Frequently, these users are in the field driving the need for solutions that are accessible through mobile devices. In crisis scenarios, a rapidly formed coalition of responders may have only their personal mobile devices for access to wildland fire information and technology. Wildland fire management needs to establish policies that ensure the broadest range of data and services are available to these users when needed.

A Web User Interface (WebUI) First strategy simplifies the distribution of capabilities and content providing access to the broadest range of wildland fire participants. This strategy includes a number of elements: preferentially procuring and upgrading solutions that can be accessed via web browsers with no special client operating system, configuration, or license requirements; driving technologies to incorporate recent standards advancement that enrich thin client solutions such as HTML 5; decoupling business logic from the presentation layer (user interface) in applications such that data and services may be reused outside the original context; developing reusable widgets that can be reused across applications for rendering certain types of data; establishing UI layout guidelines for consistent navigation and function across independently developed applications; providing core collaboration services such as presence awareness and chat to strengthen linkages among users and promote information sharing.

Applications that depend on client operating system, configuration, or licensing are difficult to develop, distribute, and maintain especially in a diverse multi-organizational operating environment. Different budget priorities, technology refresh rates, and access to information technology support services can result in slow rollout of technologies to mission elements even when the need is clear. Even with a common technology vision, these information technology barriers can result in capability fragmentation which may have a significant effect on operational continuity. In contrast, web client applications can be immediately accessible to all users with a web browser and network connectivity. While browser version issues may impact feature usability, browser upgrades are easier to manage at the enterprise level and are not usually a significant issue for users accessing systems from their own device.

The proliferation and increasing power of handheld devices, along with the need for access to real-time data in the field, are driving business applications to run on resource-constrained devices such as handheld devices, PDAs, and cell phones. Recent advancements in web presentation layer technologies, such as the growing adoption of HTML 5, have cut the gap in capabilities between thick client solutions and web client solutions. As a result, users can take advantage of rich interactive interfaces with no more than a modern web browser on their desktop, tablet, or mobile device even with limited or intermittent connectivity. Certain specialized mission functions may require thick client solutions, but these systems should be implemented as the exception with careful consideration of the consequences for disenfranchised users and with mitigation strategies to provide access, even if degraded, to users who do not have access to specially configured clients.

A WebUI first strategy emphasizes the separation of business logic from presentation layer in applications. This separation exposes data and business logic for aggregation (mash ups) in third party presentations. Common presentations (widgets) that rely on data exposed in standardized

formats (see Part 5) can be developed and reused across applications reducing development and training costs while increasing situational awareness by weaving together information from separate applications.

Requiring application providers to include navigation elements that are consistent across the enterprise can simplify tool use, reduce training time, create the feel of tightly integrated systems, and provide greater awareness of the full complement of wildland fire tools and data. Content for common navigation elements, usually rendered at the top or left of the display, is drawn from a centrally managed source and should include links to all available tools. This allows users to switch fluidly between applications. The common area can be used to display alerts or other information for enterprise distribution.

Another element of a connected enterprise is central hosting of collaboration capabilities and services. These capabilities (chat, wiki, presence awareness, etc.) should be designed to function alone and integrated into wildland fire mission systems. A wiki provides a means for end users to organize and share knowledge, experience, and practices. Presence awareness and chat help distributed users feel more connected giving rise to a stronger sense of community.

Connected Wildland Fire Community Recommendations

- Establish a WebUI Policy phasing out applications with client dependencies
- Encourage technologies to support mobile devices and use HTML 5 including offline capabilities
- Develop and enforce common user interface standards for a consistent user experience
- Establish enterprise collaboration capabilities and services

Part 4: Cloud Hosted Infrastructure

The nature of the wildland fire mission (frequent interactions outside the enterprise, usage spikes during response) is very amenable to public cloud hosted services. FEDRAMP provides a mechanism for government agencies benefit from pre-certified cloud providers. If managed properly, migrating to cloud hosting can increase accessibility, agility, accountability, scalability, and reliability while reducing complexity, risk, and cost. However, cloud hosting is not a panacea. Many wildland fire applications contain PII data (for example, incident information could include medical records, financial data, sensitive T&E species information, sensitive cultural information). If not aligned with the integrated security posture (as outlined in Part 2), cloud aware IT asset management and procurement, and automated compliance monitoring, cloud hosting benefits will be limited.

Content service responsiveness can be affected during surge conditions. However, these peaks in demand occur when system responsiveness is most critical. One of the strengths of cloud hosting is elasticity, the ability to expand resource allocations during peak demand and to return resources when they are no longer needed. As a result, it is not necessary to pay for excess capacity. Additionally, data storage in the cloud is often much cheaper and more reliable than on site storage.

The capabilities and management interfaces for cloud providers, public and private, can vary widely. These variations can make it difficult to switch from one cloud provider to another, causing agencies to be locked into a provider once selected. The difficulty of switching, cloud “vendor lock”, prevents agencies from taking advantage of more favorable cost structures or more powerful capabilities that may become available through competing vendors. This discontinuity has given rise to a new class of service provider called a cloud service broker (CSB). CSBs “wrap” underlying cloud services providing a consistent experience across cloud hosts. Agencies can switch freely between cloud hosts through a CSB benefitting from best of each while being isolated from inconsistencies between offerings.

The ease of provisioning resources in cloud hosted environments can lead to inefficient allocations (Virtual Machine “sprawl”) if not coupled with integrated IT Asset Management (ITAM). ITAM provides full traceability of all IT assets, enabling management to oversee all resources with clear understanding of mission purpose and responsible parties.

The fluid nature of IT asset allocation in cloud environments, resource allocations can expand elastically according to demand, require flexible mechanisms for cost tracking and recovery. Uncertain demand can challenge planning efforts and may require modifications to budget processes if wild variations routinely occur.

The ability to provision technology resources on demand can challenge traditional security models. One of the principle benefits of cloud technologies, the ability to provision assets instantly, is undermined if traditional security review practices, which often include lengthy review processes, are followed. Where possible, security reviews should be codified and automated to instantly validate (or deny) asset requests. “Trust but verify” security provides a more agile enterprise and stronger security posture since compliance is continuously monitored.

Migration to cloud hosting can offer many benefits including reduced cost of data storage, improved availability, and elastic scaling. The ability to derive and personalize landscape data will result in significant storage needs. Commodity cloud storage would reduce costs. Systems that scale elastically (i.e. linear expansion through even distribution of load across virtual machines) can operate effectively during peak demand and efficiently when demand decreases.

Cloud Hosted Infrastructure Recommendations

- Select one or more cloud providers from the FEDRAMP list of vendors
- Ensure cloud provider is consistent with integrated security posture (Part 2)
- Research cloud service brokers to simplify cloud management and migration
- Establish cloud integrated IT asset management (ITAM) to prevent VM sprawl

Part 5: Data Services and Governance

Effective wildland fire operations require a comprehensive assessment of risks, knowledge of available resources, and awareness of ongoing developments through secure access to authoritative data by all authorized users and users across all wildland fire applications and tools. The current wildland fire information and technology environment is application centric. Data and logic are locked within stove-piped applications that serve specific elements of the mission. Information cannot flow easily between systems making it difficult to develop a comprehensive picture of wildland fire activities. A content centered strategy breaks down application stove-pipes by exposing data and logic for reuse. This is accomplished by identifying core logic and data within applications that can be used in a broader context, exposing this data in a standardized format via service interfaces, and eliminating redundant data and capabilities. As described in the WFI&T strategy:

Interconnection among agency systems and infrastructure is an essential component of the target environment, either through commonly interpreted and applied policies or through engineered solutions.

For wildland fire data to be authoritative and readily available, several technical challenges must be addressed including information assurance, inexpensive scaling during surge conditions, and data interpretability for reuse outside the originating context.

Wildland fire activities depend on an understanding of environmental and ecological conditions. LANDFIRE is an initiative to provide 30 meter spatial resolution raster data products that depict the nation's major ecosystems, wildlife habitat, vegetation or canopy characteristics, landscape features, and wildland fire behavior, effects, and regimes¹³. This data is essential to the wildland fire mission. But, LANDFIRE data is updated infrequently approximately every 5 years. Currently available data reflects conditions in 2008. It doesn't reflect natural growth, changes due to community development, effects of wildland fire events, and fire community planning and prevention steps since then. Additionally, it can be difficult to obtain data LANDFIRE data needed

¹³ <http://www.landfire.gov/>

for mission planning. Since common tools and services for manipulating and sharing this data do not exist, use in a wide variety of tools can be laborious.

A content centered approach to this data would emphasize tools and services that facilitate the use of this data in wildland fire systems. This includes mechanisms to derive data from the original source, update to support a mission context, establish the authority of derived data, ingest into mission systems, and share with others.

Reuse of derived data sets could have great value assuming that the nature of the data was transparent and the distribution controlled according to context. Certain derived data, such as an ecological update after a fire event, might be beneficial to share broadly with the whole community. Local updates to the data are often performed prior to running an assessment, but no mechanism exists to expose this derived data for reuse even though it may be more accurate than official data. The wildland fire community would benefit a model to update LANDSCAPE data via a wiki-like (i.e. collaborative) mechanism.

Other data, such as hypothetical landscapes reflected proposed changes, might be shared amongst a group of researchers. Mechanisms should be established to permit this type of derived data sharing as well. However, this data is only beneficial in context. Broad distribution could result in misunderstanding or misuse. Processes should be established to distinguish officially approved data from modifications that may not have been intended or certified for broad use.

Authoritative data depends on change attribution. Traceability for all updates requires stronger methods of authentication, a more comprehensive approach to authorization, and system wide auditing. These principles are discussed in greater detail in Part 2.

Mediation services provide the means to translate data from one format to another facilitating reuse across systems. Wildland fire scientific models are built around landscape data stored in a specific format. Characteristics of the data (resolution, attributes, etc.) may vary across models. In some cases, this precludes the integration of specific models. In other cases, mediation between data formats may be possible. Mechanisms should be provided to allow data to be characterized and, where possible, translated to allow the dynamic composition of models into workflows.

To provide mission critical support, content services (both data and business functions) must be assured. This means that content services must be protected from malicious threats, backed up with rapid recovery in the event of a system failure, altered or deleted only by authorized users in appropriate context and with sufficient auditing, and securely and reliably delivered to authorized users. The Federal Information Security Management Act (FISMA) of 2002 provides direction for assurance of information systems. However, the strength of the security posture in FISMA compliant systems still depends on system-of-systems enabling services such as identity and access management discussed in Part 2.

Most wildland fire data is locked within systems and exists in a wide variety of formats. This limits reuse and recontextualization and impacts enterprise situational awareness. To support cross system information sharing and mash-ups, data must be interpretable outside its original context. To effectively exchange information, (1) there must be a common semantic understanding of data

among participants, and (2) the data must be formatted in a consistent manner. Data standards are developed to support system-of-systems exchanges. One standard, the National Information Exchange Model (NIEM), has been developed to streamline information sharing homeland security, emergency and disaster management, and other domains. To facilitate sharing within the wildland fire community and beyond, wildland fire systems should conform to this standard. Given their primary purpose as data providers, the LANDFIRE and iIRWIn programs should take a leadership role in establishing data standards for the community.

Data Governance Recommendations

- Survey wildland fire systems for business functions and data. Identify systems of record, expose data and functionality for reuse, and eliminate redundancies.
- Create derived data manipulation and storage capabilities to facilitate group and community sharing as well as third party system reuse.
- Create enterprise processes for establishing the authoritativeness of derived data.
- Establish wildland fire data formatting and exchange standards (e.g. NIEM, KML).

Part 6: Open Innovation Platform

Effective wildland fire operations are dependent on information and technology. Planning and response are driven by risk assessments developed from an understanding of current landscape and weather conditions, assessment of environmental & commercial impact, available resources, and other factors. Since these factors interact in complex ways, continual advancements in technologies and methods are needed to improve operational effectiveness.

But, transition of scientific and technological advances into mission systems and operational procedures is a challenging task. The effort and expense to develop and test new tools and methods, integrate them into operational systems, and train the workforce for proper use results in a “friction” that undermines innovation. This is especially true in an information and technology environment consisting of tightly bound monolithic systems. In this environment, years of planning and rework are required to integrate tools and methods into existing mission systems. Even when integrated, the methods may not be broadly available. New capabilities or novel combinations of existing technologies take considerable planning and effort to field. Since the delivery path for new applications, algorithms, workflows, and data is so onerous, implementers frequently “go it alone” resulting in tool sprawl (i.e. many disconnected systems) further exacerbating the integration challenge and undermining enterprise goals.

To address this challenge, it is necessary to create an innovation platform that bridges the gap between research and development and operations. A “self-service” integration platform moves the risk and the challenge of technology transition from the system integrator to those who have the greatest vested interest in the success of the technology (i.e. the developers). Minimizing transition “friction” reduces the dependence on systems integrators and enables innovators to develop, integrate, validate, and showcase new capabilities and technology combinations – in less time, with greater reach, and in many cases at very little cost.

An example of this model is Apple's App Store. Apple established a clear set of integration guidelines enabling developers to add their own technologies to the platform. These guidelines did not constrain *what* was created, only *how* capabilities interact with other elements via the platform. Users could readily access new capabilities via the platform. By connecting users to innovators through a standards based platform, the App Store unleashed an explosion of new capabilities.

An open integration platform (i.e. one that accessible to a broad range of innovators) like the App Store is the basis for crowdsourcing, the ability for a large number of innovators to contribute to the platform. Crowdsourcing creates an opportunity for small companies, innovators, and community outsiders (and others you didn't know to ask for) to contribute to mission needs.

The App Store model applies to the wildland fire information and technology environment to a point. However, there are important differences. For example, need for interaction between constituent systems in the wildland fire environment is not seen in the App Store model. Therefore, greater care is required to specify (and expose) the points of interaction as platform guidelines, enabling developers to "click in" new technologies without negative impact on other systems.

To unleash the innovation potential of all the participants in the wildland fire enterprise, the open innovation platform must enable contributions from all of the classes of participants described below:

Consumables builder (corporate IT): This person is a line-of-business (LOB) or IT developer with traditional programming skills; they understand integration issues and use a range of programming tools. This person has access to enterprise data; they use tools and utilities to build consumables; and they use patterns to guide reusable asset creation. They work with the community to understand and anticipate their needs, and add the appropriate Services (both retroactively and proactively).

Situational application/mashup assembler (domain expert): This person is a power user who knows, or is close to, the business or operational need. They are capable of composing situational applications/mashups using browser-based tools. They can access a range of tools to fit their skills and domain expertise and they compose applications from consumables. They also provide guidance via programming-by-example, templates, utilities, and so on. They also share their applications and collaborate to improve them.

Situational application/mashup user (end user): This is the person who knows the business or operational need. They usually need quick answers and solutions, and they have access to standard desktop tools. They find and use situational applications/mashups quickly, rating and commenting on them as they do. They describe business needs for new situational applications/mashups SAs, and they need/demand real business benefits from them.

Enabling contributions from all of these classes requires an open architecture, exposed service interfaces, and a robust but flexible authorization framework as described in Part 2.

One of the two principal objectives of the IFTDSS system was to create a platform that streamlines the integration of new scientific models. IFTDSS contains the Scientific Modeling Frame-

work (SMF) which provides an integration platform to simplify the development and deployment of new scientific models. Since the SMF encapsulates scientific models, model developers are freed from interface design, data access, handling, and mediation, enterprise guidelines (e.g. authentication, authorization), interactions with other wildland fire systems, deployment, etc. Through SMF, independently developed models can be integrated together into coherent workflows. The SMF, frees the model developer to focus on the science and reduces the cost and complexity of new model deployment. This removes transition friction and should enhance future scientific model innovation.

But further development is needed to the SMF to enhance these benefits. First, the SMF is tightly coupled with the IFTDSS interface. IFTDSS was developed in a modular fashion with a separation between interface elements and the SMF. But, the SMF is not exposed as a web service that could be consumed by third party systems that use scientific models such as WFDSS. Exposing the SMF interface as a web service is an important next step in enabling an environment where scientific models are developed once and used across all wildland fire systems.

Additionally, the SMF does not enable self-service integration. Without self-service integration, tool developers cannot leverage the benefits of the SMF during model design and validation without relying on the IFTDSS integrator. This bottleneck discourages the use of the SMF since model developers most build a standalone system with its own interface and data handling to test then modify to deploy to the SMF. With self-service integration, the a model is integrated with the SMF as it is developed leveraging the benefits of the SMF (i.e. common interface, data handling, integration with other models) along the way.

Self-service integration requires mechanisms for tool developers to integrate their tools into the framework without interacting with the systems integrator. IFTDSS has a developer's tool kit which is necessary, but not sufficient, to achieve self-service integration. The most practical model for self-service integration is, at least initially, for the tool developer to host the model (tool developers usually prefer this) exposed as a web service via a defined interface that is called by the SMF when the model is enacted. This requires (at a minimum):

- 1) A test (and possibly development depending on the number of contributing developers) version to be hosted on the web.

A service interface that can be used to "register" models. Registration includes a model name, some kind of description that allows users to select a model, provider info, callback instructions (hosted service IP or DNS), and a data requirements description (schema) of required model input and output information.

A data requirements description schema. Many of the models require user input. The description (usually an XML file) would be provided by the developer as part of the registration process and should contain the name of the field, the label (what the user sees), the data type, validation info, and display instructions (textbox, dropdown list, etc.). Systems will use this file to render an input screen to gather the required input data for a model during execution of a workflow. Some of this data may also come from the output of previous models.

This also suggests:

- 1) A heartbeat service call to determine which distributed models are available at any given time.
- 2) Robust failure handling should a model become unavailable or fail during an operation.
- 3) Mutual authentication (via PKI) to support information assurance needs to avoid attackers substituting defective models for example.
- 4) System should enable user composed workflows. Since the output of one model can't necessarily be used as an input to another, this creates sequence limitations – only certain models can be used after others.

The SMF should check available data and prepopulate (or even automate if desired) when data is provided by model outputs from earlier in the workflow. The SMF will pass the collected information via the web service API to the model when it is executed. The service call response would be the model output. Models also use data files containing information formatted in specific ways. Input and output file schema types could be easily catalogued – and would help define what models could follow others.

The SMF could be extended to stimulate innovation in wildland fire scientific modeling. But, this is only one aspect of the wildland fire enterprise. An open innovation platform should be created to extend the self-service integration model to other aspects of the wildland fire information and technology system-of-systems. This platform should contain or emulate other aspects of the wildland fire enterprise to streamline integration with and among wildland fire systems.

The open integration platform is an access-controlled, virtual environment enabling technology providers to develop against key wildland fire web service endpoints and **streamline integration with existing wildland fire information and technologies**. This platform provides a low barrier-to-entry environment to showcase the utility of new capabilities against relevant challenges and verify conformance with wildland fire data and API standards. It provides a way for users and technologists to work together to develop the capabilities to transform the mission. A "perpetual beta" model gives users the opportunity to shape next generation technologies while benefiting from them. Users can weigh in on candidate technologies for future inclusion by "voting with their feet." Promising technologies will be considered for further evaluation or, when appropriate, for direct transition to mission settings. A "try before you buy" model forces applications to stand on merit (utility and user acceptance) not marketing hype.

Early interaction with end users is the biggest factor in successful technology adoption. The open innovation platform streamlines the identification and transition of game-changing technologies by:

- Facilitating discovery and evaluation of promising tools. The platform creates an efficient path for the discovery of "disruptive" or game-changing ideas that users and managers didn't know to ask for.

- Providing a place where users and technologists can work together to develop solutions. The platform provides an opportunity for technology providers to objectively demonstrate the impact of their capabilities or adapt them if they fail.
- Enabling cheaper and faster technology insertion. The platform enables technology providers to develop against web services that emulate the classified environment streamlining transition of promising tools.
- Encouraging integrated solutions. Technology providers can integrate with other capabilities via the platform, leveraging the strengths of these services without reinventing the wheel, enabling providers to focus on core competencies.

The platform should include or connect to enterprise enabling services such as the integrated security posture developed in part 2. This encourages the development of capabilities that function properly in enterprise settings reducing integration and deployment costs. Other enterprise standards such as API guidelines and data standards should be exposed and enforced within the platform to facilitate the development of conformant technologies.

Test versions of flagship systems should be available in the environment to enable developers to integrate their ideas into these systems rather than competing against them. Technologists that reuse (rather than rebuild) existing capabilities can develop new capabilities more quickly by focusing on core competencies. The benefits of openness favor agile solutions and discourage monolithic standalone vendor locked solutions. Hosting test versions of flagship systems may involve renegotiating license agreements with their providers. The result is a tool ecosystem that is integrated more naturally and contains smaller individual components that are more easily upgraded or replaced.

Since core elements of the integration platform will receive intermittent use, it makes sense to host these components via a cloud provider. Cloud hosting is also preferred since these core components must be accessed easily by a wide audience of end users, technologists, and innovators.

Also, the platform should include community forums that permit interactions between mission users and technologists. This interaction provides end users a means to express needs, provide feedback, and shape next generation technologies. Through a “perpetual beta” model, users can try new capabilities as they evolve. Early interaction with end users is one of the biggest factors in successful technology deployment, so the importance of this forum can’t be overstated. Through this forum, technologists may also interact with one another, an important factor in stimulating innovation and propagating best practices.

In order to demonstrate readiness for consideration in a mission critical environment, applications must progress through a number of readiness steps. Progress through these steps is determined by the central controlling authority and is marked by the Technology Availability Levels (TAL) developed by the enterprise. These steps reflect enterprise readiness and measure factors such as stability, scalability, standards conformance. TALs are used to “steer” promising technologies to compliance and to inform buyers of the enterprise readiness of systems.

Enhanced Innovation Recommendations

- Establish a cloud hosted open innovation environment for the wildland fire community that hosts integration versions of mission systems and forums for idea exchange.
- Create Simple Rules governance structure and associated conformance endpoints for technology compliance
- Enhance IFTDSS to facilitate 3rd party reuse and support “self-service integration” of wildland fire scientific models.

Appendix B Task 1B Approach and Additional Information

Approach

Task 1b was conducted thru document review, discussions with key stakeholders, and a facilitated software architecture assessment. The architecture assessment process was geared towards identifying risks that could arise from the system.

The architecture assessment process was based on the SEI's Architecture Tradeoff Assessment Method (ATAM). This method provides rapid, context-based insight into an architecture, and was conducted through a two-day meeting in Boise, ID with an SEI team and representatives from both the IFTDSS developer (STI) and JFSP. The following is the detailed analysis:

Security

Risk Description: IFTDSS was not developed with a strong model of security as a design principle

IFTDSS Strengths

- The single security module of IFTDSS makes it easier to federate IFTDSS with enterprise security
- Because IFTDSS security is minimal, there is little rework necessary to remove the existing model

IFTDSS Risks

- Because identity does not flow from IFTDSS to SMF, all data stored in IFTDSS is exposed.
- Because data cannot be tagged as sensitive, human intervention will be required to ensure that no sensitive information is entered into IFTDSS.
- Exposing SMF capabilities as services will lead to data and the models being exposed.
- Other domains will require more than two roles (user and admin).
- There are no enterprise standards to which IFTDSS can adhere.

The overall message with respect to security is that the SMF has no model of security and IFTDSS has a very simple model of identity. If the SMF is made operational, a model of security will need to be applied to all services.

When capability is exposed, the attack surface of the system increases and each service needs to take some responsibility for security. It could be argued that if no sensitive data is added to IFTDSS (or the data storage), then no great harm is done, and this is true for data. On the other hand, exposing the scientific models opens up the risk that an individual could access the capabilities and use the fuels treatment models to calculate how to start the least controllable fires.

The architectural structure of IFTDSS and the SMF is such that an attribute-based model of data and capability could be added. We recommend that this be done prior to making IFTDSS operational. Further, creation of enterprise-wide standards (even if de facto standards) is highly recommended so that enterprise attributes can flow into IFTDSS ensuring that only appropriately accredited users can access the capabilities.

Performance Risks

Risk Description: IFTDSS currently performs well enough, but it is unclear how it will perform as the number of users increases

- Performance includes speed, disk space, and bandwidth consumption based on the number of users

IFTDSS Strengths:

- The use of background tasks by SMF services enhances responsiveness to user requests.
- The architecture allows for replication of capabilities such as model hosts, data storage, and even the web application.

IFTDSS Risks:

- Architectural approaches to support performance and scalability have not yet been validated through load testing including multiple model hosts and multiple data host concepts.
- The lack of resource limits (processing, data, etc.) and the inability to monitor or enforce resource consumption make system performance and user experience vulnerable to exhausted resource conditions.
- Use of load balancing for models and improved fault tolerance has not been tested.

The overall message with respect to performance is that there were no meaningful performance requirements levied on IFTDSS. As we said, IFTDSS currently performs “well enough” to support continued prototyping for data gathering. However, before being deployed community-wide, performance and scalability must be shown to be adequate, and that cannot be done until performance and scalability requirements are determined.

Some of the specific issues which must be addressed include:

Performance and Scalability

- There is currently no data correlating CPU usage and the number of users, which means there are no specifics on how much hardware is needed for full deployment. Further, when IFTDSS grows to allow users to compare model executions, this will place an unexpected demand for resources. In order to avoid resource exhaustion and provide realistic load balancing and throttling of scientific models, IFTDSS will require improved resource monitoring capabilities.
- The inability to monitor means that no load balancing can be performed and will lead to resource exhaustion.

- The lack of a resource throttling capability will lead users to inadvertently launch resource-intensive computations that affect other users.

Scientific Modeling Framework (SMF)

- The fixed number of SMF remote procedure call (RPC) pool threads and worker threads will be a bottleneck causing congestion (delays in response to users) when the number of users increases.
- The desire for load balancing across model host servers, fault tolerance of model hosts, and domain logic will increase the complexity of SMF Executive.

Data Storage

- There is no test data to confirm IFTDSS configuration with multiple data storage hosts; this means that there is no certainty that scalability can be achieved with multiple data storage servers
- The inability to monitor or enforce data storage usage means that data storage will be exhausted leading to multiple fault conditions.
- An application operating under some failure conditions, or that is buggy with respect to reference counts, will result in orphaned data sets in data storage.

Model Hosts

- There is no test data to confirm IFTDSS configuration with multiple model hosts; this means that there is no certainty that scalability can be achieved with multiple model hosts.

Extensibility Risks

Risk Description: The assertion that IFTDSS can be used to support other domains is untested. If any IFTDSS-specific business logic is found within the SMF layer then IFTDSS will not be as extensible as desired

IFTDSS Strengths:

- The three-tiered design of IFTDSS, including the separation of the user interface from the models which insulates the users from changes in the models.
- Because the software in the model host is Java, there is great flexibility to execute models on a variety of operating systems.
- Because a single module is responsible for acquisition of data from external sources, adding a new data source does not create significant issues..

IFTDSS Risks:

- Modeling assumptions such as batch operation, first-in, first-out (FIFO) queuing of model execution, and fixed data types will not be appropriate for all domains.

- SMF Executive currently contains domain specifics that will limit use of SMF in other domains.

Because scientific models incorporated into IFTDSS are available to all users at all locations, there is an increased burden on governance to determine which models should (and as important, should not) be incorporated. This contrasts with the current situation where models are only available where they are deployed. As with performance and security, there were no meaningful extensibility requirements levied against IFTDSS. The following issues should be addressed before an attempt is made to use IFTDSS in other domains:

- Failure to enforce purity of SMF (i.e., the domain specificity of SMF Executive) will limit its extensibility to other domains; for example the fuels management business logic in the SMF will affect the amount of effort it will take to use the SMF in other domains.
- The SMF assumes that the scientific models will be executed in batch mode; this will break in domains where users desire interaction with the models.
- FIFO queuing of model execution will likely not be appropriate for all domains.
- Because the data structure types in SMF and IFTDSS are fixed, incorporating a model with a new data structure will require code changes. This also applies if an existing model is modified where the modified version would require a new data structure.

Documentation Risks

Risk Description: IFTDSS software documentation at present appears to be inadequate should the government decide to pursue third-party maintenance or future capability evolution.

IFTDSS Strengths:

- The knowledge needed to create the documentation needed for third-party maintenance appears to still exist in the development team (although not yet documented).

IFTDSS Risks:

- The lack of a documented model software development kit (SDK) means that model integrations will be unique and dependent on detailed knowledge of SMF internals.
- The lack of pathway XML documentation increases the difficulty for users to create new pathways.

Creating the software design and maintenance documentation needed for maintenance by someone other than the original software development team does not happen by accident. Producing such documentation is a strenuous effort, often requiring staff with specialized documentation skills and tools. Among artifacts needed are principles of operation and correlated architectural and design views to convey key system concepts to engineers who were not among the primary authors/designers.

For example, in addition to static software structure views and behavioral sequence diagrams, the following views are also needed for an accurate representation of the actual as-built system:

- runtime views showing processing concurrency
- views showing code/module dependencies
- views describing debugging logs and procedures
- views describing porting or integration procedures
- etc.

These documentation artifacts must be kept up to date with code versions to maintain such accuracy. Documenting the rationale corresponding to why key design decisions were made (or why certain approaches were avoided) helps future maintainers avoid inadvertently undermining key design characteristics. Code module dependency diagrams help future maintainers properly scope regression test coverage when they repair software bugs or enhance capability.

We get the sense that the knowledge needed to construct such valuable documentation content exists within the IFTDSS development team. This is a strength: in our past engagements, we have observed programs lose key members of the original development team before this critical knowledge was captured.

Interoperability Risks

Risk Description: IFTDSS can consume data from other systems but is not well suited to providing data.

IFTDSS Strengths

- The addition of new data sources to IFTDSS is localized to a single module.
- SMF unit conversions can simplify the task of formatting data to provide the data to other systems.

IFTDSS Risks

- IFTDSS has no data export facility, limiting its ability to communicate with other systems.
- It is not clear whether the IFTDSS project is the appropriate unit for data export.

The description of IFTDSS as an SOA raises expectations on the manner in which other systems can communicate with it. Specifically, the phrase “service-oriented architecture” usually generates an expectation of communication via web services which IFTDSS does not currently support.

The OASIS SOA reference model is technology neutral but states that an SOA should have capability for *service discovery*, *composition*, and *invocation*. Google protocol buffers, as the communication paradigm, could certainly be considered as one of the technologies supporting the SOA reference model. Further, we can argue that IFTDSS is SOA-like in that it has a notion of service and these services can be composed with each other and invoked.

However, at present, there is no capability within IFTDSS for service discovery. This discovery mechanism need not be machine readable, but there does need to be some kind of registry of services so that developers can understand the capabilities available. This registry will likely need to be somewhat dynamic to support the registration/de-registration of models by model hosts.

The data acquirer is the mechanism IFTDSS uses to ingest data from other systems; as such, this localizes all access to other systems' data and provides a good mechanism for extending IFTDSS to acquire data from other sources or, if a data strategy is put in place, to adapt to new standards for data transmission. Because of the localization, the rest of IFTDSS and the SMF can be unaware of changes in data source or format.

At present, IFTDSS has no export facility; at best, IFTDSS can share projects with other IFTDSS instances; however, this does not suit the general purpose of being able to provide either data or even capability to the rest of the enterprise. Care should be taken at the enterprise level to choose an appropriate standard for communication—most of the data is numeric and this might be better transmitted in binary form rather than using XML (as is traditional for web services). Once chosen, the IFTDSS architecture is such that a new service can be created to provide data, analogous to the data acquirer.

Usability Risks

Risk Description: The limited ability of a user to interact with a running model can lower user satisfaction. Also, the use of a single data storage host for all users can lower user satisfaction.

IFTDSS Strengths:

- Use of the SMF Model Host software entity provides a consistent interface to all scientific models.
- The pathway mechanism within IFTDSS is a strength for usability but it is not clear why an open source workflow engine could not have been used

IFTDSS Risks:

- At present there is no capability to monitor or predict model behavior, particularly with respect to how long a simulation will run; this means that variable user experiences will occur.
- Because model timeouts are established via a single, static value, models will be erroneously terminated in conditions of high load.
- Because all users store data on a single data storage host, a failure of that host affects all users.
- A consistent user experience is among the key enablers of scoring well in the usability dimension by achieving positive user satisfaction levels.

IFTDSS uses pathways (or workflows) as a structured approach for users to interact with complex science models. The resultant process appears effective to help users manage the potentially complex workflows that are needed to initialize, start and obtain results from IFTDSS' scientific models. Workflows appear to be an IFTDSS custom workflow solution rather than using open source or commercial workflow products. The rationale for, and therefore benefits of, a custom solution is/are not clear.

The present IFTDSS architecture prohibits or limits interaction with an actively running model. To use IFTDSS to run a model, a user crafts input data and then starts a specific model to run against that input data. While the model is executing its algorithms, no mechanism exists to moni-

tor its progress or to predict how long the model will run based on current IFTDSS loading conditions.

One consequence of these limitations is that statically-established model timeout values are used within IFTDSS to detect hung or non-converging model runs. Under high load conditions where a model may be running much longer than is “typical”, a model’s static timeout value can falsely trip, thus terminating a “healthy” model run that was just taking a long time due to dynamic loading conditions.

Since the present IFTDSS architecture employs a single data storage host, a failure in this host will negatively affect all users.

The above issues taken together can yield a quite variable range of user experience, thus jeopardizing IFTDSS’s perception of usability.

Appendix C Task 2 Approach

Approach

Research for Task 2 was conducted as a series of one-on-one interviews with Fire Science developers and researchers. A total of 21 interviews were conducted, nine in person and 12 via phone. The interviews were conducted across the following agencies:

- 16 Forest Service (FS)
 - five interviews with individuals from Fire and Environmental Research Applications (FERA)
 - four interviews with individuals from Missoula Fire Sciences Laboratory, Missoula,
 - seven other interviews with individuals from the Pacific Southwest Research Station, the FVS Development group with the Missoula Fire Sciences Laboratory, and Forest Management Service Center
- Five non-Forest Service
 - Department of the Interior (DOI)
 - National Park Service (NPS)
 - University of Idaho
 - Wildland Fire Management Research, Development and Application (WFM RDA)
 - Aldo Leopold Wilderness Research Institute

The interviewees included three research administrators, drawn from

- Forest Service
- WFM RDA
- DOI

The interviews were based on a structured questionnaire designed to elicit information regarding:

- background
 - interviewee experience and expertise
 - projects worked on
- software lifecycle practices
 - requirements
 - architecture and design
 - configuration management
 - development
 - test
 - transition and operation

- maintenance
- governance practices
 - funding
 - development prioritization

The interviews also explored additional topics including:

- transition from research into operations
- the interaction between forest service research and forest management
- the role of the broader research community (e.g.—universities, etc.) in model development
- sources of innovation
- model oversight and review practices
- visions of the future
- views on IFTDSS

Appendix D Task 3 Approach

Approach

The SEI approach for gathering user feedback had three major components

- User workshops
- On-line survey
- Comparative Analysis

Workshops

The SEI was asked to gather user feedback via in person user workshops with representatives from across the numerous consortia. Working with a representative from Wildland Fire Management RD&A - DOI, and the contractor Sonoma Technologies Inc. (STI), 11 workshops were identified. Eight workshops were held in person across the nation and three workshops were conducted as virtual, on-line sessions.. The locations and dates of the workshops are shown in Figure 19.



Figure 19: Evaluation Workshop Locations and Dates

These workshops were based on existing workshops developed for JFSP by the development contractor, Sonoma Technologies Inc. (STI). The flow and context of the STI workshops was modified to enable the SEI to gather the data needed to address JFSP's questions.

The workshops were delivered by STI personnel, with SEI and Wildland Fire Management Research Development and Applications support. Workshop attendees were given access to the SEI user survey, and could fill out the survey either during or after the workshop.

Survey

The user survey was constructed based on the Work Plan questions in addition to gathering extensive demographic data for future analysis. The SEI used Qualtrics Survey tool for creation and publication of the survey. Users were provided a web link for navigation to the tool. Responses were restricted to a single response from each workshop user, while responses were anonymous. The survey was comprised of six sections: demographics, data capability, project capability, analytical models, workflows and overall comments. Single choice, multiple choice and open text questions were formulated for each area. Included below is the online survey.

Demographics

Q1. My Organization

- | | |
|---|--|
| <input type="radio"/> Bureau of Land Management | <input type="radio"/> Bureau of Indian Affairs |
| <input type="radio"/> Forest Service | <input type="radio"/> USGS |
| <input type="radio"/> Fish and Wildlife Service | <input type="radio"/> Other <input type="text"/> |
| <input type="radio"/> National Park Service | |

Q2.
My current position or role

- | | |
|---|---|
| <input type="radio"/> Fuels Management Specialist | <input type="radio"/> Administrator |
| <input type="radio"/> Management Officer | <input type="radio"/> GIS Specialist |
| <input type="radio"/> Fire Planner | Other (please specify such as Resource Manager, Fire Ecologist, etc. <input type="text"/>) |
| <input type="radio"/> Engine Boss/Crew Lead | |

Q3. Please indicate your experience:

	2 years or less	2-7 years	7 - 10 years	Greater than 10 years
Fire Management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fuels Treatment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Current Role	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q4.
Other positions or roles I have held (check all that apply)

- | | |
|--|---|
| <input type="checkbox"/> Fuels Management Specialist | <input type="checkbox"/> Administrator |
| <input type="checkbox"/> Management Officer | <input type="checkbox"/> GIS Specialist |
| <input type="checkbox"/> Fire Planner | Other (please specify such as Resource Manager, Fire Ecologist, etc. <input type="text"/>) |
| <input type="checkbox"/> Engine Boss/Crew Lead | |

Q5.
My experience using fire science computer models to perform work

- ☐ Frequently
- ☐ Occasionally
- ☐ Not At All

Q6.

I attended this workshop for the following reason(s) (check all that apply)

☐ To learn about IFTDSS to see if I might use it in the future☐ To learn how IFTDSS implemented a legacy tool or method (please specify)☐ To keep current in new tools, methods, or capabilities☐ Other (please specify)

Q7. When you perform fuels analysis, how often do you use these following Fire Science Tools? In addition, please indicate if you have had training in the tool, even if you do not use it.

	Frequency of Use				Training I have received		My Proficiency			
	Never	Rarely	Occasionally	Always	Classroom Training	Informal Training	Very	Somewhat	Not at all	Others view me as an expert
IFTDSS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Behave (all variants)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
FOFEM	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
CONSUME	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ArcFuels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
WFDSS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
FIREFAMILY+	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ArMap Arc GIS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
FARSITE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
FLAMMAP	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LANDFIRE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
FMA+	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
FVS-FFE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
FFI-Firemon	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
RERAP	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nexus	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Google Earth	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
WIMS DATA	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other <input type="text"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Preparing a Data Set for Use

Q8. Please rate your impressions of IFTDSS ability to format, edit and use data

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Reliable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Efficient	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
High Quality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ease of Use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Facilitate Sharing Data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q9. Click to write the question text

	Please indicate your satisfaction with each of the following systems data capabilities					Please check the aspects that were IMPORTANT in determining your rating of this feature. Check as many as made a significant difference					
	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Reliable	Efficient	Quality	Ease of Use	Data Sharing	None
IFTDSS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
WFDSS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Behave+, FOFUM, CONSUME	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ArcFuels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q10. Previous research indicates that the current environment requires too much time to acquire, prepare and format/reformat data. Please rank order the tools/methods in their data management, 1 = MOST favorable, 4 = LEAST favorable

- ☐ Behave +, FOFUM, CONSUME
- ☐ IFTDSS
- ☐ WFDSS
- ☐ ArcFuels

Q11. Overall, How difficult or easy was it to use the IFTDSS data features?

Very Difficult	Difficult	Neutral	Easy	Very Easy
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q12. Feel free to enter any comments you may have

Establishing and Using Projects

Q13.
Please indicate your impressions of IFTDSS's project capabilities

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Reliable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Efficient	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
High Quality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ease of Use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Facilitate Sharing Data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q14. Click to write the question text

	Please indicate your satisfaction with each of the following systems project capabilities					Please check the aspects that were IMPORTANT in determining your rating of this feature. Check as many as made a significant difference					
	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Reliable	Efficient	Quality	Ease of Use	Data Sharing	None
IFTDSS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
WFDSS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Behave+, FOFUM, CONSUME	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ArcFuels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q15. Rank order the systems' ability to create, use and manage projects

- ☐ IFTDSS
- ☐ Behave+, FOFEM, CONSUME
- ☐ WFDSS
- ☐ ArcFuels

Q16. Overall, How difficult or easy was it to use the project features?

Very Difficult	Difficult	Neutral	Easy	Very Easy
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q17. Feel free to enter any comments you may have

Using and Accessing Individual Analytical Models

Q18.

Please indicate your impressions of IFTDSS's ability to access analytical models

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Reliable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Efficient	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
High Quality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ease of Use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Facilitate Sharing Data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q19. Click to write the question text

	Please indicate your satisfaction with each of the following systems access to analytical models					Please check the aspects that were IMPORTANT in determining your rating of this feature. Check as many as made a significant difference					
	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Reliable	Efficient	Quality	Ease of Use	Data Sharing	None
IFTDSS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
WFDSS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Behave+, FOFUM, CONSUME	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ArcFuels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q20. Click to write the question text

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
3.2. All analytical models/tools needed are available in IFTDSS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3.5. IFTDSS provides access tools that are otherwise inaccessible.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3.1. I can select individual analytical models to use in IFTDSS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q21. Overall, How difficult or easy was accessing models?

Very Difficult	Difficult	Neutral	Easy	Very Easy
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q22. Feel free to enter any comments you may have

<div></div>	<div></div>
-------------	-------------

Pathways

Q23. Previous research indicated that hazard and risk analysis was too difficult for most fuels planners and current systems did not typically support the entire mission critical fuels treatment planning process. IFTDSS implements pathways in order to guide the user through these complex processes. Please tell us about your impressions of the use of pathways in IFTDSS.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Pathways were logical and easy to follow	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pathways support the entire mission critical process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pathways will encourage performance of hazard and risk analysis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Overall, pathways will improve my organization's performance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q24. Click to write the question text

	Please indicate your satisfaction with IFTDSS in the performance of each of these pathways					Please check the aspects that were IMPORTANT in determining your rating of this feature. Check as many as made a significant difference					
	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Reliable	Efficient	Quality	Ease of Use	Data Sharing	None
Hazard Analysis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Risk Analysis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fuels Treatment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Prescribed Burn Plan	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overarching Questions

Q25. Tell us about the impact IFTDSS will have on training needs

	Much Less	Less	Somewhat Less	The Same	Somewhat More	More	Much More
3.3. Training to use the models will be...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3.4. Training to understand the science in the analytical models will be...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q26.

Please indicate your impressions of IFTDSS ability to support NEPA preparation

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is straightforward to share and collaborate on NEPA analysis created in IFTDSS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2.8. IFTDSS will improve the quality of NEPA products	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q27. Overall Impressions of IFTDSS

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I think that I would like to use IFTDSS frequently.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found IFTDSS unnecessarily complex.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think that I would like to use IFTDSS frequently.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found IFTDSS unnecessarily complex.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought IFTDSS was easy to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think that I would need the support of a technical person to be able to use IFTDSS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the various functions were well integrated.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought there was too much inconsistency in IFTDSS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would imagine that most people would learn to use IFTDSS very quickly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found IFTDSS very cumbersome to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt very confident using IFTDSS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I needed to learn a lot of things before I could get going with IFTDSS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q28. 4.7 Your feedback is very important to the process. Please use the space below for additional comments, including other uses for IFTDSS, unforeseen issues with using IFTDSS and any issues or topics we may have missed.

Q29. Can we contact you in the future to follow up on any responses?

- ☐ Yes
- ☐ No

Q30. Please provide your contact information.

Name

Email

Phone

Respondents

Ninety-eight workshop attendees completed the surveys, which is a response rate of approximately 98%. Given the notional size of the fuels management community as approximately 1,000, this represented approximately 10% of the community.

Below are the various responses to demographic questions posed to the survey respondents.

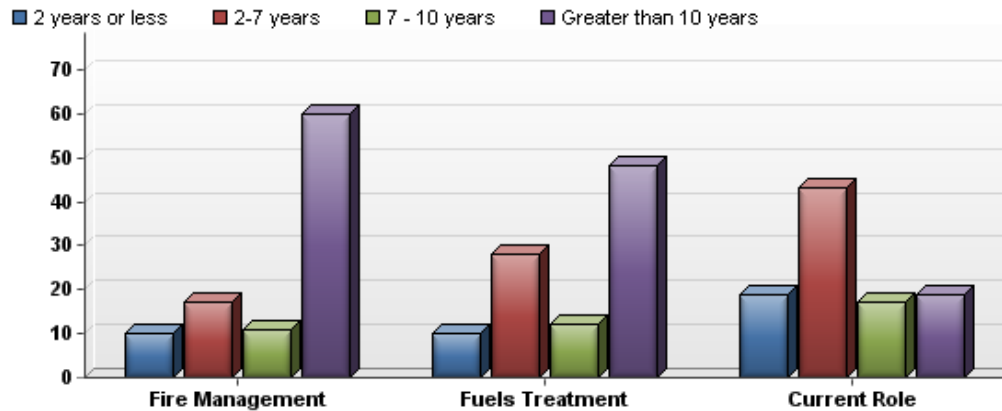


Figure 20: Experience of Respondents

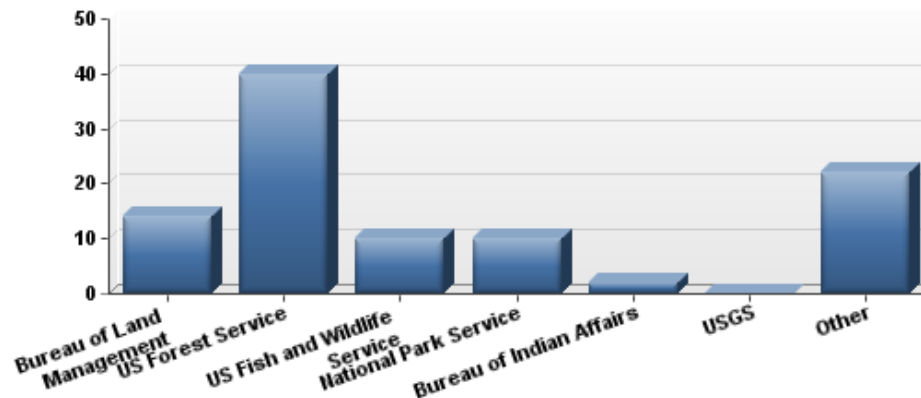


Figure 21: Organization of Respondents

Additional organizations represented by the workshop participants include the following.

Table 6: Current Positions of Respondents, Other

Respondents in the 'other' category include:	
Arizona State Forestry Division	Missouri Department of Conservation
University	Department of the Interior
Tribal (San Carlos Apache)	State of Alaska
Missouri Dep't. of Conservation	UAF
State of Florida	State Department of Natural Resources and Conservation
State of FL Ag/Forestry	OSU
Tall Timbers Research Station	University of Idaho/ NIFTT
Florida Forest Service	Private contractor
University of Missouri	Retired Forest Service



Figure 22: Previous Positions of Respondents

Table 7: Previous Positions of Respondents, Other

Other (please specify such as Resource Manager, Fire Ecologist, etc.)		
Assistant Fire Management Officer	Forester	Resource Manager
Asst. FMO	Forestry consultant	stewardship forester-work with private land-owners
Computer Specialist	Fuels Tech, Fuels SCEP	University Professor
Fire Ecologist	Hotshot Superintendent	Wildfire response supervisor
Fire modeling analyst	Hotshots	Wildland Fire Module Leader
FIRE MONITOR, FIRE EFFECTS MONITOR	Lead Fire Effects Monitor	Wildlife Biologist
Fire Science Coordinator, Fire Dispatchers, Fuels Technician	Rangeland Mgmt Specialist	Wildlife Tech
Fire Suppression Specialist	Research tech, wildland firefighter	

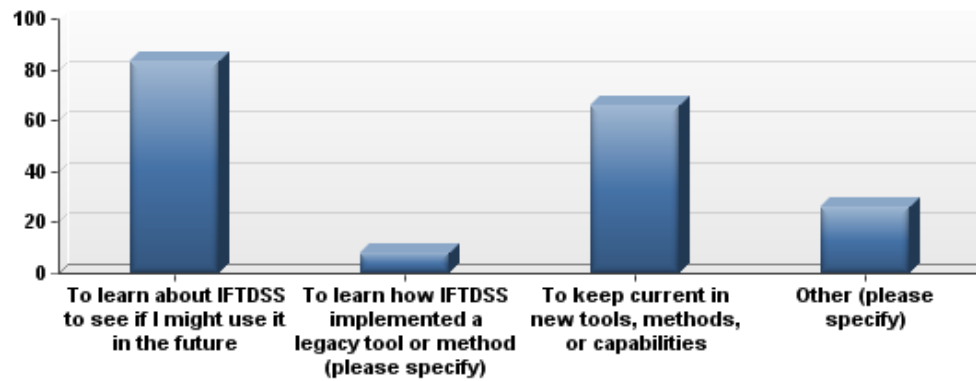


Figure 23: Reason for Attending Workshop

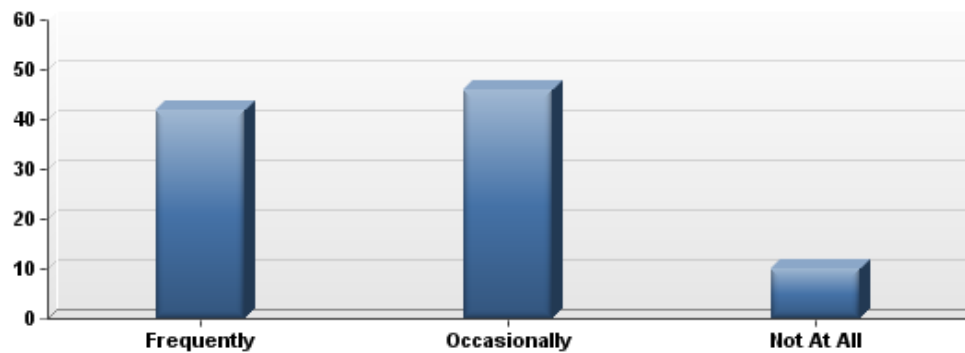


Figure 24: Experience Using Fire Models

Comparative Analysis

The SEI created a comparative analysis in order to gather expert insights from across the field in order to determine if other tools in use could be used to address the business problems. In order to discuss the tools in a common manner, the SEI worked with JFSP, Fuels Managers Working Group and STI to create a baseline fuels management process and a scenario. Interview subjects were identified by the Wildland Fire Management RD&A representative. These subjects included expert users of IFTDSS, ArcFuels, Behave, WFDSS, and FsVeg.

The SEI first developed a baseline business process for fuels treatment, starting with data gathering step and ending with fuels treatment planning products. This is shown in Figure 25.

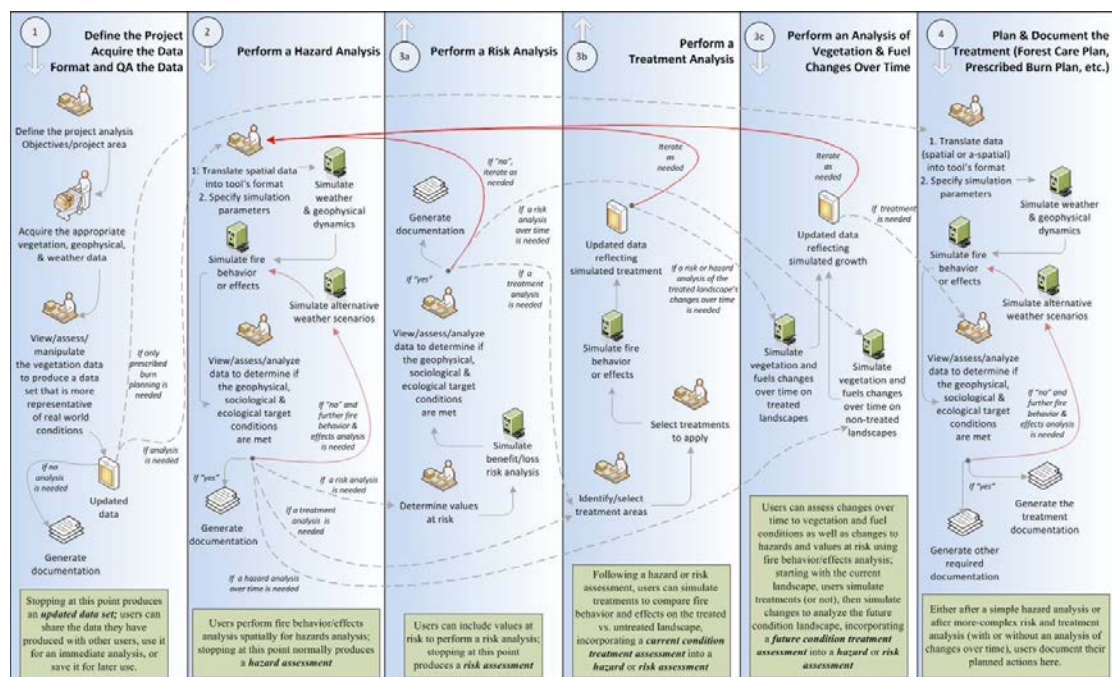


Figure 25: Baseline Business Process for Fuels Treatment

From this overall workflow, the SEI created a tailored workflow for the comparative analysis interviews, as shown in Figure 26.

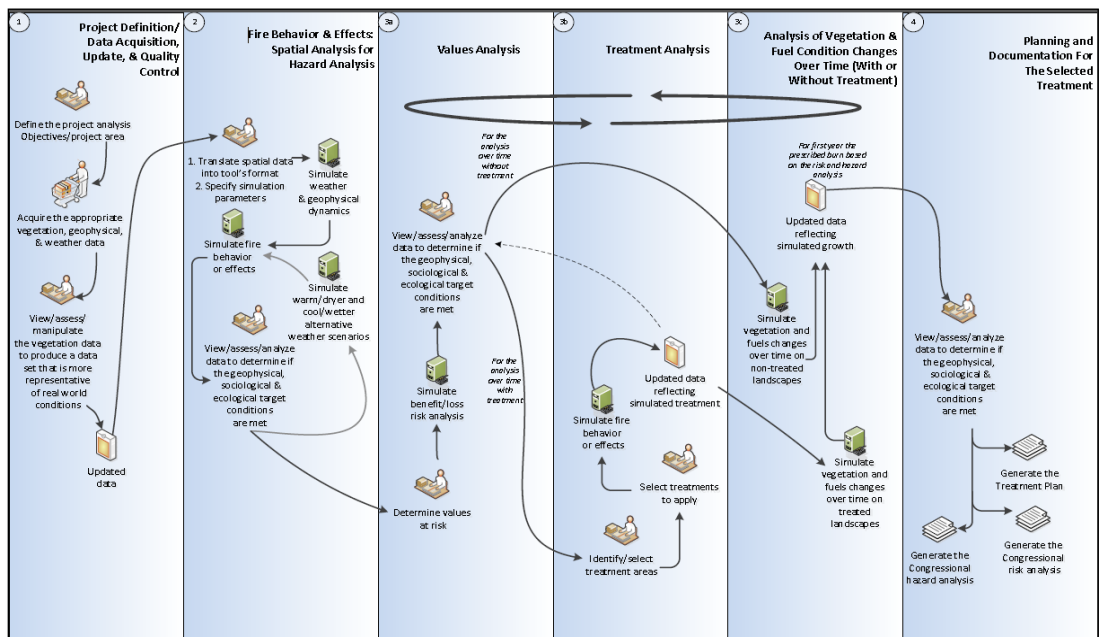


Figure 26: Tailored Workflow for Comparative Analysis Interviews

The scenario used for the interviews is described below:

Scenario

Congress recently created the nation's newest national forest. The 30,000 acre tract of land had been privately held but because of its historical significance efforts have been ongoing for nearly ten years to bring it into the national park system.

The Congressional authorization for the new park requires the Park Service to maximize and document the effectiveness of fire management programs in reducing risk from wildfires to both natural and manmade resources.

Congress went on to say that "understanding the likelihood as well as the potential benefits and costs of wildfire is fundamental to evaluating fire risk and making informed management decisions."

Therefore, the authorization bill requires the Park Service to perform a hazard and risk analysis for the new forest. The analysis should quantify the value of fire management activities in terms of reducing wildfire risk to social, economic, and ecological values within the forest.

As the terms are used in the bill, a "wildfire hazard" characterizes the potential for wildfire to harm human life and safety or damage highly valued resources and assets. The bill also defines "wildfire risk" as the magnitude of fire outcomes (beneficial and detrimental) as they relate to the wildfire hazard.

The bill went on to require a treatment impact analysis on both the current landscape as well as the projected landscape in 20 years.

While the bill itself did not specify a treatment, the Park Service has interpreted the treatment to be a prescribed burn as the bill does require a prescribed burn plan for that portion of the proposed treatment that will happen in the first year of Park Service stewardship.

Interviews

In the interview sessions, we asked how users would use [tool name] if they were tasked to perform these analyses and create the burn plan.

The areas for which we are gathered information included:

- **Enhanced understanding:** the degree to which [tool name] facilitates the user's understanding of the risks and hazards
- **Support for multiple analysis options:** the ability of [tool name] to present or allow multiple analysis options
- **Data accuracy – representation:** the percentage of input information the tool correctly depicts on a map, or captures in a database
- **Time to perform a set task:** the time needed for a knowledgeable tool user to complete a process with pre-defined, fixed steps (i.e., gather and QA vegetation data for a project)
- **Time to perform a variable task:** the time needed for a knowledgeable user to complete a process with both pre-defined, fixed steps and steps requiring the development and/or the analysis of options
- **Collaboration support – multiple locations:** the number and variety of locations and organizations that are able to easily share information produced by [tool name]
- **Collaboration support – common process:** the ability of [tool name] to support multiple business processes across multiple participants, organizations, and locations
- **Ease of use:** the ease of access, manipulating, and using information needed for or created by [tool name]

Wildfire Risk Assessment

The interview sessions were not designed to teach wildland fire risk and hazard assessment; it was assumed that each interviewee was selected for their experience performing these types of assessments with [tool name].

However, for consistent data gathering we followed a simple framework. We understood that this did not exactly match any of the user's normal approach or process.

For the interviews, we postulated that assessing wildfire risk requires an understanding of two things:

- the likelihood of wildfire interacting with valued resources, and

- the magnitude of potential beneficial and negative effects to resources from fire

This is a standard “likelihood and impact” risk characterization, and using this definition, to estimate wildfire risk a user will need:

- maps of the likelihood and predicted intensity of wildfire across a given landscape
- the locations of high-value resources or assets across the same landscape, and
- characterizations of the effects of fire on the high-value resources or assets.

To build these, we asked the users to use [tool name] (and only [tool name]) in the workflows shown in the attached sheet:

- Project Definition/Data Acquisition, Update, and Quality Control
 - In this work flow, project data is acquired, updated, and checked for quality
- Fire Behavior and Effects: Spatial Analysis for Hazard Analysis
 - In this work flow, information is generated about the distribution of possible fire behaviors across a landscape, which when combined with estimates of tree mortality, fuels consumption, soil heating, etc. allows a user to assess potential fire hazard across a landscape
- Risk Analysis
 - In this workflow, areas of high value resources and assets are identified on a landscape, after which fire behavior and effects are simulated over the area of interest
 - Approaches to assigning risk vary, but are generally determined by some variant of the equation $\text{fire risk} = \text{burn probabilities} \times \text{fire hazard index} \times \text{value at risk}$
- Treatment Analysis
 - In this work flow, fuels treatments are simulated in high fire hazard areas to examine how these treatments may modify potential fire behavior
 - Once the treatments have been simulated on the landscape, fire behavior and/or fire effects models are used to simulate potential fire behavior and fire effects on the treated landscape
- Analysis of Vegetation & Fuel Condition Changes Over Time (With or Without Treatment)
 - In the “with treatment” work flow, the fuels treatment effectiveness over time is evaluated to estimate how long (in years to decades) a treatment continues to affect fire behavior and fire effects within an area of interest
- Fire Behavior & Effects: Spatial or A-Spatial Analysis for Prescribed Burn Planning
 - In this work flow, the necessary information to plan, document, and conduct a proposed prescribed fire is gathered

Data from these interviews was synthesized to determine the ability of the various tools to address the business problems as stated in the Work Plan.

Appendix E Task 4 Approach

Approach

Task 4 was conducted through document review and discussions with key stakeholders. Some Task 4 areas of interest had direct overlap with the Task 3 user survey, so these were incorporated into the survey.

The population interviewed for the study included the following roles:

- instructors of S495
- members of the advisory board for the TFM education program
- managers of field offices that include fuels specialist, who had themselves acted in the role of fuels management planner
- participants in user workshops in various roles, several of whom were active fuels specialists
- trainer/tester for ArcFuels
- Director of the TFM program

The questions asked in the interviews varied depending on the role. Questions differentiated into groups of questions for fuels specialists/former fuels specialists, instructors/trainers, and governance roles. Some questions were asked of all interviewees, and are marked as such below. Not all questions were asked of all interviewees of a particular role, depending on how the conversation progressed.

Questions for All Interviewees:

- Please describe your role and experience with regard to fuels management planning.
- How would you expect IFTDSS to contribute to your role if it were available to you?
- What should we have asked you about that we did not? (always asked at the end of each interview)

Questions Generally Used for Instructors:

- How would you envision incorporating IFTDSS into your course/courses?
- What advantages would IFTDSS bring to your course(s) in terms of preparing fuels management specialists?
- What disadvantages do you see in incorporating IFTDSS into your training course(s)?
- How, if at all, could IFTDSS help to promote better critical thinking and problem solving skills for fuels management specialists?

Questions Generally Used for those in Governance Roles:

- How could the availability of IFTDSS change the curriculum associated with fuels management specialist training?
- What kinds of additional courses would you like to see added to a curriculum for fuels management specialists? How, if at all, could IFTDSS contribute to the feasibility or effectiveness of building those courses?
- How does the current qualification criteria for fuels management and other specialties affect the training you provide and how different is what you can do from what you think should be done?

Questions Generally Used for Current/Former Fuels Specialists:

- How do you envision a tool like IFTDSS changing the way you would perform fuels management planning activities?
- How well does IFTDSS meet your expectations for breadth and depth of models that are needed to perform the fuels specialist role?
- How well does IFTDSS meet your expectations for the workflows associated with risk and hazard analysis that support fuels management?
- What would you like to see handled differently in IFTDSS?
- What would you want to see stay the same as IFTDSS evolves?
- If IFTDSS were available to support you in your fuels management activities, how likely would you be to use it? What would contribute to that decision?

Appendix F Work Plan Questions

Refinement of the IFTDSS Evaluation Tasks

Software Engineering Institute, Carnegie Mellon University

October 24, 2012

Task 1

JFSP seeks an independent assessment of how well IFTDSS meets the vision and strategy outlined in the WFI&T plan. JFSP is also interested in an evaluation of the IFTDSS as an interconnected system-of-systems architecture in the context of current wildland fire business practices and available software systems.

Task 1a: IFTDSS and Its Relationship to WFI&T (*i.e., IFTDSS Looking Outward*)

The SEI assessment will address questions agreed upon between JFSP and the SEI during the initial planning session and are envisioned to address these types of issues:

- a. Is the IFTDSS consistent with the key concepts of the WFI&T Plan?
 - i. Mission requirements drive integrated, modular-based applications and tools
 - ii. Authoritative data are readily available for all uses and users
 - iii. Interconnection and accessibility regardless of organization affiliation or user location
 - iv. Technology, research, and innovation enable and enhance mission accomplishment
- b. What elements of IFTDSS can be used to advance the WFIT vision, e.g., the scientific modeling framework?
- c. Does the IFTDSS contain the essential elements to function as a SOA within an enterprise architecture?
 - i. I.e., what is the fitness of IFTDSS to function as a structural element of an enterprise architecture?
 - ii. Conversely – what elements and systems are needed within an enterprise approach so that IFTDSS can fully function as an enterprise-level SOA within the WFIT Plan?
- d. How well does the IFTDSS Scientific Modeling Framework support a system-of-systems vision that can lead to an effective, mutually supporting network of functions between IFTDSS, WFDSS, BlueSky and potentially other framework architectures?
- e. Is the IFTDSS consistent with and support the White House CIO 25 point plan for IT management?

- f. To what degree does the IFTDSS have the potential to be used in other fire and fuels business domains?

Task 1b: IFTDSS As a Software Tool (*i.e., IFTDSS Looking Inward*)

- a. How well does the IFTDSS:
 - i. Support software module reuse?
 - ii. Provide a common graphical interface for new modules?
 - iii. Support flexible and easy updates or upgrades?
 - iv. Support extensibility?
 - v. Integrate the wildland fire community's most commonly used independent software modules in one framework system?
- b. Does (or could) the IFTDSS architectural framework allow flexibility and convenience to the user especially when compared to other legacy systems? For example, does the IFTDSS architectural framework allow:
 - i. Flexibility to improving and adding additional work flows? Do the other systems have workflows?
 - ii. Easy flexibility to include new science models and equations?
 - iii. "One stop shopping" (user convenience) for multiple work flows/applications?
 - iv. The ability to create a system of record for burn plans, risk assessments, etc.?
- c. As architected and if deployed as envisioned, would IFTDSS be available to users regardless of location and agency?
- d. As architected and if deployed as envisioned, would IFTDSS authoritative data sources be available to users regardless of location and agency?

Task 1 Deliverables

- a. Monthly updates of progress, issues, and suggested areas of focus
- b. An appropriate section of the final report of findings and recommendations due NLT 1 July 2013 (pending a work start of 1 October 2012 and access to IFTDSS V2.0 on 1 November 2012)
- c. An appropriate portion of mutually agreed-upon publication-quality material for a JFSP-authored article in a fire science related scientific journal of their choice

Task 2: IFDTSS and Software Lifecycle Management

Most wildland fire models and tools are currently developed independently by small teams of researchers addressing specific problems. Funding is usually small, the scope of work is narrow, and the models and tools developed frequently can't/don't communicate with other software models and tools.

In addition, the researchers developing the models and tools are also responsible for managing the entire software life cycle process, including user interface development, functional business needs

development, training, user help support, versioning support, IT support, software maintenance, etc.

To help improve the efficiency of this process, JFSP seeks an independent assessment of the potential impact IFTDSS could have on the lifecycle maintenance activities of current fuel treatment models and software systems.

The SEI assessment will address questions agreed upon between JFSP and the SEI during the initial planning session and are envisioned to address these types of issues:

- a. Does the IFTDSS have the potential to increase the efficiency or reduce overall cost of software management by moving from unique, stand-alone software systems to a broadly-scoped, service-oriented architecture (SOA) framework system?
 - i. I.e., does the IFTDSS have the potential to re-engineer how scientific models are developed by creating a larger scope functional network within which smaller scope models can function?
- b. If large-scope integration frameworks specific to particular business domains such as IFTDSS are maintained by (other) managers, could researcher developer responsibilities be limited to:
 - i. Development
 - ii. Documentation
- c. Would large-scope integration frameworks specific to particular business domains such as IFTDSS that are maintained by (other) managers allow researcher developers to focus on improving scientific functionality instead of lifecycle maintenance activities?
- d. From the software lifecycle management perspective and in comparison to existing processes and options, does IFTDSS alleviate or resolve these fuels treatment business problems? If so – how well?
 - i. Profusion of unconnected, fragmented, and overlapping software systems
 - ii. No integrated data environment offering authoritative data sources exists
 - iii. Software system and data availability is a function of agency and location
 - iv. New science and technology is not readily identified and integrated into mission critical fuels treatment planning processes across agencies and locations

Task 2 Deliverables

- a. Monthly updates of progress, issues, and suggested areas of focus
- b. An appropriate section of the final report of findings and recommendations due NLT 1 July 2013 (pending a work start of 1 October 2012 and access to IFTDSS V2.0 on 1 November 2012)
- c. An appropriate portion of mutually agreed-upon publication-quality material for a JFSP-authored article in a fire science related scientific journal of their choice

Task 3: IFDTSS User Evaluation

JFSP seeks an independent assessment of whether IFDTSS improves fuels treatment planning in the field, including a comparison with current methods and major software systems used for this purpose.

User Workshops

The SEI will develop and facilitate a series of workshops to gather the data needed to independently and creditably assess user feedback. The questions listed below will be addressed through the user workshops, or through other more appropriate methods, as agreed by JFSP and the SEI.

- a. When compared with the existing modeling and analysis environment tools, does IFDTSS:
 - i. Save time or money
 - ii. Enable effective use of new or improved analytical methods
 - iii. Otherwise improve the quality of fuels treatment planning
- b. When compared with the existing modeling and analysis environment tools, how functional and easy-to-use is IFDTSS with regards to:
 - i. Data acquisition
 - ii. Preparation and management for project level1 analysis
 - iii. Acquisition and use of the available and necessary software systems
 - iv. Use of analytical models to support fuels treatment analysis and planning
- c. How well does IFDTSS:
 - i. Provide a web-based multi-platform approach to access software?
 - ii. Provide support for landscape scale analyses while maintaining project scale focus?
 - iii. Provide access to the functionality of multiple, currently stand-alone software systems within a single software framework and a single user interface?
 - iv. Provide support for fuels specialists with integrated corporate data access and one-stop-shopping solution to fuels treatment planning?
 - v. Improve the quality of the current fuels treatment analysis process by simplifying complex analyses such as risk assessments?
 - vi. Support collaboration capabilities so users can share runs and results?
- d. To what degree has IFDTSS improved the data acquisition, quality control, and preparation process in support of fuels treatment planning as compared to current systems?
- e. To what degree has IFDTSS improved the efficiency and quality of fuels treatment planning for each of the following mission critical tasks
 - i. Prescribed burn analysis and burn plan preparation

- ii. Hazard analysis
 - iii. Risk assessment
 - iv. Treatment type and location effectiveness at the area of interest spatial level
 - v. Treatment type selection and longevity analysis at the stand level
- f. Are there additional applications and uses that IFTDSS could effectively address?
- g. Does the IFTDSS have the potential to effectively support model performance comparisons by running modules with similar functionality within the same framework using the same data?
- h. How does the workflow organization, the range of functionality, and the quality of implementation of IFTDSS compare with other software systems with standalone interfaces that are used for fuels treatment planning? I.e., has IFTDSS improved:
 - i. ease of use
 - ii. user guidance
 - iii. usability
- i. From the user perspective and in comparison to existing processes and options, does IFTDSS alleviate or resolve these fuels treatment business problems? If so – how well?
 - i. Lack of a consistent fuels treatment analysis framework across agencies and location
 - ii. Too much time spent in acquiring and preparing data for an analysis
 - iii. Too much time spent formatting and reformatting data for different software systems
 - iv. Hazard and risk analyses are too complicated for most fuels treatment planners to do
 - v. No integrated data environment offering authoritative data sources exists
 - vi. Software system and data availability is a function of agency and location
 - vii. Users cannot easily share work, compare notes, teach each other across agency and location
 - viii. Available software systems do not typically support the entire mission critical fuels treatment planning process

There will be approximately 10-12 workshops held at various locations around the country. Each workshop will have approximately six to eight attendees from various wildland fire user communities. JFSP will arrange for the facilities and coordinate with the attendees for each workshop.

In support of the workshop development, JFSP will provide domain expertise. Additionally, JFSP will arrange for Sonoma Technologies, Inc. (STI) to support the SEI's workshop development efforts as well as to provide direct technical support for the workshops themselves.

Pre-Workshop Webinars

To ensure that the workshops make the best use of the attendee's time and to ensure that the SEI collects the data it needs, workshop attendees will be required to complete webinar training prior to their workshops. This webinar will be hosted by either JFSP or STI and will principally draw upon existing wildland fire software tools training.

The SEI will support the development of the webinar by describing the goals of the workshop, its expected format, and what each attendee should expect to contribute. The SEI will also support each webinar.

The number of webinars is TBD but notionally there will be several webinars prior to the start of the workshops, and then several more during the course of the workshops.

Task 3 Deliverables

- a. Monthly updates of progress, issues, and suggested areas of focus
- b. An appropriate section of the final report of findings and recommendations due NLT 1 July 2013 (pending a work start of 1 October 2012 and access to IFTDSS V2.0 on 1 November 2012)
- c. An appropriate portion of mutually agreed-upon publication-quality material for a JFSP-authored article in a fire science related scientific journal of their choice

Task 4: IFTDSS and User Training

Current wildland fire training courses are software-tool specific; they typically address only a few (or even one) software tools, and only teach how the specific tool or tools solve or address fuels management-related problems.

JFSP is shifting training away from tool-centric courses to training emphasizing the theory and practice of fuels treatment analysis and planning. The goal of this shift is to encourage and improve the student's critical thinking and problem solving skills.

To assist JFSP with these issues, the SEI will assess whether the IFTDSS has the potential to support a more effective and efficient training framework and/or training delivery methods for fuels treatment planning. In particular, the SEI will assess if the workflows that are designed as part of IFTDSS represent ways to use existing tools as part of a fuels treatment solution process.

- a. From the training perspective and in comparison to existing processes and options, does IFTDSS alleviate or resolve these fuels treatment business problems? If so – how well?
 - i. Too much time spent learning numerous different software interfaces
 - ii. Too much time spent training and retraining on using numerous software systems
 - iii. Lack of a consistent fuels treatment analysis framework across agencies and location
 - iv. Too much time spent in acquiring and preparing data for an analysis

- v. Too much time spent formatting and reformatting data for different software systems
- vi. Hazard and risk analyses are too complicated for most fuels treatment planners to do
- vii. Users cannot easily share work, compare notes, teach each other across agency and location
- viii. Available software systems do not typically support the entire mission critical fuels treatment planning process
- ix. New science and technology is not readily identified and integrated into mission critical fuels treatment planning processes across agencies and locations

Task 4 Deliverables

- a. Monthly updates of progress, issues, and suggested areas of focus
- b. An appropriate section of the final report of findings and recommendations due NLT 1 July 2013 (pending a work start of 1 October 2012 and access to IFTDSS V2.0 on 1 November 2012)
- c. An appropriate portion of mutually agreed-upon publication-quality material for a JFSP-authored article in a fire science related scientific journal of their choice

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