Investigation of Geospatial Support of Incident Management

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Executive Summary

Increasingly, geospatial technologies are being employed to support the management of wildfire incidents. The application of these technologies have emerged as focal points in enhancing fire suppression efforts and increasing the effectiveness of fire fighters in their task of protecting life and property, while meeting resource objectives. This report documents research initiated by the Geospatial Task Group (GTG) to gather and analyze field-based information on the effectiveness of geospatial technology in support of wildfire management.

The study was conducted during the summer of 2002 and represents collaboration between The National Center for Landscape Fire Analysis, The Bolle Center for People and Forests (both at The University of Montana), and staff from the GTG. Participant observation techniques were used during visits to the following fires: the Rodeo-Chediski Fire in Arizona, the Cathedral Fire in Montana and Idaho, and the Monument, Easy Creek, and Biscuit Fires in Oregon. In all, the investigation team visited seven Type I Teams, two Type II Teams, and three Area Commands. During site visits interviews were conducted with appropriate fire management personnel and geospatial technicians. The interviews were audio taped and later transcribed for qualitative analysis.

Respondents to the investigation provided richly detailed evaluations of both the overall utility of geospatial technologies for supporting wildfire incident management and factors that affect the development of those technologies. Respondents identified a positive role of Geographic Information System (GIS) products to support decisions related to fire suppression, particularly on large complex fires. These products, however, must be produced in a timely manner and in a format that conforms to the specific needs of incident commands. Respondents revealed that the availability of GIS products in the initial stages of fire events present a potential strategic advantage in fire management. High quality, visually displayed information on fuels, infrastructure, and topography could guide fundamental decisions on suppression or containment approaches, providing opportunities for efficiencies in the allocation of suppression resources. However, there was no evidence of this form of strategic GIS application on the specific fires observed by the research team.

Field interviews confirmed the notion that the utility of GIS products is directly related to the reliability of data inputs. Respondents generally found that GIS map products offered quality information that assisted in fire suppression efforts. It was also recognized that continued reliability depends on improved on-site, comprehensive data acquisition. Reliable GIS products were also credited for the support that they provide for both firefighter safety and public relations during wildfire events.

The utility of GIS in producing maps was universally affirmed by respondents. The flexibility of GIS allows technicians to tailor map size and level of detail to fit the demands of users. Several respondents recognized that current GIS use places a near exclusive emphasis on map production, leaving other potential applications (such as landscape analysis, rehabilitation inventory, or archiving of impacts) largely unutilized. Although geospatial data may be easily stored in common electronic formats, respondents recognized an absence of formalized protocols for the transfer of GIS data generated during incidents. This may hinder the adoption of GIS as a more comprehensive tool for long-term fire, fuels, or other management purposes.

The use of portable Global Positioning System (GPS) units by fire managers was widely acclaimed as an advance in tactical fire fighting capabilities. Even recreational grade GPS units

can be useful in mapping fire perimeters and identifying the location of hot spots. GPS data can also be quickly loaded into GIS tools for more systematic application.

This study also documents several factors that affect the development of geospatial products for incident support. Significant issues were articulated about the availability of relevant data. Data quality, consistency, accuracy, compatibility, documentation, comprehensiveness, and format were all points of concerns for respondents. Even if data needs are resolved, and reliable, standard geospatial products become readily accessible to users, findings from this study suggest that the effectiveness of geospatial applications can be constrained by limitations in the physical infrastructure available at remote wildfire locations. Two major categories of infrastructure were repeatedly mentioned as cause for concern, namely, hardware and connections to electronic networks that provide pathways for information exchange.

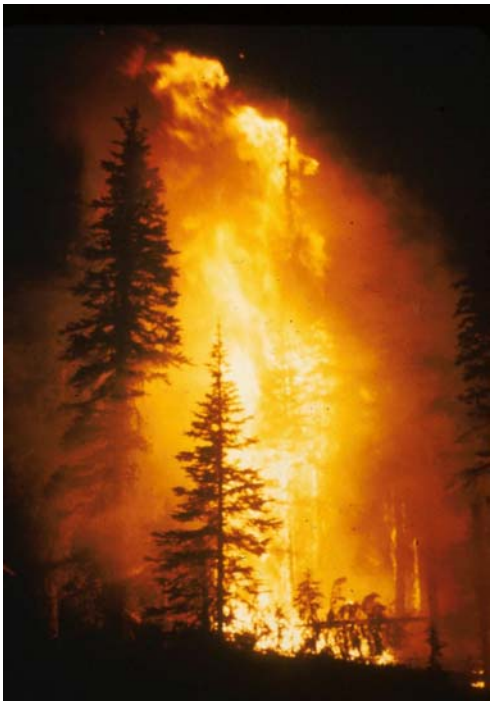
Personnel concerns also emerged as a critical factor affecting the application of geospatial technologies to wildfire incidents. Of key concern to respondents is the ability of a GIS person to understand the culture of fire suppression teams – to have the personality to fit into to an intensive, stressful incident environment that includes little sleep, camp-out conditions, and high-stakes, time-dependent work. In particular there is a clear call for on-the-ground training that is practical and focused on the particular needs of incident support.

The report concludes that the significant benefits of GIS technology on complex wildfire incidents cannot be realized without simultaneous attention to the development of high quality data, personnel, and infrastructure. GIS will fail to meet growing expectations for its capabilities if any of the three legs of the stool of preparation are missing. As one Incident Commander succinctly expressed:

> *There's really three components to it. It's not just the data, its just not the people, and its just not the technology, its all three of them working together.*

Introduction

Wildfire events have become an increasingly important public issue in the western United States. With the expansion of the population into ex-urban areas along the forest fringe, people have become more concerned about the occurrence of wildfire and its potential to cross into areas of human settlement. Through major fire seasons in the years 2000 and 2002 in the western United States, public expectations for effective wildfire management have increased (Burchfield 2001), and political attention forced the generation of an interagency National Fire Plan that calls for more aggressive treatments of fuels and additional fire fighting capabilities (National Fire Plan 2002).



Although there are multiple dimensions within the National Fire Plan to generate a coordinated response to western wildfires, the application of remote sensing technologies and geospatial analyses have emerged as focal points to improve suppression responsiveness and effectiveness. The use of geospatial information, such as Geographic Information Systems (GIS) and Global Positioning Systems (GPS) has become more commonplace during the past decade for managing wildfire incidents. The capacities of these systems to offer reliable, time-sensitive information to fire managers appear promising. Within accepted protocols of the Incident Command (IC) system, this technology has been incorporated into the generation of maps, Incident Action Plans (IAP), and other forms of intelligence gathering and reporting about the status of wildfires and associated suppression efforts. However, there has been little field-level research to evaluate the strengths and weaknesses of geospatial technologies during wildfire incidents, especially from the point of view of primary actors within the user community, the IC teams.

This research is an exploratory effort to understand the utility of geospatial technology in the context of wildfire events, drawing on evidence collected from wildfire management staff during the fire season of 2002. Although there are multiple forms of geospatial technologies, such as satellite and hyperspectral imagery, this investigation focuses specifically on the strengths and weaknesses of the most common GIS and GPS applications and their effectiveness in meeting the multiple demands of managers of wildfire incidents. The research only examines a small proportion of the body of consumers of GIS products, since the IC teams and their associated support staffs represent only one of many potential interests in geospatial applications. Additional investigations beyond this exploratory study will be necessary to generate a more thorough understanding of the potential uses of geospatial technologies in fire and fuels management.

Research Objectives

This investigation aims to gather and analyze field-based information on the effectiveness of geospatial technologies in support of wildfire management. Specifically, the research was designed to identify efficient uses of geospatial technologies among the business areas within the incident management community during active fire assignments. As part of this larger objective the current study was designed to provide an exploratory phase, the outcome of which was a conceptual understanding of how geospatial technologies are being applied. This conceptual and prepositional development will pave the way toward a systematic testing of hypotheses on the antecedent conditions, utility, and barriers to the application of geospatial products.

Methods

In order to examine how geo-spatial technologies are applied to incident support this study used participant observation techniques at five fires during the summer of 2002. Participant observations offer an efficient means for gathering information on a complex phenomenon (Babbie, 1998). The goal of these observations was to ground the development of theory regarding the utility of GIS, and other geo-spatial applications that support incidents, in propositions derived from interaction with fire personnel as they performed their duties. Since the observations occurred at the incidents, the specific locations and types of fires visited were determined by the nature of the 2002 fire season. Several very large complex fires that burned in Colorado, Oregon, Arizona, and California characterized the season. Therefore the investigators for this study had the opportunity to visit several Type I and Type II teams associated with firefighting efforts on very large fire complexes. These large fires also provided the opportunity to visit Area Command headquarters and interview personnel and observe the use of geo-spatial technologies at that level.

Field observations took place on the following fires during the 2002 fire season: the Rodeo-Chediski Fire in Arizona, the Cathedral Fire in Montana and Idaho, and the Monument, Easy Creek, and Biscuit Fires in Oregon. Within the larger fires several individual Type I or Type II teams were observed. In all the investigation team visited seven Type I Teams, two Type II Teams, and three Area Commands.

At all the sites the investigation strategy followed several procedures. First, a four person team was drawn from the principal investigators on the project: Joe Frost (USDA, Forest Service, Washington Office of the National Interagency Fire Center and Geo-spatial Task Group Chairperson), Dorothy Albright, (USDA Forest Service, Region 5, Geo-spatial Task Group Advisor), David DelSordo, (National Park Service, Geo-spatial Task Group Advisor), LLoyd Queen (Director, National Center For Landscape Fire Analysis, University of Montana), and Theron Miller and James Burchfield (Bolle Center for People and Forests at University of Montana). Study investigators were selected from this list in such a way that two members of the team represented the interagency fire GIS community, one person represented geo-spatial technology applications in fire through the National Center For Landscape Fire Analysis (NCLFA), and one person represented the Bolle Center. The presence on the team of investigators from the GIS fire community (both NIFC and NCLFA) helped to provide entrée to the fire camps while the Bolle Center personnel provided expertise in social science and qualitative research methodology.

Prior to the actual site visit the investigation team contacted personnel at Area Command (for the larger fires) and as many Type I and Type II Incident Commanders as possible. Members of the investigation team associated with the fire GIS community made this initial contact. Once the team was on-site they would arrange meetings with personnel at the various units (Area Command, Type I and/or Type II Incident Commands and GIS personnel within the teams). Fire personnel present at the meetings included area commanders, incident commanders, situation unit leaders, fire information officers, GIS technicians, and computer specialists.

Discussions with fire personnel on the incidents were structured to allow a free-flowing interchange of ideas and issues. At each meeting or interview session a short description of the project was distributed to each participant (Appendix 1). Although respondents were encouraged to describe their own issues in-depth, a list of general questions was developed and applied across incidents to serve as a framework for the discussions (Appendix 2). The discussions were audio taped and later transcribed for analysis. At the conclusion of each site visit the investigators delivered to either the Area or Incident Commander a one-page summary of the observations made during the visit. The purpose of this summary was to inform the participants about what the investigators heard during the visit and to allow for those involved to provide feedback regarding observations.

Subsequent analysis of transcripts from field visits along with the notes taken at the interviews were submitted for content analysis and serve as the data source for findings reported in this document. Content analysis is a systematic procedure to draw valid inferences from text (Weber 1990). Project analysts applied an open coding process to the transcribed texts following the procedure outlined by Strauss and Corbin (1998). Both the frequency of commentaries and the emphasis given by respondents reveal conceptual categories and the properties and relationships among ideas. Analysis was assisted by the application of qualitative research computer software, Nud*ist Vivo 1.1, 1998-1999 for accessing and organizing text. As in other qualitative studies, the repeated examination of the language of informants provided insight into the significance of concepts and relationships between key variables (Patton 2002). Other members of the research team and other fire scientists reviewed provisional conclusions emerging from content analysis before organizing findings into their final form.

Summary Of Fires And Incidents Observed

The summer of 2002 generated a series of large fire events, and the research tema had the opportunity to observe incidents from June through August. The Rodeo-Chediski Fire was the first fire visited. The Rodeo fire started on June 18th and the Chediski Fire started on June 20th in and around the Arizona communities of Hon-Dah and Show Low. One hundred percent containment of the Rodeo-Chediski complex of fires was accomplished on July 9th at 468,638 acres.

The site visit occurred on June 29th and 30th. When the investigation team was on-site the fire was 10% contained and residents were returning to the communities of Hon-Dah, Summer Pines, Pinetop-Lakeside, Linden, Pinedale, Heber, Clay Springs, McNary, Forestdale, and Show Low. During the investigation at this fire the team met with Area Command and three Type 1 Incident Management Teams.

The second fire visited was the Monument Fire, located approximately nine miles southwest of Unity, Oregon on the Malheur National Forest. The team spend one day at this fire, July 23, 2002. At the time of the visit there was a Type I IMT assigned to the fire and an area command, and the

fire was burning in mixed conifer forest, ponderosa pine, and grass. The fire was threatening seventy-five residences in the area. The team was able to able to meet with the Area Commander, the IMT and GIS specialists at both Area Command and the IMT. On July 24, 2002 the investigation team visited the Easy Creek Fire in Oregon. The team met with the Situation Unit Leader from the Type II IMT assigned to the fire. At the time of the visit the fire consisted of the Roberts, Easy, and several smaller fires burning in mixed conifer forest, eight to 25 miles south of Prairie City, Oregon. The situation report at the time indicated fifty residences, several commercial properties and numerous outbuildings were threatened, and that structure protection was in place.

The research team also investigated a smaller scale event with a visit to the 333-acre Cathedral Rock Fire located on the Salmon – Challis National Forest was ignited by lightning, detected on August 1st, and controlled on August 9th. On August 7th the investigation team interviewed the type II ICT assigned to the fire. At the time of the interviews many of the resources on the fire were demobilizing and this allowed for easier access to the Incident Commander, Plans Section Chief, Situation Unit Leader, and computer specialists.

The final major complex of fires visited was the Biscuit Fire was a lightening caused fire that started on July 13th. During August 14th and 15th the investigation team conducted interviews with incident personnel at several incident commands. Located 26 miles southwest of Grants Pass, Oregon, the Biscuit Fire was declared contained on September 5th at 499,570 acres. Estimated controlled date for the fire was November 1, 2002 with fire costs as of September 18th at $147,760,000. During the visit the team met with the Situation Unit Leaders, incident commanders, and GIS technicians at three Type I teams along with the GIS coordinator in Area command.

Findings

In all of the fire incidents observed, GIS and GPS applications were utilized by members of the Incident Command teams and/or the firefighters assigned to suppression operations. The research team discovered through its observations and interviews that geospatial technologies offer a series of benefits to fire suppression operations, although these benefits do not come without associated costs. To describe how geospatial technologies affect fire suppression operations, findings have been divided into two major sections: (1) the utility of geospatial technologies to incident management; and (2) the requirements for successful applications of geospatial technologies to wildfire incidents. Each section is subdivided into thematic categories for clarity of explanation. A closing discussion section offers a brief interpretation of the findings by the research team.

Utility Of Geospatial Technologies

Decision Support

The role of GIS and GPS in incident support depends on how effectively it can support the primary function of the IC team: to control the wildfire. The majority of respondents in the research believed that there is a positive role to be performed by GIS products, and all respondents believed that it would be impossible to return to a situation where maps and other data products would be produced by hand. This dependence on geospatial technology is heightened on large, complex fires, especially when the focus of public attention demands continuous information delivery to the residents and concerned political representatives. The potential for GIS to provide support to decisions was summarized by a representative from the Area Command on the fires in eastern Oregon:

> *The role of GIS is only going to increase. And our reliance on that's only going to increase. You get good information from that, [it] gives us rapid information, it's real time information, accurate information, and that is what we want to have until we leave there. The more of that, the better.*

A central interest among fire managers is the capability of GIS to produce maps. GIS possesses a capability to process multiple data inputs, so that any available attributes can be displayed with

remarkable clarity, or conversely, hidden in the wash of colors of other data layers. This flexibility allows fire managers, aviation officers, or public relations specialists to generate products tailored to their specific needs, highlighting those attributes that are deemed significant. Data can be scaled to print maps of virtually any size from large display maps for public information, or smaller maps that can fit on the knee of a helicopter pilot. There was agreement among nearly all respondents that the maps produced via GIS were indispensable to modern fire fighting especially air operations.

> *We have gotten to the point with air that we can't really operate without them. We use them for our briefings… for our helicopter operations, our air tacs. We give them to our air tanker bases as well. And, as far as doing the temporary flight restrictions, that's crucial.*
>
> *It would be tough going back … before the year 2000, in terms of the expectations amongst others…They really depend on us to produce those [GIS] products now.*
>
> *I was a Situation Unit Leader several years ago [on] Type II teams and hand cranking display maps. I never want to go back. ...I feel very dependent [on GIS]; it's a much superior product. It's so much easier to update and edit. I'm a believer. I would like to continue with this type of technology and move forward.*

Alternatively, not every respondent agreed that GIS provides unlimited advantages. One comment observed that GIS may be valuable for information gathering, but its current applications do not necessarily advance fire management operations as much as advertised.

> *The standard to achieve your IP and all of that, it's really high quality GIS product, what is it buying? I think its buying us a lot of fire information, but operationally, I am not so sure that it is buying us that much over the old hand-done maps.*

Of the maps produced, those that meet the most pressing demands of fire fighting operations are required for every operational period of the fire. These Incident Action Plan (IAP) maps and briefing maps are fundamental requirements of GIS operations from IC leaders.

> *The first priorities are an IAP map, then a debriefing map at about 1/24000, and a transportation map …(and) an aviation map.*
>
> *An action plan and then the maps. Those are the two obviously important documents you have to have, they are documents to go to the field with.*

There was agreement across fire incidents that there are only a relatively few layers of data essential for this type of immediate incident support: digital raster graphics (DRG's) that show topographic features (perhaps using hill shading); a roads layer that provides information on access and egress for fire suppression teams; water sources for suppression operations; and ownership boundaries. Although other demands for maps might emerge, a series of specific characteristics need to be represented visually for effective fire management.

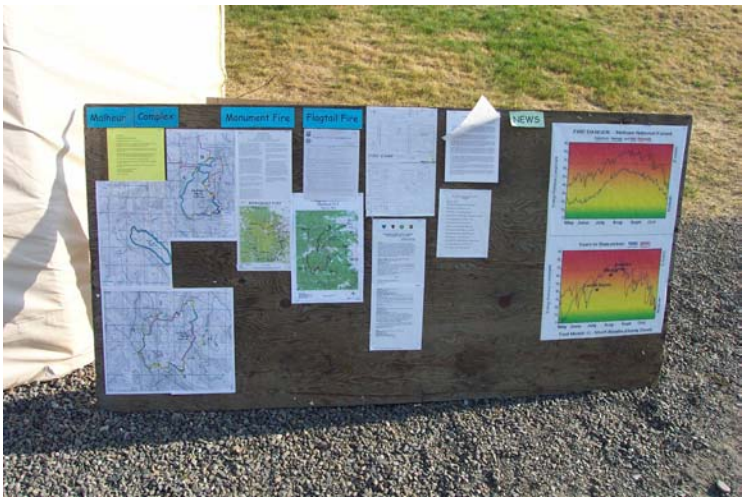
> *The normal things that you want are the most current road system that they've got, the streams, lakes and ponds and any restrictive type areas like botanical areas … and those type of things.*

> *You have a set of CD's for each area and the fire is set. It has the DRG's, has the roads, has administrative boundaries, has the ownership. Those are the basics that we need right away.*
>
> *You can get a long ways if you just have DRG's for the area you are working…people can see some things, but clearly, if you can have shaded relief, if you can have fuels, if you can have conditions plus your fire regime, all these things they just make it better and better and better. And I can do a more and more intelligent job of managing it.*

The production of maps also must conform to the demands of the users, and the focus of GIS can easily drift to other "nice to have" products. One respondent emphasized the need for map products to supply critical information to those who are fighting the fire on the ground:

> *My satisfaction isn't [the same as] the satisfaction of the people on the ground, so you always have to go to them and ask them, "Are these maps going to be satisfactory and meet their needs?" 'Cause really what are the maps for? You know I can have a pretty map for briefing and that's great because everybody out here isn't looking at the detail. But really, is that producing what the people on the ground need for a map? That would mean that contours, streams, especially roads are readable, discernable for them. To be able to get around, to be able to plot where they are, plot line locations… is (it) showing them enough area?*

Fire suppression operations contain a variety of management responsibilities and roles, especially during major fire events. For example, the needs of personnel within Area Command for GIS data are quite different than on-the-ground situation unit leaders. Some members of the Area Command units visited during observations felt that most GIS applications were not important for them, indicating that a state highway map was all the geographic information needed for Area Command's primary functions of coordination of available suppression resources. Other respondents at Area Command posts believed that GIS could be more useful, depending on the assignment:



> *Some of it's part of the nice-to-have stuff. Some of its needed and we don't have it and we are trying to get it and will get it. And some of it we have already. But there are Area Command assignments where, I have been on some that have had twice as many fires and we needed very little due to opportunities. In 2000 and last year in Montana the Area Command needed a lot of information. It was all GIS Based information. They relied heavily on that. And this time I would probably put this assignment in between these two categories. We have needs for water information. So I guess I am saying it is very important and we do rely on it, we do want to have access to it. The amount of information that we are actually need is going to vary from assignment to assignment.*

GIS products have advantages in that they can be adapted to necessary demands - for example, someone that is in an aircraft dropping fire retardant requires a different level of detail than someone attempting to make strategic decisions over a series of fires on a landscape. Respondents acknowledged that this flexibility represents a major strength of GIS for decision-makers, and the ability to allow interactive creations between capable technicians and information consumers allows for different levels of decisions to be made with the best available information.

> *Because different users have different expectations and needs. … So as you go down to the ground you are going to get more and more implementation and still have command decisions. And as you come up from that you get less and less implementation activities and more and more broader command type decisions, long-term strategic type decisions.*

The utility of GIS information generated during incidents is not restricted to IC or Area Command teams. Comments were raised from various sources about the value of GIS in addressing post-fire rehabilitation needs.

> *Some of the stuff I have seen from that is extremely important for rehab … we get asked now on fires of what's the fire severity across the fires. And we are kind of limited to a visual observation of where we had stand replacement vs. undisturbed burning …with the fuel situation that we have with the severity of the fires that we are seeing… rehab is a key issue and with the national fire plan, the emphasis on rehabilitation. That's going to be a prerequisite (GIS) to be able to go out and do successful rehab.*

Several respondents indicated that GIS has its greatest potential for decision support if data are assembled and verified prior to the fire ignition, such that complex information can be applied to a strategic decision on suppression – such as to control or simply confine a fire – within the fire's initial phases.

> *Cost is an issue, there's no way around that. But you know we have to weigh the benefits vs. the cost. And what is the value added or what are the main implications we get from incurring that cost. And you know, if you look at the large fire costs that we have primarily on of the factors contributing to that is initial decisions. For example, if we make the initial decision to control the fire and it escapes initial attack, and we don't back up on that, we get in to the situations of these siege fires where we are throwing resources at them for weeks and weeks and weeks and they are costing tens of millions of dollars. When the initial (evaluation happens), maybe once we have done that we will need to look at different alternatives. Maybe the primary alternative will end up with the same burned area anyway because we are unsuccessful in suppression, but at a fraction of the cost. And so to look at … GIS throughout the duration of the fire, may not be as contributive to the total cost as we would let on. Using that throughout the process I'm thinking from my perspective would be worth the cost. … I come back to decisions supported, having the best information in the beginning should help us get to better initial decisions… preplanning kind of stuff is when to help, not at the time the decision is made. You're going to have to have your information ahead of time. But a good solid system …that you could access at any time or get to is going to be necessary to do that… costs are critical to that, but they would be well worth it.*

Finally, fire managers realize that generating quality data for GIS applications will incur substantial costs, but to them the data sets provide benefits that will outweigh these costs. Firefighter safety and effectiveness in allocating suppression resources require both information and experienced judgment, and it's difficult for IC staff to draw the line on where information needs might end.

> *Every little piece that you can add to take away the uncertainty is valuable. And that is what we need to strive for. (Other respondent) …In the fire behavior area even redundant data is valuable. I mean if things start building up and all saying kind of the same thing, you start having the confidence to really go ahead and implement something. And so it is a little risky I think to just say "we'll get this is the minimum amount of data that we need to do our job, that's enough that will do our job".*
>
> *Because we are not going to put the fire out and so we have to really know where its going to go…what it might affect, how soon it might get there, how long it's going to last, what the fuels are and where every possible place is that we can take a mitigation action. And we can never get enough information. Well I shouldn't say that we just hunger for all the information we can get. And everything that we have talked about we use.*

Efficiency

The scale and complexity of a wildfire event affect the overall utility of GIS applications. In general, respondents observed that the more complex fires (and not necessarily the larger size fires in terms of acreage) provide opportunities for GIS applications to gain efficiencies in displaying and understanding relevant conditions. For some relatively uncomplicated small fires, or on fires where there is not a significant amount of change occurring, GIS may be something entirely superfluous to the suppression effort, as one Type II situation leader commented:

> *If it's just one fire like this I don't see any reason to bring in a GIS person to do one dinky little fire. And it also has to do with how much change is going on. If its changing a lot you need help, but if its one fire, especially after it gets into mop-up, you know when it's mop-up only, nothing changes. So you don't need it.*

The scale of the fire also relates to whether additional personnel are needed to address the demands for geospatial data. Although GIS can offer advantages of a permanent record, the location of a GIS staff on every small fire might not be practical. The necessary data entry for historic records could be done at a later time.

> *I don't know if we need to bring in a separate person just to do GIS as a separate position. To me there's not enough work, I don't think…like, we go on some sagebrush fires and two days guys we're leaving…(other respondent) by the time you order somebody its time to go home.*

> *A lot of our assignments are short. You know, but sometimes they go 14 days or 21. But it still could be a relatively small fire…you just have to do mop up on it, you know, for a week afterwards. You don't need a map for that. You made it once, it doesn't change, you are just kind of keeping track as far as the SIT. You are just keeping track of how much they actually got done, and you don't really need a map for that I don't think.*

On the other hand, larger-scale, complex fires appear to reap the greatest benefits from GIS applications. Several factors play into the use of GIS on larger fires – the demands of a wider audience, an increased value of the resources at risk, and the physical limitations of producing sufficient intelligence and map products for fire crews.

> *A lot of it depends on the size of the fires we are dealing with. I think this is like 450,000 [acres] plus change. I don't think we can do it by hand…A small 1,000-acre, 2,000-acre, 3,000-acre, we still know how to do things by hand. We could still make things work. But size kind of becomes a physical limitation. Complexity is certainly becomes a part … With the air operations and we start adding in communities and other hazards or resources of risk because we are trying to put on cultural resources, TD species, habitat, that type of thing. And all that when you start talking about doing that by hand becomes pretty cumbersome, and probably not very doable. Whereas with the GIS system in this case you can slap something together pretty quick.*
>
> *The demand[s] on the Type I teams now are to produce incredible products very early, and a lot of them. And so that's just been a fact of life, especially with the huge media interest.*
>
> *[GIS] is expensive but then there's a point [where] the complexity of the fire … structures threatened, company threatened, lives threatened… the benefits outweigh the costs. The effectiveness [is in] being able to know where the line is not hot, they actually can allocate limited resources*

Complexity of fires might be related to a fire's size, but a few respondents indicated that the increase in houses and human developments has made even smaller fires more difficult to manage.

> *The complexity has risen such that even on the smaller incidents the level of specificity on the information is just becoming more and more critical. On my home forest the [Name Deleted] National forest we had a 1,350-acre fire, right in the urban interface … generally speaking, the complexity is increasing irrespective of the size of the fire. And so that level of detail needed has just increased. At this point in time we couldn't go back to how we operated even a season ago*

The question of whether GIS is an efficient use of financial resources may well depend on how GIS is applied. As the earlier comment indicated, an early analysis of resource conditions using geospatial data might affect critical suppression or containment decisions. Or, the manner by which GIS resources are applied might generate cost savings. Several respondents recognized that GIS costs are high – for example, renting a GIS contractor with a trailer of equipment can run over $2,500 per day.

> *On the Purdy fire, and we had a contractor, GIS contractor. Trailer alone was $2,400.00 a day, the generator was $800.00 a day. Then you paid the company and they charged you by the foot of paper. So that is a lot of expense for two weeks.*

The specific conditions that warrant the use of GIS products remains uncertain. Criteria such as fire complexity and changing conditions were mentioned by respondents as important attributes that demand greater levels of information delivery, but thresholds for the complexity or dynamism that call for GIS applications were not clearly expressed.

Reliability

The reliability of GIS data could emerge as one its most important attributes. If it is based on sound data collection, it provides a consistency and stability that can be utilized even beyond the fire events. Respondents generally found GIS map products to offer reliable, quality information that assisted their efforts to control fires.

> *So the field folks, operations folks had maps to work with when they went out in the field right from the get go. And that meant the accuracy of the data that they then brought back into the situation was much higher than taking an agency rec. map and trying to figure it out, or even a topo.*

GIS technicians also found GIS to be a valuable supplement to infrared (IR) data that is typically utilized to identify fire perimeters through night over-flights. It allows for a more consistent mapping of fire perimeters and assists in the integration of IR data to other mapping needs.

> *I think this system of uploading and downloading the IR data as shape files has been very valuable. The first time I tried to do GIS on a fire I would get the IR data on a copied map that somebody just … whipped off for me, and the scale of the map varied from one side to the other because it was done on a flight printer; it wasn't accurate. …I finally convinced the guy to give me shape files by the next fire. So that shape file thing, exchanging data between us and the IR folks, I think it's really advantageous.*

Conversely, this integration of IR data and GIS has created some overly ambitious expectations that GIS actually can represent existing conditions at any given moment. As a few respondents indicate, there is a danger that technology can be oversold, and consumers of information must recognize the limitations and delays within even the most up-to-date representations of fire conditions.

> *One problem with using GIS information is often the [information is]…a day old. …. Incidents are so huge that they are using IR data from the night before so the incident had actually traveled.*
>
> *In the first couple of days of this fire the only time we knew what was going on was when they flew IR at 10:00 at night. And the next day it was roaring and going miles and miles and miles and we would have no idea where it was until 10:00 the next night. People were surprised by that. You know they thought we had like instant, we know it's here, we know it is here now, we know it's here, when we don't.*

Another aspect of reliability is how consistently GIS products meet the demands of the users. Since GIS is still experiencing growing pains in its applications, there are voices within the IC system that recognize its current limitations, especially when technological problems create problems that can stop map production altogether.

> *You never know what you are going to end up with. GIS has not proven to be 100% reliable yet. And I found out the hard way what happens when you just say "Oh, sorry we didn't get the map done." You have to have a (backup) solution if everything else goes to heck on you.*

The accuracy of geospatial products also depends on the quality of inputs provided, and as the description on data quality in subsequent sections of this report reveals, the record of GIS reliability is mixed. On the other hand, respondents indicated that the performance of GPS units has been highly satisfactory, and even recreational grade GPS units seem to work well. Hand-held GPS units can be distributed relatively easily to field crews, and reliable information on key issues such as the location of the fire perimeter can be generated with relative ease.

> *A really common thing that's happening out there is GPS perimeters. My experience is almost everybody I run in to is doing it with recreational grade GPS's and its working very, very well. That does the job more than adequately in my opinion. I have never seen real problems with that.*

> *We knew it's down there in the trees somewhere. And … so rather than fly out a flight… we called up the hot shot crew that was there and … we just sent them out two Garman 12's with breakfast. And they'd take those, go walk the line, walk the perimeter, save some way points along the way and stuff. And then when the evening meal came out we sent them two more GPS's and those two GPS's went back kinda. And we just kept rotating them that way. And so we could get 4, 5, 6-hour old GPS to plot that was walked. You know, not flown from way up there, (with) who knows what accuracy. … It was really slick.*

Even with the positive testimonials about the accuracy and effectiveness of hand-held GPS, some individuals believe that the recreational quality GPS units are not good enough. This raises the question of the necessary degree of accuracy to be able to complete necessary tasks.

> *So it's been a battle and its still a battle within the Park service with our regular GIS folks. Collecting with a recreational grade GPS is very upsetting to some of those people. And we try to explain to them, I mean, it's a fire. By the time they land the fires in a different place than it was when they flew it. I mean you know, this is a dynamic environment.*

Some technicians identified horizons for future developments in geospatial technology that would increase both the reliability and utility of its application. There are emerging products that are not widely used at present, but have been tested in some locations with positive results.

> *And it turned out, they'd fly with Palm IR, they'd see a hot spot, they'd go hover over the hot spot, they'd save a way point. And then on the hood of the car after they landed they'd take these way points in lat/long. And they'd find on the grid map, and they'd do that, and then the division supe. would bring up their IP map and they'd say, "OK, it's right by that little curly-q" and they'd put it on the map and all. And, so I said, "Let's see if we can do better on this tomorrow". So I went out, and as soon as they landed, … I'd just download the GPS data. I had a little portable printer you know, in the back of the Explorer there, and plugged-in to the cigarette lighter, and I just dropped those points on the regular IP map. I printed out a nice color IP map with these points located, and you would have thought I was giving them a hundred-dollar bill. I mean they were just thrilled, they were just so, "wow that is so cool". And, the good news is that it worked really well. They were really happy with the results and everything.*

Safety

The significance of geospatial products – especially high-quality maps – corresponds to the overriding concerns of IC staff in fire operations – the safety of firefighters, the public, and the protection of infrastructure on both public and private property. The location of roads is an issue of particular importance for fire managers, since roads offer escape routes for fire fighting crews. In addition, the location of the fire perimeter is important to understand the growth of the fire, the types of fuels it may be entering, and the potential intensity of the fire in the immediate future.

> *At least they are getting some roads on there so they kind of have a feel for where they are going. There's definitely a safety element there.*

> *Look at, first of all, a map of the fire perimeters, where they are in proximity to the National Forest or BLM District or National Park we are working with, and in proximity to the road system so we can see what access is. We would like to look at fuels in case we have to look at maybe moving resources. We might want to look at the fuels and the concerns or the potentials for those fires, which fuels can give us an indication of that.*

Under ideal conditions, GIS products would be produced early in the planning cycle of a response to a wildfire event. If GIS data are sufficiently comprehensive, they could allow for a rapid evaluation of the potential risks and alternative responses.

> *Looking at fuels, looking at road systems, looking at water sources, those kinds of things would enter into possible evaluations of different strategies such as confinement vs. control would be valuable to us. And those are all things that we can extract from GIS if we find we have a good system accessible to us, and that can be very helpful.*

Several respondents regarded the cost of GIS and other potential inefficiencies as secondary considerations, since the level of detail provided an extra margin of safety for firefighters and the public.

> *It's (GIS) very expensive…But it does, yes it does increase firefighter safety, and so to me the value is not an issue. Even though we have to keep down large fire costs, and we try to do that in any way that we can, but its not going to be in that area. And the reason for that is because those people on the ground are everything - that they know where they are on the ground, and they know how to get in, and they know how to get out of there. … it has everything to do with safety.*

Public Relations

Respondents at all fires visited by the research team commented on the ability of GIS to provide believable, quality information to members of the public who are affected by fire events. People are able to grasp information on a GIS display much more easily than from traditional map products, and the communication value of GIS maps appears to be quite high.

> *If you can drape fuels or DRG's or DOQ's or something over 3-D images, or over an elevation, that's really useful. Often when your working with the public you know they're not as tuned in to a topo map or something like that. But if they can see something that looks like a photograph from an airplane, and here's the fire perimeter and here is their house. They can see the road that goes right to their house, its always easier for them to understand and get a feel for it and stuff. …So if you can give them a way to visualize it and see "Oh, well, that's a dinky little fire in our great big wilderness", they feel better. You know, versus just a plain flat map.*
>
> *I think there's a public relations aspect. I don't know how well they are received in the community, but having the occasional pretty map where … local people can see where the fire is… in relation to their house, where it is in relation to the ocean, and stuff like that, … has a value.*
>
> *I guarantee you the information that comes back to me says the maps are great, the maps are great. [On] every fire we have been getting that kind of feedback at the public meetings.*

Information delivered promptly to key political decision-makers can also be highly important to the continued support of fire management organizations. With limited patience for information, political offices can receive accurate information about wildfires through GIS products that can be posted over web sites to inform people across the region and the nation.

> *The governor is getting real time information and that is beneficial to the host agencies on this incident. The same stuff is going to Rep. Hayworth's office, Sen. Kyle's office. And they are all looking at the same information and it's real time.*

A major concern of the public with wildfires is smoke. Satellite imagery, which was not discussed much by respondents, may have a role to play to offer information to the public on smoke plumes.

> *Another thing that we like to have access to is a satellite picture of the smoke columns. That's real important to us from a public information standpoint, and smoke dispersal… there were four or five fires going right outside Yosemite, and we had the Hoover complex in Yosemite, and we had a real smoke issue, and we just popped up the one image that showed all the smoke columns, and these four highest priorities in California. They were all going right into the park ..and once we had that picture, I mean that solved a lot of problems except for the issues of people who had to work in it…but from a public standpoint and a media standpoint, that took care of it.*

Transportability

A major advantage of GIS applications is its capacity to be saved in electronic formats for later use by other resource management professionals. Data generated by the GIS specialists on a fire can be stored and transferred onto CDs or other electronic networks much more easily than old-style map products. Several GIS technicians interviewed indicated that they leave a record of the events of a fire on CDs, and attempt to leave them with local agency representatives prior to leaving the incident. These CDs are highly transportable to other users, and create a permanent record of fire events.

> *The last two fires I had give the local GIS person a CD. We also… identified that the agencies that we are working with have GIS capability. All agencies that we close out with will get a CD, like the fire at Prescott, Arizona. Both the County and the City got a copy of my data also.*

There is an expectation for GIS products at this time to provide a certain level of continuity to the management of an area affected by fire, because the data has multiple applications to other management operations, especially Burned Area Emergency Rehabilitation (BAER), led by special BAER teams.

> *The host units are by and large expecting and demanding that GIS product. The stuff we have has become a valuable resource for them after the fire is all over…. it all feeds right in to the BAER teams, and the BAER teams start showing up. Well, GIS is one of the first places (they go).*

However useful this information might be for future management, there do not seem to be established protocols for handing off the material between the GIS team on incidents, and those local unit representatives that could best utilize the data for post-fire management. Some of the time, CDs are prepared of the data and dropped off, without any formal debriefing or explanation of the formatting or structural attributes of the data. When asked how one GIS technician on a Type II team supported the post-fire effort, he admitted that there was none:

> *I haven't been involved with them providing them support…we just give the files and leave.*

After a fire most people aren't really ready to spend time with local GIS staff to conduct conversations on the data that has been collected during the fire.

> *I think its unrealistic to think that during closeout the GIS person is going to sit down and write FGDC compliant meta-data for the shapes. It's just not going to happen. Closeout is a really busy time, … but if those attributes are left in there then, somebody at the local unit could convert that to real FGDC compliant meta-data.*

The potential for incident-generated GIS data to be applied more systematically to future fire management operations (and the means for this to occur), appears to be an important topic for administrators across fire suppression agencies.

Factors Affecting The Utility Of Geospatial Products For Incident Support

Although there is agreement among respondents that GIS has an important role to play in incident support, there were clear indications that GIS operations have yet to realize their full potential. In fact, several key elements in the application of GIS are constrained by conditions quite separate from the actual capabilities of these emerging technologies. In reviewing the observations made on the five fire events visited in the summer of 2002, the research team identified three major categories of operational conditions and behaviors that affect the application of geospatial products. These three categories are data, infrastructure, and personnel, and each will be reviewed in turn.

Data Concerns Associated With Geospatial Support Of Incident Management

The effectiveness of any intelligence system depends on the quality of the information applied. GIS systems depend on data, and three major issues surrounding data were raised by respondents: the availability of data (including its accessibility as well as its existence), the quality of available data, and the compatibility of multiple data products that must be applied simultaneously. Since GIS applications have arisen almost organically over the past decade within both land management agencies and the fire suppression community, there are multiple forms of data utilized and multiple manners in which the data is characterized, displayed, and stored. In general, respondents acknowledge that many data products are still under development, and several highly useful forms of data – fuel conditions, for example – do not presently exist in forms that are highly accessible to users. Other significant data sets are available to GIS technicians, and respondents identified a mixed record (across the five incidents examined in this research) in the data's ability to be applied efficiently. In some cases, key data sets were immediately available and readily applied to incident management, while in others, flaws in data accessibility, quality, or compatibility created delays or bottlenecks in effective application.

One of the most important concerns among respondents regarding data is the quality of information that has been assembled to characterize landscape conditions. It is beyond the scope of this report to investigate quality control standards within data systems for land management agencies, but from the point of view of field staff on at least two incidents, data quality was not what fire managers expected:

> *We are dealing with pretty old stuff. You know we struggle trying to get road accuracy out there, these base maps are not accurate. You know that's a real problem and it goes back to the safety issue in a lot of ways. There's a lot of confusion when people are out there and they are looking at a map and the roads are gone.*
>
> *It depends on what the Forest has in their shops. You know, what do they have in the system, what do we pull out of there. So, if they don't have any type of organization, or if … they don't keep up on all the latest greatest stuff, then we can have layers that come up missing data. So really, the product that is produced has a direct connection to how a forest or an area or wherever you are an agency, what kind of quality and oversight that they have to their program.*

It does not appear that the capabilities of the technologies are necessarily at fault in assuring data quality, it might well be that the administration of data and its ongoing management are issues that require attention. As one insightful comment revealed:

> *Really, the technology that we have has probably exceeded our ability to collect accurate data. That's the weak link that I am seeing right now, is accurate and timely data collection.*

Data quality is also affected by its maintenance. Several respondents commented on having staff responsible for updating data layers and ensuring that its quality and availability remained high. However, there does not seem to be a formalized process for addressing the incident-generated data within general data packages sustained by land management agencies.

> *There's no real manual direction or anything that says they have to keep those databases up to speed… (Other respondent) No, and it's a lot of work, I mean, it just takes a lot of time.*

Different situations will require different types of data. The availability of quality data arose as a critical need for all GIS users. As mentioned above, data demands for many elements of the IC task portfolio rest on several key layers: digital raster graphics (DRG's), ownership, roads, and water sources. In the majority of incidents examined, these data sets were available on CDs or through servers housed at the administrative units where the fires occurred. When this data is available, the GIS teams called to a fire can be very efficient in meeting immediate demands for map products and producing maps in either the first or the second operational period. However, some types of data that could be useful to incident support, such as fuel types of fire regime, simply are not available in many instances.

> *Fuels layers, I think, are really important, really critical and something that I often see - there's not just plain old fuels layer in the database.*

Geospatial data products to apply on fires do not come from central sources. Nearly every respondent described a relatively ad-hoc system for acquiring the data they needed to support their GIS applications. Much of this comes from the host unit where the incident occurs, but the data quality and availability across districts are highly variable.

> *I call up the BLM state office GIS person and tell them exactly where I am going and where the fire is at, and cut me this data, and give them a list of data, and tell them to overnight express it to this district, ranger district. It's always been there when I have gotten there so it's worked so far. I can't depend on the local Forest Service or local BLM agency to get the data, it's a hit or miss proposition but its getting better.*

Respondents frequently mentioned how data availability under current conditions relies on the agency staff members who work with GIS products. Without centralized repositories of data products, acquisition of data depended in several instances on tracking down the people on administrative units that could put their hands on the data. Since personnel change jobs with frequency in land management agencies, data can even be lost.

> *We were on the Helena National Forest …and they had good digital history of the fires from 1909 or 1939 through 1993, and that was it. … I tried to track that down and they said the guy who cared about fire history left in 1993 and so that's that. And, the longer they go with out getting that data in a digital format the less likely the are to be able to track it on down. You know it's in boxes in a cardboard box under somebody's desk or somewhere. But as that stuff gets loaned to teams and loaned to people for other purposes, and all it's going to go away. That can be a problem. …If you show up at the scene if you don't have that data, there is no easy way to deal with that.*
>
> *Other parks have no GIS folks at all and stuff. And so for me to go to a Park and find the GIS data, I don't look in the network and follow a path. I try to find somebody who does some GIS stuff. And if they're not there I'm probably not going to find the data. …And then if that person leaves, somebody else moves in to that office and they say "what are these" and pretty soon they are in the trash. And we have lost that kind of data.*

A more commonly mentioned barrier to applying GIS data revolves around the issue of data compatibility. Data might exist that can be useful to incident management, but the formatting or storage might be such that it can't be utilized. For example, even within the same organization, data might be collected or stored in different formats. In the Monument Fire in Oregon, the roads layer was not useable for the GIS contractor called into the IC command area because of differences between data protocols on two adjacent National Forests, limiting the effectiveness of the GIS products.

> *The data has been a tremendous struggle on this fire, …The last fire we were on is the Cannon Fire in Eastern California. …(Since the contractors) are based in California they travel with a book of CDs that they have got all the base layer for the entire state. And they were able to stop at the Supervisor's office of the Ranger District on the way in and picked up whatever additional layers they needed. And when they arrived at fire camp they had 100% of the data they needed. Coming here they thought they could do the same thing and they stopped at the Ranger District here… and found out that well they don't even have any of their own data. … Eventually they did get the Forest GIS specialist to copy data off of a disk on to a CD and bring that over to us … (But) we have two data sets, one from each forest. And unfortunately they do not match. They're different structures. …. We still do not have all the data straightened out. …last night I think we finally gave up after about 6 days of trying to make sense out of the road theme.*

More common were examples of data incompatibility between land management agencies, such as the Park Service and the Forest Service, or the BLM and the Forest Service. A GIS technician on the Rodeo Fire in Arizona expressed what seems to be a common problem across agencies:

> *We were in Montana last year. We had Forest Service data, we had Park Service data, and you know, they were right up to each other, but Park Service is in one data and Forest Service is in another. If everyone would do just one thing, it would make it so much easier.*

This lack of compatibility can often lead to frustrating consequences in terms of what the IC teams are able to accomplish. A compelling example of incompatibility emerged from an IC representative describing county-level GIS information and the GIS data layers among land management agencies. The former is focused on houses, roads, and county infrastructure, while the latter does not share a similar focus on structural protection (and identification) in their GIS systems. Thus, when the fire management team wants to load the layers that will identify the location of structures, the incompatible data formats block access to this very valuable information.

> *I charge the people in our shop to make it happen, our supe's to make it happen (identify structures). So they come back and tell me that there's compatibility issues with other programs…to be able to combine two things…A lot of times we will interface with fire departments or fire councils, and really, we would love to take a, do a structure protection-type map and take it out there… but we can't.*

Data compatibility also depends on willingness for multiple users to adopt an architecture that applies to common standards. Although there will continue to be tensions from competing manufacturers to provide discrete, stand-alone products, the need to standardize data formats, file structures, and symbols will lead to much greater efficiencies in use and reliability of products. Several comments from respondents complained about the lack of a protocol for file structures for data storage, and since the protocols don't exist, technicians simply develop their own based on their own experience and familiar terminology.

> *From the Type II to the Type I … there wasn't a file structure set up. So … the guy that was here, was very productive, he made great maps but there wasn't a file structure to take over once we got in, so it was hard to use the projects that he had already set up. We almost rebuilt what he had already done.*
>
> *This is my first time working with fires. I've worked with GIS, but I just made a file structure that I felt comfortable with.*
>
> *[We don't have a] predetermined file structure and about half of the incidents I have been on. Ventura tools were used and the other half it was not used. And it just depended on the knowledge of the GIS person that was there as to how they did things, so… in a couple of instances… we ended up redoing things. Moving the file structure into something that was a little more understandable.*

Even in GPS applications, the research team noted that standardization remains a problem among users. For example, latitude and longitude descriptions have yet to conform to a single system. This became a problem on the Monument Fire, where National Guard personnel, summoned to assist in fire fighting, insisted on a latitude/longitude designation different than what had been utilized by the GIS contractors on earlier fires (degrees/minutes/decimal minutes versus degrees/minutes/seconds). Another respondent mentioned how this lack of standardization was a problem for reaching the full potential of GPS technology, right at the time when highly portable GPS units are becoming more commonly available to a range of personnel on incidents.

> *I have one field observer on this fire, I should have six, and he is using GPS. Air people, pilots, helicopters, all have GPS. You know there's surprising numbers of crew leaders and other miscellaneous resources that are just showing up with it these days. One of the problems that we run in to is standardization. People …separating it into degrees within seconds, and so many degrees, and this decimal and … you can't tell where you are or what it is, so we are trying to figure out how fast to do that standardizing.*

> *There is the data collection format issue that comes over GPS units. We've printed out a handout or two that comes with this team about what data are you collecting. The issue is if they are reading coordinates off to us, I need to know what coordinate system they are in, although that is usually obvious, but what datum they are in, what zone they are in, and make sure that they are actually giving it to us correctly. There is an area for errors there that we have seen. A lot of data we get is just single points, and they are giving us a slip of paper with coordinates on it, and they are not telling me what datum they are in.*
>
> *Every field observer brought his own GPS from his home unit. We ended up with about 4 different brands and 4 different types… So … if they don't make a common cable for GPS I'm not going to lug around 15 cables. Somebody … suggesting that there almost ought to be a GPS coordinator that would sit down with everyone that has them [GPS], get everybody on the same page*

Compatible data standards were also recognized by respondents as important elements in effective transitions – either between IC teams on fires, or especially post-incident when land management professionals would likely desire a reliable body of geospatial data for future work.

> *I'm not trying to pick on somebody but, for example, somebody has come in, they have been working the fire they give you the CD, you maybe (you've) never even see them, we never saw these folks, someone else brought a CD in, and we look at the perimeter, we have no idea how it was gathered. Did somebody sketch it on a map, did somebody GPS it? … We can make guesses based on what we see, but we don't know. And in some cases we are not sure what data the perimeter goes with. … I'm really a fan of putting the meta-data in the DBF file of an ArcView shape file, and then I can't possibly lose the meta-data -- It's just part of the shape file. I can't lose it. And then if somebody wants to write real meta- data later from that, wonderful. But I think that's a really, really smart move*
>
> *I figure it would be handy from a general sense as you walk into one of these [incidents] is to know where some of these [data] sources are that you guys are talking about. That [list] could publish both physical things [resources] and where you can get the data.*
>
> *The Type II team that will probably come in and take our place many not have the GIS capability that we have. So what do we do?*

GIS technicians across incidents expressed a universal desire for a more standardized system for data acquisition, GIS tools, GPS units, and file systems for storing data. One solution proposed by a few respondents was the creation of a national database to be able to archive key data. A Park Service representative observed that great variation exists among National Parks in the GIS information generated and noted a more standardized system would greatly support suppression needs.

> *What I would really like to see…is that automatically any fire over x acres, 10,100,1000 what ever a good number is, will automatically be mapped, and it will be put into a national database …And the cost is not astronomical, I mean we are talking a couple thousand bucks to do a fire, maybe. And we spend a lot of money on fires…To me, having a rock solid nationwide fire history that I can access even on Saturday morning …that has real metadata with it, we know when the fire occurred and all that kind of stuff, would be worth a lot.*
>
> *I think your standardization needs to be in things like the training level and directory structure and the some of the tools for symbolization. Every team is going to have a little bit of a style, you know, put our logos on it. But I think there should be some standard as to the type of product at least that goes out to the field.*
>
> *That'd be nice if all SIDs, like when we went to Colorado, that'd be nice if all that stuff was on one website, one FTP site that you could get any SID you needed, any DRG you needed and any BEM you needed without having to wake somebody up at 2:00 in the morning. …if we had it all centrally located that everybody, all the SIT leaders knew where the data was at. It wouldn't matter if you went to Wyoming, or Colorado, or Oregon. It would help a lot. Because right now have to hopefully find the GIS person on the local unit, and hopefully they are not gone.*

Infrastructure Concerns Associated With Geospatial Support Of Incident Management

Even if data needs are resolved, and reliable, standard geospatial products become readily accessible to users, the effectiveness of geospatial applications to incidents can be constrained by limitations in the physical infrastructure available at remote wildfire locations. Two major categories of infrastructure that were repeatedly mentioned by respondents as cause for concern were equipment and connections to electronic networks that provide pathways for information exchange.

Since GIS requires adequate equipment – computers and plotters, for example – to be functional, the supply of equipment can affect it's utility to a fire. On the smaller, Type II fires that were observed, the quality or availability of equipment were not satisfactory to the GIS technicians.

> *I mean they gave me a laptop, the CD drive doesn't even work in it, so I have to plug another laptop on in the network, just so I can get data off, and that's my own personal laptop, just so I could get it on to the corporate machine. So I'm kind of frustrated with the hardware stuff…So to me there needs to be a change there if we really want to be realistic about producing GIS products that are usable. I can't produce this kind of thing on a 755 in mass quantities, and enough. I can make it, but I would be up all night with this.*
>
> *Not having the hardware to plot is one of the biggest bottlenecks. When I walk into someone's office and I use someone else's plotter I almost never can network.*
>
> *I really had to pull strings to get [administrative] access on that laptop. I had to pull major strings, they didn't want to give it to me.*
>
> *The issue is getting the equipment. Getting equipment is like pulling teeth just to get a plotter. I haven't gotten permission to take a plotter from the office yet. We have one sitting in the office that is not being used, and they won't let me have it.*

GIS technicians frequently must get by with whatever equipment might be available at a local site. Respondents across all five fire incidents agreed that the equipment shortcomings needed to be solved, that locally available equipment did not meet their needs for compatibility and speed. The pressures on GIS team members to produce necessary products can be extreme, and technical failures can reduce their effectiveness and hinder the fire suppression effort.

> *The local district was trying to help but their equipment was so screwed up that it was taking so long to get anything out of it…We have got to have a quick turn around…I get division Sups coming in. Sometimes they don't come in until 9:00 and I go off at 2:00. Then I got to make sure the map is right the best I can by that time. And they weren't able to do that…They had networking problems or something.*
>
> *Well we're critically linked to good plotters and plotter supplies. Today where we [have a] crisis is more black ink. We've got about a 24-hour supply of black ink and where do you find that? Well, you sure can't find it in Medford, and you sure can't find it anyplace close by.*

Equipment also must be stored and transported in a reasonable manner to protect its function, and field personnel indicated that the care and handling of equipment has not been considered, especially on smaller fires.

> *One thing that needs to be, type II teams it's hard for us to get money to buy the equipment for what we use on fires. They're going to require us to use computers for everything. They need to give us money to at least buy the boxes to pack them around in.*
>
> *Nobody wants to take their $12,000 plotter out to an alfalfa field and sit it down in the dirt.*

Electronic connections to the Internet to utilize web products can be challenging at the remote settings of most Incident Command Posts (ICP's). Although satellite hook-ups are a potentially useful tool, they have yet to be commonly applied. Other systems, such as specialized GIS trailers or recreational vehicles (RV's) were observed on the large Type I fires sampled by this research, although in times of multiple large-scale fires, demand can outstrip the availability of these units. Respondents rejected the idea to have geospatial capabilities located off-site from command centers, since opportunities for interaction with IC team members become limited, and the inefficiencies of traveling considerable distances (or even short distances) to field camps to deliver maps or other results constrain responsiveness to IC demands.

> *We tried to do GIS offsite at the local Ranger District or Forest. At times that can be up to two hours away, and that does not work.*
>
> *Like at Georgia, not an atypical case, the ICP was half a mile, I guess, from the admin. building, (and) the plotter was in the admin building. The GIS person needed to be located with the incident command team, with the team. And so you know to make a plot somebody hops in the car with a CD, runs down there, does it, runs back. I'm sure you guys see that all the time.*

Electronic capabilities at remote locations are far from ideal, but even when these capabilities are present, other networking limitation, such as agency technology "firewalls" prevent adequate sharing of data. Among the GIS technicians that were interviewed on fire events, they all hoped that there could be a shared electronic site, such as an FTP site, so that data could be easily shared and stored. This implies not only the setting up of the site, but also the day-to-day maintenance to keep a smooth information flow and protect the site from unwanted access.

> *What we need is something you could pass files to and back. And then someone's got to be watching to make sure that stuff, you know, immediately delete stuff that doesn't belong there.*
>
> *Somewhere outside, it needs to be interagency, anyway, … a site that is a fire site that is outside the firewall. You need really good administration on it because its going to be wide-open, so that you don't have people putting stuff on it that you don't want on there.*
>
> *We do not have good access to the web. Particularly when we first arrive on a fire. If I am lucky, I might have a 28.8 modem. Even if I have a 56K modem my phone lines are poor or I am on a satellite phone and I am only getting 12K. Sometimes the best I can do is get text messages out. You want geographic data. I need my DRG's.*

Quality information was identified by all respondents as critical during the early stages of a fire event. Yet the technical demands to prepare a setting to use electronic equipment and the accessories to make maps (such as a plotter) can cause delays in operational capability. Several respondents recognized the slow set-up of GIS equipment as an ongoing problem.

> *It is typical that we will get to an incident and camp location is pretty sketchy, and we're gearing up and it may not be that we get the tents or the construction buildings for a couple of days. So we found a lot of difficulty, idle time waiting until we got power or whatnot. And then, inevitably, we would move, move camp. In fact we did that a couple of times I think on … so that's a big disruption, your moving all your stuff and it's down time so this again eliminates that.*
>
> *So I get this big plotter that weighs 200 lbs. How do I get it into a rental car and get it out of there? Those are probably the biggest issues. Once I am here and set up, the operation becomes pretty smooth. It's those first days that can be frustrating.*

Respondents indicated that an infrastructure to apply GIS efficiently might involve a more integrated system that considers efficiencies of personnel, supplies, data access, and transportation. The timeliness of information provision is highly important to IC team members. The ability to create an organization with all the necessary tools to respond to a fire event might require a new, more highly mobilized infrastructure for geospatial data.

> *If we had an agency trailer or something that could provide that same kind of support then we would do that too. But I think, I think cost benefit is if we are going to use GIS, then we need to recognize the cost and bring in as much technology and support as we need right from the get go.*
>
> *(We need) availability of mobile GIS units that could come with data and analyze it. And I don't care whether they are agency people or contractors.*
>
> *As far as being able to mobilize people, and get plotters in place, and be able to roll in a very short period of time, I think that is one of the things that is really killing us right now, is just the lack of hardware and software to get as well as the people.*

Personnel Concerns Associated With Geospatial Support of Incident Management

Personnel issues are vital to address in understanding the application of GIS products. At present, both agency staff and contract specialists provide geospatial technical support for incident management, and during field visits research staff observed both contract and non-contract technical support operations. Even under situations where contract specialists are on-site, there is a great deal of interaction between GIS technicians and agency staff representatives on the IC teams. There was no attempt to evaluate the advantages and disadvantages of each type of support – the responses of agency and non-agency GIS technicians, at least on the surface, appear to be quite similar. Of more significance to this analysis are the issues raised by all respondents regarding the operational capacities of GIS technicians and the personal dynamics that emerge when GIS technicians are thrust into the demands of supporting wildfire incidents.

Nearly all people interviewed identified a need for GIS personnel on incidents to possess a working knowledge of wildland suppression operations. It is not enough to simply be a good technician because incident management raises a series of demands quite different from the duties of a GIS technician conducting more traditional land management analysis. Of key concern to respondents is the ability of a GIS person to understand the culture of fire suppression teams – to have the personality to fit into to an intensive, stressful incident environment that includes little sleep, camp-out conditions, and high-stakes, time-dependent work. GIS people do not necessarily fit this mold. On many units, the GIS person does another job.

> *I think one of the things that was causing quite a bit of confusion before I arrived was your normal GIS person doesn't understand fires. They don't understand the immediacy of getting something done in a particular time line; GIS isn't normally done in an immediate time line. It's really pushing the system of what GIS is. In a fire situation, you're practically drawing a map with GIS and then replacing it on a twelve-hour schedule, so it really stresses the system the way it works. ...If you don't have the familiarity with fire, ... what's needed, ...why it's needed, and how to draw things, ... then that gets really hard for a person, and [the situation is] really stressful because people are all of a sudden really angry because you don't have something done. Well, on the district you could take a week to do it, and here you have got six hours. It's really different.*
>
> *At the little 7,000-acre park we have in Colorado the archeologist and the paleontologist may be the person who does some GIS stuff, so they maybe will get roped in if something is going on. That's real typical.*

> *A lot of the times GIS technicians have never been on a fire at all and they are just thrown into this environment and it had its own problems, different things that need to be displayed that they haven't known about how to do. Ordinarily a really good GIS technician doesn't have to do this in their everyday job.*

Beyond a familiarity with information needs, and reporting time requirements, GIS technicians need to possess the capability to deal with demanding personal schedules. Attempts at reducing the work to rest requirements have some particular problems when applied to the demands of producing GIS product that support the needs of incident managers.

> *We are striving very hard to meet the work/rest rotation. And one person cannot work both ends of the day, so we are bringing some people on early and some are staying later. Right now we have got four GIS technicians.*
>
> *Because of the work/rest guidelines this finance group wants us to work five. I work from ten in the morning to two at night. Because I am making the maps. Normally I wouldn't do that. …and I don't get the intelligence until later and it takes a while to make these maps. You know if I had a GIS person I can Ok, here's the new, all the little points I can give it to them and go to bed.*

The problem of keeping the workload of GIS technicians to a reasonable level is further exacerbated by the national demand placed on critical resources during some wildfire years. Sometimes fire situations are so severe that personnel demands cannot be met. An example was given of a particular Type II fire, where the Situation Leader needed to double as the GIS staff and was not able to acquire any help. Thus, at the very time when the flexibility of GIS to respond to disparate fire situation is most in need, -- during peak fire fighting efforts -- may be the very time when resources are not sufficiently available.

> *This one I am doing a lot because I didn't get any help. …I haven't got out to the field on this fire near as much as I should have, but I haven't had any help. I can't get anybody. I have had orders for FOB's and GIST's since I got here, nothing. So, I finally got one FOB, then OPs steal him all the time.*

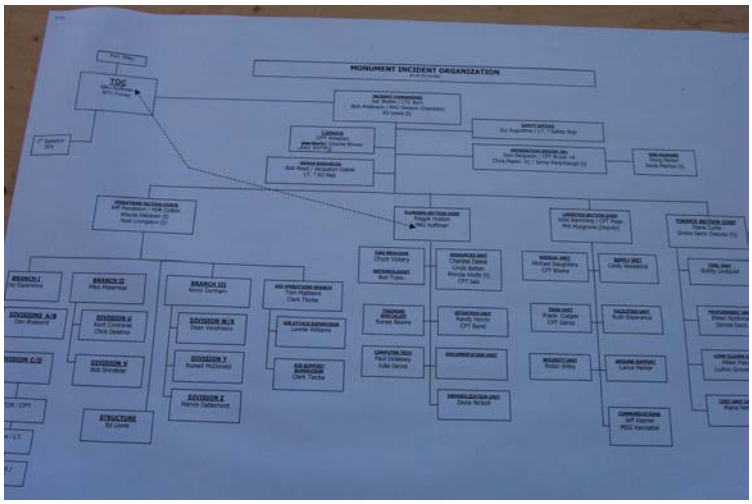
Moreover, there are institutional barriers to providing for a GIST as a permanent member of IC teams, namely, the set structure of the teams allows for a limited number of positions. Thus,

having a GIST fit onto a IC team means squeezing the person into an already full group of other specialists. To some, this might mean making room by removing another. This limitation is most apparent for the Type II teams.

> *Approximately 34 to 37 (on the Type II team). We bring equipment, time recorder, the same one all the time. And like the bigger radio operator and same one all the time. We bring three Ops chiefs, four division supe's., two resource unit leaders, and a status check in requirement. … it would be nice to have another GIS person so I don't have to be in here all the time and I can check the situation out a little more.*

Incident command staffs require that GIS products be produced in a timely fashion and designed in a way that conforms to standard symbology and map formats. There are certainly individual preferences of ICs and certain teams have developed specialized needs. Still the basic reporting and schedule for reporting is fairly predictable. On the GIST side, the lack of standardized training and the wide variety of backgrounds among these technicians can lead to frustration among IC staff and inefficiencies in meeting the demands placed on geospatial technology's contributions to incident management.

> *We need more consistency in when we bring in a GIST. What kind of training and background they are going to have? One of the worst experiences I ever had was two years ago when we were on a fire on BIA land. We were working out of the BLM office and it was all set up in ArcView. And we brought in a GIST who was a Forest Service employee who was highly trained and skilled in using ArcInfo but had never used ArcView at all. So we had somebody that was unfamiliar with the software. Nobody was familiar with the data; they were working in an office that had no relationship to the fire at all. It was a mess.*



Effective use of personnel is not only about building and sustaining skilled individuals; it also implies an organization that is structured to take advantage of human dynamics and a reasonable distribution of duties among team members. The creation of effective GIS products will require capable organizations that can utilize multiple talents of geospatial staff members. The composition and the size of the team might depend on the complexity of the incident, but especially where there are multiple demands, the synergistic effect of multiple geospatial skills may create not only greater efficiencies, but also original applications to solve problems.

Ideally what I like to do is bring in someone who can be a lead GIS specialist and let them handle the distribution of duties. Then we have got one person who focuses on our briefing map … someone else is taking on the progression map and keeping that up-to-date. Someone else is doing, we do an air operations map… having a lead GIS specialist helps a lot. I know a lot of the teams have created a GIS position on that team and that's what I would see that role doing.

I wouldn't expect a type III organization to bring in something like this but our fires seem like they are always (large), so we are going to need two or three GIS analysts every time. They learn a lot from each other. They talk and they trade off ideas, and if you bring in three, the total is more than the individual parts.

GPS training was mentioned as something that could have immediate benefits. The larger personnel question is building the capability of agency staff through on-the-job training. If agencies make decisions to utilize in-house staff as GIS technicians, field staff on fire incidents indicated that training programs would need to go well beyond the technical aspects of GIS programs. In particular there is a clear call for on the ground training that is practical and focused on the particular needs of incident support. Among the GIS technicians interviewed, several had prior experience in fire suppression in another capacity and believed that this experience helped them become better evaluators of what was necessary to supply to the IC teams.

It seemed like a lot of the people that have been on the same fires that I have, the GIS people had no idea what it was going to be like and you sort of have to train them. Well this is the terminology for fire to start with. And then here's how we make a map to produce whatever so and so wants. So I think more training needs to be done if we're going to continue [ordering people] from the agency or agencies.

I am probably doing more for fire now than I was as an engine foreman.

> *What I have tried to do then is during break is go talk to their boss and say,' is it ok if I identify them as the key contact for your group to be the GIS wizard?' And so, … if they say ok, which they typically do, I talk to the person, and if they're ok with it then I say so in front of everybody. You know, 'so and so is really catching on quickly, and I am going to give them all the manuals for these and they are going to take them home and read them tonight and by tomorrow they will know every answer to every question you could ever have about GPS". And I mean, it kind of puts a little load on them but then people have somebody they're comfortable with local to go get help. So they aren't you know, they're not that crazy about calling the Regional office with what sounds like a dumb question but to ask their buddy you know, that's next to them in the truck, that's pretty easy. And um, I have seen skills really spread quickly that way…You know and those skills come in fast. I'm sure you probably already heard this a zillion times, … I think some teams go to a place and think we'll have the local folks do the GIS. My experience is that almost never works. They have a real job, they have a real family, they have a boss just down the hall. It's harder for them to get 100% committed to the incident. And so, if your thinking in terms of well, should it be somebody that comes in with the team or should I, I think that's pretty clear. And maybe that's self-serving you know because I like going out with teams, but I think that's kind of true.*

Discussion

Responses from the field recognize the expanding potential for geospatial technology to serve as a useful tool for a series of significant functions in wildfire incident management. GIS applications provide high-quality maps that combine critical information layers in displays whose visual qualities aid decisions, field operations, and communications with the public. Maps generated through GIS can reveal with clarity and accuracy features important to fire managers, such as fire perimeters, topography, and locations of key infrastructure (roads, power lines, and water sources. Several respondents emphasized that the qualities of GIS maps enhance the safety of both flight crews and firefighters through a more clear understanding of landscape features, and the necessary investments in GIS are well worth the costs based solely on these improvements over traditional map products. When GIS is coupled with GPS, a greater accuracy and reliability is achieved in mapping fire perimeters and other key attributes of a fire environment (hot spots, cliffs, etc.). The capacity of geospatial technology to assemble and store information in electronic formats offers tremendous efficiencies for information transfer and archiving, such that data might be utilized for ongoing forest management actions.

Respondents within fire incidents repeatedly confirmed the flexibility of GIS and GPS applications, implying that the use of geospatial data in wildfire incidents is not an all-or-nothing proposition. Pieces of geospatial technology – GPS units or GIS mapping – may be incrementally adopted and tailored to relevant conditions and capabilities facing incident managers. Although evidence from the field points toward a certain economy of scale in the application of GIS products (the larger, Type I fire events are more prone to obtain and utilize GIS applications), several observations support the use of GIS on even smaller fire events. As the fire suppression environment becomes more complex and demands to protect structures in the urban interface increase, the utility of GIS products will likely increase to handle the multiple interests and constraints facing incident managers.

The findings strongly indicate that an efficient expression of geospatial technology to support wildfire incidents will require an integrated preparatory phase of investments that are substantially interdependent. The significant benefits of GIS technology on complex wildfire incidents cannot be realized without simultaneous attention to the development of high quality data, personnel, and

infrastructure. GIS will fail to meet growing expectations for its capabilities if any of the three legs of the stool of preparation are missing. As one Incident Commander succinctly expressed:

> *There's really three components to it. It's not just the data, its just not the people, and its just not the technology, its all three of them working together*

Evidence from interviews on the five incidents sampled reveal that this integrated preparatory phase has not been well-considered by the agencies that house fire suppression staffs. This does not imply that there aren't well-organized IC teams that have figured out how to get what they need from GIS – ordering the contracted trailer that comes fully loaded with the necessary data to produce maps quickly and efficiently. Yet if a primary goal of geospatial data applications is to produce maps for the IAP and crews involved in aviation or fire-fighting, then the performance revealed in the 2002 fire season is quite mixed. Depending on the incident observed, the current application of GIS on wildfire incidents could be criticized under an uncharitable view as an unorganized, ad-hoc experiment, plagued by questionably reliable or incompatible data streams, inadequate infrastructure, and marginally suited personnel. Too many respondents identified too many problems with GIS on fires to ignore the shortcomings of the current system.

There are no standards for GIS data acquisition among the many teams in the field in a given fire season. Respondents revealed a series of coping strategies to gather necessary data, and highlight the importance of acquiring data sources in advance of their assignments. There will clearly be conditions, however, where these experienced GIS technicians my not be available and the acquisition of quality data will be problematic. Under today's technological capabilities, with web-based access to data sources only a high-speed Internet connection away, there should be no need to place journeymen GIS technicians, on whom IC teams more commonly depend, in situations where they cannot easily and rapidly acquire high-quality data on a few basic features (topography, roads, and water) that might ultimately save the lives of firefighters.

It will not necessarily be the responsibility of fire suppression organizations to rationalize the wide array of data demands for natural resources management among the host of land management agencies. They can, however, advocate for the key data elements in a standardized format across all fire prone landscapes so that this data can be rapidly obtained in any remote location for incident management.

Although the long-term potential for GIS applications to support incidents appears bright, the research team did not observe the application of those data layers that would supply the intelligence necessary to make key decisions in advance of major commitments of suppression resources. An Area Commander's recognition that GIS's efficiency lies in its ability to make "initial decisions" on whether to control or contain a fire has yet to be applied. This circumstance presents a major challenge to researchers, planners, and IC professionals to test emerging products that estimate forest fuel loadings and fire spread rates to evaluate whether they can estimate with sufficient confidence potential fire behaviors. This type of information appears to remain out of reach to decision-makers, even though its use might offer the greatest potential to justify the substantial investments involved in widespread adoption of geospatial technologies.

The capacity of GIS to provide a rapid cartographic service is well demonstrated in these findings. Even though there are demonstrated risks in depending on GIS for the production of necessary maps for fire operations (connecting to power, failures of equipment, etc.), when infrastructure, data, and personnel imperatives are addressed, the system seems to work well. However, it remains unclear whether this map-making function will remain the central, overriding focus for geospatial applications. There might be other technological forms or data applications that are more efficient, less expensive, and more flexible in producing maps than current and future product lines within the umbrella of GIS. Further, it may be argued that the full capacity of GIS is hardly utilized in fire management, for the ability to of GIS to characterize landscape conditions and apply time-series analyses could support different fire and fuel management strategies than currently applied. Already field personnel are experimenting with new tools and geospatial applications to find hot spots and utilize personnel more efficiently, yet a strategic vision for the use of geospatial technologies on fire incidents was not apparent to the research team.

The advantages of GIS products have been recognized sufficiently by IC leadership to the degree that all respondents confirm the institutionalization of GIS as part of the fire suppression tool box, and there no expectation to retreat from GIS applications in the future. Since geospatial technologies already contribute substantially to incident management, the most important questions facing planners and policy makers revolve around the levels of commitment and coordination that will be afforded to geospatial applications. It seems logical that these questions will consider both the short and long- term use of these technologies for fire suppression, as well as the potential applications of geospatial information for the management of forest resources beyond the incidence of fire.

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Appendix 1 – Project Information Handout

INVESTIGATION OF GEOSPATIAL SUPPORT OF INCIDENT MANAGEMENT

Project Investigators

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David DelSordo, NPS GTG

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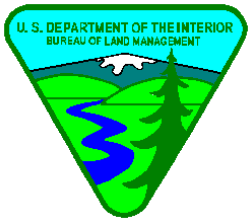

PROJECT SUMMARY
INVESTIGATION OF GEOSPATIAL SUPPORT OF INCIDENT MANAGEMENT

June 25, 2002

Purpose

The Geospatial Task Group (GTG) within the Information Resource Management (IRM) working team of the National Wildfire Coordinating Group (NWCG) will work with the National Center for Landscape Fire Analysis (Fire Center) at the University of Montana to identify economic and efficient uses of geospatial technologies among the business areas within the incident management community during active fire assignments. This research project will provide greater understanding to incident managers and resource professionals in the following areas:

- Geospatial skills and abilities needed to support incident operations of various sizes and severities;
- Preparation, planning, and organization necessary to effectively apply geospatial technologies during incidents;
- Infrastructure, such as software, hardware, and product support, necessary to support incident operations; and
- Utility of geospatial products in providing timely and effective intelligence to support incident decision-making.

Approach

The investigation will consist of two phases: an exploratory phase conducted during the fire season of 2002, and a quantitative survey phase administered in late 2002 through 2003. The exploratory phase will develop working hypotheses on the antecedent conditions, utility, and barriers to the application of geospatial products, based on direct observations by members of the research team of a range of fire incidents in the summer of 2002. These hypotheses will be tested in the survey phase of the research through a methodologically rigorous sampling strategy that covers the spectrum of fire management professionals working in the western United States.

During the exploratory phase, team members composed of both federal agency representatives and Fire Center researchers will visit fire incidents to observe the use of geospatial technologies and conduct on-site interviews with geospatial technicians and other relevant decision-makers on these fire events. At least two observations will be made at each of the following types of fire incidents: Type I (large fire); wildland fire use; Type 2 or Type 3; Area Command; wilderness; rangeland; and fires in California.

Expected Outcomes

By the end of October 2002, there will be a report on the exploratory phase of the project. This report will summarize the results from all observations and generate a series of hypotheses about the effectiveness of geospatial technology across different incident types. In addition, this report will provide the following:

- A task analysis for GIS technicians working at the various types of incidents;
- An analysis of costs and benefits of the application of geospatial technologies across fire incidents;
- Efficiencies gained in fire mapping and intelligence gathering on fire events
- Analysis of the effectiveness of geospatial technologies based on the scale and complexity of fire events;
- An analysis to the barriers to the use of geospatial technologies and the changes necessary to overcome these barriers;
- Staffing needs and preparation necessary to apply geospatial technology across incidents;
- Analysis of supervisory and coordination needs for the management of various forms of geospatial technology; and
- A summary of the current and potential future priorities for the more widespread use of geospatial technologies.

Personnel

The following individuals will be responsible for the administration of the investigation:

Dr. Lloyd Queen, Director, National Center for Landscape Fire Analysis, University of Montana

Joe Frost, USDA Forest Service, GTG

David DelSordo, National Park Service, GTG

Dorothy Albright, USDA Forest Service, GTG

Dr. James Burchfield, Director, Bolle Center for People and Forests, University of Montana

Dr. Theron Miller, Research Director, Bolle Center for People and Forests, University of Montana

Appendix 2 – Project Framework for Discusions

EXPLORATORY RESEARCH PROTOCOL

INVESTIGATION OF GEOSPATIAL SUPPORT OF INCIDENT MANAGEMENT

June 25, 2002

The following open-ended questions provide an initial framework for the inquiry into the use of geospatial technology in fire incidents:

FOR GIS TECHNICIANS

- What type of training have you received in geospatial technologies?
- What level of experience do you have supporting fire incidents as a GIS technician?
- What type of geospatial products do you generate?
- Who provides oversight for your work?
- What is your assessment of the quality of the data products you produce?
- What are the communication channels that you use for delivering the information that you produce?
- What are the barriers that you see for generating GIS products?
- What seems to work well in your work?
- How receptive would you say your superiors are to the work you produce?
- If you could change one thing about your work situation, what would it be?

FOR DECISION MAKERS

- How do you use geospatial products in your work?
- How do you receive geospatial information?
- How would you assess the timeliness of geospatial information?
- What do you do differently because of GIS information?
- How would you assess the completeness of geospatial information? The accuracy?
- What about GIS information do you find unclear?
- What particular piece of information is most important to you on a fire? How do you get that information?
- What pieces of information would you like, but are unable to receive?
- Based on all the information available to you on a fire, how would you rate the relative value of geospatial information? Why?
- What barriers are there to you receiving geospatial information?
- If you could change one thing about the information that you receive to make decisions, what would it be?

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