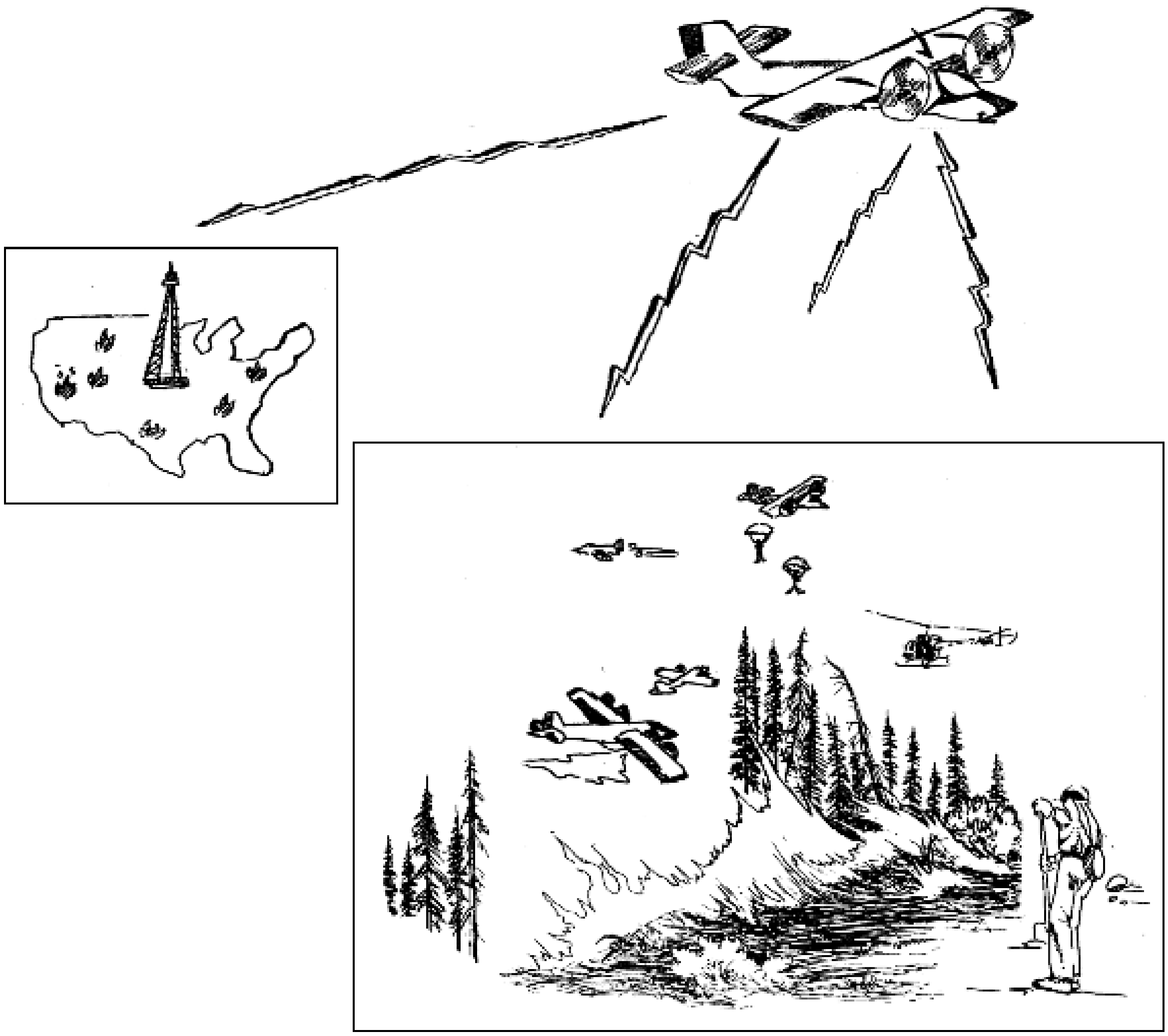
National Study of Tactical Aerial Resource Management to Support Initial Attack and Large Fire Suppression

Final Committee Report
October, 1998



USDA Forest Service
Department of Interior
Bureau of Land Management

A special thanks is sent to Scott Vail, Fire Staff on the Eldorado National Forest, who provided the ideas and artwork for the report cover.

NATIONAL STUDY OF TACTICAL AERIAL RESOURCE MANAGEMENT TO SUPPORT INITIAL ATTACK AND LARGE FIRE SUPPRESSION

Final Committee Report
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USDA FOREST SERVICE
DEPARTMENT OF INTERIOR

Table of Contents

Table of Contents

Table of Contents

Table of Contents

APPENDICES

AVIATION MANAGEMENT TRIANGLE

The Aviation Management Triangle reflects the essential elements of sound, professional aviation management. Aviation management is a service function. Our objective is to provide safe, cost effective, and appropriate aviation services.

The foundation of aviation management is SAFETY. If the mission cannot be accomplished without compromising safety, say NO! Insure an acceptable level of risk through sound risk management.

Strive for COST EFFECTIVE aircraft use. Question requests that are not cost effective - explain why and recommend a better alternative.

Use the RIGHT tool (aircraft) for the job. Question requests to the contrary - explain why and recommend a better way. Do what's right!

ACKNOWLEDGMENTS

To accomplish the analysis work necessary, a large number of people graciously gave significant amounts of time and expertise. The professionalism and dedication of the personnel who responded to the surveys from the committee provided a clear view of issues and potential solutions. The cooperation of the National Aeronautics and Space Administration (NASA) in providing personnel and support was invaluable. All the individuals connected with the National Aerial Firefighting Safety and Efficiency (NAFSE) Project provided valued support and information. Jon Little contribution to the summarizing of Field Survey and his professional guidance and support of the NAFSE project were invaluable. The committee would like to express special thanks AGAIN to Doug Ford and Brian Booher for their dedication to excellence, modeling expertise and commitment to continually search for solutions. The study committee wishes to say THANKS as you are the real heros who deserve the highest level appreciation for your patience, determination and pursuit of excellence.

EXECUTIVE SUMMARY
NATIONAL TACTICAL AERIAL
RESOURCE MANAGEMENT STUDY

THE TARMS STUDY

Aerial supervision in many agencies consists of tactical advice and direction provided by a Leadplane Pilot and/or Air Tactical Group Supervisor (ATGS). Both these programs and positions evolved to meet the need for better control and standardization of aerial firefighting operations, with the ultimate goal of better meeting fire program objectives.

The current aerial firefighting organization structure, personnel, and airframe systems have evolved over time to support ground firefighting efforts. The operating techniques and procedures for both the leadplane and air tactical group supervisor function and operation were predominantly developed during actual fire conditions by Leadplane Pilots and Air Tactical Group Supervisors working in the environment with ground supervisory personnel. The approach was and continues to be an evolutionary process rather than a fully-planned and implemented "systems" approach to aerial firefighting.

The systems and organization currently employed to meet aerial firefighting supervision objectives continue to be stretched to the limits by a number of factors:

- The effects of competition for dollars within budgets as aircraft and personnel costs continue to rise.
- Retirements, competition for pilots with the private sector and general reduction in personnel ceilings with a constant to increasing workload have effected both the air tactical and leadplane programs. The ability to train and qualify replacement leadplane pilots and air tactical supervisors in a timely enough manner has been difficult and in some cases not possible.
- Successive intense fire seasons over the past decade.
- Changes in land use trends and demographics, which are less agrarian and more urban require aerial firefighters to perform in close proximity to populated urban interface areas where air traffic density can severely reduce operating efficiency and pose additional safety hazards. This situation appears to be increasingly throughout the country.

Regardless of location, urban or wildland, the aerial firefighting job today is characterized by an increasing workload and complexity, particularly in the procedural and communications requirements. This situation affects fatigue levels, productivity and decision-making processes where the potential exists for accidents and incidents.

The study methodology will display the current program structure and components, focusing on the assets and liabilities. Retention of what is working well is most certainly a goal. That goal will coincide with recommendations on organization, technology, and aircraft systems to support fire management objectives in the future. The study offers the firefighting agencies the opportunity to step back and take a structured, systems approach to addressing present and future issues and problems related to aerial firefighting operations.

THE STUDY CHARTER

The full test of the Study Charter is contained in Appendix A.

Vision

Tactical Aerial Resource Management Study shall provide managers with information, guidance and support for National and Geographic Area decisions affecting the National Leadplane, Air Tactical Group Supervisor and Helicopter Coordinator programs.

Mission

The Tactical Aerial Resource Management Study shall determine the most appropriate organization, staffing and aerial platforms necessary to safely and cost effectively manage and direct aerial fire suppression resources. Support and interrelationships to fire suppression will be obtained and evaluated. The outcome of Phase 2 of the National Airtanker Study (NATS2) and other relevant projects will be important considerations as well.

Goals/Objectives

The goal of the Tactical Aerial Resource Management Study is to identify the best way or alternative ways to manage and direct aerial suppression resources, to determine preferred platforms and to make recommendations for improvement. It will be necessary to properly consider and evaluate the aerial supervision management roles, missions and platforms.

Guiding Principles (Assumptions) Used In The Study

The Tactical Aerial Resource Management Study shall be conducted interagency in scope with committee representation from the USDA-Forest Service, USDI-Bureau of Land Management and the States. Coordination with local State wildfire suppression agencies, USDI-National Park Service, Bureau of Indian Affairs, Fish and Wildlife Service and Office of Aircraft Services shall be through the geographic area representatives. The initiative for this study is a USDA-Forest Service effort to provide guidance for the timely replacement of their leadplane fleet.

Conventional decision analysis and problem solving techniques, supported as needed by routine computer software programs, will be utilized. There should be no major software development or application required. Options for aircraft acquisition will not be a part of this study and should not be a consideration during this process.

Traditional methods of operation shall be examined and challenged where appropriate.

Benchmarks and time frames for the study were developed as well as a study communications plan. The plan defined actions to convey study progress and status to effected groups.

Recommendations And The Product Expected

At the completion of this study, a written report will be prepared addressing the following:

A. Identification of aerial supervision missions and tasks such as:

   1. Required communications.
   2. Fire intelligence and tactical advice.
   3. Airtanker coordination and direction.
   4. Helicopter coordination and direction.
   5. Overall aircraft/airspace management.
   6. Requirements of urban interface versus wildfire incidents.
   7. Identify training requirements to facilitate accomplishment of the missions and tasks.
   8. Potential uses of human aiding technology.

B. Identify and evaluate alternative organizations and staffing to accomplish missions and tasks. Identify roles and responsibilities of the staff.

C. Identify and evaluate alternative aerial platforms to perform or support the roles identified above. This will include recommendations for the number of, type and locations of these resources.

The Timeline

A completion date of December, 1997, was desired. The Draft Report will be completed by April, 1998.

Summary of Organizational Options Analyzed

Ten Organizational Options were developed to respond to problems and issues defined in the TARMS User Survey, to respond to the Task Workload rating for the current aerial supervision structure and to respond to concerns and opportunities developed by the study committee. Organizational Option 1-5 represent the current organizational structures used in aerial supervision. Organizational Option 6-9 are developed to examine the effects of workload on different configurations of the ASM Concept. Organizational Option 10 has no aerial supervision present. Alternatives 2 and 8 as well as a combination of Alternatives 4 and 5 are appropriate for Large Fire Suppression. It is assumed that the personnel within each organizational option can be either contract or government employees unless regulations prohibited either. For purposes of the workload analysis to evaluate the options, it was assumed that both individuals would receive equivalent training and knowledge.

Organizational Options 1 and 2

Both Organizational Options 1 and 2 staff the ATGS and leadplane roles in separate aircraft. In the leadplane aircraft, the leadplane pilot is performing the current roles and responsibilities of the leadplane function. In the ATGS aircraft, there is the ATGS performing the current roles and responsibilities of the ATGS. The difference between Organizational Options 1 and 2 is the experience level of the ATGS aircraft pilot.

In Organizational Option 1, the ATGS aircraft pilot is ‘inexperienced” in the performance of the support role to the ATGS. The ATGS aircraft pilot, though fully qualified to fly the aircraft, lacks training and experience in the tasks where he/she could assist the Air Tactical Group Supervisor in the performance of his/her job. In this Organizational Option, there are two aircraft and three people involved in the aerial supervision jobs defined.

In Organizational Option 2, the ATGS aircraft pilot has the training and experience that allows he/she to assist the ATGS in the performance of his/her tasks. In this Organizational Option, there are two aircraft and three people involved in the aerial supervision jobs defined.

<u>Organizational Options 3 and 4</u>
Organizational Option 3, the ATGS aircraft is staffed with an ATGS and an inexperienced ATGS aircraft pilot and there is no leadplane present. Organizational Option 4, the ATGS aircraft is staffed with an ATGS and an experienced ATGS aircraft pilot and there is no leadplane present. The absence of the leadplane is the difference between these two Options and Options 1 and 2. In these Organizational Options, there is one aircraft and two people involved in the aerial supervision job defined

<u>Organizational Option 5</u>
In this Organizational Option, the ATGS aircraft is not present but the leadplane aircraft In this Organizational Option, there is one aircraft and one person involved in the aerial supervision job defined.

<u>Organizational Option 6</u>
In this Organizational Option, there is one person in one aircraft performing the Aerial Tactical Pilot (ATP) and Airborne Suppression Supervisor (ABSS) positions.

<u>Organizational Option 7</u>
In this Organizational Option, there is one person in one aircraft performing the Aerial Tactical Pilot (ATP) and Air Tactical Group Supervisor (ATGS) positions. This Organizational Option differs from Organizational Option 6 in the lack of ground firefighting duties for the ATGS that the ABSS has in Organizational Option 6.

<u>Organizational Option 8</u>
In this Organizational Option, there is two people in one aircraft performing the Aerial Tactical Pilot (ATP) and Air Tactical Group Supervisor (ATGS) positions. This Organizational Option differs from Organizational Option 7 in that two people are performing the duties of the ATP and ATGS.

<u>Organizational Option 9</u>
In this Organizational Option, there are two people in one aircraft performing the Aerial Tactical Pilot (ATP) and Airborne Suppression Supervisor (ABSS) positions.

<u>Organizational Option 10</u>
This option represents “no aerial supervision present.”

Table ES-1 - Organizational Options							
	Air Tactical		**Lead**	**Aerial Supervision Module (ASM)**			
Option	**ATGS**	**ATGS Pilot**	**Lead-Plane Pilot**	**Air Tactical Pilot**	**Airborne Suppression Supervisor**	**No. of Persons**	**No. of Aircraft**
1	Yes	Inexper	Yes			3	2
2	Yes	Exper	Yes			3	2
3	Yes	Inexper				2	1
4	Yes	Exper				2	1
5			Yes			1	1
6		Yes				1	1
7	Yes					1	1
8	Yes		Yes			2	1
9			Yes		Yes	2	1
10	No Aerial Supervision						

Summary of Human-aiding Technology Options

Table ES-2 summarizes the Human-aiding Technology Options.

Table ES-2 - Human-aiding Technology Options

Option	Functionality	Costs/Unit	Availability
1	Current Situation	-----	-----
2	- Moving map - Display of traffic information - Target ID and display - Display of airspace structure - Hazard display - Display of fire scene info. - Air-air and air-ground data link	Each aircraft unit is estimated at $35,000.	Further development and testing needed. Hardware is available and software is public domain.
3	Option 2 plus FLIR (enhances visual range for heat)	HAT Option 2 costs plus $50,000-$90,000 for FLIR	Analysis and development needed
4	Option 3 plus TCAS (enhances collision avoidance)	HAT Option 3 costs + Unknown amount but should be less than cost of independent TCAS	Industry says can be done; not available at this time. Analysis and development needed
5	FLIR and/or TCAS independently	FLIR: $50,000 -$90,000; TCAS: $35,000	Available currently
6	– Complete information distribution system and Long-range flight following and ground/air datalink	Unknown	Analysis and development needed.

Summary of Aircraft Evaluation Process and Evaluation Criteria
An initial aircraft evaluation process was developed and tested to screen aircraft. For the evaluation of aircraft, two types of evaluation criteria were developed, "Must Have" and "Ranking" criteria. “Must Have” criteria, as the name implies, are those criteria that provide a screening process for the candidate aircraft. The potential aircraft were required to have these attributes before being able to be considered for further evaluation. Ranking criteria are those criteria where the performance or capabilities of the aircraft can be compared allowing for a ranking of the aircraft as to the ones that best meet the ranking evaluation criteria Ranked criteria were divided into four categories as follows: Specific Mission Requirements, Aircraft Performance, Ergonomics, and Cost. To standardize the evaluation of performance, parameters such as power settings, density altitude and aircraft configurations were identified.

To test the criteria developed in this study for evaluating potential aircraft as aerial surveillance platforms, multiple sources were consulted to develop a listing of aircraft for consideration. Appendix B contains a complete list of the aircraft contained in this test as well as their disposition from the Must Have criteria. Four aircraft which met all “Must Have” criteria where evaluated using the Ranking Criteria. In addition, the OV-10A was evaluated using the Ranking Criteria even though it did not meet all “Must Have” criteria. The OV-10A has evaluated since it is the most current leadplane aircraft used by the BLM and hence it serves as a benchmark.

Additionally, a flying evaluation was performed to simulate the missions of both the ATGS and Leadplane pilot including observation of a following aircraft. The evaluators completed a subjective evaluation form based on a modification of the Cooper-Harper Aircraft-Handling Characteristics Scale, 1969, that documented their observations. In scoring this criteria, both measures were averaged together. Appendix E contains the flight evaluation forms and the associated flight cards for all of the flight evaluation portions.

Recommendations to Address the Goals and Objectives
Recommndations are grouped in the following categories:

- General Recommendations
- Aerial Supervision Organization Recommendations
- Human-aiding Technology Recommendations
- Aircraft Recommendations
- National Shared Forces Studies Recommendation

The recommendations were generated to address characteristics and issues within the leadplane and ATGS programs where changes could enhance performance and efficiency. These changes are in the areas of management and operations, communications, personnel, aircraft resource management, airspace coordination, safety and organization. The following recommendations are made to support (1) the determination of the best <u>aerial</u> firefighting structure and organization to direct and manage fire suppression resources; 2) the identification of the best aviation platform that will support that organization; 3) the identification of components of human-aiding technology that will best support the organization in the identified platform; and (4) training that will effectively implement (1) through (3).

The preferred organization, platform, and technology will perform in the wildland fire environment by meeting task criteria for the identified aerial firefighting missions and operations. All recommendations are based on safety, efficiency, and effectiveness selection criteria.

General Recommendations

1. The Committee recommends the establishment of an Implementation Team to oversee implementation of recommendations. This team will provide coordination and direction to Subject Area Groups developing implementation plans for Organizational, Human-Aiding Technology and Aircraft recommendations. The Implementation Team should provide benefit/cost analysis where necessary. Provide a group and charter by 10/01/98 to implement Recommendations 2-19.

2. The Committee recommends that known and proven training protocols be used in order to accomplish the training objectives. The National Aerial Firefighter Academy's (NAFA) approach is advocated and its expansion encouraged. The Committee recommends immersed simulation training for aerial supervisors supplemented by traditional classroom instruction. The committee supports cooperative efforts between the NWCG Training Working Team, the NAFA cadre, NASA and industry to accomplish these goals. This committee's members are willing to assist in any way possible to create a training curriculum to meet the needs of new or existing positions.

Aerial Supervision Organization Recommendations

3. The Committee recommends implementation of Organizational Option 8. (Aerial Supervision Module with an Air Tactical Group Supervisor and Air Tactical Pilot). The committee recommends no changes in the Helicopter Coordinator and Airtanker Coordinator positions.

   The Aerial Supervision Module (ASM) with an Air Tactical Group Supervisor and Air Tactical Pilot is the result of the recognition that if a person with extensive fire management training and experience is teamed with a person with extensive aviation/flight training and experience in the same aircraft, specific benefits can be realized. Training can be accomplished quickly because each individual is working within a domain in which they have an extensive background. Efficiencies are realized for most fires in the initial and extended attack mode because the mission can be accomplished with fewer aircraft on scene.

   In this configuration, the aviation and fire experts arrive at the same time on the wildland fire allowing for concurrent development of the size up, the strategy and tactics and the joint risk assessment. This should lead to a more efficient operation with a greater attention to safety and detail.

   Crew member fatigue can be minimized by operating as a Team. For fires that require two modules for supervision, modules can be switched periodically to rest the flight crew carrying the greatest workload. Frequency congestion can be reduced because the Leadplane/Air Tactical dialog will be accomplished with normal voice communication within the aircraft or via intercom communication. Either way, those communications occur within the module and do not utilize fire frequencies.

4. The Committee recommends for Initial Attack/Extended Attack, the staffing of 41 Aerial Supervision Modules (ASM). Forty-one represents the total number that are recommended for the California, Great Basin, Northern and Northwest Geographic Areas. The fire seasons with these Geographic Areas frequently coincide. This staffing is designed to fulfill the aerial supervision needs for Initial Attack and Extended. These modules would be mobile nationally and respond to staffing needs within all Geographic Areas.

   Table 16 displays the recommended number of ASM modules to federally staff within each geographic area during fire season. Also displayed in Table 16 are four columns from Table 14 containing data on the expected average and maximum of ATGS and leadplane dispatches during the highest fire occurrence periods (EpiDays). These numbers should be reviewed and adjusted during the implementation phase. This recommendation is based on analysis from the NFMAS data base, analysis of the character and frequency of episodes by geographic area and the professional judgement by the committee and management personnel in each Geographic Area.

Table ES-3 - Number Of ASM Modules To Staff Within Each Geographic Area

		Air Attack Dispatches per EpiDay		Air Attack Dispatches per EpiDay	
	Number of ASMs	Average	Maximum	Average	Maximum
Alaska	3	N/A	N/A	N/A	N/A
California	12	29	282	7-17	92-182
Eastern	5	N/A	N/A	N/A	N/A
Great Basin	12	23	205	6-11	60–115
Northern	8	16	129	2-5	21-45
Northwest	9	25	165	4-10	32-88
Rocky Mt.	4	2	19	3-10	24-58
Southern	7	N/A	N/A	N/A	N/A
Southwest	8	12	76	4-8	30-53
N/A Indicates Data Not Available At This Time					

Use of analysis from the NFMAS database and episodes provides a conservative estimate of the number of ASM modules that should be staffed. As was noted in the section on episodes and as shown in Table 14, the staffing of the "dispatch workload peaks" during fire occurrence episodes is critical. It is during these episodes that firefighter safety has the greatest potential to be compromised when the likelihood of extended attack and large fire suppression will occur. Mobility of ASM aircraft and modules between geographic areas assists in supplying aerial supervision resources during these peak demand periods.

5. The Committee recommends the establishment of a Subject Matter Expert Group to implement the Aerial Supervision Module organization. Key components are: Staffing, Training, Human Factors, Standard Operating Procedures, and Qualifications.
6. The Committee recommends Crew Resource Management training as necessary to realize the added safety margin envisioned with the "module" concept. This crew training will be further enhanced with the development of a immersed simulator based training. Immersed simulation training will provide training advantages in terms of expanding repertoires, establishing and maintaining standards, and to provide training for situations too dangerous to do “live". To maintain consistency, this training needs to be accomplished by a dedicated training cadre.

   Instruction on components of the task of leading fixed wing airtankers should be considered for any aerial supervision position with the responsibility for the dropping of retardant from fixed wing airtankers. Not all candidates will be military trained so classes in theory and mechanics of “proximity” flight, performance and operational information about each different airtanker, low level instructional information, and human factors instructional information should also be considered as part of the aviators necessary training curriculum.

7. The Committee recommends the role of Airborne Suppression Supervisor (ABSS) versus the role of Air Tactical Group Supervisor (ATGS) be referred to NWCG for further review and evaluation.

8. The Committee recommends that ASM modules be additional resources available to Incident Management Teams.

   In examining the requirements for large fire aerial supervision, three roles emerged; 1) the role of the Incident Management Team’s (IMT) ATGS; 2) the role of the ASM; and 3) the traditional role of the leadplane. The mix of using these roles depends on the complexity, size of the fire and other factors. In very complex terrain or on large or complex fires, the IMT’s ATGS could assign divisions of the fire to one or more ASM’s. Alternately, for less complex fires where the IMT’s ATGS has responsibility for all divisions, the ASM or leadplane can fill the role of a leadplane to aid in the dropping of retardant from fixed wing airtankers.

9. The Committee recommends a cadre of "call-when-needed" Air Tactical Group Supervisors be maintained and certified to operate in the ASM environment.

Human-Aiding Technology Recommendations
In the implementation of Recommendations 10-13, human-aiding technology tools should be functionally integrated and cross-linked. For all factors of cost, training, and human factors, it is highly advantageous to have only one "black box" on the flight deck rather than two or three. The functionality of FLIR, aircraft position reporting, TCAS, and air-to-air and air-to-ground data link can be effectively and economically integrated into one on-board system and display. To determine the true impact of these technologies on the users though, a formal task analysis should be conducted, and the human-aiding technology should be installed and tested on a limited basis prior to installation in the fleet.
Collectively, Recommendations 10-13 provide for an integrated systems approach to hardware, software, and the human-machine interfaces.

Through the implementation of these human-aiding technology recommendations, wildland fire management can be facilitated by better real time information provided by technology. Identification of known flight and ground hazards will be consistent and real time. Increased hazard awareness and a safer environment will result. Critical fire intelligence will be real time. The potential exists for aerial supervision and ground based personnel to have the same information for deployment of ground and air resources. Information provided will have improved accuracy, provide for a safer fire environment for firefighters, will aid in more effective use of retardant and water drops and will enhance resource utilization. A major benefit will be a significant reduction of voice radio transmissions allowing more efficient use of existing radio frequencies. The real benefit in implementing these recommendations will be more reliable information provided in a timely fashion to support the decision-making process, resulting in an increase in safety and efficiency.

10. The Committee recommends the technology defined in HAT Option 2 be installed on all exclusive-use contract helicopters and airtankers and On-Call contract ASM aircraft.

11. The Committee recommends the technology defined in HAT Option 2 be available in a portable configuration for quick installation on any aircraft.

12. The Committee recommends the technology defined in HAT Option 4 (HAT Option 2 plus TCAS and FLIR) be installed on all ASM aircraft.

13. The Committee recommends the implementation of automated flight following by dispatch and coordination centers in a manner that will be consistent and integrated with HAT systems. The potential to furnish the entire array of HAT products (fire scene information, FLIR, etc.) to the ground and remote locations such as dispatch centers will be examined.

14. The Committee recommends that consideration should be given, as soon as the software/hardware defined in HAT Option 2 is mature, to including this technology requirement in CWN/BOA/rental agreements.

15. The Committee recommends that previous aerial firefighting and other-domain research and testing on hardware/software interfaces, human-machine relationships, installations, and developed communications protocols be utilized. Immediate opportunities exist for a partnership among agency Equipment and Development Centers, agency telecommunications personnel, academia, NASA, FAA, and private industry.

Aircraft Recommendations

16. The Committee recommends the procurement of an aircraft that supports the full potential of ASM.

    The evaluation process included the development of criteria and their associated importance (weighting) before identification of aircraft or any systematic re-evaluation of ground rules. All criteria are rooted in the characteristics needed to support the aerial supervision mission and role of the aircraft. The acquisition process should consider the characteristics of the benchmark aircraft as specified in this study.

17. The Committee recommends that 41 aircraft be procured to support the national ASM organization. Implementation processes should determine additional needs for spare aircraft and an adequate parts supply source.

    The procurement of a single aircraft type is most desirable. The history in both the Forest Service and BLM has shown that operational impacts are negligible or non-existent using a single aircraft. Also, the cost savings of training, maintenance, and operations far out weigh any minor impacts.

18. The Committee recommends the establishment of a Supplemental National fleet of aircraft for ATGS support to large fire and overload situations that occur under fire occurrence episodal conditions. These aircraft can be On-Call contract or agency owned, and must have an appropriate mix of fixed and rotor wing. The appropriate number for this fleet will be determined during implementation.

    These aircraft will support the aerial supervision requirements of large fires being managed by an Incident Management Team as well as to provide aircraft to support workload overload situations. This National program will provide support for management of large fires and multiple fire occurrence episodes with appropriate resources and preparedness.

19. The Committee recommends for large fire and specific local areas, that rotor wing aircraft are acceptable platforms for either ASM, ATGS or traditional HLCO roles.

    The need for speed is based on the national mobility concept for the fleet to support initial and extended attack. However, in considering large fire support and some local geographically dense areas, speed is not as important. In large fire support, there is ability to adequately plan and execute to achieve the most effective and efficient operation. Also in some local geographic areas, the historical record shows a average dispatch distance of less than 50 miles. At this short distance, the difference in arrival times to the fire between slow and fast aircraft does not make much difference.

National Shared Forces Studies Recommendation

The National Study of Type I and II Helicopters To Support Large Fire Suppression recommended the staffing of Type I and Type II helicopters with management modules to provide support to large fire suppression. The Type II component of this recommendation is currently being staffed and is noted in the following diagram as “7 Nat Eff Heli” or seven national efficiency helicopters.

The National (Large) Airtanker Study, Phase 1, recommended staffing 38 large airtankers to support initial and extended attack of wildland fires. Information presented in the study documented a need for three additional airtankers to “swell” the total fleet based on the demand to support large fire suppression.

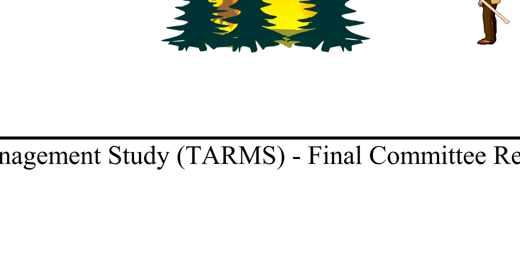
```
       |<----------IA/EA-------->|<---------Large Fire Suppression---------->|
       |<--Ag./Coop.-->|<--Pvt.->|<----Ag./Coop.---->|<--Pvt.-->|<---Mil.--->|
Eff.
Helis. |<----Forest Analysis---->|<-7 Nat Eff Heli-->|<--Pvt.-->|<---Mil.--->|
Study

NATS   |<--38 Large Airtankers-->|<--3 Added/NATS2-->|<--Pvt.-->|<---MAFFS-->|
Studies
                                 |<-----------LP/ASM for Lead--------------->|
TARMS  |<-------41 ASM's-------->|<-- ATGS-CWN A/C-->|<-ATGS/CWN or Mil A/C->|
```

The use of the military and call-when-aircraft from other sources when demand reaches a very high percentile of supply was not considered but information on when use can be expected is displayed. It is recognized that other resources are needed when private vendor sources for large airtankers are fully committed. Use of the military is an integral part of the total airtanker support during these events.

20. The Committee recommends that study goals and processes based on the National Shared Forces Task Force Report be acknowledged as a continuing model for future studies. The process, which defines a clear Charter implemented by a highly qualified and motivated team supported both through leadership and budget, has provided quality analysis and reports yielding tangible results in policy and in the field on wildland fires.

A Risk Mitigation Strategy For Organizational and Human-aiding Technology Recommendations is described with the report.



NATIONAL TACTICAL AERIAL
RESOURCE MANAGEMENT STUDY

PREFACE

As one reads this report, the study committee suggests the reader's view remain strategic. Be open to different ideas and to change. Ask yourself the questions:

> "How should aerial supervision over wildland fires be structured and perform for the next 20 years?"
>
> “What should aerial platforms and organizations look like in the year 2020?”

Release yourself from the current situation and your ownership of today’s firefighting operational policies and procedures. The Committee was tasked to do its job without sideboards. Hence, review the report without the sideboards of either past or current situations. Review the analyses and decision processes utilized in this report and the recommendations with vision.

Scientific data collection and analysis methodologies as well as professional expertise and judgment were used to support the recommendations found in this report. The committee and others have spent thousands of hours developing the data and concepts that may appear on a single sheet of paper within this report. This work has definitely advanced our knowledge base and our cooperation with other agencies and industry. Some of this knowledge and expertise has already been used to save money and support other studies and management-related decisions.

The history of the development of aerial firefighting systems, procedures, and organizational structure has been one of an evolutionary approach taken unilaterally by various segments of the aerial firefighting organizations, rather than a fully-planned, integrated, and implemented approach. For this study effort, new methodologies and evaluation processes relating to workload of aerial supervisors (leadplane and ATGS), organizational structure, technology, and aircraft have been developed to achieve what the Committee feels is the integration that is necessary to achieve maximum safety, efficiency, and effectiveness. Use of these methodologies and processes during the procurement and implementation phases will be valuable.

Operational and economic efficiency across state, agency, and geographic area boundaries was also a major goal. Retaining what works well, together with minor alterations as well as new proposals for the future, form the foundation of the recommendations. Please consider the report in its entirety. It is the product of a highly qualified set of individuals who worked diligently as a TEAM.

BACKGROUND

The National Shared Forces Task Force Report (NSFTFR) (1991) proposes a "schedule" for completion of National Shared Forces studies. The studies conducted under the umbrella of the Report are led by the U.S. Department of Agriculture-Forest Service (USDA-FS). They are interagency in scope, with committee representation and/or coordination with State wildfire suppression agencies and the U.S. Department of Interior wildland firefighting agencies: Bureau of Land Management (BLM), National Park Service (NPS), Bureau of Indian Affairs (BIA), U.S. Fish and Wildlife Service (FWS).

The first study completed under the umbrella of the NSFTFR was the National Study of Type I and II Helicopters To Support Large Fire Suppression (1992). The second study is the National Aerial Delivered Firefighter (ADFF) Study which is currently in progress.

The third study chartered, the National Airtanker Study (NATS), was completed in two phases. Phase 1 was completed in March, 1995, and recommended the most efficient number and initial staffing location for large airtankers to support fire initial attack and large fire suppression. Phase 2 of the NATS was completed in November, 1996. The study recommended airtanker platforms and airtanker base locations to guide modernization of the airtanker program. It also allowed for stabilization of the airtanker supply and agency demand situation.

THE TARMS STUDY

Aerial supervision in many agencies consists of tactical advice and direction provided by a Leadplane Pilot and/or Air Tactical Group Supervisor (ATGS). Both these programs and positions evolved to meet the need for better control and standardization of aerial firefighting operations, with the ultimate goal of better meeting fire program objectives.

The current aerial firefighting organization structure, personnel, and airframe systems have evolved over time to support ground firefighting efforts. The operating techniques and procedures for both the leadplane and air tactical group supervisor function and operation were predominantly developed during actual fire conditions by Leadplane Pilots and Air Tactical Group Supervisors working in the environment with ground supervisory personnel. The approach was and continues to be an evolutionary process rather than a fully-planned and implemented “systems” approach to aerial firefighting.

The systems and organization currently employed to meet aerial firefighting supervision objectives continue to be stretched to the limits by a number of factors:

- The effects of competition for dollars within budgets as aircraft and personnel costs continue to rise.

- Retirements, competition for pilots with the private sector and general reduction in personnel ceilings with a constant to increasing workload have effected both the air tactical and leadplane programs. The ability to train and qualify replacement leadplane pilots and air tactical supervisors in a timely enough manner has been difficult and in some cases not possible.

- Successive intense fire seasons over the past decade.

- Changes in land use trends and demographics, which are less agrarian and more urban require aerial firefighters to perform in close proximity to populated urban interface areas where air traffic density can severely reduce operating efficiency and pose additional safety hazards. This situation appears to be increasingly throughout the country.

Regardless of location, urban or wildland, the aerial firefighting job today is characterized by an increasing workload and complexity, particularly in the procedural and communications requirements. This situation affects fatigue levels, productivity and decision-making processes where the potential exists for accidents and incidents.

The study methodology will display the current program structure and components, focusing on the assets and liabilities. Retention of what is working well is most certainly a goal. That goal will coincide with recommendations on organization, technology, and aircraft systems to support fire management objectives in the future. The study offers the firefighting agencies the opportunity to step back and take a structured, systems approach to addressing present and future issues and problems related to aerial firefighting operations.

THE STUDY CHARTER
The full test of the Study Charter is contained in Appendix A.

Vision
Tactical Aerial Resource Management Study shall provide managers with information, guidance and support for National and Geographic Area decisions affecting the National Leadplane, Air Tactical Group Supervisor and Helicopter Coordinator programs.

Mission
The Tactical Aerial Resource Management Study shall determine the most appropriate organization, staffing and aerial platforms necessary to safely and cost effectively manage and direct aerial fire suppression resources. Support and interrelationships to fire suppression will be obtained and evaluated. The outcome of Phase 2 of the National Airtanker Study (NATS2) and other relevant projects will be important considerations as well.

Goals/Objectives
The goal of the Tactical Aerial Resource Management Study is to identify the best way or alternative ways to manage and direct aerial suppression resources, to determine preferred platforms and to make recommendations for improvement. It will be necessary to properly consider and evaluate the aerial supervision management roles, missions and platforms.

Guiding Principles (Assumptions) Used In The Study

The Tactical Aerial Resource Management Study shall be conducted interagency in scope with committee representation from the USDA-Forest Service, USDI-Bureau of Land Management and the States. Coordination with local State wildfire suppression agencies, USDI-National Park Service, Bureau of Indian Affairs, Fish and Wildlife Service and Office of Aircraft Services shall be through the geographic area representatives. The initiative for this study is a USDA-Forest Service effort to provide guidance for the timely replacement of their leadplane fleet.

Conventional decision analysis and problem solving techniques, supported as needed by routine computer software programs, will be utilized. There should be no major software development or application required. Options for aircraft acquisition will not be a part of this study and should not be a consideration during this process.

Traditional methods of operation shall be examined and challenged where appropriate.

Benchmarks and time frames for the study were developed as well as a study communications plan. The plan defined actions to convey study progress and status to effected groups.

Recommendations And The Product Expected

At the completion of this study, a written report will be prepared addressing the following:

A. Identification of aerial supervision missions and tasks such as:

    1. Required communications.
    2. Fire intelligence and tactical advice.
    3. Airtanker coordination and direction.
    4. Helicopter coordination and direction.
    5. Overall aircraft/airspace management.
    6. Requirements of urban interface versus wildfire incidents.
    7. Identify training requirements to facilitate accomplishment of the missions and tasks.
    8. Potential uses of human aiding technology.

B. Identify and evaluate alternative organizations and staffing to accomplish missions and tasks. Identify roles and responsibilities of the staff.

C. Identify and evaluate alternative aerial platforms to perform or support the roles identified above. This will include recommendations for the number of, type and locations of these resources.

The Timeline

A completion date of December, 1997, was desired. The Draft Report will be completed by April, 1998.

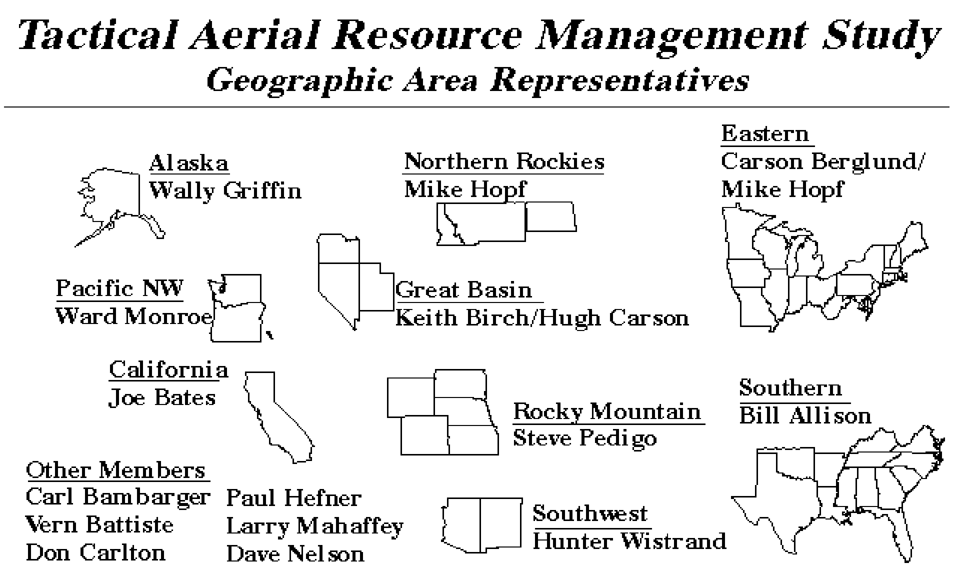
THE STUDY COMMITTEE

The NSFTFR Steering Committee requested the Forest Services's Rocky Mountain Region to provide the coordination and leadership for a Tactical Aerial Resource Management Study (TARMS). A Study Committee was established to conduct this effort under the guidance of a Steering Committee, with representatives from the USDA-FS, BLM, and USDI- Office of Aircraft Services (OAS).

The committee had federal firefighting agency membership from all Geographic Areas. The State of Minnesota provided representation for the National Association of State Foresters. Coordination with the NPS, BIA, and FWS at the National level was through the OAS.

The committee members selected represent agencies, technical specialty, and/or geographic areas, and are listed in Appendix A. At the request of the Steering Committee, an human factors specialist/research psychologist from the National Aeronautical and Space Administration (NASA), Ames Research Center, an Aeronautical Engineer from the Forest Service's San Dimas Equipment Development Center and a Systems Analyst were included on the committee. Individuals on the committee involved in fire suppression had an average of 27.5 years of experience per individual. Fireline positions represented included Incident Commander I and II, Operations Section Chief, Division Group Supervisor, Air Operations Director and Aerial Attack Group Supervisor. The three leadplane pilots on the committee have an average of over 20 years of leadplane flying experience per individual. Management perspective was provided by three individuals with a background in administrative line management positions. The Team Leader is a Deputy Director for Cooperative Fire Programs for Forest Service Region 2. Coordination with each geographic area was through the team member representing that area. Figure 1 outlines the geographic areas and identifies the individuals on the Study Committee representing the areas.

Figure 1



SCOPING BY THE STUDY COMMITTEE OF ISSUES AND FIELD SURVEY OF CURRENT TACTICAL AERIAL RESOURCE MANAGEMENT PERSONNEL

The study committee did initial internal scoping to identify characteristics and items within the leadplane and ATGS programs that were working well. This study deals with the areas where improvement could enhance performance and efficiency. These characteristics and issues were grouped initially into three categories: organization, technology and aircraft.

Characteristics and Items Going Well

Organization

- Classroom ATGS training
- National Aerial Firefighting Academy program
- Leadplanes are being used as initial attack resources
- The Helicopter Coordinator (HLCO) and Airtanker Coordinator (ATCO) positions are being utilized and are performing well
- Type I Incident Management Teams (IMT) organization is appropriate and adequate for management of large incidents
- Interagency cooperation in airtanker and helicopter base staffing
- Dispatch organization is dedicated and within constraints works well
- Airspace coordination efforts in the Northwest Geographic Area specifically and in general Nationally
- Federal National Aviation Policy is well coordinated between agencies
- National aviation coordination and leadership is done through the National Fire Aviation Coordinating Committee

Technology

- Installation of Global Position System (GPS) in most aircraft and Traffic Collision Avoidance System (TCAS) in leadplanes
- Implementation of the Transponder Code 1255
- Forward looking Infrared (FLIR)

Aircraft

- Adequate air attack aircraft do exist in some areas of the country
- The concept of using one aircraft model for leadplane (ie; Forest Service's Baron 58P fleet) allows for efficiency in training and utilization of leadplane pilots.

This initial scoping provided the basis for the development of a TARMS User Survey. The TARMS User Survey was developed in response to the need and desire to assess the current and future air organization and operations over wildland fires. The ongoing BLM/USFS/NASA National Aerial Firefighting Safety and Efficiency (NAFSE) Project was being conducted to evaluate some of these same issues. The objectives of the National Aerial Firefighting Safety and Efficiency (NAFSE) Project were to collect and compare current data on air operations over wildland fires with data collected after the introduction of a standard phraseology, improved airspace structure and human-aiding technology. The TARMS study committee therefore had access to information and methodologies which were currently being used to acquire similar data sets during the NAFSE Minden Flight Tests being conducted by NASA in Nevada. The TARMS User Survey was a natural derivative of the mission questionnaire used by NASA to assess pilot issues and workload before, during, and after each mission.

The TARMS field survey was distributed in December 1996 asking for ideas, opinions and suggestions relating to aerial firefighting resource management in the future. The survey was distributed to the aerial and ground firefighting community nationwide, including federal and state agencies. The survey was distributed primarily to elicit ideas, not to offer an opportunity to vote on selective issues. The numbers that will be displayed should be considered indicators of areas of concern. For purposes of analysis, all responses to the survey questions were examined for the kernels of thought expressed. Each "kernel" was reduced to no more than ten words. When several "kernels" could be validly combined, they were.

Several of the respondents indicated qualification in multiple firefighting roles. To facilitate tabulation of the data, a single primary role was selected for each respondent based either on direct contact with the individual or on further information provided by the questionnaire response itself. This process was, by necessity, subjective, offering numerous opportunities to misrepresent or misinterpret the data. However, every attempt was made to avoid error and to make the process as fair, objective and representative of the raw data as possible.

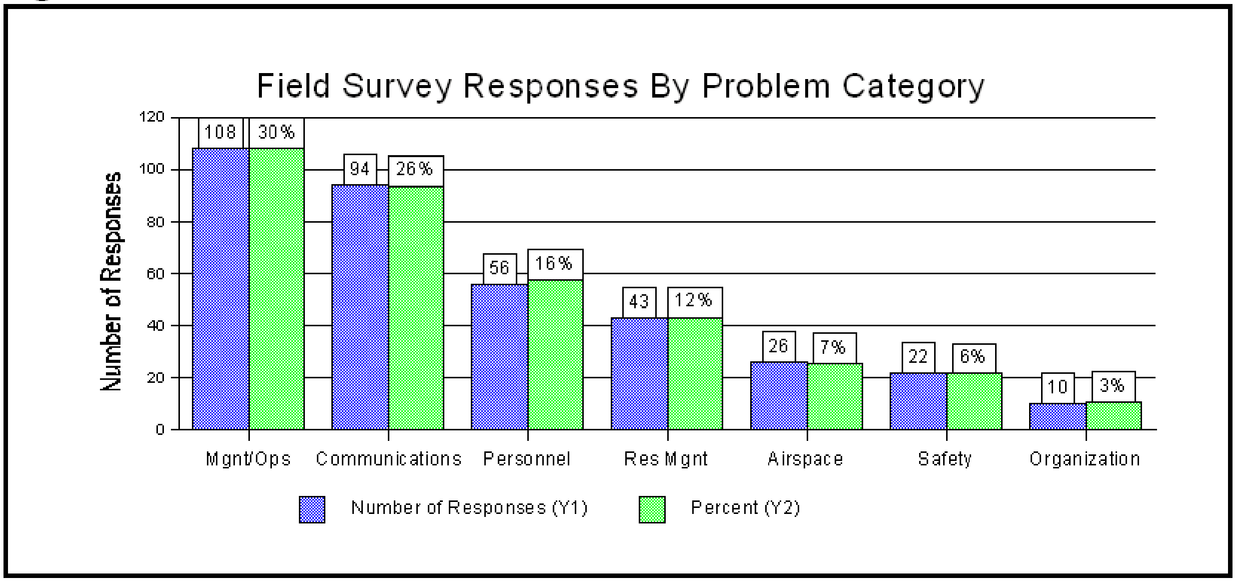
Summary of Responses to the Field Survey

Responses were received from 135 firefighting personnel. Identified problems were grouped into seven categories. These categories are listed below with the number of respondents that identified problems.

Number of Responses	Problem Category
108	Management and Operations Program Administration (50), Firefighting Tactics (20), Operational Procedures (15), Program Emphasis (15), Interagency Cooperation (4), Aerial Tactics (3), Operational Limitations (1)
94	Communications Information Exchange (46), Frequencies (37), Radio Adequacy (11)
56	Personnel Training (34), Performance (13), Experience (9)
43	Resource Management (of Leadplane/ATGS) Equipment Limitations (19), Inappropriate Use (10), Availability (10), and Lack of Technology (4)
26	Airspace Airspace Structure (17), Airspace Intrusions (9)
22	Safety Operations (11), Geographic Awareness (4), Compliance (3), Workload (3), Situational Awareness (1)
10	Organization Roles (10)

Figure 2 displays the field survey responses by problem category.

Figure 2



Management and operational problems are to be addressed by organizational options. Personal problems can also be addressed by these organizational options. It is clear from the Survey and verified by personal experience of committee members that communications problems and issues rank very high in an area where standardization of equipment and terminology provide opportunities for problem resolution. Resolution of airspace coordination problems and issues have a high potential to effect the reduction of the risk of accidents and incidents. Resources management problems and issues can be addressed by organizational options. However, the ordering process and utilization requirements for the ATGS and leadplanes also apply here.

The display of the respondents' identified problem areas by sub-category provides insight into issues that organizational, human-aiding technology and aircraft options could address.

Number of Responses	Program Sub-Category	Number of Responses	Program Sub-Category
50	Program Administration	10	Roles
46	Information Exchange	10	Inappropriate Use
37	Frequencies	10	Availability
34	Experience	9	Airspace Intrusions
20	Firefighting Tactics	9	Training
19	Equipment Limitations	4	Geographic Awareness
17	Airspace Structure	4	Lack of Technology
15	Program Emphasis	4	Interagency Cooperation
15	Operational Procedures	3	Workload
13	Performance	3	Aerial Tactics
11	Radio Adequacy	3	Compliance
11	Operations	1	Operational Limitations
		1	Situational Awareness

As organizational, human-aiding technology and aircraft options and evaluation criteria are developed in Step 3, the results of this User Survey will be referenced often.

AVIATION SAFETY IN THE TACTICAL FIREFIGHTING ENVIRONMENT

Data

From 1910 to 1997, 407 firefighters have lost their lives on the fireline. Since 1959 there have been 187 firefighters killed on the fireline. Of these fatalities, 78% were from being overrun by fire. Since 1955, there have been 247 known aviation fatalities in 148 separate aerial firefighting accidents. This data is known to be incomplete and is being updated and verified on a regular basis (Bushey, 1997). These fatal accidents are broken down as follows:

Type Mission	Number of Fatal Accidents	Percent of Total Fatal Accidents	Number of Fatalities	Percent of Total Fatalities
Airtanker	94	63%	136	54%
Helicopter	24	16%	45	18%
Leadplane	7	5%	7	4%
"Other" A/C	23	16%	59	24%
TOTAL	148	100%	247	100%

Fire related aircraft fatalities during the last 43 years account for approximately 29% of the total wildland fire deaths in the United States extending back to 1910 (88 years). The only category that exceeds aircraft fatalities are ground-based entrapments which are approximately 45% of the national wildland firefighter related death total (Bushey, 1997).

Safety Studies

A review (Veillette, 1997) of the key contributing factors for 55 USFS fixed-wing mishaps from 1976 through 1995 found the following data and made the following statements pertinent to the TARMS Study:

- "The mishaps resulted in 58 fatal injuries, 10 serious injuries and 11 minor injuries. Twenty-two (40%) of the 55 mishaps resulted in fatal injuries, while seven mishaps (12.7%) caused serious injuries."

- "The most common phase of flight [for mishaps examined] was the "drop' phase [32.7%]. Activities included in this phase were aerial delivery of smokejumpers, retardant drops, and fire reconnaissance.....The type of aircraft involved in the drop phase accidents varied across the fleet of mission support aircraft. Four leadplanes (Beechcraft B-58P), nine airtankers, and five reconnaissance aircraft were involved...."

- "Of the 55 mishaps, human errors committed by the flight crew were found as a primary causal factor in 41 mishaps [74.5%].... Pilot judgment was found deficient in 37 (67.2%) mishaps. While the finding of faulty pilot judgment does carry a negative connotation, the underlying reasons must be examined for prevention purposes."

- "*Human error* was the most common element in 55 mishaps. Global findings suggest improvements are needed to reduce human error in all mission aircraft (leadplane, airtanker, smokejumper, and reconnaissance). Enhancement in pilot judgment, situational awareness, crew resource management, stress management, attention management, attitude management, and risk management are suggested intervention measures."

- " *Low level* mishaps while accomplishing fire missions clearly suggests the need for a comprehensive, systems safety program....This would include examining methods to reduce pilot workloads, reduce distractions, and enhance communications and situational awareness."

Note that non-firefighting aircraft were included in this study, but the data pertaining to low-level fire operations is relevant.

<u>Review of Operations</u>
Wildland fire suppression and aviation fire missions have inherent risks. Aviation activity in this environment, particularly on initial attack/extended attack, are often high-tempo in nature. They tend to be initially chaotic as issues of establishing communication, tactics, airspace structure, and working relationships among pilots and air crews who may or may not have worked together previously are resolved.

Operations on both initial attack and large fires are both affected by a considerable number of interrelated environmental and mission factors: poor visibility, high winds and turbulent conditions, steep terrain, high density altitudes, low-level operational altitudes. Human factor issues of fatigue (both long- and short-term), effects of a difficult working environment, high sensory input (both visual and aural), and high task loading arise.

This type of flying results in operations at the upper limits of the abilities of humans and machines. The flight crews operate their aircraft in a hostile environment in smoke and turbulence while being inundated by radio traffic, maintaining aircraft separation at low level, and providing support to ground personnel.

One of the aerial supervisor's major responsibilities is ground firefighter safety. This is not only in the simplest sense of ensuring firefighters are clear of drop zones, but also on the larger scale of continually observing fire behavior and communicating potential safety risks to the ground. Flight crew and ground firefighter safety are critically linked in every wildland fire operation. The combination of interrelated ground and air operations being conducted simultaneously greatly increase risk for the aviation mission while attempting to decrease firefighter risk.
Risk assessment and planning are critical steps for flying each firefighting mission. The risk of incident aviation operations must be continually assessed and calculated for the degree of risk involved, followed by continual risk decision-making and risk mitigation. Standard risk assessment and planning techniques include: 1) identifying the hazards; 2) assessing the hazards; 3) the making of a decision; 4) implementing controls; and 5) supervising the operation. These are often conducted

in a "hasty" manner.

According to Army Aviation risk management theory (Flightfax, 1991 and 1994), risk assessment is performed in one of three ways: (1) hasty; (2) deliberate; (3) in-depth. The term "hasty" should not be interpreted in this sense with any negative connotation. It is merely a very descriptive word for the compressed time frames within a highly dynamic environment where risk assessment judgments must be made quickly, often in fractions of a second.

The ATGS mission in certain areas of the country such as California, Alaska, Nevada, Arizona, New Mexico and eastern state agencies, is performed utilizing contracted and/or agency-owned aircraft staffed with agency ATGS's and pilots. This list of areas is not mentioned to be fully inclusive but to provide examples. These pilots are often highly experienced in and knowledgeable of both ground and aerial firefighting operations, and can assist the ATGS considerably. However, the ATGS mission has been flown and continues to be flown in many areas with pilots that are not trained in the ATGS aviation mission, with little or no knowledge of fire. This limits their ability to provide much support to the ATGS, despite their desire to do so.

The leadplane mission has in most cases been flown in the single pilot configuration without the backup assistance of a second crew member, with a consequent reduction in workload. Even the most highly skilled, experienced, and knowledgeable leadplane pilot or ATGS can become task overloaded in the aerial firefighting environment.

Task overload situations can cause flight crews both in the Air Tactical Group Supervisor (ATGS) and leadplane profile to "shed" some tasks that are considered a lower priority at that given moment. However, as the wildland fire situation changes, those tasks which may have been ignored may reappear as critical tasks.

<u>Summary</u>

Failure to perform tasks to an acceptable level at all times can cause accidents or incidents, both in the air and on the ground. It is critical to assign ground and aerial firefighter safety as top priorities when determining the best way to manage and direct aerial suppression resources over a wildland fire incident. Improvements in safety and operational efficiency can occur via the assessment of current aerial firefighting operations with its inherent risks and problems. The potential exists to mitigate risk factors in the future through changes in organizations, training, technology and aircraft.

Analysis of existing and potential aerial supervision and management components (organization, training, technology, and aircraft) can define the extra margin of safety needed for the aerial firefighter in a high workload environment. This benefit can also accrue to an extra margin of safety for the individuals on the ground who are supported by the aerial firefighter. Research in human factors indicates that a reduced workload and better situational awareness will <u>always</u> result in better, relatively error-free decision-making. Since research (Veillette, 1997) indicates that many fixed-wing accidents are due to poor judgment (decision-making), the result should be a reduced accident/incident rate, increased aviation and firefighter safety, cost savings, and increased mission efficiency and success.

THE STUDY PLAN AND PROCESS FOR TARMS

The study plan and process was structured within the six steps that follow. A summary of each step follows. The steps are the basis for the chapters within this report and detail on each step can be found there.

Step 1. Overview and a review of historic use, demand and trends in use.

A review of the history of the leadplane and air attack program is presented together with recent data on use. Initial attack data from local NFMAS analysis and use records, together with data on aerial supervision to support large fire suppression was identified as needed to be collected to support this analysis. Information on the issues and problems related to the current aerial supervision organizational structure and the aircraft platforms used to perform the jobs was needed.

For each area, the purpose, data needed, data sources, and responsible person were identified. The historic period for gathering initial attack analysis varied based on local NFMAS analysis but in general included the time period 1980 - 1995. Data on large wildland fire occurrence varied but in general covers the 1980-1997 period of time.

Step 2. Gathering of information on current and potential organizations, human-aiding technology, aircraft and related topics.

For the determination of potential organizational structures, human-aiding technology and aircraft, information was gathered via a survey completed by personnel currently performing these roles as well as personnel who are the receivers of the services. In addition, information was gathered on the

current roles of responsibilities, supervision, experience and training requirements for the aerial supervision positions. The data gathered from surveys as well as the development of a matrix to measure aerial firefighter workload is presented. Various methods for procurement of aircraft are described. Initial analysis is completed providing information on the economic value of the leadplane program and the effect of leadplane speed on acres burned as well as suppression lost and losses.

Step 3. Develop evaluation criteria and organizational, human-aiding technology and aircraft options.

Criteria to be used in the evaluation of potential organizations, human-aiding technology and aircraft, will be developed in this step. In addition, Organizational, Human-aiding and Aircraft Options will be developed.

Step 4. Perform analysis of options and development of a preferred aerial supervision alternative.

The functional roles and the efficiency by which roles can be performed start with organizational and human-aiding technology options. The aircraft is the vehicle from which these roles are performed. Identification of the preferred aircraft characteristics follow from definition of the optimum organization and supporting human-aiding technology within appropriate economic and physical constraints.

Some of the analysis of organizational and human-aiding technology was performed during the Minden Flight Test portion of the National Aerial Firefighting Safety and Efficiency Project. Not all potential combinations of organizations and human-aiding technology were tested during the Minden Flight Test. In these cases, professional judgement was used to rate all combinations using tested combinations as a benchmark.

Potential aircraft platforms which meet minimum "Must Have" criteria were evaluated based on data gathered from flight manuals, during flight evaluations and from other pertinent documents.

A final "reality" check against professional judgement will be done to assure the proper integration of analytical results with experience, skill and intuition.

Step 5. Develop recommendations to address the goals and objectives and risk mitigation strategy. Recommendations are presented based on Steps 1-4.

Step 6. Concerns and opportunities generated by the this study.
As work progresses within a study process, information and observations occur which has value beyond the immediate task as defined in the Study Charter. Concerns and opportunities which have value to the agencies missions are presented.

The process used is displayed in Figure 3 which diagrams the flow of activities in this study.

Figure 3 - Study Process and Flow

```
    ------------------       -----------------       --------------------------------------
   |      Step 1      |---->|     Analysis    |--->|                 Step 2                 |
   |  Historic Data   |      -----------------     | Gather Information on Organizations, |
   |   Interagency    |--------------------------->|   Human-Aiding Tech. and Aircraft    |
    ------------------                              ---- ---------------------------------
            |                                                      |
             -----------------------------------------------------
                                        |
                                        V
    ------------------------------------------------------------------------------------
|<-| Step 3-Develop Evaluation Criteria & Options for Organizations, HAT and Aircraft      |
|  | Step 4-Perform Analysis of Options and Development of a Preferred ASM Alternative     |
|   ------------------------------------------------------------------------------------
|
|   --------------------       -------------
|  | Are there enough   | Yes | Procurement |--------
|->| adequate aircraft? |---->|   Options   |        |
|   --------------------       -------------         |
|            | No                   ^                |
|            V                      |                |
|   ---------------------           |                |
|  | Define ways to get  |          |                |
|  |  more aircraft or   |----------                 V          -------------
|  |  display effects.   |                      ----------    | Recommended |
|   ---------------------                      | Analysis |-->| Alternative |->|
|                                               ----------      -------------   |
|                                                   ^                ^          |
|   ----------------------                          |                |          |
|  | Can we adequately    |     -------------       |                |          |
|  | implement technology,| No |  Staffing   |-------                |          |
|->| operate and staff    |--->|     and     |                       |          |
|  | Aerial Supervision?  |    |    Basing   |                       |          |
|   ----------------------     |   Options   |                       |          |
|            | Yes              -------------                        |          |
|            V                                                       |          |
|       -----------                                                  |          |
|      | Implement |--------------------------------------------------          |
|       -----------                                                             |
|   --------------------      -------------                    -------------    |
|  |  Is the dispatch   | No |   Display   |    ----------    | Recommended |  |
|->| flow as efficient  |--->|   Dispatch  |-->| Analysis |-->| Alternative |->|
   |    as possible?    |    |   Options   |    ----------     -------------   |
    --------------------      -------------                          ^          |
            | Yes                                                    |          |
            V                                                        |          |
       -----------                                                   |          |
      | Implement |--------------------------------------------------          |
       -----------                           ---------------------------------------
                                        |
                                        V
     -------------------------------------------------------------------
    |    Step 5 - Develop Recommendations and Risk Mitigation Strategy   |
    | Number of and how to Procure!!   How to Staff!!  How to Mobilize!! |
     -------------------------------------------------------------------
     -------------------------------------------------------------------
    | Step 6 - Display Concerns and Opportunities Generated by the Study |
     -------------------------------------------------------------------
```

STEP 1: OVERVIEW AND A REVIEW OF HISTORIC USE, DEMAND AND TRENDS IN USE

In Step 1, the major sections are as follows:

- Leadplane and Airtanker History
- Air Tactical Group Supervisor History
- Current Tactical Aerial Resource Management Aircraft and Bases
- Current CWN ATGS Aircraft
- Current Staffing Period of Leadplanes and Air Attack
- Current Human-Aiding Technology (HAT)

The current aerial supervision organizational structure has four identified positions within the ICS system. The two primary roles are performed by the Air Tactical Group Supervisor (ATGS) and Leadplane Pilot (LPP). Additional roles utilized as needed (usually after fire escapes initial or extended attack) include the Airtanker Coordinator and the Helicopter Coordinator. On a specific wildland fire, roles are performed as needed by personnel in a single-role configuration (either ATGS or leadplane) or in a joint-role status (ATGS and leadplane both present). Configuration depends upon proximity of dispatch base to the wildland fire, availability of aerial supervision resources, timeliness of the dispatch of the ATGS and/or leadplane and agency requirements.

In some state and local agencies and other countries, the leadplane role is not filled. In these agencies, the leadplane role may be fully or partially performed by an Air Tactical Group Supervisor or Airtanker Coordinator who may be either also piloting the aircraft or may be an observer riding with a pilot. The aircraft may perform leadplane or low-level "show-me" runs, or may stay at high level performing an Airtanker Coordinator role.

In the BLM for the past several years, the leadplane mission has been performed with the leadplane pilot and the ATGS in the same aircraft. This is frequently referred to as a "dual role" configuration.

The current federal leadplane program is staffed by the Forest Service with 20 Beechcraft Baron 58P aircraft Six OV-10 aircraft used by the BLM for leadplanes were deactivated at the end of the 1997 fire season. To provide replacements on an interim until the recommendations from this study are dealt with by the participating agencies, the BLM is utilizing exclusive-use contracting to procure aircraft for the leadplane mission. These aircraft will be staffed by BLM pilots and the configuration for some aircraft will be as dual role, leadplane pilot and ATGS in the same aircraft.

The Air Tactical Group Supervisor ATGS, Airtanker Coordinator and Helicopter Coordinator positions and support aircraft are staffed at the Regional and Forest levels within the Forest Service and at the State and District levels within the Bureau of Land Management. In some cases, these positions and aircraft are ordered and dispatched after a fire has escaped initial attack and/or an Incident Management Team has been assigned. It is not common for local management units to staff an ATGS with aircraft in anticipation of the potential need for initial attack/extended attack as well as large fire support.

<u>Leadplane and Airtanker History</u>

The leadplane concept evolved from early airtanker retardant operating experiences. In the 1950's many post World War II aircraft were available for fire fighting. As more airtanker aircraft like N3N's and TBM's were being flown, the need for coordination and control became clear. Light aircraft like Cessna 180's were being used for reconnaissance work and hence they were used also to help direct airtanker drops. Radio communications between the spotter aircraft and the airtankers was used to direct airtankers to the desired drop targets. Spotter aircraft also flew low passes over the target area to aid in target identification. These methods met with varied degrees of success.

Often, environmental conditions over a fire such as smoke and terrain would make target identification difficult. Also, airtanker flight patterns and techniques were not standardized during this period. It was found that a spotter aircraft that were fast enough to fly at airtanker speeds would be able to fly in front of the airtanker and provide for both better target identification and more standardized flight patterns.

The accident rate for airtanker operations was quite high during this same period. The role of the spotter/leadplane was seen as a means of reducing this rate. By placing experienced pilots in a spotter/lead aircraft, the direction and orderliness of retardant operations improved with a resultant increase in safety. The Forest Service hired pilots for this “Airtanker Boss” position or leadplane role. Some pilots were also hired to fly Forest Service-owned airtankers.

Monty Pierce, the National Aviation Officer in the 1950's, and other Forest Service aviation personnel, Steve Ayers in particular, helped the Forest Service acquire surplus aircraft from the military for use as leadplanes. These aircraft were early version T-34's, a modified Beechcraft Bonanza single engine airplane used by the U.S. Navy for basic flight training. Some of these same aircraft are still flying for natural resource management agencies; ie. State of North Carolina Forest Service. The T-34's were strong, agile, gave the pilot excellent visibility and were fast enough to fly in front of the airtankers on their drop runs. Approximately 20 T-34's were acquired and distributed to the Forest Service Regions. Additionally, in 1959, a Piper PA-24-205 and a Beech K-35 Bonanza were acquired for leadplane use. Most of the pilots that were hired to fly these aircraft had flown airtankers or other large aircraft previously. This type of experience was considered very important in order to be an effective leadplane pilot; ie, Airtanker Boss.

In 1967, Beech Baron C-55s were purchased for leadplane work. Attention continued to focus on accident prevention. In 1968, a study group was formed to evaluate single-engine vs. multi-engine aircraft. This group recommended that all airtankers and leadplanes be multi-engine aircraft. In 1971, the Forest Service acquired from the military U3A's, the military designation for the Cessna 310, a light twin engine airplane. All Regions used the U3A's except Region 5 (California) which acquired additional Beechcraft Barons. Region 6 (Pacific Northwest) augmented its U3As with leased Cessna 310s and Region (Southwest) used leased Barons instead of U3As. The transition to multi-engine leadplanes and airtankers occurred in the early 1970's.

As the size and speed of airtankers and leadplanes increased, they were used by all geographic areas. The increased use of these resources nationally gave rise to issues that only standardization could address. In 1975, the Forest Service proposed a acquisition of a National fleet of standardized leadplanes that would be multi-engine and multi-purpose; ie. capable of transporting passengers. A study group was formed to select an aircraft. Three models were in the final selection process: Beechcraft 58P Baron, Cessna 340, and Piper Aerostar 601. The Baron 58P was selected with procurement of 20 new Barons occurring between 1978 and 1984.

The Forest Service is the largest single operator of Baron 58P aircraft. Approximately 100,000 flight hours have been flown on the fleet as of late 1996. There have been five Baron aircraft destroyed in accidents. Three of those five were during leadplane missions. The high time Baron in the fleet now has approximately 7,500 flight hours and the lowest has approximately 3,000 hours.

Table 1 displays the number of hours flown and the costs for 1996 for leadplanes used by the Forest Service and BLM.

Table 1- Leadplane Use By the Forest Service and BLM, 1996

	Aircraft	Hours	Flight Cost	Rate/ Hour
F/W	Cheyenne H	20.1	$7,785	$387
	OV-10	692.6	$282,995	$409
	Baron 58	188.2	$77,727	$413
	Baron 58P	4109.2	$1,381,895	$336
	Fixed Wing Total	5010.1	$1,750,402	$349
R/W	Bell 206 B	98.7	$35,457	$359
	Helicopter Total	98.7	$35,457	$359
	Leadplane Total	5108.8	$1,785,859	$350

The factory recommended life limit on the Baron 58P airframe is 10,000 hours. The Baron airframe and engines have not been modified significantly since they were new. There has been one major upgrade to the avionics equipment and two additional modifications to upgrade the navigation equipment.

The BLM leadplane program evolved slightly later and differently from that of the Forest Service. The Alaska Fire Service realized the need for standardization, control, enhanced safety, and greater efficiency such as the Forest Service had realized. In 1971, the BLM began utilizing a single aircraft in the dual role configuration (Leadplane Pilot and ATGS in same aircraft). BLM started with a C-180, frequently upgrading aircraft over the years, employing aircraft such as the C-185, C-402, Navajo, Twin Otter, Gruman Goose, Baron, Aero Star 600, 601 & 601P, Aero Commander 680, 690, T-28 and since 1992 the OV-10A.

The need for leadplane pilot positions has been identified at the national and geographic area levels and is tied to improving safety, effectiveness and efficiency over an incident. There is also a requirement in some agencies to have leadplane supervision for airtanker operations in certain defined cases. These cases are referred to in the Interagency Leadplane Operations Guide (ILOG) and agency manuals. It is important to remember that these requirements are based on past experiences and the desire to prevent similar occurrences in the future. For example, the Forest Service requirement to use a leadplane in congested airspace (Grant of Exemption 392) was the result of an injury to a child during a fire retardant drop, the subsequent negotiations with the FAA, and the need to provide for public safety. The role of the leadplane pilot continues to be an asset to the fire management organization.

The primary users of large airtankers, and hence leadplanes, are the Forest Service and BLM. The states of Alaska, California and Minnesota contract for large airtankers. Many states use airtankers with a retardant capacity of less than 1000 gallons. The primary use for leadplanes and Air Tactical Group Supervisors is initial attack of wildland fires but large fire support is also significant. Increased use of Type I helicopters on large wildland fires to deliver fire retardant, foam and water has lessened the use of large airtankers and hence leadplanes on large wildland fires.

In summary, the leadplane program evolved to meet the need for standardization and control over aerial retardant operations. The operating techniques and procedures were developed in actual wildland fire conditions by pilots working in that environment. Those techniques that proved most successful over time have remained and continue in use today. The theme of using practical solutions and available off-the-shelf technology, particularly in radio configurations, is very evident in the history of the leadplane program as it is in all of natural resource aviation. Considerations for replacement of this fleet is now an issue. In addition, considerations on how human-aiding technology and organizational structure affect the leadplane pilot's effectiveness and mission should be considered concurrently.

Air Tactical Group Supervisor History

The Air Tactical Group Supervisor position evolved from the early use of light aircraft in the observation and reconnaissance role. As the use of aircraft increased, the person in the observation aircraft was assigned the responsibility of coordinating the "air attack" for the person in charge of the suppression effort on the ground.

It was thought that if the organization was going to have someone in the air over a wildland fire, then the person should have a good deal of experience and knowledge about the business of wildland fire suppression, and an excellent working knowledge of aircraft operations. This led to a position within the organization known as the Air Attack Boss.

As different organizations evolved such as the Large Fire Organizational (LFO) structure and the Incident Command System (ICS) structure, the person responsible for directing the air attack operations became known under different titles. In some cases the different titles somewhat reflected the differences in the way the different organizations operate.

United States federal firefighting organizations

Table 2 - ATGS Use By the Forest Service and BLM, 1996

	Aircraft	Hours	Flight Cost	Rate/ Hour
F/W	Baron 55	1368.8	$367,133	$268
	Baron 58/58P/58TC	348.1	$109,407	$314
	Beech Duchess	4.8	$864	$180
	Beech King 100	4.5	$2,588	$575
	Cessna 172	5.7	$486	$85
	Cessna 180	7.0	$980	$140
	Cessna 182	261.5	$34,769	$133
	Cessna 185	27.8	$4,155	$149
	Cessna 205	124.3	$18,710	$151
	Cessna 206/206T	737.5	$116,151	$157
	Cessna 207	1.1	$162	$147
	Cessna 210/210 Turbo	521.8	$100,912	$196
	Cessna 303	23.9	$7,277	$305
	Cessna 310	485.7	$154,019	$317
	Cessna 337	1094.6	$290,847	$266
	Cessna 340	977.3	$338,794	$347
	Cessna 401	54.0	$20,243	$375
	Cessna 414	110.1	$60,572	$550
	Cessna 425	13.6	$10,011	$737
	Cheyenne H	21.7	$8,420	$388
	Commander 500B	763.6	$187,093	$245
	Commander 980	231.0	$197,713	$856
	Commander Shrike	953.5	$214,207	$225
	Navaho Pa 31	5.5	$1,994	$360
	OV-10(Also See Table 1)	284.8	$116,483	$409
	Partenavia 68/c	225.2	$47,289	$210
	Piper Aerostar	105.2	$39,452	$375
	Piper Aztec PA-23	41.2	$9,599	$233
	Piper Seneca	196.8	$43,524	$221
	Twin Otter	6.3	$3,565	$566
	Fixed Wing Total	9006.8	$2,508,633	$279
R/W	Bell 206B	440.6	$152,606	$346
	Bell 206L	115.9	$58,550	$505
	Bell 212	143.4	$100,296	$699
	Bell 412	1.1	$1,172	$1,065
	Hughes 500	82.5	$27,348	$331
	Aerostar 350	23.8	$20,917	$879
	Bk 117	11.9	$18,659	$1,568
	Helicopter Total	819.2	$379,548	$463
	ATGS Total	9826.0	$2,888,181	$294

developed the Air Attack Boss position who reported to the Line Boss under the Large Fire Organization system. The organization also contained two additional aviation positions: the Airtanker Boss and the Helicopter Boss. All of these positions were supervised by the ground-based Air Service Officer.

With the adoption of the Incident Command System, the position of Air Operations Branch Director, which is also ground-based, replaced the Air Service Officer. Position names were changed to Air Attack Supervisor (subsequently changed to Air Tactical Group Supervisor), Airtanker Coordinator, and Helicopter Coordinator. Responsibility for all air operations was placed under the Air Operations Branch Director. The duties of the three positions listed above did not change.

There are areas (e.g., California, Nevada, Alaska) where Permanent-Full Time (PFT) or long-term While-Actually-Employed (WAE) ATGSs are available to staff exclusive-use contract or agency-owned ATGS aircraft. This is not the case in most areas of the country. The Helicopter Coordinator position is filled as necessary by individuals who meet the qualification standards contained within the National Interagency Fire Qualification System (NIFQS) for this position. Both Air Tactical Group Supervisors and Leadplane Pilots can be qualified as Airtanker Coordinator (ATCO).

The California Department of Forestry and Fire Protection developed a position which is entitled Air Coordinator. In the mid-1970's, the position name was changed to Air Attack Supervisor and in 1997 was changed to Air Tactical Group Supervisor. This position performs the duties of both the Air Tactical Group Supervisor and the Airtanker Coordinator but does not lead airtankers.

Canadian Provinces have developed a position which they call Bird Dog Officer. This position also performs the duties of both the Air Tactical Group Supervisor and Airtanker Coordinator (Leadplane). The BLM dual role configuration closely resembles the Canadian system.

- The need to have a person with extensive firefighting experience in the air over an incident has not changed. In fact, the need has increased and become more critical to both aerial and ground firefighter safety. Factors supporting the need for an Air Tactical Group Supervisor not only for extended attack and large fire but, also to be available and dispatched for initial attack are:

- The increasing number of fires exhibiting high to extreme fire behavior at initial attack.

- The increasing number of episodic fire events occurring in one or more Geographic Areas simultaneously.

- The increasing number of fires within the Urban-Wildland Interface where multiple agencies are dispatching many different types and a large number of resources on initial attack. These fires demand a greater degree of coordination to provide for firefighter and public safety.

- The reduction in the numbers of initial attack resources due to the reduction in the fire preparedness budgets. An ATGS on scene can assist with the most efficient allocation of these resources.

- The implementation of the new national Fire Policy by providing intelligence critical to management decisions affecting suppression alternatives.

Current Tactical Aerial Resource Management Aircraft and Bases

Following is a summary of current basing of leadplane and ATGS aircraft and personnel by the Forest Service, BLM and state agencies.

Table 3 - Current Tactical Aerial Resource Management Aircraft and Bases

Geographic Area	Location	No. of Federal Airtankers Based on NATS*	No. of Leadplanes	# of Full Time ATGS With Aircraft	No. of ATGS's Qualified/Trainee
ALASKA					10/6
	Ft. Wainwright	3	2 (BLM)**	2 (BLM)**	
	Ft. Wainwright		1 (State)**	1 (State)**	
CALIFORNIA					37***
	Bakersfield			1 (Kern Co.)	
	Chester			1 (FS)	
	Chico			1 (CDF)	
	Columbia			1 (CDF)	
	Fresno	1		1 (FS)	
	Fresno			1 (CDF)	
	Ft. Jones			1 (FS)	
	Grass Valley			1 (CDF)	
	Hemet-Ryan			1 (FS)	
	Hemet-Ryan			1 (CDF)	
	Hollister			1 (CDF)	
	Lancaster	2	3 (FS)	1 (FS)	
	Mather	2			
	Paso Robles			1 (CDF)	
	Porterville	1		1 (CDF)	
	Ramona			1 (CDF)	
	Redding	2	2 (FS)	1 (CDF)	
	Rohnerville			1 (CDF)	
	San Bernardino	3			
	Santa Barbara	1		1 (FS)	
	Santa Rosa			1 (CDF)	
	Ukiah			1 (CDF)	
EASTERN					2
	Bemidji	1			
	Brainard	1		1 (MN-DNR)	
	Hibbing	1			
	Grand Rapids			1 (MN-DNR)	
GREAT BASIN					31
	Boise	2	1 (FS)	1 (FS/BLM/OAS)	
	Cedar City	1			
	Hill	1			
	McCall	2	1 (FS		
	Minden	1	1 (BLM)	1 (BLM)	
	Minden		1 (NDF)	1 (NDF)	
	Moab			1 (FS)	
	Pocatello	1	1 (BLM)		
	Ogden		1 (FS)		
	Stead	1			
	Winnemucca			1 (BLM)	

Geographic Area	Location	No. of Federal Airtankers Based on NATS*	No. of Leadplanes	# of Full Time ATGS With Aircraft	No. of ATGS's Qualified/Trainee
NORTHERN					23
	Billings	1	1 (BLM)****		
	Coeur d' Alene	1			
	Helena	1			
	Missoula	2	2 (FS)		
	West Yellowstone	1			
NORTHWEST					25/25
	Baker City		1 (FS)		
	Klamath Falls	2			
	La Grande	2			
	Medford		1 (FS)****		
	Moses Lake	2			
	Redmond	2	2 (FS)	1 (FS)	
ROCKY MOUNTAIN					5
	Colorado Springs	1			
	Durango	1			
	Grand Junction	1		1 (BLM)	
	Jeffco		2 (FS)		
SOUTHERN					10
	Asheville				
	Ft. Smith	1			
	Knoxville	3			
	Atlanta		1 (FS)		
	North Carolina		4 (State)	4 (State)	
SOUTHWEST					18/20
	Alamogordo	1			
	Albuquerque	2	3 (FS)	1 (FS)	
	Ft. Huachuca	1			
	Phoenix	1	1 (BLM)****		
	Prescott	1	1 (FS)****		
	Roswell	1			
	Silver City	2	1 (FS)****		
	Winslow	2	1 (FS)****		

Note: The data on the Number of Qualified and Trainee ATGS With Aircraft was supplied by each Geographic Area.

* Listing of bases is from recommendations from the National (Large) Airtanker Study, Phases 1 & 2 as modified by the Study Implementation Plan and Local Geographic Area agreements.

** Indicates dual role platform. ATGS and Leadplane

*** South Zone has 29 State of California and County fully qualified ATGS. These State and County ATGS may be restricted to assignments within California only.

**** Indicates a Leadplane at this location that is detailed from another Geographical Area during fire season.

Current CWN ATGS Aircraft

At the present time there are no national standards for federal CWN ATGS aircraft. ATGS are assigned locally and any standards for aircraft are those that have been developed locally. In many cases, the aircraft used for aerial detection are also used for the ATGS mission. These aerial detection aircraft generally perform the mission satisfactorily from an aerial platform standpoint, however, the major deficiency is in the radio communication package. Most of the communication packages for these aircraft are in a portable configuration which allows for use in different aircraft. Most of the portable packages do not connect to an intercom system and/or are not integrated with the aircraft radios. This has the effect of isolating the ATGS aircraft pilot from the VHF-FM radio communications. Without an intercom system, communications between the ATGS and pilot are difficult due to the flight deck noise. Proposals exist for potential typing of these aircraft based on radio system capability.

Current Staffing Period of Leadplanes and Air Attack

Peak utilization occurs generally in February-April in the Southern and Eastern Areas, May-July in Alaska and in the Southwest Area and June-September in the western United States. Figure 4 shows the critical time periods by Geographic Area when leadplanes and ATGS personnel and aircraft are needed in initial attack, extended attack and large wildfire suppression. Staffing may vary some from these periods to achieve overall National and local cost efficiencies.

Figure 4 - Critical Time Period to Staff Leadplanes and ATGS Personnel and Aircraft

```
                                        MONTH
AREA     FEB----MAR----APR----MAY----JUN----JUL----AUG----SEP----OCT----NOV
Northern                                         <------------>
          |      |      |      |      |       |     |      |      |      |
Rocky Mt                                    <--------------->
          |      |      |      |      |       |     |      |      |      |
Southwest                      <------------------>
          |      |      |      |      |       |     |      |      |      |
Great Basin                           <------------------------>
          |      |      |      |      |       |     |      |      |      |
California                            <--------------------------------------->
          |      |      |      |      |       |     |      |      |      |
Pacific NW                                <-------------------------->
          |      |      |      |      |       |     |      |      |      |
Southern   <----------------------->                 <------------->
          |      |      |      |      |       |     |      |      |      |
Eastern              <----------------->
          |      |      |      |      |       |     |      |      |      |
Alaska                         <----------------------->
          |      |      |      |      |       |     |      |      |      |
```

Current Avionics and Human-Aiding Technology (HAT)

Multi-channel programmable radios have been in use for several decades, with increasing technological improvements. However, the TARMS User Survey identified radio hardware systems, frequencies, and human interfaces as a major problem area.

The Forest Service recently installed Traffic Collision Avoidance Systems (TCAS) in the Forest Service leadplane fleet. Use of TCAS, and the potential to integrate other information into a TCAS-similar system that provides much wider and greater functionality to all aerial firefighters than stand-alone TCAS, is discussed in depth later in the report.

For several years, a few Forest Service and other state agency ATGS aircraft have been equipped with Forward-Looking Infrared (FLIR) equipment. User (both ground and air) reaction to FLIR-equipped aircraft has been predominantly positive, with economic and safety benefits easily recognized and realized. As with TCAS, use of FLIR and the potential to integrate FLIR into other data collection and information transmittal systems, is also discussed in depth later in the report.

Use of HAT (defined here in terms of cockpit displays and associated computerized data collection/transmittal systems) on aerial firefighting flight decks has been very limited, if not non-existent. Only recently has technology with specific applications to aerial firefighters become available and caution must be displayed during testing and integration of human-aiding technology to maintain what will most likely remain “a heads-up, eyes-out environment.”

STEP 2: GATHERING OF INFORMATION ON CURRENT AND POTENTIAL ORGANIZATIONS, POTENTIAL AIRCRAFT AND RELATED TOPICS
To support the determination of the current status of, as well as potential options for, organizational structures, human-aiding technology and aircraft selection, information was gathered via many processes and tools.

2. A User Survey (referred to as the TARMS User Survey) was widely distributed to both aerial and ground based firefighting personnel to gather information on the issues and problems related to the current aerial supervision organizational structure and aircraft platforms used. The survey was completed by 135 firefighting personnel currently performing in the following roles: Air Tactical Group Supervisors, Leadplane Pilots, other tactical aircraft pilots (airtanker, ATGS aircraft, and helicopter), as well as ground-based personnel. See Appendix E for a copy of the survey.

3. A request for information concerning human-aiding technology in the flight and emergency services environments was sent out to industry and other government agencies involved in technology development. A copy of the letter is contained in Appendix F.

4. A Task Workload Matrix was developed to identify tasks and communications associated with the aerial firefighting mission and to rate individual and cumulative associated workloads.

8. A survey of potential aircraft platforms was developed by the Forest Service's San Dimas Technology Development Center. Aircraft identified are contained in Appendix B.

9. Initial attack data from local NFMAS analysis and use records, together with data on aerial supervision to support large fire suppression was collected. For each geographic area, the purpose, data needed, data sources, and responsible person were identified. The historic period for gathering initial attack analysis varied based on local NFMAS analysis but in general included the time period 1980 - 1995. Data on large wildland fire occurrence varied but in general covers the 1980-1997 period of time.

10. Numerous TARMS committee sub-group meetings and conference calls were held to support the analysis process which led to the report's final recommendations.

Information gathered is presented in the follow order.

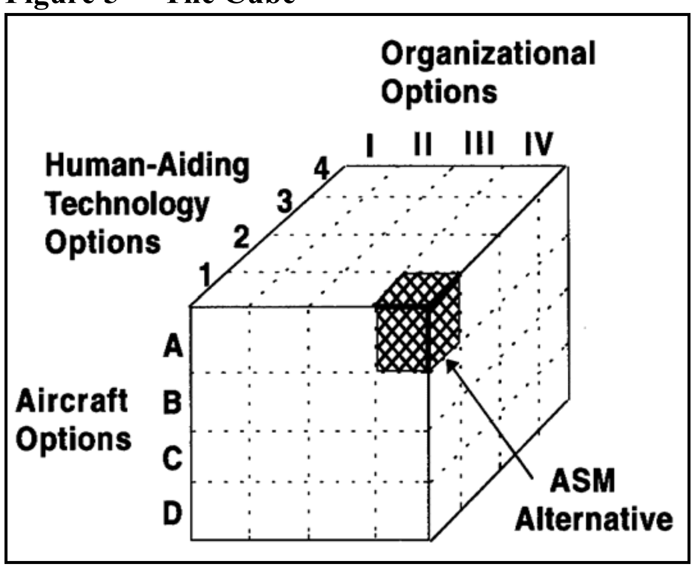
- Interrelationship of Organization, Technology and Aircraft
- Current Aerial Supervision Roles, Organization and Structure
- Current Roles and Responsibilities,
- Current Tactical Aerial Resource Management Supervision Requirements
- Current Experience and Training Requirements
- Current Large Wildland Fire Suppression Organization
- Current Aerial Firefighting Tasks
- Methodology Used To Establish Current Aerial Firefighting Workload
- Current Technology
- ATGS Aircraft Vendor Survey
- Potential Future Tactical Aerial Resource Management Aircraft
- Aircraft Procurement Options
- Analysis of the Estimated Economic Value of Current Leadplane Program
- Analysis of the Economic Value of Having Initial Attack Qualified Airtanker Pilots
- Analysis of How Critical Speed Is For Leadplane Aircraft

Interrelationship of Organization, Technology and Aircraft

To allow for development of organizational, human-aiding technology or aircraft options, a clear understanding of the current status of each is needed. In addition, understanding the issues, concerns and opportunities for change that surround each must be understood and evaluated. The majority of this section (Step 2) is devoted to this objective. The sources for the information on the current organizational structure were derived from the TARMS committee members and agency manuals and regulations.

The aircraft is the vehicle by which the personnel and technology (equipment and tools) are transported to the wildland fire. To be of the most value, the aircraft should perform and house the personnel and technology in a manner that optimizes task performance. Performance of tasks by personnel utilizing knowledge, skill, experience and technology is the "function" being performed utilizing an aircraft as one "form" of the way to travel to the wildland fire. In this study, the committee consistently prioritized these two, with "function" first, followed by "form;" (ie. "form" follows "function"). The interrelationship of organization, technology and aircraft, the three

Figure 5 - "The Cube"



components of aerial firefighting, most likely will function at an optimum level if they are well-integrated.

In this report, the term "alternative" will refer to a unique and discrete proposal that combines particular organizational, human-aiding technology or aircraft "options." The cube in Figure 5 displays these three categories uniquely on their axes. A "box" within the cube that is defined by a unique organizational option, human-aiding technology option and aircraft option will be referred to as an "Aerial Supervision Management (ASM) alternative".

Current Aerial Supervision Roles, Organization and Structure

The current aerial supervision organizational structure has four identified positions within the ICS system:

- The two primary roles are performed by the Air Tactical Group Supervisor (ATGS) and Leadplane Pilot (LPP).

- Two additional roles utilized as needed (usually after fire escapes initial or extended attack) are the Airtanker Coordinator (ATCO) and the Helicopter Coordinator (HLCO).

On a wildland fire, none, some, or all of these roles may be filled at any given moment. Several permutations which may occur include:

- No aerial supervision
- Air Tactical Group Supervisor and a Leadplane
- Air Tactical Group Supervisor and no Leadplane
- Leadplane and no Air Tactical Group Supervisor

The presence, or lack thereof, of these positions is affected by a variety of factors:

- Incident complexity, including factors of terrain, numbers of aircraft, fire size, etc.
- Agency and/or local policy regarding requirements for this type of supervision
- Timeliness of dispatch
- Availability of resources as affected by local, geographic area, and/or national activity

Some federal agencies have adopted policy, procedures and guidance documents (e.g., Interagency Leadplane Operations Guide (ILOG), Interagency Air Tactical Group Supervisor Guide) that specify requirements for aerial supervision.

States, local agencies, and other countries have not necessarily adopted specified requirements for leadplane and/or Air Tactical Group Supervisor. In these agencies, the function of the leadplane role may be fully or partially performed by an Air Tactical Group Supervisor or Airtanker Coordinator. The ATGS or ATCO may either be piloting the aircraft, or be an observer riding with a pilot. The aircraft may perform the traditional leadplane role, low-level "show-me" runs, or may stay at high level performing the Airtanker Coordinator role.

Current Roles and Responsibilities

The primary tactical related roles and responsibilities follow. The reference is the NWCG Handbook 410-1, the NWCG Fireline Handbook and Position Checklists.

Air Tactical Group Supervisor (ATGS)

1. Determines and recommends aircraft needs over the incident
2. Recommends temporary flight restrictions when appropriate.
3. Responsible for airspace and air traffic management for the incident.
4. Develops and/or recommends and implements communications plan for air to air and air to around.
5. Makes tactical and logistical recommendations to the Incident Commander.
6. Takes appropriate action on aircraft incidents and accidents that occur within his or her jurisdiction.
7. Fulfills responsibilities of the Leadplane/Airtanker Coordinator when there is no Leadplane/ATCO available. The ATCO does not lead airtankers though.

Leadplane Pilot (LPP)/Airtanker Coordinator (ATCO)

1. Establishes communications with ATGS and obtains operational briefing on overall strategy and tactics of incident control objectives.
2. Establishes communications with airtanker pilot and insures compliance with the communications plan.
3. Surveys incident for hazards to insure the safe operation of all aircraft.
4. Assigns airtankers to specific targets based on action plan and the limitations of the airtanker.
5. Insures that the airtanker pilot understands the overall strategy/tactics of the action plan.
6. Coordinates with ATGS for safe separation of rotor and fixed wing aircraft.
7. Gives direct supervision to airtankers. Leads airtankers on specific runs for safety and efficiency of drops and exit.
8. Fulfills some functions of ATGS based on requests and the presence or absence of ATGS..

The position of leadplane pilot is not included in ICS system but the position of Airtanker Coordinator (ATCO) is. In practice, the ATCO roles and responsibilities are performed by a leadplane pilot or ATGS when present over a wildland fire.

Helicopter Coordinator (HLCO)

1. Establishes communications with ATGS and obtains operational briefing on overall strategy and tactics of incident control objectives.
2. Establishes communications with incident helibase to determine logistical needs of incident to be supported by helicopter.
3. Surveys incident for hazards to insure the safe operation of all aircraft.
4. Assigns helicopters to specific tasks based on incident action plan and the capabilities and limitations of the assigned helicopter.
5. Insures that the helicopter pilot understands the overall incident communications plan.
6. Briefs each helicopter pilot on the overall strategy and tactics for the incident.
7. Briefs each helicopter pilot on the incident transportation plan in regards to the location of the helispots and helibases.
8. Coordinates with the ATGS for the safe separation of rotor and fixed wing aircraft.
9. Fulfills some functions of the ATGS if requested.

Airtanker Coordinator (ATCO)

1. Directs tanker airplanes to targets designated by ATGS.
2. Designates the drop flight pattern for tanker airplanes.
3. Maintains drop sequence and physical separation of tanker airplanes.
4. Remains alert for unsafe and inefficient tanker operation and advises ATGS or takes direct action in extreme cases.

To learn more on how these roles and responsibilities are performed by others, two committee members spent one week in Alberta participating in and observing their process. The structure in Alberta provides for an Air Attack Officer and a Bird Dog pilot in the same aircraft as the equivalent of the ATGS and leadplane pilot. The Air Attack Officer is a Province employee with the fireline qualifications equivalent to Division/Group Supervisor in the ICS system. The Bird Dog pilot is a contract employee from one of the airtanker companies that provide airtanker services to the Province. Experience requirements for a Bird Dog pilot include the attainment of minimum flight hour and certificate requirements as well as experience in flight at low levels and in back country conditions. The use of personal computer based decision support systems, the use of a laser disk based fire training simulator and the use of FLIR technology in Bird Dog aircraft were observed and evaluated as to applications within this study.

Current Tactical Aerial Resource Management Supervision Requirements

Situations and complexities dictate the level of supervision required to safely and efficiently conduct aerial supervision over a wildland fire. Levels of air tactical supervision required by the Forest Service and the BLM are contained in Forest Service Manual (FSM) 5700 and BLM Manual 9400 respectively. These requirements are summarized below as they are displayed in the Interagency Leadplane Operations Guide (ILOG).

A leadplane is required to be over a wildland fire if any one of the following are present:

- the airtanker pilot is not initial attack rated,
- the operations are over a congested area (FS required, BLM requires that a resource order be submitted)
- Modular Airborne Firefighting System (MAFFS) C-130's are assigned.
- two or more airtankers are over an incident
- when a leadplane is requested by an airtanker pilot or ATGS

An ATGS is required to be over a wildland fire if any one of the following are present:

- there is a presence of smokejumpers/paracargo aircraft with two or more airtankers (Note: BLM smokejumper spotters are qualified to perform ATGS duties on a limited basis in Alaska)
- there are two or more branches associated with an wildland fire

An ATGS or leadplane/ATCO is required to be over a wildland fire if any one of the following are present:

- foreign government airtankers are being used
- single engine airtankers (SEAT) are operating with other tactical aircraft
- retardant drops are being made in low ambient light conditions

Both an ATGS and a leadplane are required to be over a wildland fire if any one of the following are present:

- four or more airtankers are assigned to an incident
- two or more helicopters with two or more airtankers over to an incident
- there are periods of marginal weather, poor visibility or turbulence associated with the use of airtankers over an incident.

These criteria for the use of an ATGS on a fire was reviewed by the study committee. The value of having "eyes over a fire or group of fires" providing supervision to aerial attack resources and providing information to ground based personnel (Incident Commander, etc) is high. All decisions made by ground-based firefighters depend on accurate and precise information. This becomes highly critical when a high number of fire ignitions have occurred in a short period of time. The quality of this information provided when provided by a fully qualified ATGS is grounded in training and experience as a Division/Group Supervisor. Implementation to the Federal Wildland Fire Policy whereby wildland fires may potentially be managed for resource benefits has increased the value that can be provided by an ATGS, a highly skilled wildland fire and aviation manager.

Current Experience and Training Requirements

The current firefighting position(s) requirement to be an Air Tactical Group Supervisor (ATGS) is satisfactory performance as a Division/Group Supervisor. For a Helicopter Coordinator (HLCO), it is satisfactory performance as a Strike Team/Task Force Leader and as a Helibase Manager II. For a Leadplane Pilot or ATCO, there are no prerequisite firefighting position requirements.

Table 4 - Current Required Curriculum For Qualification

Course No.	Course Name	ATGS	LP*	ATCO	HLCO
S-110	Wildland Fire Suppression Orientation			R	
S-130 & S-190	Firefighter Training, Introduction to Fire Behavior	R			R
I-200	Basic ICS		R		
S-205	Fire Operations in the Urban Interface	R	R**		
S-217	Interagency Helicopter Training Guide				R
S-270	Basic Air Operations		R		
J-374	Helicopter Coordinator				R
S-290	Intermediate Fire Behavior	R	R		R
S-320	Unit Leader			R	
S-336	Fire Suppression Tactics	R	R		R
S-371	Helibase Manager				R
J-376	Airtanker Coordinator			R	
S-378	Air Tactical Group Supervisor or the California Dept. of Forestry Air Attack Management Course	R	R		
S-390	Fire Behavior Calculations	R			R
Crew Resource Management & Aerial Retardant Application and Use			R**		
National Leadplane Standardization			R		

* - Federal agency requirements are contained in the Interagency Leadplane Operations Guide (ILOG).
** - Required within two years of initial qualification

The required training for qualification in these positions are contained Wildland Fire Qualifications Subsystem Guide 310-1 (NFES 1414, October 1993)and the Interagency Leadplane Operations Guide (1998). Note that agencies can specify additional training requirements and that additional training and experience is required for prerequisite positions.

Current Large Wildland Fire Suppression Organization

Aerial supervision for wildland fires managed by National (Type I) and Geographic Area (Type II) Incident Management Teams currently is accomplished by:

- An ATGS (usually assigned to National teams; ordered for Geographic Area teams). On larger incidents additional ATGSs may be ordered to support relief needs, need for continuous coverage over wide areas not able to be covered by a single ATGS, etc.

- A Leadplane assigned via Resource Order (and usually only when airtankers are being utilized on the incident). Leadplanes are not considered as “assigned” to a specific fire but are usually assigned and controlled by Geographic Area Coordination Centers.

- Helicopter Coordinator assigned via Resource Order, usually for wildland fires where supervision of numerous helicopter resources is necessary, or those to which Type 1 helicopters are assigned.

- The Leadplane Pilot normally will function as the ATCO. When helicopters are dropping water/fire retardant, the HLCO performs the ATCO duties.

The transition and/or growth of an incident management organization and operation can occur over a period of several days or it may happen quickly within a few hours. Many safety problems, organizational issues and cost efficiency concerns emerge as the incident transitions. The early stages of complex incident management frequently is hindered by the lack of current fire intelligence by individuals with “a need to know.” Planning cycles rely on the need for valid information for the optimal assignment of resources. As fire intelligence becomes available, adjustments in resource assignments and ordering occur. Adjustments are made to improve safety and effectiveness resulting in a more efficient fire management organization. With the most current information, the fire management effort can enhance the efficient and safe use of resources. Critical fire intelligence could be real time and the potential exists for aerial supervision and ground based personnel to have the same information for deployment of ground and air resources.

Current Aerial Firefighting Tasks

In order to evaluate the current workload in the aerial firefighting environment, a Task Workload Matrix was developed. The source data for the matrix was originally developed by Sandra G. Hart, a world renowned NASA researcher on aviation workload and performance, and Jon Little, a retired-Forest Service ATGS working under contract to the NASA-Ames Research Center . The matrix was based on a task listing designed to support the evaluation of workload, communications, airspace structure and human-aiding technology in the NASA/BLM/USFS National Aerial Firefighting and Safety (NAFSE) Project.

This source data for the matrix was acquired from video and audio tapes of actual aerial firefighting operations collected during the 1995 and 1996 fire seasons. The data collected during these fire seasons was compiled into a human factors database originally designed to support a comparative analysis of current and proposed aerial firefighting operations in terms of communications, airspace structure, and human aiding technology. Task workload ratings by aerial firefighters working on actual fires were also collected during the same periods.

Major aerial firefighting task areas were identified. Specific sub-tasks under these major categories were developed by TARMS subject matter experts using the NAFSE human factors database, Position Task Books developed by the National Wildfire Coordinating Group and subject matter knowledge of the aerial firefighting domain. A list of 134 tasks were selected for evaluation in the matrix. The major task areas and their percent of occurrence are displayed in Figure 6. It is recognized that the task of Flying the Aircraft is a task performed constantly (100% of the time). For the purpose of the Task Workload Matrix, only those flying tasks that involved a change from the normal cruise configuration such as descending to a lower-level were included. The Phase of Mission provides a chronology of the air operation from start to finish. Operational phases and their percent of occurrence are displayed in Figure 7.

For the purposes of evaluating the current workload, a "Representative Fire" scenario was developed to provide those completing the matrix with a common frame of reference. The Workload Analysis was completed with the idea of the following "Representative Fire" in mind:

- Mission duration is 3-4 hours.
- Arrival is mid-afternoon.
- There are 3-4 large airtankers dropping per hour.
- There are 2-3 helicopters performing logistics and tactical missions
- Fuel type is a combination of brush and timber.
- Aerial supervision is present on various combinations based on Organizational Option
- The fire is staffed on the ground with a variety of ground resources continuing to arrive over the course of the afternoon and early evening.
- The fire is 84 miles from the closest airtanker base.

Figure 6

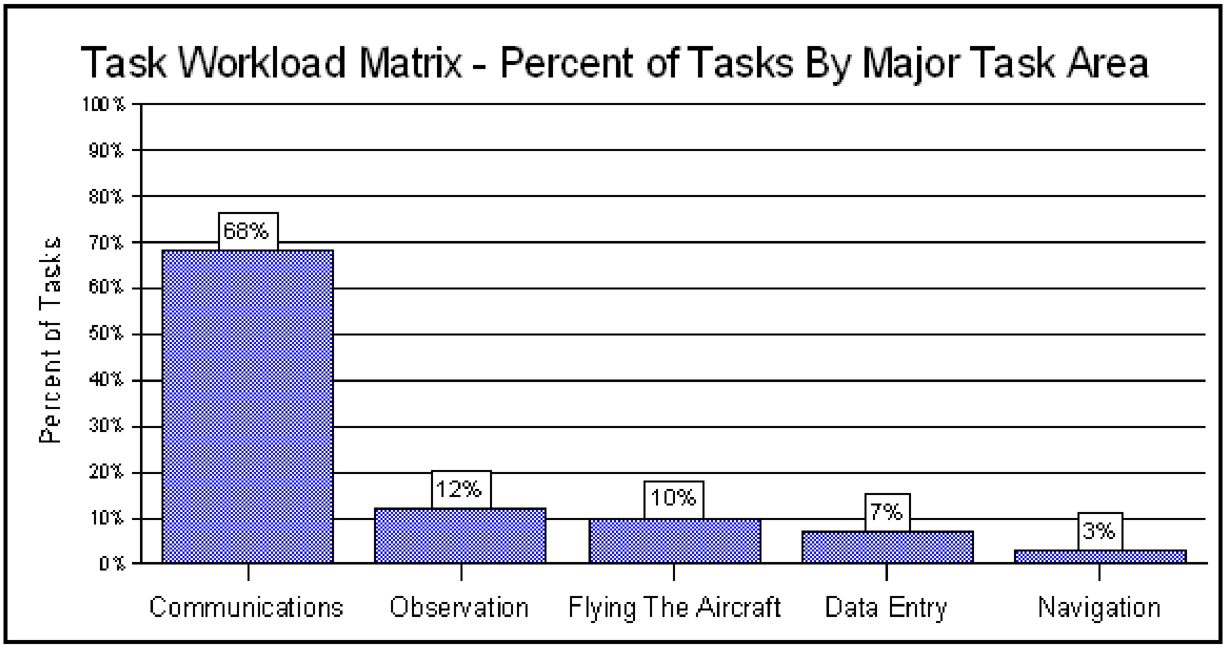
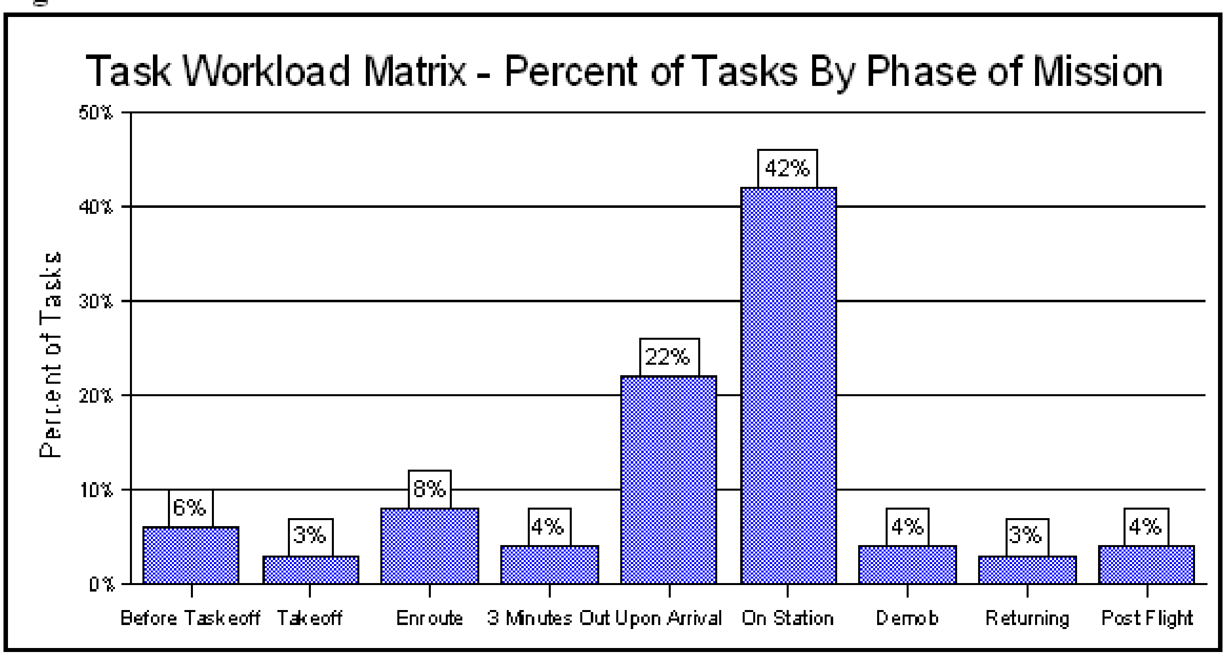


Figure 7



Methodology Used To Establish Current Aerial Firefighting Workload

Each task was rated as to its importance by the Study Committee and an Importance Factor was assigned. This Importance Factor was defined as follows.

- Importance Factor - Relative to all tasks involved in the mission, the rating for this task is: its importance:

  1 = Low Importance
  2 = Moderate Importance
  3 = High Importance

Each task was rated as to its workload based on the follow Workload Weighting Key.

- Workload Weighting Key

  0 = No Workload: Task is Never Performed
  1 = Low Workload: Workload of Task Itself is Low
  2 = Moderate Workload: Workload of Task Itself is Moderate
  3 = High Workload: Workload of Task Itself is High

Each task was rated as to how often it was performed based on the following Task Performance Rating Key.

- Task Performance Rating Key

  A = Task Is Never Performed
  B = Task is Performed Only Once/Rarely; Usually Does Not Require Simultaneous or Near-Simultaneous Performance With Other Tasks
  C = Task is Performed Several Times; Some Other Tasks Are Usually Being Performed Simultaneously or Near-Simultaneously
  D = Task is Performed Frequently; Many Other Tasks Are Usually Being Performed Simultaneously or Near-Simultaneously with This Task

The 134 tasks that comprise a typical initial attack/extended attack mission are contained in Appendix G. Note that there is no Task 84 as it was omitted based on duplication with another Task. To avoid error, Tasks were not renumbered. The column on the right side of the page with the title IMP indicates the Importance Factor (1, 2 or 3) for the task.

The Task listing contains an indication of where the Task was performed (ie. internal to the aircraft) and with whom it was performed (ie. To Airtanker means communication with an airtanker pilot).

Eight members of the study committee completed the Task Workload Matrix over a two day period during a sub-group meeting at the Sierra Front Dispatch Center in Minden, Nevada. The purpose was to evaluate workload in the current aerial firefighting organizations to identify issues and concerns that could be addressed in potential Organizational, Technology or Aircraft options. The results of the workload analysis for current aerial firefighting organizations as well as for potential Organizational, Technology or Aircraft Options are summarized in Step 4, the Analysis of Options and the Development of a Preferred ASM Alternative. All Organizational and Human-aiding Technology Options are developed and evaluated using the current task summary ratings as a benchmark. Appendix H provides an example of the form used. The current Organizational Options 1-5 noted are defined in Step 3, Development of Evaluation Criteria and Organizational, Human-Aiding Technology and Aircraft Options.

Current Technology

Most aircraft are 15 to 25 years old and equipped with the avionics technology for aircraft of this time. Multi-channel programmable aircraft radios have been in use for several decades, with increasing technological improvements. Agency-owned lead planes and exclusive-use contracted or agency-owned ATGS have required the inclusion of radio hardware to meet communications requirements. However, no such requirement exists for call-when-needed (CWN) ATGS aircraft. Some vendors have installed 9600-channel programmable radios, and these aircraft are in high demand for CWN ATGS work during periods of peak activity. Portable kits have been developed to meet the CWN need, but are not comparable to a fully equipped ATGS avionics suite. The use of the portable kit is not recommended on incidents with any degree of complexity of aerial firefighting tactics or air traffic management. The TARMS User Survey identified radio hardware systems, frequencies, and human interfaces as a major problem area. This is an area where a recommendation could be made to adopt typing of CWN ATGS aircraft, based primarily upon avionics .

The advent of Global Positioning System (GPS) capability has resulted in the inclusion of a GPS requirement in many agencies' exclusive-use contract aircraft. However, some pilots of ATGS CWN and airtanker aircraft are using hand-held Global Positioning System (GPS) units.

The Forest Service recently installed Traffic Collision Avoidance Systems (TCAS) in the Forest Service leadplane fleet. Use of TCAS, and the potential to integrate other information into a TCAS-similar system that provides much wider and greater functionality to all aerial firefighters than stand-alone TCAS, is discussed in depth later in the report.

For several years, a few Forest Service and other state agency ATGS aircraft have been equipped with Forward-Looking Infrared (FLIR) equipment. User (both ground and air) reaction to FLIR-equipped aircraft has been predominantly positive, with economic and safety benefits easily recognized and realized. As with TCAS, use of FLIR and the potential to integrate FLIR into other data collection and information transmittal systems, is also discussed later in the report.

A few ATGS aircraft, leadplanes, and airtankers are equipped with external cameras to record retardant drops, audio devices to record fire communications, and computers tied to GPS to provide moving map information, map fires, etc.

Use of human-aiding technology (defined here in terms of flight deck displays and associated computerized data collection/transmittal systems) on aerial firefighting flight decks has been very limited, if not non-existent.

Only recently has technology with specific applications to aerial firefighters become available. A survey (see Appendix F) was performed with industry to determine the current state of technological applications with potential to aid aerial firefighting, with encouraging results. The BLM/USFS/NASA National Aerial Firefighting Safety and Efficiency (NAFSE) Project also developed a system with specific relevance to aerial firefighting. Technology with specific benefit currently exists and will continue to evolve in the future. The caution is to remember that any such system must be developed by users and fully tested and integrated into what will most likely always remain a heads-up, eyes-out environment.

The information in this section and other sections will be used in Step 3 to aid in the development of human-aiding technology (HAT) options with the potential to enhance aerial firefighting safety and effectiveness.

ATGS Aircraft Vendor Survey

A need was identified to define the numbers of CWN ATGS aircraft available to the agencies within the United States. Complicating this effort was the lack of defined National criteria by the Forest Service or USDI (OAS) for specifications for ATGS aircraft.

Accordingly, an ATGS Aircraft Vendor Survey was distributed to all Forest Service and USDI (OAS) vendors. See Appendix D for a copy of the letter to vendors and a copy of the Survey forms. In the Survey, the vendor was asked to submit data on aircraft based on a defined set of criteria that primarily centered around avionics equipment.

The committee divided the responses into three types of ATGS aircraft, based upon avionics as defined below:

TYPE 1 - Dual audio panel with 3rd rear seat position for trainee; Two-720 channel AM radios; Two-vendor owned multi-channel programmable FM radios capable of receiving both guard and operating frequency simultaneously in all three positions; dual mounted broadband antennas; intercom with switchable hot mike or VOX capability; and GPS.

TYPE 2 - Dual audio panel with 3rd rear seat position for trainee; Two-720 AM radios; 1-vendor owned multi-channel programmable FM radio capable of receiving both guard and operating frequency simultaneously in all three positions; vendor installed FM handheld radio interface; dual mounted broadband antennas; intercom with switchable hot mike or VOX capability; and GPS.

TYPE 3 - Two 720 channel AM radios; wiring harness for NIFC and commercial slip-in radio packages capable of receiving both guard and operating frequency simultaneously in all three positions; vendor installed FM handheld radio interface; dual mounted broadband antennas; and GPS.

The quality of responses from vendors varied. The effort to determine the numbers of properly-equipped CWN ATGS was abandoned due to the inability to construct a data set with any degree of confidence in its accuracy. Excluding those ATGS aircraft under exclusive-use contract with an agency, a preliminary review of the data indicated the following approximate number of aircraft available nationwide :

Type 1: Less than 5 aircraft   Type 2: 5-10 aircraft   Type 3: 10-20 aircraft

Anecdotal experience relayed by Geographic Area Coordination Centers and members of the study committee verified the difficulty in obtaining CWN ATGS aircraft with the avionics capability required.

This Vendor Survey and its results indicate a need to develop aircraft options in this study to support the CWN ATGS aircraft need in the field.

Potential Future Tactical Aerial Resource Management Aircraft

The purpose of this portion of the study is to develop and test a method to be used for the selection of a replacement Aerial Supervision Aircraft. The method is to be rooted in the mission needs and emphasis safety for the flight crew and aircraft. As this is a criteria development and test, only US manufactured aircraft were completely evaluated to the method. The study team recognizes that there are foreign aircraft available may perform well against the criteria. However, completeness in evaluating all available aircraft was deemed unnecessary for the purpose of developing and testing criteria.

A survey was conducted of the current production and development aircraft. The source for this survey was Jane's All the World's Aircraft 1996-1997 and The Aircraft Bluebook – Price Digest, Summer 1997. The survey resulted in the identification of over 80 current production or development aircraft of both fixed and rotor wing. The survey list can be found in Appendix B.

The detailed process used to determine aircraft to be formally evaluated is described in the Step 3, Development of Evaluation Criteria and Organizational, Human-Aiding Technology and Aircraft Options.

Aircraft Procurement Options
For purposes of this discussion, there are basically four (4) different procurement options.

- Government Owned Aircraft

- Government Leased - Long-Term Basis (Exclusive-Use). The aircraft are available exclusively to the government based on the period specified in the contract. During the period of the contract, the government is the "exclusive" user of the aircraft. Hence the term, exclusive-use contract. The contractor is usually guaranteed a number of flight hours over a specified period of time or a guaranteed amount of money for each hour or day of availability. There are very specific performance and avionics specifications and requirements. These aircraft can be piloted by a contractor or government employee.

- On-Call Contract. These aircraft are available for a guaranteed number of hours over a long-term basis (e.g., 6 months, one year) based on the requirements in the contract. Penalties may be incurred if contractor cannot perform within a specified period of time (e.g., 12 hours, 24 hours, etc.). Aircraft can be used for other uses by the vendor. There can be very specific performance and avionics specifications and requirements. If the requirements are extensive, the hourly guarantee rate can be relatively high unless a large number of flight hours are guaranteed as this is the only way a contractor can recover the costs of the requirements.

- Call-When-Needed (CWN) or Basic Ordering Agreement (BOA) These aircraft are rented usually by the hour on an as-needed basis. There is no penalty for not responding to an order for service. There can be very specific performance and avionics specifications and requirements, but unless guarantee is high, vendor has no monetary incentive to make modifications, buy equipment, etc.

Initial Attack/Extended Attack, Large Fire Support, and Local Call When Needed Aircraft
An analysis of aircraft evaluation criteria must be done considering the intended use of the aircraft; i.e. support of initial attack/extended attack (IA/EA), large fire suppression (LF) and local Call When Needed (CWN) aircraft. Through discussions and analysis, many aircraft criteria requirements were found to be different for the aerial supervision mission between these uses.

The exclusive-use, on-call contract, and call-when-needed procurement vehicles can be used to procure aircraft not owned by the government. The use of all categories to obtain aircraft provides the firefighting agencies the flexibility to deal with situations beyond either the pre-suppression funded level or when all available resources are committed.

Three categories of procurement for aerial supervision aircraft will be defined as follows for use later in this Report.

IA/EA/LF National Fleet
This is a National initial attack/extended attack fleet of aircraft that the government would own or lease (exclusive use contract) on a long term basis. The purpose of these aircraft is to provide a platform from which the leadplane and air attack missions could be performed. The aircraft would have very specific performance, configuration, avionics, and technology requirements. For the current leadplane program, this fleet is comprised of 20 Forest Service owned aircraft of two models of the Beechcraft Baron 58 (19 model 58P and one model 58) and 6 BLM owned OV-10A aircraft. Also note that the BLM in 1998 has decommissioned their OV-10 aircraft and are examining options pending the implementation potential TARMS report recommendations.

Supplemental National Fleet
This fleet is defined as a fleet of aircraft that would have defined aircraft characteristics and contain specified human-aiding technology or the capability to quickly install such equipment. These aircraft would not be used to lead airtankers but only as a platform to perform the air attack mission. The procurement vehicle would be On-Call Contract method. As supplemental to the IA/EA/LF National fleet, these aircraft are expected to provide the same nationwide service under the national mobility concept. The contract would include a guaranteed number of flight hours based upon historic use and supplemental coverage needs. It would also specify a defined (but more liberal than exclusive-use) time period for the operator to respond to an order requesting service.

CWN Local Fleet
This fleet is currently procured at the geographic or sub-geographic (local) level for the air attack mission using the Call-When-Needed or BOA (rental) procurement method. This fleet is a local resource, so funded, and is not expected to support nationwide service. These aircraft would be typed based on a National definition, primarily according to avionics specifications and pilot training and experience requirements. Justification and staffing of local ATGS personnel and aircraft are through the NFMAS process.

Acquisition of One or More Aircraft Types
The committee examined whether the acquisition of one or more aircraft types was appropriate.

The advantages of acquiring a single aircraft type are as follows:

- Reduced Training Requirements and Cost
  With a fleet of one aircraft type, training and currency requirements are less.

- Reduced Maintenance Cost
  While the flight maintenance requirements may be similar between any two aircraft, by pooling the maintenance of a single aircraft fleet the costs can be reduced.

- Commonality in Aircraft Systems and Equipment
  The layout and accessibility of avionics and other equipment can vary significantly between aircraft. Under stressful or highly demanding workload situations (which are typical in the aerial supervisory role) and if the pilot (while current in the aircraft) does not normally fly the second aircraft, safety can be impacted.

- Reduced Potential Confusion during Operations
  During operational activities, the leadplane must join up with other aircraft. These rendezvous occur under visual circumstances. Both the aerial supervision fleet and the airtanker fleet are highly mobile and can be dispatched to any geographic area. While common painting schemes can improve the recognition factor, commonality in a single leadplane fleet will reduce confusion during operations.

The main disadvantages of acquiring a single aircraft is the potential for grounding of the entire fleet from an FAA Airworthiness Directive or other safety issue. Grounding issues are not predictable and could result in a disruption to aerial supervision during fire season.

A review of historical data on the current Beech 58P Baron and other records was conducted, and found that the grounding potential was minimal or non-existent. In most cases of FAA Airworthiness Directives, an inspection is required to determine if the problem does in fact exist. If the inspection identifies the existence of the problem, the problem is fixed and the aircraft returned to service.

NFMAS Analysis - General

The National Fire Management Analysis System (NFMAS) was used to examine the economic value of the current leadplane program. and to display the economic tradeoff of the cruise speed capability of a leadplane. Through the analysis, it was possible to display the economic value of having initial attack qualified airtanker pilots though this is not the focus of this study. In Step 4, the Analysis of Options and the Development of a Preferred Alternative, NFMAS will be used to determine dispatch workload for leadplanes and ATGSs which will support recommendations on the quality of aircraft and modules.

Data Used In the Analysis

The NFMAS data base for these runs was the same data base used in the National (Large) Airtanker Study, Phase 2 (NATS2). This data base includes all National Forests in the California, Northwest, Northern, Rocky Mountain and Southwestern Geographic Areas. This data base also includes all but two BLM Districts in the California, Northwest, Northern, Rocky Mountain and Southwestern Geographic Areas. One BIA unit is included in the Northwest Geographic Area. This extensive data base provides a large data set by which inferences can be made as to effects on lands not presented.

Forces used for initial attack of wildland fires are analyzed and justified using the National Fire Management Analysis System (NFMAS). NFMAS interagency initial attack assessment (IIAA) model analyzes initial attack effectiveness and was used to analyze the effect of the alternatives. All dollar amounts displayed in this report are in 1997 dollars unless otherwise stated. The current OMB Price Adjustment Index was used to calculate factors to adjust dollar values.

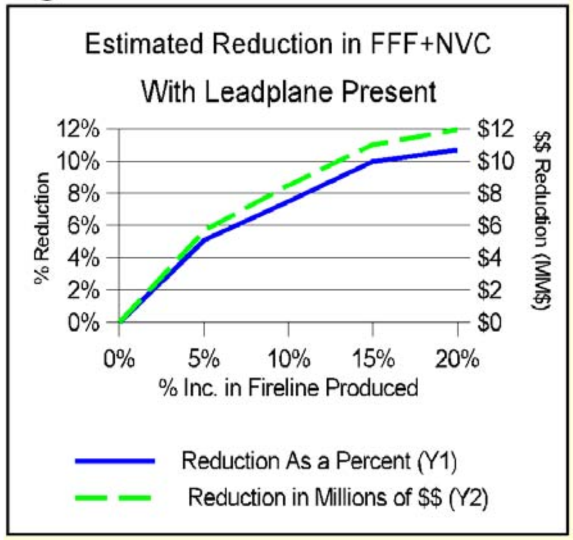
The term Fire Suppression (FFF) Costs is used to describe the sum of the cost to suppress a wildfire. These costs are accounted for in two ways, unit mission costs and average acre (suppression) costs. Unit mission costs are "trip" costs for fire suppression resources. For airtankers, these costs would be the flight costs (flight rate times hours flown) and retardant cost. Retardant cost was assumed to be $0.80 per gallon. Average acre costs include all other fire suppression costs expressed on a per acre basis.

The term Net Value Change (NVC) Costs is used to describe the algebraic sum of the effects of a fire keeping in mind that some effect are negative and some positive. In general, the algebraic sum is a negative number.

Potential Economic Value of Current Leadplane Program

To the committee's knowledge, no studies have been done that quantify the change in fireline production efficiency by airtankers or ground-based firefighting resources based on the presence or absence of aerial supervision. To test the sensitivity of acres burned and expected annual FFF+NVC to changes in fireline production efficiency, runs were made using the IIAA. When a leadplane is present and performs the lead function, collectively the drops can be expected to be placed more accurately. Figure 8a displays the estimated economic value of this accuracy. Through no analytical study has been completed to verify potential economic savings, it does appear that savings are possible and attainable through efficiency goal setting during implementation of adopted recommendations.

Figure 8a



Due to the lack of a national consistent staffing of an ATGS program, an attempt was not made to analyze the economic value of the current ATGS program. An assessment of the potential value of aerial supervision to ground-based firefighter efficiency is made in the documentation of Step 4 of the process.

Potential Economic Value of Having Initial Attack Qualified Airtanker Pilots

Currently, many pilots of large airtankers are qualified to perform a fire retardant drop without a leadplane in areas where a leadplane is not required or available. Pilots with this qualification are referred to as "initial attack qualified." As has been noted earlier, a leadplane is required to be over a wildland fire if:

- the airtanker pilot is not initial attack qualified,
- the operations are over a congested area (FS required, BLM requires only that an order be submitted)
- Modular Airborne Firefighting System (MAFFS) C-130's are assigned.
- two or more airtankers are over an incident
- when a leadplane is requested by an airtanker pilot or ATGS

The ability to compare the difference in expected annual acres burned and FFF + NVC between this current situation and one which would require all airtankers to wait for a leadplane before dropping would show the value of this "initial attack qualified" qualification. The economic value for airtankers not having to always wait for a leadplane measured in reduced expected annual FFF + NVC was determined to be $10,000,000. This is a conservative estimate since not all users of leadplane services are represented by the NFMAS data base.

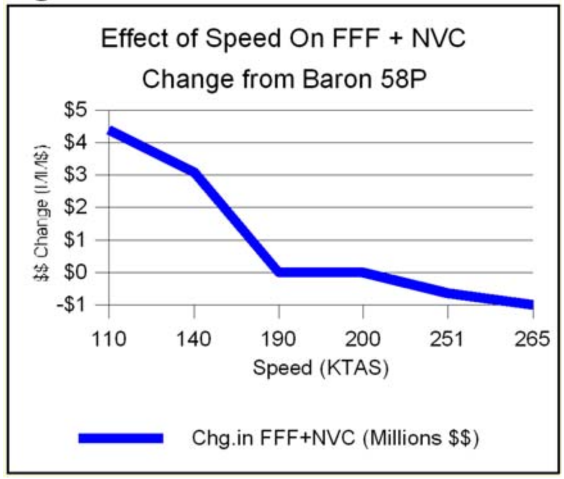
Analysis of How Critical Speed Is For Leadplane Aircraft

When a leadplane is required, time spent loitering by airtankers while waiting for leadplane is costly and inefficient in the support of ground-based firefighters. The average hourly flight rate for the current airtanker fleet is about $2300, or about $38 per minute, and this rate for the future large airtanker fleet recommended in the NATS2 report is $2908 per hour, or about $49 per minute.

To analyze the economic value of speed for the leadplane, comparative runs were done on the NFMAS data base using lead aircraft as follows:

Cruise Speed	Aircraft Represented
110	Average Helicopter
140	Fastest Helicopter
190	Baron 58P
200	Benchmark Average Future
251	OV-10A
265	Benchmark Fast Future

Figure 8b



Cruise speeds are measured knots indicated true air speed (KTAS). The results shown in Figure 8b. In the Figure, the current Forest Service leadplane, Beechcraft Baron 58P, with a cruise speed of 190 KTAS is the benchmark. The values are from the NFMAS database for the California, Great Basin, Northwest, Northern and Southwest Geographic Areas. Significant increases in expected annual acres burned and expected suppression cost plus loss (FFF+NVC) are noted for aircraft that have a KTAS cruise speed of less that 190-200 knots. This includes all helicopters. It is of note that though ATGS aircraft were not modeled for the effects of speed, similar results would be expected.

STEP 3: DEVELOP EVALUATION CRITERIA AND ORGANIZATIONAL, HUMAN-AIDING TECHNOLOGY AND AIRCRAFT OPTIONS

Criteria to be used in the evaluation of potential organizations, human-aiding technology and aircraft, will be developed in this Step. In addition, Organizational, Human-aiding and Aircraft Options will be developed. These options are generated to address characteristics and issues within the leadplane and ATGS programs where changes could enhance performance and efficiency. These changes are in the areas of management and operations, communications, personnel, aircraft resource management, airspace coordination, safety and organization. The major sections within this Step are as follows:

- Evaluation Criteria for Organizational and Human-Aiding Technology Options
- Organizational Options
    - The Shared Mental Concept
    - ATGS Aircraft Pilots
    - The Aerial Supervision Module (ASM) Concept
    - Summary of Organizational Options
- Human-aiding Technology Options
    - Human-Aiding Technology Specifications
    - Human-Aiding Technology Options
- Training Objectives and Potential for Change
- Aircraft Evaluation Criteria
    - Must Criteria
    - Ranking Criteria
- Aircraft Options

Evaluation Criteria for Organizational and Human-Aiding Technology Options

There will be only one objective evaluation criteria to measure organizational and human-aiding technology option. Based on an assessment of workload for tasks to be performed, the evaluation will display the relative change in workload from the current Organizational and Human-aiding Technology Options. This comparison will be made in a manner where there is not a commensurate loss in task accomplishment.

Organizational Options

The Shared Mental Concept

A critical factor in firefighting is communications. From the TARMS User Survey, 26% (94/359) of the problems identified in the TARMS User Survey were related to communications issues. Communications issues are second only to Management and Operations issues (30% = 108/359). Of the 94 responses in the communications category, 46 were related to the exchange of information.

Within the 134 tasks in the Task Workload Matrix, 68% are Communications tasks. This compares to 12% of the tasks which are Observation, 10% which are Flying the Aircraft, 7% which are Data Entry, and 3% which are Navigation. Refer to Figures 6 and 7 for graphic representations of these percentages. As was noted earlier, it is recognized that the task of Flying the Aircraft is a task performed constantly (100% of the time). For the purpose of the Task Workload Matrix, only those flying tasks that involved a change from the normal cruise configuration such as descending to a lower-level were included.

When people communicate, they communicate best when they share the same mental model of the task, goals and objectives, and the environment in which the task must be performed. A mental model is defined by Donald A. Norman (1990) in *The Design of Everyday Things*, as "..the models people have of themselves, others, the environment, and the things with which they interact."

The lack of a shared mental model is one of the major factors which hinders the distribution of information about the terrain, the fire, the airspace structure, and the interactions of aerial as well as ground firefighters. This lack of shared information manifests itself in:

- Inadequate or poor communications between aerial firefighters. Examples include inadequate, incorrect or confusing position reporting, target description and instructions, holding dimensions, terrain descriptions, etc.

- Inadequate or poor communication between ground and aerial firefighters. Examples include incorrect or confusing location reports by ground-based firefighters, and inaccurate communication frequently due to a lack of common terminology.

The lack of a shared mental model among leadplane pilots, ATGSs, helicopter pilots, airtanker pilots and ground firefighters is due to variations in operating altitudes among participants, flight deck outward visibility, resource demands of other tasks that must be performed (ie. flying the aircraft), position over the terrain, and the obscuring effects of smoke. For example, when an airtanker is flying into an area at 3000' AGL from the northwest, while the leadplane is completing a drop with another airtanker on the opposite heading, the central point of reference for these two aircraft pilots will be significantly different. The same holds true for an ATGS at 3000' AGL describing a target for a helicopter pilot flying up a canyon at 100' AGL.

Participants have different task to perform, such as the dropping retardant for an airtanker pilot, the leading of an airtanker for the leadplane pilot, or the supervising of the entire operation for the ATGS. These differing objectives also contribute to the lack of a shared mental model of the world.

Current aerial supervision procedures allow for descriptions of airspace and airspace structures that are not precise, are not descriptive, and are not informative to the extent that assures maximum safety and efficiency. Examples include the routing instructions into and away from the fire as well as the instructions given to define the proper position for an aircraft to loiter outside the fire area (NAFSEP Report, 1998).

When participants do not share the same mental model, target descriptions may become difficult as different terms may be used to describe the same object or location in the terrain. Not all pilots will interpret the terms “ridge” and a “saddle” equally, or know the distinguishing features between a “Unimog” and an “engine.” Contributing to these problems include aerial firefighters who possess different backgrounds and experiences, come from different geographic areas, perform procedures in a non-standard way, and/or who have been exposed to various levels of training. The pure physical fact that two aircrews (leadplane and ATGS) with aerial supervision responsibilities operating two different aircraft at different points in space contributes to lack of shared mental models.

The problem is magnified when one addresses the lack of a shared mental model between air and ground resources. The first major difference between these two is related to the global perspective of the fire that the aerial firefighter possesses, as opposed to the local perspective of the ground firefighter. The ground firefighters “world view” is limited by position on the ground, by terrain, and by obscuring fuels and smoke. The aerial firefighter’s view, though global, lacks detailed information about the terrain, fuels, and fire behavior that the ground firefighter possesses. When the two attempt to communicate, they frequently lack a central point of reference (ie. shared mental model) that is the first key to geographical orientation, navigation, or communications about any description of that environment. The shared mental model is another reason why the ground-based Division Supervisor qualification is a prerequisite for ATGS. With extensive ground-based firefighting experience, the ATGS can relate to the ground firefighting effort.

Traditionally, communications between individuals are facilitated by a shared mental model. Individuals will use fewer words to convey their message, and the receiver will be able to anticipate the flow and meaning of the words used. Thus, each individual’s communication will take less time and both will experience lower workload. A shared mental model between individuals can result in optimal performance. The lack of a shared mental model traditionally results in degraded performance and higher workload, with a consequent effect on safety and efficiency (Schumacher, R.M., (1988); Collins, A. M., & Gentner, D., (1986). Another factor which has an impact and effect on individuals’ ability to develop a shared mental model is their background or training (Kieras, D & Bovair, S., (1984) and Polson, P. G. & Kieras, D. (1985)).

ATGS Aircraft Pilots

In federal agencies, there is no identified training for ATGS aircraft pilots. The Forest Service evaluates candidates for the ATGS aircraft pilot, and issues a card for that qualification. The Office of Aircraft Services (OAS) evaluates for “precision reconnaissance” skills but does not “card” pilots specifically for the ATGS mission. Neither agency provides in-depth training for the ATGS aircraft pilot role.

For the following discussion, it is essential to understand in this document, in associated Task Workload Matrices and data analyses that the references to “experienced” and “inexperienced” pilots does not refer to flying ability. Such references are to training and experience, or lack thereof, in assisting the Air Tactical Group Supervisor in the performance of his/her job.

If the ATGS aircraft is being flown by an experienced pilot (commonly an Agency or exclusive use contract pilot) who is familiar with and has been trained in aerial supervision roles, duties and responsibilities, then the ATGS aircraft pilot can share some of the ATGS's workload. The tasks where sharing can primarily occur are in the area of communications with dispatch, the leadplane, and with airtankers pilots. Based in responses to the TARMS User Survey, Air Tactical Group Supervisors estimate 20% of their workload can be assumed by an experienced ATGS aircraft pilot.

Although an inexperienced ATGS aircraft pilot may acquire expertise through locally-provided training and frequent use, they are commonly not trained in this role. In this situation, the ATGS must assume the workload that an experienced ATGS aircraft pilot could normally assist in performing.

The Aerial Supervision Module (ASM) Concept
The components of this option are:

- A Platform (aircraft and flight deck systems)
- An Air Tactical Pilot (ATP)
- Either an Air Tactical Group Supervisor (ATGS) or an AirBorne Suppression Supervisor (ABSS).

A description of each of the positions follows as well as the integration into the Aerial Supervision Module.

The Air Tactical Pilot (ATP) Concept
The Air Tactical Pilot (ATP) fulfills a combination of the roles and responsibilities included in the current positions of leadplane pilot and Air Tactical Group Supervisor pilot. The ATP would be qualified under the leadplane training program.

The Air Tactical Group Supervisor (ATGS) Concept
The ATGS roles and responsibilities remain unchanged. Based on training provided, the sharing of some duties and workload with the Air Tactical Pilot (ATP) would be possible.

The AirBorne Suppression Supervisor (ABSS) Concept
The AirBorne Suppression Supervisor (ABSS) would fulfill the present day role of the Air Tactical Group Supervisor (ATGS), but with additional and/or altered duties and responsibilities. The ABSS would be responsible for supervision of all tactical fire operations, both ground and air. This supervisory responsibility for all tactical operations would be maintained from arrival on scene until transferred to ground personnel. The ABSS essentially becomes an "airborne" Operations Section Chief. Due to a number of factors (better vantage point, often higher firefighting qualifications than ground-based initial attack personnel, etc.), the ABSS may retain this operational supervision for a longer period of time than under current practice with the ATGS. Under current practice in most areas, the ATGS, if first on-scene, is the Incident Commander (IC). Upon arrival of a qualified Incident Commander on the ground, the ATGS-as-IC role is turned over to the ground IC. However, the new IC will frequently continue to defer to the ATGS on operational decisions and recommendations under this proposal. The ABSS would still work for the IC.

The Aerial Supervision Module

The ATGS and ATP, or ABSS and ATP, work as in integrated flight deck team, sharing fire suppression, air tactical, and aviation duties. In this module, each team member brings unique skills, background and knowledge and together will achieve synergism to the aerial supervision. The ATP provides the aviation expertise, and the ATGS/ABSS provides fire behavior expertise. Through teaming increased capability will occur. As the workload for either role is high, the other can assist in reducing stress and workload while gaining new perspectives and knowledge to aid in performing their roles. For example in the leading airtankers, the ATGS can assist the ATP in picking up traffic, monitor radio traffic and flight instruments when the ATP is performing 'eyes out' tasks, etc. An additional benefit for the ATGS will be close up monitoring of fire behavior, fuel type, etc.

Together in the same aircraft, they will be referred to as an Aerial Supervision Module (ASM). If the ABSS or ATGS were not in the aircraft, the ATP and aircraft would have the same role filled currently by the leadplane. The term leadplane is not eliminated in this concept and remains a part of the aerial supervision organization.

The proposed ASM module will be staffed by an ATGS and an ATP. The roles and responsibilities of the ASM crew are as follows:

The ATGS fills the position of Mission Commander. The Mission Commander is responsible for and has authority over all aerial fire suppression assets and operations. The Mission Commander will work closely with the ATP to develop tactics and strategies to support the mission objectives.

The ATP fills the position of Aircraft Commander. The Aircraft Commander is responsible for and has authority over all aircraft safety of flight issues. These include but are not limited to:

- Go-no-go decisions for each mission
- Requirements for air tanker leads
- Airspace coordination and air traffic management
- Provide information to and coordination with all aircraft operating within the control jurisdiction of the fire.

The Aircraft Commander will work closely with the Mission Commander to successfully complete all mission objectives.

Operations similar to the ASM concept, roles and responsibilities have been conducted in BLM Alaska, and BLM Nevada to support the staffing of their aircraft. An additional implementation of the proposed roles and responsibilities can be found in the staffing of aerial vehicles used to support the California Highway Patrol (CHP). The CHP staffing protocol was documented in a report by Linde and Shively, (1988).

ASM During Initial and Extended Attack
Operationally, when the ASM arrives at an initial attack fire, the ATGS will perform size-up, communication, and formulate tactics etc. (just as the roles currently function). Simultaneous the ATP will determine airspace structure exit routes, "basic" arrival altitudes for airtankers, etc. When the ATGS has finished the initial size-up, coordination and communications the module will assume the traditional role leadplane role in establishing airtanker lead ins, confirming exits and noting hazards. The module will then return to the ATGS altitude until airtanker arrival. From this point priority and resource arrival will determine whether the module will function in the leadplane or air attack roles. If resource arrival become too frequent to allow dual role operations, a second ASM module will be ordered with one module doing the traditional lead and one doing the traditional air attack. A CWN ATGS with aircraft could also be ordered if the incident has potential to grow to a Type II or Type I situation.

ASM on Large Fires Managed by National (Type I) and Geographic Area (Type II) Incident Management Teams (IMT)
An ATGS is a position filled within the current structure of these IMT's. The duties of this ATGS would be the same as for Initial/Extended Attack, except on Incident Management Teams where tactical supervision of overall fire operations is performed by the Operations Section Chief. Implementation of the ASM concept would cause no change from the present-day situation. This means that the ABSS concept would not be implemented on large fires managed by Type I and II Incident Management Teams.

In examining the requirements for large fire aerial supervision, three roles do emerge as follows:

1) the role of the Incident Management Team's (IMT) ATGS
2) the role of the ASM and
3) the traditional role of the leadplane.

The mix of using these roles depends on the complexity, geographic size of the fire and other factors. In very complex terrain or on geographically large or complex fires, the IMT's ATGS could assign divisions of the fire to one or more ASM's. Alternately, for less complex fires where the IMT's ATGS has responsibility for all divisions, the ASM or leadplane can fill the role of a leadplane to aid in the dropping of retardant from fixed wing airtankers. The use of large fixed wing airtankers on large fires has decreased due to the increased use of Type I helicopters on these fires to provide aerial support to ground-based operations. This has resulted in a lessening of demand for leadplane use on large fires. Aerial supervision for these helicopters is by the Helicopter Coordinator (HLCO).

The requirements for the aircraft to support these various roles needs to be flexible as well. If these requirements are not flexible, the result will be the excessive specification to the need and higher than required acquisition costs.

Summary of Organizational Options

Ten Organizational Options were developed to respond to problems and issues defined in the TARMS User Survey, to respond to the Task Workload rating for the current aerial supervision structure and to respond to concerns and opportunities developed by the study committee. Organizational Option 1-5 represent the current organizational structures used in aerial supervision. Organizational Option 6-9 are developed to examine the effects of workload on different configurations of the ASM Concept. Organizational Option 10 has no aerial supervision present. Alternatives 2 and 8 as well as a combination of Alternatives 4 and 5 are appropriate for Large Fire Suppression. It is assumed that the personnel within each organizational option can be either contract or government employees unless regulations prohibited either. For purposes of the workload analysis to evaluate the options, it was assumed that both individuals would receive equivalent training and knowledge.

Organizational Options 1 and 2

Both Organizational Options 1 and 2 staff the ATGS and leadplane roles in separate aircraft. In the leadplane aircraft, the leadplane pilot is performing the current roles and responsibilities of the leadplane function. In the ATGS aircraft, there is the ATGS performing the current roles and responsibilities of the ATGS. The difference between Organizational Options 1 and 2 is the experience level of the ATGS aircraft pilot.

In Organizational Option 1, the ATGS aircraft pilot is ‘inexperienced” in the performance of the support role to the ATGS. The ATGS aircraft pilot, though fully qualified to fly the aircraft, lacks training and experience in the tasks where he/she could assist the Air Tactical Group Supervisor in the performance of his/her job. In this Organizational Option, there are two aircraft and three people involved in the aerial supervision jobs defined.

In Organizational Option 2, the ATGS aircraft pilot has the training and experience that allows he/she to assist the ATGS in the performance of his/her tasks. In this Organizational Option, there are two aircraft and three people involved in the aerial supervision jobs defined.

Organizational Options 3 and 4

Organizational Option 3, the ATGS aircraft is staffed with an ATGS and an inexperienced ATGS aircraft pilot and there is no leadplane present. Organizational Option 4, the ATGS aircraft is staffed with an ATGS and an experienced ATGS aircraft pilot and there is no leadplane present. The absence of the leadplane is the difference between these two Options and Options 1 and 2. In these Organizational Options, there is one aircraft and two people involved in the aerial supervision job defined

Organizational Option 5

In this Organizational Option, the ATGS aircraft is not present but the leadplane aircraft In this Organizational Option, there is one aircraft and one person involved in the aerial supervision job defined.

Organizational Option 6
In this Organizational Option, there is one person in one aircraft performing the Aerial Tactical Pilot (ATP) and Airborne Suppression Supervisor (ABSS) positions.

Organizational Option 7
In this Organizational Option, there is one person in one aircraft performing the Aerial Tactical Pilot (ATP) and Air Tactical Group Supervisor (ATGS) positions. This Organizational Option differs from Organizational Option 6 in the lack of ground firefighting duties for the ATGS that the ABSS has in Organizational Option 6.

Organizational Option 8
In this Organizational Option, there is two people in one aircraft performing the Aerial Tactical Pilot (ATP) and Air Tactical Group Supervisor (ATGS) positions. This Organizational Option differs from Organizational Option 7 in that two people are performing the duties of the ATP and ATGS.

Organizational Option 9
In this Organizational Option, there are two people in one aircraft performing the Aerial Tactical Pilot (ATP) and Airborne Suppression Supervisor (ABSS) positions.

Organizational Option 10
This option represents “no aerial supervision present.”

Table 5 - Organizational Options

<table>
<tr><th rowspan="2">Option</th><th colspan="2">Air Tactical</th><th>Lead</th><th colspan="2">Aerial Supervision Module (ASM)</th><th colspan="2"></th></tr>
<tr><th>ATGS</th><th>ATGS Pilot</th><th>Lead-Plane Pilot</th><th>Air Tactical Pilot</th><th>Airborne Suppression Supervisor</th><th>No. of Persons</th><th>No. of Aircraft</th></tr>
<tr><td>1</td><td>Yes</td><td>Inexper</td><td>Yes</td><td></td><td></td><td>3</td><td>2</td></tr>
<tr><td>2</td><td>Yes</td><td>Exper</td><td>Yes</td><td></td><td></td><td>3</td><td>2</td></tr>
<tr><td>3</td><td>Yes</td><td>Inexper</td><td></td><td></td><td></td><td>2</td><td>1</td></tr>
<tr><td>4</td><td>Yes</td><td>Exper</td><td></td><td></td><td></td><td>2</td><td>1</td></tr>
<tr><td>5</td><td></td><td></td><td>Yes</td><td></td><td></td><td>1</td><td>1</td></tr>
<tr><td>6</td><td></td><td colspan="4">Yes</td><td>1</td><td>1</td></tr>
<tr><td>7</td><td colspan="4">Yes</td><td></td><td>1</td><td>1</td></tr>
<tr><td>8</td><td>Yes</td><td></td><td colspan="2">Yes</td><td></td><td>2</td><td>1</td></tr>
<tr><td>9</td><td></td><td></td><td colspan="2">Yes</td><td>Yes</td><td>2</td><td>1</td></tr>
<tr><td>10</td><td colspan="7">No Aerial Supervision</td></tr>
</table>

Area Command Organization
The ASM assigned to an Area Command Organization would work for the Area Command Aviation Coordinator (ACAC). The ASM has distributed duties among the fires in the complex as follows:

- Airspace Management
- Aircraft Scheduler between incidents when resources are transferred or loaned
- Frequency Management

For situations with a relatively low complexity, the standard ASM can probably function effectively. During high-complexity operations such as occurred in Yellowstone in 1988, consideration could be given to implementing an agreement with the military to be utilize AWACS-type aircraft and DOD ATC personnel working jointly with the ASM and ACAC.

Human-aiding Technology Options
Human-aiding technology can provide "tools" that can enhance human awareness, understanding and efficiency. For example, research has shown (Battiste, Downs, 1992) that when ground taxi maps were introduced into transport aircraft that heads-down time was increased. However, the additional heads-down time improved efficiency on a number of heads-up tasks: own-ship's location and the location of traffic was acquired rapidly and efficiently; identification and acquisition of terrain features was improved; etc.

The following human-aiding technology options, in conjunction with organizational options, are proposed to implement the previously-discussed shared mental model concept among all aerial firefighting participants. Several options also implement the previously-discussed shared mental model concept among all firefighting participants, both ground and air. These options specifically address issues and problem areas identified in the TARMS User Survey and committee scoping such as communications and tasks which have a high workload rating from the Workload Task Matrix.

Assumptions
The following assumptions are with regard to human-aiding technology. They are made by subject matter experts using knowledge acquired through experience and extensive research in other areas of aviation. The research was conducted in both part-task and full mission simulation. The assumptions and conclusions drawn from this body of other-domain research should be validated in the aerial firefighting domain where needed.

- All tactical aerial firefighting operations are conducted in visual meteorological conditions under Visual Flight Rules (VFR) in Visual Meteorological Conditions (VMC). It is a heads-up, eyes-out, see-and-avoid fight regime. Quality heads-down time can be more efficient than non-quality heads up time.

- The introduction of human-aiding technology (HAT) into the aerial firefighting platform(s) could require additional heads-down time if not properly implemented. Human-aiding technology installation in flight decks has associated risks that must be mitigated in order to achieve safety and efficiency objectives. To alleviate risks, any human-aiding technology installed on any aerial firefighting platform needs to be well-designed so that it will enhance rather than hinder aerial supervisors and tactical pilots performance of their duties.

- Efficient and effective training is required.

- Human-aiding technology (HAT) has the potential to increase safety and efficiency for both aerial and ground firefighting operations which can reduce costs and decrease incident, accident, and fatality rates for both aerial and ground firefighting operations.

- Utilization of human-aiding technology can have a positive effect on firefighting operations, regardless of the air organizational structure.

- Over the next five years, costs of flight deck technology will continue to decrease as systems capabilities increase.

- Proposed changes by the Federal Aviation Administration to the National Airspace System (NAS) will dictate the installation of computers, flight deck displays, and air-air and air-ground data link in aircraft over the time frame 2000-2010. This initiative will have an effect on all aircraft flight decks, including those of aerial firefighting aircraft. (FAA Future Air Navigation System (FANS) and Air Traffic Management (Free Flight)).

- Issues of certification of flight deck technology will be addressed satisfactorily by government and industry.

Human-Aiding Technology Specifications

The following are broad but nonetheless critical specifications for any flight deck technology that might be adopted for the aerial firefighting environment. A long-term strategic approach to technology introduction and implementation was utilized rather than a purely “tactical”, short-term approach of rectifying immediate and long-standing problems. However, the strategic approach allows for the implementation of immediate solutions to long-standing problems. The methodology utilized in compiling this list also took into consideration both the near- and far-term programmatic objectives and procurement policies. These two considerations (program and procurement) suggest that the design of all human-aiding technology should be modular and integrated, allowing additional capabilities as they become available and are funded.

Technology installed in aerial firefighting vehicles must have the following characteristic:

- Open, non-proprietary hardware and software architecture, enabling timely updates/revisions to software.

- Design must meet human-factors considerations for the low-level, high-tempo aerial firefighting environment (see Assumptions).

- Testing and training is critical prior to the implementation phase to ensure quality results with a minimum of risk

Technology installed in aerial firefighting vehicles should have the following characteristics with the maintenance of safety a paramount design criteria:

- Utilization of "Commercial Off-The-Shelf (COTS) hardware/software where possible

- "Plug-and-play" implementation by users

- Integration with any ground-based flight following implemented by dispatch/coordination centers (see NATS2 Report Recommendation 10)

- Integration with FAA requirements for future air traffic management (see Bibliography)

- Cost must be commensurate with benefits.

- The basic system with add-on capability needs to be integrally designed into the ASM platform's (aircraft's) avionics suite.

Human-Aiding Technology Options

The primary benefit of human-aiding technology is to positively affect safety by using technological aids in a fast-paced, high-tempo environment. The TARMS Workload Analysis indicates that the predominance of tasks an ATGS or Leadplane Pilot performs are communications-related. Due to high task loading in the aerial firefighting environment, efficiency and completeness of task assignment may suffer due to lack of information and decision-support tools that could be furnished by human-aiding technology.

The term "HAT Option X," where X is the option number, will be used in the definition of human-aiding technology options. Some of the HAT components were designed and tested during the joint USFS/BLM/NASA National Aerial Firefighting Safety and Efficiency (NAFSE) Project, 1995-1997. Most of the components are either in full or mostly-completed stage of development and could be implemented after human factors testing.

Human-Aiding Technology Option 1 (Current Situation)
Current exclusive-use contracts for aerial firefighting aircraft have the required radio hardware to meet communications requirements. There is no such requirement for aircraft used as call-when-needed (CWN) ATGS aircraft. Portable kits are developed to meet the CWN need, but are not comparable in functionality, capability, or ease-of-use to exclusive-use requirements.

Global Positioning System (GPS) capability can be required based on agencies discretion in exclusive-use contract aircraft. Traffic Collision Avoidance System (TCAS) exists on all Forest Service leadplanes. Forward-Looking Infrared (FLIR) and the equipping of ATGS aircraft, leadplanes, and airtankers with external cameras to record retardant drops, fire communications, etc. is at agency discretion.

Human-Aiding Technology Option 2
This option consists of hardware and software configured in such a manner that components and functional modules can be integrated over a period of time as technology matures and funds become available.

Ultimately it may consist of an on-board display screen(s) with touch screen overlay or pen tablet with wireless pen, dual radio modems (digital datalink), GPS, antennas, power supplies, and associated software and map data bases. Note that most software was tested during the NASA/BLM/USFS NAFSE Project.

In some cases, such as with ATGSs, the operator of the technology will interact actively with the display, performing a variety of functions such as marking/drawing targets and airspace structures, etc. Other users, primarily single occupant aircraft or airtanker crews, will utilize it in a more passive mode, since their primary attention is to fly the aircraft in a heads-up, eyes-out mode during low-level operations.

The technology in this Option provides for a “shared mental model” of the air and ground fire fighting environments that potentially can maximize effective communications and situational awareness. In that respect the technology is also congruent with the shared mental model fostered by the Organizational Option that places both aerial supervisors (ATGS/ABSS and ATP) in the same aircraft.

The technology in this Option also essentially establishes a “corporate history” for the fire that can be retrieved and effectively used later for debriefing, analysis, fire planning, etc.

The functionality of the technology in this Option consists of air to air and air to ground data links (messaging) that provide:

- Moving map background or map databases.

  Position information for own-ship and traffic is provided by the GPS/radio modem system. This system provides for a timely, autonomous distribution of position information on all participating vehicles through the use of a Time Dependent Multiple Access (TDMA) protocol instantiated in the GPS/radio modem system. The GPS/radio modem provides the vehicle position information to the system's computer for display on the aircraft's display.

- Display of traffic information

  Traffic position information is provided by the GPS/radio modems interface explained above. Own-ship position, which is normally at the center of the display, may be offset to any position. ATGSs, airtankers, and leadplane pilots participating in the NAFSE project have identified a need, in certain cases, for a geographical location to be at the center of the display. To support this need, the display may be oriented in either a north-up or track-up position, dependent on task objectives. The position of traffic on the display is based on autonomous individual GPS reported positions via the radio modems. Traffic equipped with TDMA/GPS/radio modem capability are displayed with any number of attributes (x-y-z position, heading, speed, designator, etc.)

- Target identification and display

  ATGS/ABSS, Leadplane Pilot, and Aerial Tactical Pilot (ATP) personnel are provided tools which support the identification, annotation, and delivery of target information to other participating fire fighting aircraft. The tools which support this operation in the Air Tactical Group Supervisor's aircraft are the magnetic tablet and wire-less pen, map databases, and a communications data link. The pen and magnetic tablet are natural extensions of the human ability to use pen and paper to draw or to record information.

- Construction and display of airspace structure

  The ATGS and ABSS may construct an airspace structure, as needed, using the electronic pen and pen tablet. As presently conceived, the airspace structure should support the organization and movement of all aircraft operating in the airspace. Some components of the airspace structure are: Control zone (area of operation), ingress/egress routes, holding areas, "no-fly" zones, etc.

- Hazard display (on-scene, as well as other "hazardous" airspace structures such as Class B, Special-Use Airspace, and Military Training Routes)

  A variety of map databases have proven useful to aerial firefighters in support of the various missions which need to be accomplished. Included in these different map databases (Aeronautical Sectional Charts, 1:250K AMS maps; 1:24K USGS topographic maps, forest or district maps, etc.) are a variety of different on-scene displays of hazards. As an example, the aeronautical sectional chart contains information on special use airspace, military training routes, class "B" airspace, and high power lines. In a more active mode, the user can mark/draw hazards not portrayed on standard maps and transmit this overlay information to other participating aircraft.

- Display of fire scene information

  As with other features, fire scene information such as perimeter with labels, helibases and dip sites, can either be marked/drawn by the user or incorporated automatically into the map during overflights of the specific areas. The identified features are then depicted as a graphic overlay on the moving map display. Once the user is satisfied the information is depicted correctly, the information can be transmitted to other participating aircraft.

HAT Option 2 Costs
Costs for HAT Option 2 for the aircraft are estimated at $30,000 per system, including installation, with installation being the most variable cost since it is dependent upon type of aircraft, configuration for one or two users, available panel space, and other factors. Integration of all components of the HAT Option 2 system listed above would be less expensive than separate independent component installations. Integration reduces attendant risks of non-interoperability, incompatible or proprietary software, etc.

HAT Option 2 Availability
The software/hardware development by NAFSE project is in the public domain, freely available to industry for use in their own development. At least one company has produced a HAT Option 2-similar unit, though without all identified components.

Human-Aiding Technology Option 3
This option consists of Human-Aiding Technology Option 2 plus a functionally integrated Forward-Looking Infrared System (FLIR). FLIR provides:

- Definition of accuracy and placement of retardant, suppressants, and water

- Fire line perimeter, fire behavior, and fire intensity information

- Extension of aerial firefighter's visual range (light spectrum)

- Extension of ground-based personnel's knowledge of effectiveness of retardant, suppressants, and water

HAT Option 3 (FLIR) Costs
FLIR costs as of 1997 were in the $90,000 range. The price is expected to drop over the near-term as units without the cooling requirement enter the market. Cost of developing software for integration of FLIR with the technology HAT Option 2 are undetermined, but are felt by NAFSE NASA project specialists to be not significant.

HAT Option 3 (FLIR) Availability
Several companies produce FLIR units that are certificated for aerial applications. FLIR is in wide use in the military and law enforcement agencies.

Human-Aiding Technology Option 4
This option consists of Human-Aiding Technology Option 3, plus a functionally integrated Traffic Collision Avoidance System (TCAS). TCAS provides for a warning when other aircraft are within such close proximity where there is potential midair possible. The nesting of FLIR and TCAS components with the technology in HAT Option 2 achieves integration.

HAT Option 4 (TCAS/ARMS Integration) Costs
These are unknown at this time but there is industry interest in developing this integration. Currently, stand-alone TCAS systems are installed in all Forest Service owned leadplanes at a cost of approximately $35,000 per system (excluding installation).

HAT Option 4 (TCAS/ARMS) Availability
The supplier of the USFS TCAS systems indicated to the NASA NAFSE Project Leader that the integration is achievable.

Human-Aiding Technology Option 5
This Option consists of the installation of FLIR and/or TCAS independently. This Option is feasible if agencies only select one or both of the functional components of FLIR and TCAS but there is a high risk of a non-integrated proliferation of "black boxes"on the flight deck.

Human-Aiding Technology Option 6
This Option is defined independent of the integrated HAT Options 2-5. This system consists of ground-based display systems in dispatch/coordination centers, at on-scene locations (e.g., Incident command Posts), and/or in ground vehicles at the incident.

Its functionality is as follows:

- Long-range flight following.

  Note that Recommendation #10 from the NATS2 Report supports the creation of a long-range flight following system for airtankers, leadplanes and air attack aircraft. Respondents to the TARMS User Survey indicated that long-range flight following should be implemented as a priority. This portion (module) of HAT Option 2 would address this situation and provide an immediate solutions. As with all human-aiding technology, adequate testing prior to implementation is critical to system success.

- Transmittal via air-ground data link of HAT products.

  The system is supported by satellite and/or radio base stations/repeaters links that provide information from firefighting aircraft to ground-based Incident Commanders and to more remote locations.

HAT Option 6 Costs
These are unknown at this time. HAT Option 6 costs for long-range flight following are undetermined due to the difference in various implementation options: ground-based transmittal system via existing radio repeaters; a satellite based system; etc.

HAT Option 6 Availability
Several tests of downlink have been performed. The NATS2 Report documented a system in use in British Columbia that has most of these capabilities. The military has well-developed downlink capability which function with hand-held video-FLIR systems for the foot soldier utilizing information from a unstaffed aerial vehicle (UAV) or other staffed surveillance aircraft. NASA and the California Department of Forestry and Fire Protection (CDF) have used a system to provide real time video images of fires to local Internet sites.

Non-integrated, stand-alone flight following systems are available from a number of companies, but due to concerns about non-interoperability, additional costs, etc., implementation of these are not recommended. There is some history in the agencies of attempts to implement automated flight following. Each has been unsuccessful to date for a variety of reasons. Therefore, the strategic, integrated approach to this objective is highly desirable.

Summary of HAT Options
Table 6 summarizes the Human-aiding Technology Options.

Table 6 - Human-aiding Technology Options

Option	Functionality	Costs/Unit	Availability
1	Current Situation	-----	-----
2	- Moving map - Display of traffic information - Target ID and display - Display of airspace structure - Hazard display - Display of fire scene info. - Air-air and air-ground data link	Each aircraft unit is estimated at $35,000.	Further development and testing needed. Hardware is available and software is public domain.
3	Option 2 plus FLIR (enhances visual range for heat)	HAT Option 2 costs plus $50,000-$90,000 for FLIR	Analysis and development needed
4	Option 3 plus TCAS (enhances collision avoidance)	HAT Option 3 costs + Unknown amount but should be less than cost of independent TCAS	Industry says can be done; not available at this time. Analysis and development needed
5	FLIR and/or TCAS independently	FLIR: $50,000 -$90,000; TCAS: $35,000	Available currently
6	– Complete information distribution system – Long-range flight following and ground/air datalink	Unknown Unknown	Analysis and development needed. Analysis and development needed.

Aircraft Evaluation Criteria

For the evaluation of aircraft, two types of evaluation criteria were developed, "Must Have" and "Ranking" criteria. "Must Have" criteria, as the name implies, are those criteria that provide a screening process for the candidate aircraft. The potential aircraft were required to have these attributes before being able to be considered for further evaluation. Ranking criteria are those criteria where the performance or capabilities of the aircraft can be compared allowing for a ranking of the aircraft as to the ones that best meet the ranking evaluation criteria. A more extensive explanation of ranking criteria is provided in Appendix J. To standardize the evaluation of performance, parameters such as power settings, density altitude and aircraft configurations were identified.

Must Have Criteria

In the following Table, the "must have" criteria are described and each criteria's application to the procurement categories defined in Step 2 is presented.

Table 7 - "Must Have" Criteria For Aircraft

Criteria	IA/EA/LF National Fleet	Supplemental National Fleet	CWN Local Fleet
Wing and Rotors Mission Related - The mission of aerial supervision requires mobility of the fleet. In the initial attack mode, the location of the fire is rarely known. The fleet of aircraft must be able to respond quickly to arrive at the fire. In general, aircraft which use wings or rotors as their lift generating device meet this mobility requirement.	Yes	Yes	Yes
Basic IFR Safety and Mission Related - Aerial supervision responds to the Incident Command System. It provides its services as needed, when needed. This can result in the aircraft being dispatched anywhere in the country. There is a possibility of encountering adverse weather in route. Therefore the aircraft is required to be equipped with basic IFR equipment as defined by the FAA. Note: CWN aircraft are local resources and IFR flight is not anticipated.	Yes	Yes	No
Minimum Flight Endurance Is 4 Hours Safety, Mission and Economics Related - The aircraft must be able to support aerial supervision over the wildland fire for a length of time which provides continuity for the resources it will provide direction and guidance to. During large fire support, the complexity of the fire suppression effort is manifested by the number resources under management and can require a significant familiarization period.	Yes*	Yes	Yes

* - Does not apply to rotor wing aircraft due to the unique capabilities; ie. ability to hover, etc.
** - Applies only if aircraft will be owned by the U.S. Government

Table 7 - "Must Have" Criteria For Aircraft			
Criteria	**IA/EA/LF National Fleet**	**Supplemental National Fleet**	**CWN Local Fleet**
Ability to Add Target Marking Mission Related - The dropping of retardant requires that the location and direction of the drop be identified. To build a retardant line, the drops must overlap to provide adequate coverage and not result in gaps in the fireline. The leadplane is used to identify placement of the retardant. A number of methods have been used in the past to identify the start of the retardant drop for the airtanker. These have been voice calls on flyover, aileron wiggle and smoke trail. All of these except for the smoke trail have the inherent disadvantage of a parallax view from the airtanker. The smoke trail, however, remains relatively stationary over the target as the airtanker follows the leadplane and executes the drop. The aircraft must have the ability to add smoke generation for the leadplane role. Note: The Supplemental and CWN fleets will not be used as leadplanes.	Yes	No	No
Certified for Single Pilot Safety, Cost and Mission Related - The aircraft shall not be so complex that the FAA has certified it to require two pilots.	Yes	Yes	Yes
Dual Controls Mission Related - Leadplane pilots are required to maintain proficiency and other training requirements. These checks require that a second set of controls be available for the instructor/check pilot.	Yes*	Yes*	Yes*
Standard Avionics Safety and Mission Related - The candidate aircraft must be capable of having the following standard avionics included with the aircraft: Glide Slope/Localizer, Two Communication/VHF Navigation Radios, Low Frequency Receiver, Transponder, Global Positi9oning System, IFR Certified Autopilot, Two 9600 Channel Radios, Dual Audio Selection Panels, Collision Avoidance System, Voice Recorder. These avionics have been established as a standard for aircraft supporting aerial suppression. These are required in both the government owned and contracted fleets.	Yes	Yes	Yes
* - Does not apply to rotor wing aircraft due to the unique capabilities; ie. ability to hover, etc. ** - Applies only if aircraft will be owned by the U.S. Government			

Table 7 - “Must Have” Criteria For Aircraft

Criteria	IA/EA/LF National Fleet	Supplemental National Fleet	CWN Local Fleet
Ability to Add Visibility Enhancements Safety Related - The management of the airspace environment over a fire is all accomplished visually. While new avionics are becoming available to aid in airspace management/collision avoidance, the pilot’s first reaction is to acquire the air traffic visually. Many previous studies by the FAA, the military, and others have shown that colors and high intensity lighting improve the visibility of aircraft from ground to air and air to air. The aircraft must be capable of being visually enhanced. The Supplemental and CWN fleets support the ATGS mission only. ATGS activities generally occur at an elevation well above the fire for observation, and above the level that aerial suppression resources are fighting the fire. However, strobe lights should be considered on these aircraft.	Yes	No	No
Air Conditioning Safety Related -Aerial supervision is demanding, fatiguing and stressful. The decisions and guidance provided to any resource on the fire, at times, can directly involve their personal safety. To maintain the alertness and cognitive abilities of the flight crew, the aircraft must be acquired with systems which aid in the reduction of stress. The CWN fleet based on anticipated use for fire suppression, duration of that use, availability of aircraft and cost are not required to have air conditioning.	Yes	Yes	No
Positive Ability To Deal With Foreign Objects (FOD) Safety Related - All aircraft systems must not be vulnerable to the particulate found in the air environment over a fire. The aircraft engines must be capable of operating with the ingestion of smoke and particulate (Foreign Object Debris) found in the fire environment, the inlets designed to by-pass this particulate from ingestion, or both. The Supplemental and CWN aircraft which support the ATGS mission are expected to be flying above or around the smoke column.	Yes	No	No

* - Does not apply to rotor wing aircraft due to the unique capabilities; ie. ability to hover, etc.
** - Applies only if aircraft will be owned by the U.S. Government

Table 7 - "Must Have" Criteria For Aircraft			
Criteria	**IA/EA/LF National Fleet**	**Supplemental National Fleet**	**CWN Local Fleet**
Capability to Install Relief System The aircraft must be equipped with, or modifiable with a flight crew relief system. Mission Related - Aerial supervision occurs in 3 to 6 hour blocks of time. The time aloft can depend on the fuel capacity of the aircraft. A minimum of 4 hour fuel requirement is being established for the aircraft to be acquired. This extended work time requires that the aircraft be able to be equipped, or modifiable with a flight crew relief system. Note: The supplemental and CWN fleets are not required to meet this requirement due to the unique structural modification required and the availability of other portable alternatives.	Yes*	No	No
Certified For Ice Protection Safety and Mission Related - Aerial Supervision can be dispatched to any location within the country. While routes to the fire are planned to that avoid hazardous situations, at times adverse weather may be encountered. The aircraft must be FAA certified to operate in known icing conditions. Note: The Supplemental National fleet is an extension of the IA/EA/LF National fleet and is expected to provide nationwide service. The CWN fleet is not anticipated to encounter icing conditions while servicing its local area.	Yes*	Yes*	No
Meet the Implementation of the Buy American Act The aircraft must meet the Federal Acquisition Regulation implementation of the Buy American Act and its exceptions. The US Trade Representative has waived the Buy American Act for the acquisition of civil aircraft and related articles for certain countries. Currently the following countries are included in this exemption. Austria BelgiumCanadaDenmark Finland FranceGermanyGreece Ireland ItalyJapanLuxembourg Netherlands NorwayPortugalRomania Spain SwedenSwitzerland United Kingdom	Yes**	No	No
* - Does not apply to rotor wing aircraft due to the unique capabilities; ie. ability to hover, etc. ** - Applies only if aircraft will be owned by the U.S. Government			

Table 7 - "Must Have" Criteria For Aircraft			
Criteria	**IA/EA/LF National Fleet**	**Supplemental National Fleet**	**CWN Local Fleet**
Currently in Production or Nearing Production For aircraft not currently production, a minimum of 400 aircraft must have been produced, and that the mid point of that production must be 1990 or later. These requirement are to assure that a government acquisition would not effect the used aircraft market, and that a sufficient spares pool would be available to support the life of the program. Excess military aircraft are exempt to the used aircraft requirements. Excess military aircraft which may be acquired would include sufficient spares to support the program. Note: For the National Supplemental and CWN fleets, the aircraft are leased or rented and the operator is responsible to maintain the aircraft.	Yes	No	No
Manufacturer Built In consideration of product liability and replacement lead time, only aircraft completely built by the manufacture will be considered, i.e. no 'Kit Planes.'	Yes	Yes	Yes
Minimum Flight Deck Capacity of Two Mission Related - The aircraft must support the needs of training of the pilot and the flight crew. The aircraft must maintain flexibility to support other future aerial supervision flight crew organizations. Therefore, the aircraft must have a minimum of two seats.	Yes	Yes	Yes
Minimum Cruise Speed is 200 KTAS Mission Related - The Team's professional judgement established this minimum cruise speed based on the need to arrive at the fire as quickly as possible, having adequate speed to lead airtankers, and having an adequate selection of aircraft to evaluate. Additionally, as a part of this study, an evaluation of required aircraft speed was conducted. Those results can be found in the NFMAS General Section of the Part 3 Chapter. Note: The CWN fleet are not required to meet this speed since they are local resources.	Yes*	Yes	No
* - Does not apply to rotor wing aircraft due to the unique capabilities; ie. ability to hover, etc. ** - Applies only if aircraft will be owned by the U.S. Government			

Table 7 - "Must Have" Criteria For Aircraft			
Criteria	**IA/EA/LF National Fleet**	**Supplemental National Fleet**	**CWN Local Fleet**
Minimum Maneuvering Speed is 150 KIAS Safety and Mission Related - To accomplish the lead mission, the candidate platform must be capable of flying all airtanker drop zone approach profiles. These profiles match the safety of flight for the airtanker with retardant drop speed requirements. Retardant studies have shown that at speeds greater than 150 knots, the retardant cloud shears too much such that the effectiveness of the drop is compromised. Additionally the environment over the fire can be extremely turbulent, and require that full flight control deflections from the pilot to maintain course for the lead. Hence, it is critical that the candidate aircraft structure be capable of withstanding full control deflections to a minimum of 150 KIAS. Note: The Supplemental and CWN aircraft which support the ATGS mission do not lead airtankers.	Yes*	No	No
Minimum Control Airspeed (100 KIAS maximum) Safety Related - In the lead role, the aircraft is close to the ground and can be flying at speeds as low as 120 KIAS. While the loss of an engine is remote, the aircraft must have adequate margin between the lowest airtanker drop speed and its minimum control airspeed. Hence, a platform's minimum control air speed shall not exceed 100 KIAS. Note: The Supplemental and CWN aircraft which support the ATGS mission do not lead airtankers.	Yes*	No	No
Stall Speed (maximum speed is 90 KIAS) Safety Related - Aerial supervision in the lead role requires the platform to operate at high angles of attack potentially approaching a stall condition. These conditions can occur at low air speeds or as accelerated stalls at higher airspeeds. The leadplane pull-up maneuver is a classic example for the Beechcraft Baron 58P. During this maneuver the aircraft approaches an accelerated stall regime, but done properly the maneuver is safe. Since the mission requirement is fixed, a low stall speed represents an increase margin of safety. Note: The Supplemental and CWN aircraft which support the ATGS mission do not be leading airtankers.	Yes*	No	No
* - Does not apply to rotor wing aircraft due to the unique capabilities; ie. ability to hover, etc. ** - Applies only if aircraft will be owned by the U.S. Government			

Table 7 - "Must Have" Criteria For Aircraft			
Criteria	**IA/EA/LF National Fleet**	**Supplemental National Fleet**	**CWN Local Fleet**
Minimum Single Engine Service Ceiling Is 10,000 feet MSL Safety Related - The role of the leadplane takes place in various types of terrain. If an engine becomes inoperative, the aircraft must be capable of flying the most direct route back to base. This may require the aircraft to climb to a significant altitude to clear terrain which may exist between the location of the fire and the leadplane base or suitable alternative. (This criteria applies to only multi-engine aircraft.)	Yes*	Yes	Yes
Single Engine Best Rate of Climb Speed is 120 KIAS Safety and Mission Related - Much of the leadplane role is performed in close proximity to the ground; and while the terrain varies across the country, mountainous terrain is very demanding on both the pilot and the aircraft. The climb performance, especially engine out for twin engine aircraft, is crucial while performing the lead role in this terrain. Airtankers can drop retardant as slow as 120 KIAS. In performing the lead, if an engine becomes inoperative it is inappropriate and potentially dangerous for the leadplane to be sped up to achieve the best rate of climb. (This criteria applies to only multi-engine aircraft.) Note: The Supplemental and CWN aircraft which support the ATGS mission do not lead airtankers.	Yes*	No	No
Maximum Ground Floatation Is 19,000 Pounds Mission Related - The bases and airports where leadplanes and ATGS aircraft operate from are typically small county or municipal airports. The ramps, taxi-ways and runways are not stressed for high loading. Excessive aircraft tire loading on airport ramps would restrict the use of an aircraft at some airports. Tire loading must be consistent with the maximum allowable at the tanker bases. Based on the recommendations from Phase 2 of the National Airtanker Study for the tanker bases, Troutdale (a reload base) has the minimum allowable single wheel loading requirement of all airtanker bases (19,000 lbs).	Yes*	Yes	Yes
* - Does not apply to rotor wing aircraft due to the unique capabilities; ie. ability to hover, etc. ** - Applies only if aircraft will be owned by the U.S. Government			

Ranking Criteria

The development of the ranking criteria was based on the mission of the aircraft as a leadplane/ATGS platform. A more extensive explanation of ranking criteria is provided in Appendix J. The criteria emphasized safety based on the role the aircraft was to perform. The ranking criteria were divided into four groups:

- Specific Mission Requirements (10.0)
- Aircraft Performance (7.8)
- Ergonomics (3.9)
- Cost (3.3)

Each ranking criteria group was weighted in terms of importance among the other groups and the result are noted following the criteria. Similarly, criteria within each ranking criteria were weighted as to their importance. The team established both the weighting of the ranking groups as well as the criteria with each ranking group prior to the determining of candidate aircraft. In each of the ranking criteria groups, the values for each candidate aircraft were based on that aircraft's performance compared to the aircraft that performed the best for the criteria.

Aircraft evaluated were both single and multi-engine equipped. Four of the ranking criteria within the four criteria groups specifically apply to multi-engine aircraft. These criteria are:

- Single Engine Best Rate of Climb Speed
- Single Engine Best Rate of Climb
- Single Engine Service Ceiling
- Minimum Control Airspeed

The study discussed the benefits of single versus multi-engine aircraft and also gathered information regarded the safety benefits. Information gathered indicated that there as no compelling safety difference based on accident rates or other data that show the benefit of either type of aircraft. The available information is based on typical general aviation-type flying. The leadplane role and its environment is not well represented by this data. In some cases, this is also true for ATGS aircraft. The leadplane aircraft spends a significant amount of flight time flying "low and slow" in turbulent smoky air, frequently in mountainous terrain. The study committee identified the value and benefit of having a second engine available and decided to apply all criteria to all aircraft, including single engine. Hence for the four aforementioned criteria that apply to multi-engine aircraft, single engine aircraft received a "score" of 0.

Specific Mission Requirements - Group Ranking Weight = 10.0
Specific Mission Requirements are those performance or characteristics of the candidate aircraft that are extremely important to the successful completion of the mission. For example, visibility – the ability to view the environment over, in, and around a fire from both the pilot's seat and the co-pilot's seat. Aerial supervision in the fire environment is performed visually. The greater the outward visibility characteristics of the aircraft, the better its ranking among the other aircraft. The criteria established for the evaluation were:

Weight	Specific Mission Requirements:
10.0	Aircraft Visibility Outwards

Safety and Mission Related - The airspace and environment in and around a fire is a visual one requiring high situational awareness. The fire's perimeter, location of resources on the ground, aerial resources working the fire, inadvertent unauthorized aircraft incursions, etc. are all located through the visual sense. The aircraft to be used in aerial supervision must not hinder or increase the effort or workload of the pilot or ATGS in their ability to view the fire scene.

Criteria compares the visibility to see both the fire environment and air traffic. Two methods were implemented in measuring this criteria. The first was an objective measurement of the window area using a transit from both the pilot's and co-pilot's position. Additionally, a flying evaluation was performed to simulate the missions of both the ATGS and Leadplane pilot including observation of a following aircraft. The evaluators completed a subjective evaluation form based on a modification of the Cooper-Harper Aircraft-Handling Characteristics Scale, 1969, that documented their observations. In scoring this criteria, both measures were averaged together. Appendix E contains the flight evaluation forms and the associated flight cards for all of the flight evaluation portions.

7.7 Complexity of Flight In Lead Role

Safety Related - In the lead role, retardant drops are made while maintaining a constant AGL altitude. The terrain over which these drops occur varies widely. The drop which is most demanding for pilot workload is the "down hill" (descent) drop. The leadplane must match the airtanker's profile for the drop. This profile, airspeed and flight pattern, is maintained until the target is over flown. In a down hill (descent) drop, the aircraft has a natural tendency to gain speed. Therefore, the leadplane must be configured to maintain a constant speed while descending. Upon completion of the lead phase, the drop must be observed. This requires the aircraft to "clean-up," speed-up, and bank while climbing. The observation of the drop is a "heads out" function. The workload to maintain safe flight while keeping attention outside must be considered and evaluated in the new platform.

Criteria examines the pilot workload of flying the aircraft in combination with the aerial supervision during the lead to the target and observation of the airtanker drop. The pilot workload is that which is needed to configure the aircraft for the specific airtanker profile (speed and pattern to the target) and required decent rate. The profile flown was a decent rate of 2500 fpm at both 120 and 150 KIAS. The decent value is based on leadplane pilot involvement, Interagency Airtanker Board requirements for the airtanker fleet, and FAA requirements for Non-Federal Navigation Facilities (see appendix J).

The complexity of flight in the leadplane role was a subjective evaluation. It is intended to be a measure of the tasks required to configure an aircraft to obtain a descent prior to a typical leadplane mission. The subjective evaluation was performed by two Leadplane pilots using a form which was based on the Cooper-Harper Aircraft-Handling Characteristic Scale, 1969. The scoring form and flight card can be found in Appendix C.

4.7 Minimum Control Airspeed (minimum speed is 100 KIAS)

Safety Related - In the lead role, the aircraft is close to the ground and can be flying at speeds as low as 120 KIAS. While the loss of an engine is remote, the aircraft must have adequate margin between the lowest airtanker drop speed and its minimum control airspeed. The value was based on professional judgement.

The criteria examined the airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative, and thereafter maintain straight flight at the same speed in accordance with FAA requirements.

The candidate aircraft are rank ordered based on the lowest and highest, not exceeding 100 KIAS, values obtained from their respective flight manuals.

4.6 Flight Crew Capacity and Arrangement

Mission Related - The criteria examined the number of seats available in the aircraft and whether they are side by side or inline. A minimum of two seats are required for the aircraft to be considered, while three is desired. Three seats provides maximum flexibility of the aircraft for performing the aerial supervision role. It allows for a leadplane pilot, an ATGS and a trainee. The seating arrangement is also important. Inline seating was identified as more beneficial to the mission than side by side. Inline seating allows for both the pilot and observer (ATGS) to view the same ground resources at the same time. Additionally, flight patterns over the incident do not have to be just right or left hand patterns, as with side by side seating aircraft. Also, interference by one or the other while doing their respective missions is not as prevalent in inline seating; ie. unfolding and re-folding maps.

For this study a strict definition of side by side and in-line seating arrangement was used. Hence, there was no consideration of placing the pilot and ATGS in an in-line configuration on the same side of the aircraft in four place (or higher) side by side style platform. The reason for this is that in their current form, aircraft are not maximized for visibility as needed for flying the aerial supervision mission in this configuration. It is left to the aircraft selection process and the ingenuity of industry to take, not only this specific requirement but other appropriate ones, and examine aircraft modifications or new developments which would allow for improved performance of the platform for this criteria.

Aircraft with 3 inline seats or greater scored 10; aircraft with 2 inline seats scored a 8 aircraft with 2 seats in a side by side configuration scored a 5; and side by side seating with 3 or greater places scored a 7.

4.2 Single Engine Best Rate of Climb

Safety Related - Much of the leadplane role is performed in close proximity to the ground; and while the terrain varies across the country, mountainous terrain is very demanding on both the pilot and the aircraft. The climb performance, especially engine out for twin engine aircraft, is crucial while performing the lead role in this terrain.

The candidate aircraft are rank ordered based on the lowest and highest values obtained from their respective flight manuals for engine out climb performance. While data is inconclusive with regard to the safety of single engine aircraft over twin, or vise versa, due to the proximity to the ground and flying in and around the fire environment, twin engine aircraft are seen a preferred due to having a redundant power plant. Hence, while twin engine aircraft will be rank ordered for this criteria, single engine aircraft will receive no points for this criteria..

4.2 Flight Deck Design

Future Modification Related - The selected aircraft will be operated as the aerial supervision platform for 15 to 20 years. This large investment must be made with consideration of future incorporation of new avionics. Additionally, this study is examining the introduction of automation into the flight deck for the crew. However, the exact solution with respect to hardware is not known. Therefore, the amount of available panel space beyond standard avionics will be considered.

The candidate aircraft are rank ordered based on the unused panel space available to insert one or more standard 3.5 inch altimeter(s).

1.9 Aircraft Visibility of Being Seen

Safety Related - As has been stated, the aerial environment is visual. While any aircraft can be fitted with strobe lights and painted with highly visible colors, the size of the aircraft is important in being seen. This criteria compares the size of each candidate aircraft as the sum of the length of the fuselage, the span of the wings and the height of the tail.

Each aircraft is rank ordered based on the values of all of the aircraft.

Aircraft Performance - Group Ranking Weight = 7.8

Aircraft Performance are those characteristics of the candidate aircraft that are performance related.

Weight Aircraft Performance:

10.0 Rate of Climb (All Engines)

Safety and Mission Related - Aerial supervision in the lead role occurs in many different topographical terrain. Of these the mountainous terrain is the most severe when considering the platforms rate of climb requirements. Air operations, both lead and air attack, can place the aircraft below terrain within steep topography. While policy and training establish that egress shall not rely strictly on the ability to climb, a margin of safety must be established for the aircraft. Hence, the aircraft must have an adequate rate of climb to assure that the mission and safety of the flight crew is not compromised. Additionally, many of the airports from which the platform will be dispatched are at the foot of hills or mountains. On dispatch, the aircraft must climb to an safe altitude to cross this terrain.

The aircraft's all engine rate of climb is rank ordered with that of all the other aircraft being considered.

8.1 Stall Speed (maximum speed is 90 KIAS)

Safety Related - Aerial supervision in the lead role requires the platform to operate at high angles of attack potentially approaching a stall condition. These conditions can occur at low air speeds or as accelerated stalls at higher airspeeds. The leadplane pull-up maneuver is a classic example for the Beech 58P Baron. During this maneuver the aircraft approaches an accelerated stall regime, but done properly the maneuver is safe. Since the mission requirement is fixed, a low stall speed represents an increase margin of safety. A maximum stall speed of 90 KIAS is established and represents 75% of the lowest allowed retardant drop speed.

The aircraft's stall speed is rank ordered with all other aircraft being considered in the evaluation. Except that any aircraft with a stall speed greater than the maximum is eliminated from consideration.

7.7 Responsiveness

Mission and Safety Related - Aerial supervision in the leadplane role brings the aircraft in close proximity to the ground. In this environment, the fire causes convective air currents, the wind and the topography require constant and frequently quick flight control deflection to maintain an "on-line" path to the drop zone, avoid obstacles, and maintain aircraft separation. The responsiveness of the platform to flight control changes provides a measure of safety to the flight crew and aircraft. A flight evaluation of the aircraft for acceleration, deceleration, stall, lead role profiles, roll rate, and steep turns was performed with two leadplane pilots.

Responsiveness of the aircraft was a subjective evaluation performed by two leadplane pilots. The evaluation form was based on the Cooper-Harper Aircraft-Handling Characteristics Scale, 1969. The average of the pilots' evaluations for each aircraft was rank ordered with the evaluations from the other aircraft. Appendix E contains the evaluation form and the flight card used in this evaluation.

5.8 Maximum Cruise Speed (minimum speed for consideration is 200 KTAS)

Mission Related - The role of aerial supervision is to arrive on the scene of a fire, direct both aerial assets, provide fire behavior information from the aerial view, and coordinate tactics with ground personnel and equipment. The conclusion of the National Airtanker Study was to upgrade the airtanker fleet from piston to turbine powered aircraft. The aircraft which are being pursued for the airtanker fleet all have speed capability of FAA limit below 10,000 feet of 250 KTAS. Since efficiency and effectiveness of retardant use is greatly improved with the role of the aerial supervision, the arrival of the platform ahead of the airtanker is required. Hence, the new platform must be capable of similar performance (250 KTAS) as the airtanker fleet. The minimum speed to be considered as a leadplane was established at 200 KTAS, an average value from 0 to 10,000 feet. While this is slower than that of the airtanker, the leadplane is quicker in leaving the field.

The aircraft's cruise speed was rank ordered with those of the other aircraft being considered in the evaluation.

5.5 Maneuvering Speed (minimum speed is 150 KIAS)

Safety Related - The environment over a fire is extremely turbulent, both at altitude and while leading an airtanker. Course corrections are required continuously to maintain level flight or avoid terrain. At times, due to the local winds, the fire's convection column, or the topography full control deflection is required. When leading airtankers, the acceptable drop speed range for retardant is 120 to 150 KIAS. The aircraft in consideration must be capable of allowing full control deflection within the entire airtanker drop speed range. The aircraft's maneuvering speed was rank ordered with those of the other aircraft being considered in the evaluation.

4.5 Single Engine Service Ceiling and Single Engine Best Rate of Climb Speed

Safety and Mission Related - Much of the leadplane role is performed in close proximity to the ground; and while the terrain varies across the country, mountainous terrain is very demanding on both the pilot and the aircraft. The climb performance, especially engine out for twin engine aircraft, is crucial while performing the lead role in this terrain. Airtankers can drop retardant as slow as 120 KIAS. In performing the lead, if an engine becomes inoperative it is inappropriate and potentially dangerous for the leadplane to be speed up to achieve the best rate of climb. Hence, the maximum single engine rate of climb is established at 120 KIAS.

The role of the leadplane takes place in various types of terrain. If an engine becomes inoperative, the aircraft must be capable of flying the most direct route back to base. This may require it to climb to a significant altitude to clear terrain which may exist between the location of the fire and the leadplane base or suitable alternative. Therefore, a minimum single engine service ceiling of 10,000 feet is established.

The candidate aircraft are rank ordered based values obtained from their flight manuals for engine out climb performance. While data is inconclusive with regard to the safety of single engine aircraft over twin, or vise versa, due to the proximity to the ground and flying in and around the fire environment, twin engine aircraft are seen a preferred due to having a redundant power plant. Hence, while twin engine aircraft will be rank ordered for this criteria, single engine aircraft will receive no points for this criteria..

3.5 Airframe Strength, G-Loading

Safety Related - The flight environment above a fire is severe. Convective air currents caused by the fire, the winds, and the topography can result in violent wind shears. Aerial supervision in the leadplane role will subject the platform to these winds as well as potentially more severe conditions winds in close proximity to the terrain. These violent winds impart high forces on the airframe. The platform must be capable of surviving this environment without damage or increased required inspection.

The aircraft were rank ordered based on the values found for each of the aircraft.

2.6 Fuel Endurance

Mission Related - The number of hours the aircraft could remain aloft at 5000 PA, ISA + 30F, 55% METO or Economy Cruise Power, based on the fuel tank capacity.

Aerial supervision in the from of leadplanes are National assets and can be dispatched to support fire suppression activities from one end of the country to the other, including Alaska. In addition, missions under multiple fire occurrence can entail traveling to multiple fires and refueling too frequently would restrict mobility and efficiency.

0.3 Accelerate & Stop on Take-off

Mission Related - Accelerate and stop on take-off is the distance traveled by an aircraft from start to stop on the runway when a engine failure occurs just prior to rotation for lift off. The criteria measures the compatibility of the aircraft with the NATS2 recommended airtanker bases.

The fire season for the US is over nine months long. Over 50% of the airtanker bases are at 5000 feet elevation for higher. Operations in support of fire typically peak in the summer months of June, July, August and September. During this period elevated air temperatures exist, resulting in high density altitude conditions. While engine failure is rare, candidate aircraft for this mission should provide the highest degree of safe operation. As a measure of safety, the platform in consideration must be able to accelerate and stop within the paved portion of the runways of the NATS Phase 2 recommended airtanker bases.

Ergonomics - Group Ranking Weight = 3.9

Ergonomics are those characteristics of the candidate aircraft that relate to the comfort or work space within the aircraft.

Weight Ergonomics:

10.0 Flight Deck Working Space

Mission Related - The pilot and observer must perform their tasks in an environment without interfering with the other's tasks. Efficiency, stress and safety are all improved with adequate room to meet these needs. Some of tasks that need to be performed include flying the aircraft, moving to make observations, working communications equipment, and changing, laying out and reading charts and tables.

Two methods were used to evaluate this criteria. The first was the interior dimensions of the flight deck, and the second was a subjective evaluation of the interior space by leadplane pilots and an ATGS. The interior dimensions measured the width and height within the flight deck of the aircraft. The subjective evaluation was also based on a modified Cooper-Harper Aircraft-Handling Characteristics Scale, 1969. Appendix E contains the evaluation form and the flight card used.

8.5 Pressurization

Safety Related - While flying in the vicinity of the fire, the aircraft will seldom need to fly above 10,000 feet mean sea level (MSL). Oxygen is not required for the flight crew until above 12,500 ft MSL. However, at altitudes above 8,000 ft MSL greater than ambient oxygen improves crew performance, especially on extended flights. Additionally, safety is improved due to reduced crew stress and fatigue.

Aircraft which are equipped with pressurization received a score of two, aircraft with supplemental oxygen received a score of one, and aircraft without either were not considered.

3.1 Seat Comfort

Mission Related - The role of the leadplane and ATGS requires them to remain on station over a fire for extended periods of time. Additionally, potential cross-country dispatch can result in 8 hours or more of flying. A comfortable seat reduce flight crew fatigue. Seat comfort is equated to the number of adjustments the seat is capable of.

The aircraft were rank ordered based on the number of seat adjustments provided with the basic aircraft.

Cost - Group Ranking Weight = 3.3

Cost is cost of ownership of the aircraft, both operating and amortized acquisition. The monthly availability is assumed to occur for 12 months and the flight rate for 200 hours per year to allow for calculation of an annual total cost.

Weight Cost:

--- Monthly Availability

Mission Related -Fiscal responsibility in the cost efficiency of ownership of an aircraft is required for this acquisition. Expenditure of the public's money must be based on prudent and justifiable rationales.

The monthly availability costs was based on the indicated fixed costs developed by Conklin & deDecker Associates, Inc. The monthly availability includes hull and liability insurances, recurrent training, aircraft modernization, refurbishment, and depreciation.

The annualized fixed costs was spread over a twelve month year for each aircraft, and the aircraft were rank ordered based on their value for this evaluation.

--- Flight Rate

Mission Related - Fiscal responsibility in the cost efficiency of operation of an aircraft is required for this acquisition. Expenditure of the public's money must be based on prudent and justifiable rationales.

The flight rate is based on the direct operating costs of the aircraft developed by Conklin & de Decker Associates, Inc. These costs include fuel, lubricants, engine overhaul, airframe and avionics repairs, propeller (as appropriate), and thrust reverser (as appropriate). These rates may differ from experienced rates by the Government for specific aircraft but provide a consistent approach for comparative purposes.

The flight rate for each aircraft was rank ordered based on the values obtained for the other aircraft in this evaluation.

<u>Aircraft Tested Against Ranking Criteria</u>

To test the criteria developed in this study for evaluating potential aircraft as aerial surveillance platforms, multiple sources were consulted to develop a listing of aircraft for consideration. Appendix B contains a complete list of the aircraft contained in this test as well as their disposition from the Must Have criteria. The following five aircraft except for the OV-10A met all "Must Have" criteria. All where evaluated using the Ranking Criteria including the OV-10A as it is the most current leadplane aircraft used by the BLM and hence it serves as a benchmark.

Beech Baron 58P	This is a baseline aircraft as it is the current Forest Service leadplane platform. This option would perform maintenance operations to the engines and airframe to allow for 15-20 years of operation.
Beech King Air C-90B	No additional comment added.
Beech King Air 200/200C	No additional comment added.
Rockwell OV-10A	This aircraft is included as a baseline since this is the current BLM leadplane. There appears to be are no OV-10A models left for acquisition from the military and hence it is not a viable future platform.
Rockwell OV-10D	The OV-10D has improved performance over the OV-10A model. Availability is uncertain due to competition with other federal government agencies.

STEP 4: PERFORM ANALYSIS OF OPTIONS AND DEVELOPMENT OF A PREFERRED ASM ALTERNATIVE

The results of comparison of Organizational, Human-aiding Technology and Aircraft Options based on evaluation criteria follows in this Step. The major sections within this Step are as follows:

- Organization and Human-Aiding Technology Options
  - Workload Related To The Proficiency Level Of ATGS Aircraft Pilots
  - Workload On ATGS Based On The Presence or Absence Of A Leadplane
  - Workload On the Leadplane Pilot Based On The Presence or Absence Of ATGS
- Aircraft Options
  - Evaluation of Specific Mission Needs
  - Evaluation of Aircraft Performance
  - Evaluation of Ergonomics
  - Evaluation of Cost
  - Summary of Test Evaluation Using Ranked Criteria
- Analysis To Support Determination Of Numbers and Locations for ASM Aircraft
  - Analysis Of Expected Dispatch Frequency Based On NFMAS
  - Analysis of Episodes
  - Potential Economic Value of Aerial Supervision

<u>Organization and Human-Aiding Technology Options</u>

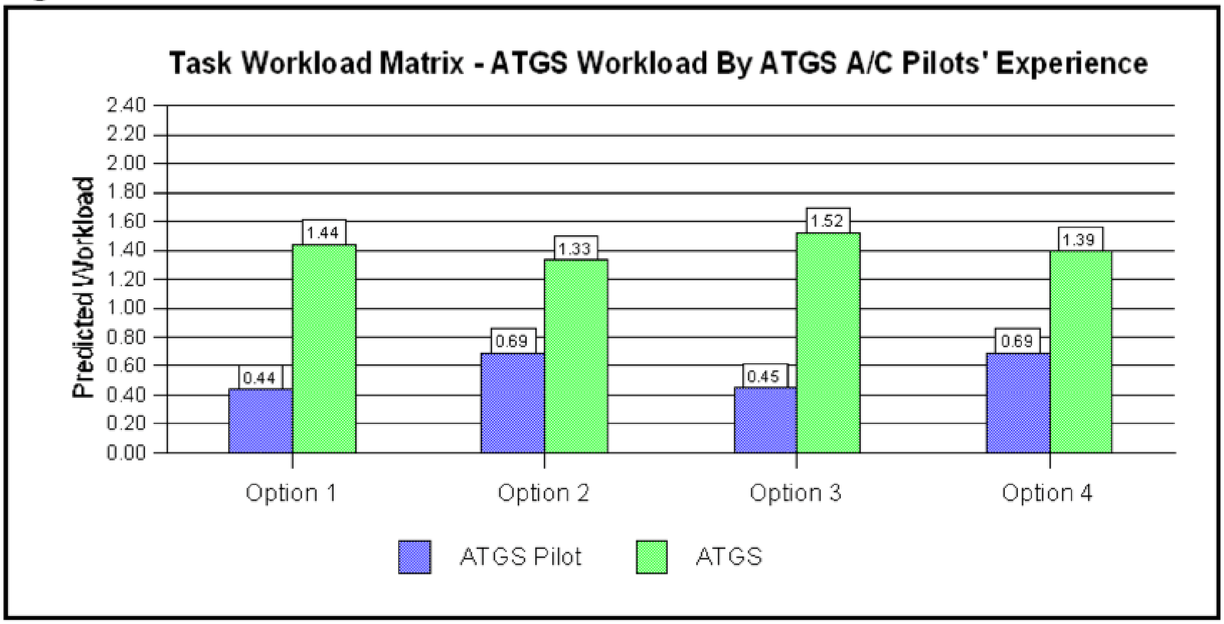
As noted in Step 2, the Task Workload Matrix was developed to support the evaluation of workload, communications, airspace structure and human-aiding technology in the NASA/BLM/USFS National Aerial Firefighting and Safety (NAFSE) Project. The results that follow are based on this Project.

<u>Workload Related To The Proficiency Level Of ATGS Aircraft Pilots</u>

Please Note: As stated earlier, references in this document to “experienced” and “inexperienced” pilots does not refer to flying ability. Such references are to training and experience, or lack thereof, in assisting the Air Tactical Group Supervisor.

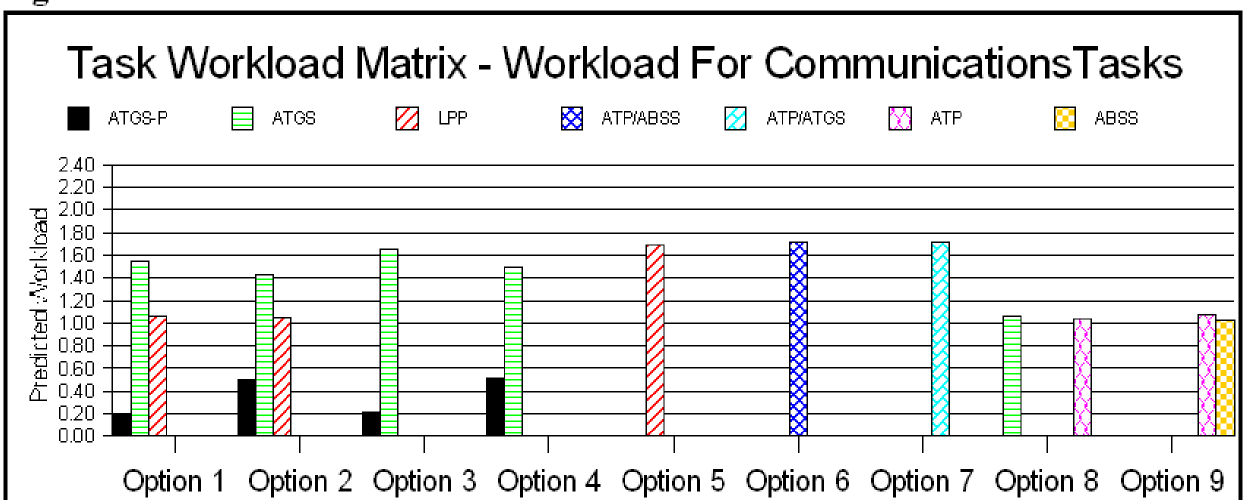
If the ATGS aircraft is being flown by an experienced pilot who is familiar with and has been trained in aerial supervision roles, duties and responsibilities, then the ATGS aircraft pilot can share some of the ATGS’s workload. In Figure 9, the Organizational Options 1 and 3 have an inexperienced ATGS aircraft pilot and Options 2 and 4 have an experienced ATGS aircraft pilot. The ATGS workload decreases from a rating of 1.44 to 1.33 between Options 1 and 2 and from 1.52 to 1.39 between Options 3 and 4. Note the commensurate increase in workload rating for the ATGS aircraft pilot between Options 1 and 2 and between Options 3 and 4. As one can see, the ATGS is assuming some of the workload that an experienced ATGS aircraft pilot could normally perform.

Figure 9



The areas where sharing can primarily occur are in the area of communications with dispatch, with the leadplane, and with airtankers (Refer to Figure 10). Air Tactical Group Supervisors estimate 20% of their workload can be assumed by an experienced ATGS aircraft pilot, as reported in response to the field survey.

Figure 10



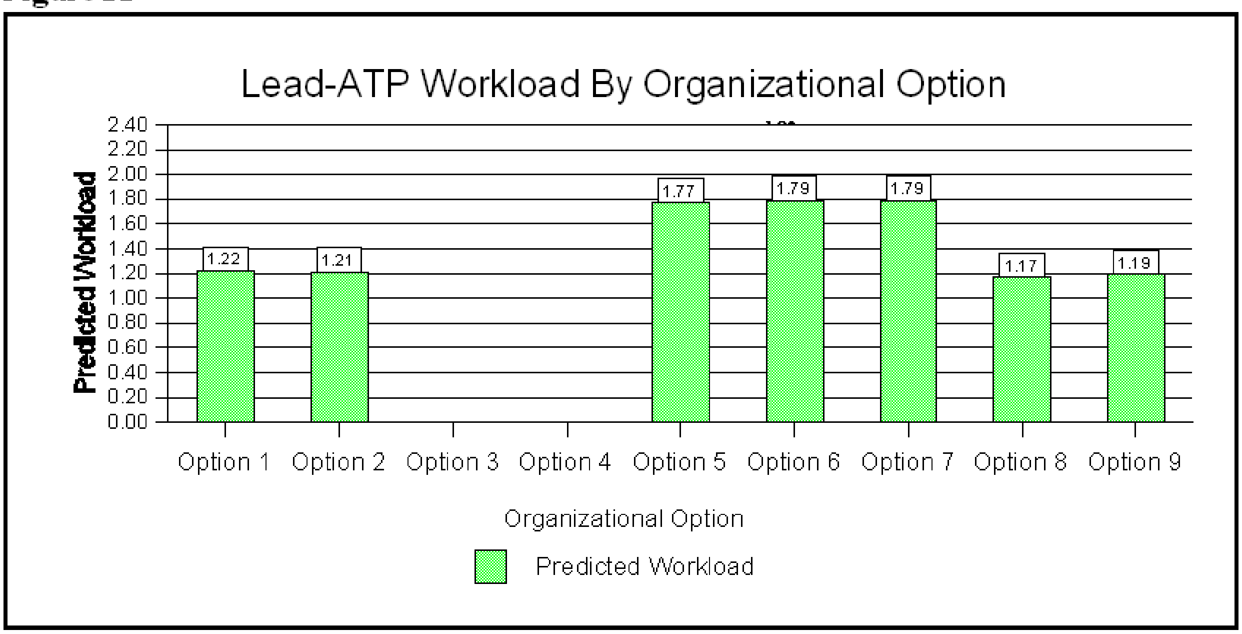
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
ATGS-P	0.20	0.50	0.22	0.51					
ATGS	1.55	1.43	1.65	1.50				1.06	
LPP	1.06	1.05			1.69				
ATP/ABSS						1.72			
ATP/ATGS							1.72		
ATP								1.04	1.07
ABSS									1.03

Workload On ATGS Based On The Presence or Absence Of A Leadplane
When no leadplane is present as in Organizational Options 3 and 4, the ATGS workload increases in a number of areas, particularly communications. Two key additional tasks includes communicating with airtanker pilots to relay target description information and in feedback to the airtanker pilots based on fire retardant drop evaluation. Figure 10 shows that when there is only one person in the aircraft to perform all tasks in the roles and responsibilities of both functions (Organizational Options 5, 6 and 7), the workload increase is the highest.

Workload On the Leadplane Pilot Based On The Presence or Absence Of An ATGS
As has been noted, when no ATGS is present, the leadplane pilot role, duties, responsibilities and workload increase. In Figures 11 and 12, note that Organizational Options 1 and 2 have both an ATGS and leadplane over the fire and the leadplane's workload rating is about the same, 1.21 and 1.22. The mean is 1.215.

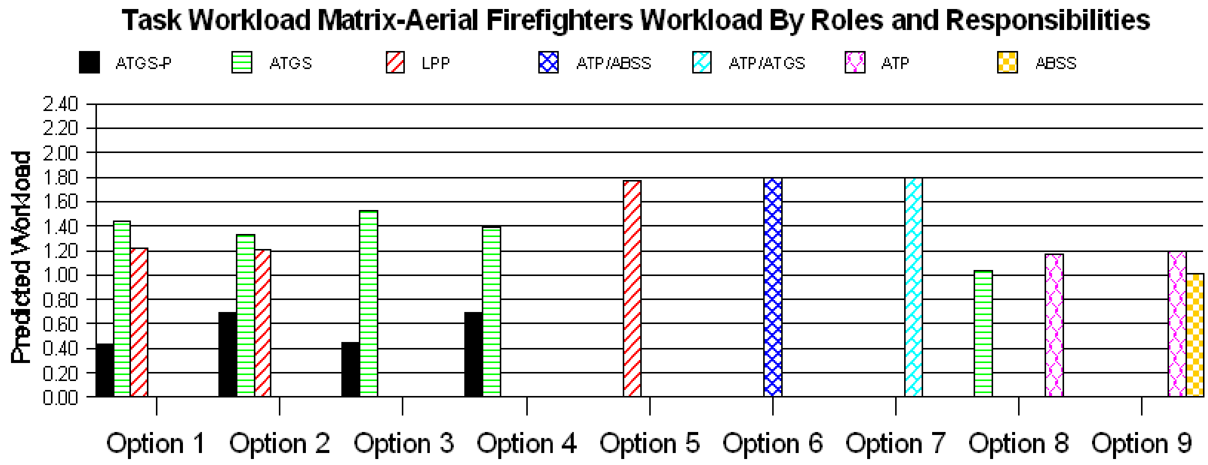
In Organizational Options, 5, 6 and 7, there is only one aircraft and one person in that aircraft performing all tasks, the workload is substantially higher, ranging from 1.77 to 1.79. The mean is 1.78. This workload rating is the highest for all options analyzed.

Figure 11



When a leadplane is dispatched to a fire primarily for the purpose of leading airtankers, a major portion of the aerial supervision responsibility is placed with the leadplane pilot. However, the data from the TARMS User Survey suggests that a substantial portion of the ATGS tasks will frequently not be performed or will be performed with a compromise in timeliness and quality. The complexity of the aerial and ground operations will determine the magnitude of the compromise.

Figure 12



ATGS-P	0.44	0.69	0.45	0.69					
ATGS	1.44	1.33	1.52	1.39				1.03	
LPP	1.22	1.21			1.77				
ATP/ABSS						1.79			
ATP/ATGS							1.79		
ATP								1.17	1.19
ABSS									1.01

This is particularly true in those geographic areas that do not have an ATGS with aircraft (exclusive-use contract or agency-owned) on standby. As the situation evolves, an ATGS is requested to respond. Dispatch will need to locate an ATGS and order an aircraft. When the ATGS and aircraft get together at the airport, the aircraft needs to be checked out, the portable radio system needs to be installed, tested and ATGS and pilot briefed before they can respond. In the mean time, the Leadplane pilot has all of the aerial supervision responsibility until the ATGS arrives on scene. Frequently the ATGS arrives with the second or third trip of the airtankers. This causes the ATGS to be behind the power curve, in every aspect of the incident (airtanker rotation, ground tactics, fire behavior etc). It also increases the potential for missed information during the briefing between the lead and ATGS because of the heavy initial attack workload.

Data from the TARMS User Survey also indicates that it is common during complex situations for tasks of lesser importance to be ignored or not performed optimally by the leadplane pilot when the ATGS is not on scene. The data from the Task Workload Matrix suggest that tasks related to observation and data entry are high workload tasks. Thus during the period when the leadplane must perform all aerial supervision duties, these tasks are the ones most likely impacted (See Figures I-1 and I-2 in Appendix I). The workload associated with performing flying and navigation tasks remains at about the same high levels when one or both aerial supervisors are on the fire. (See Figures I-3 and I-4 in Appendix I).

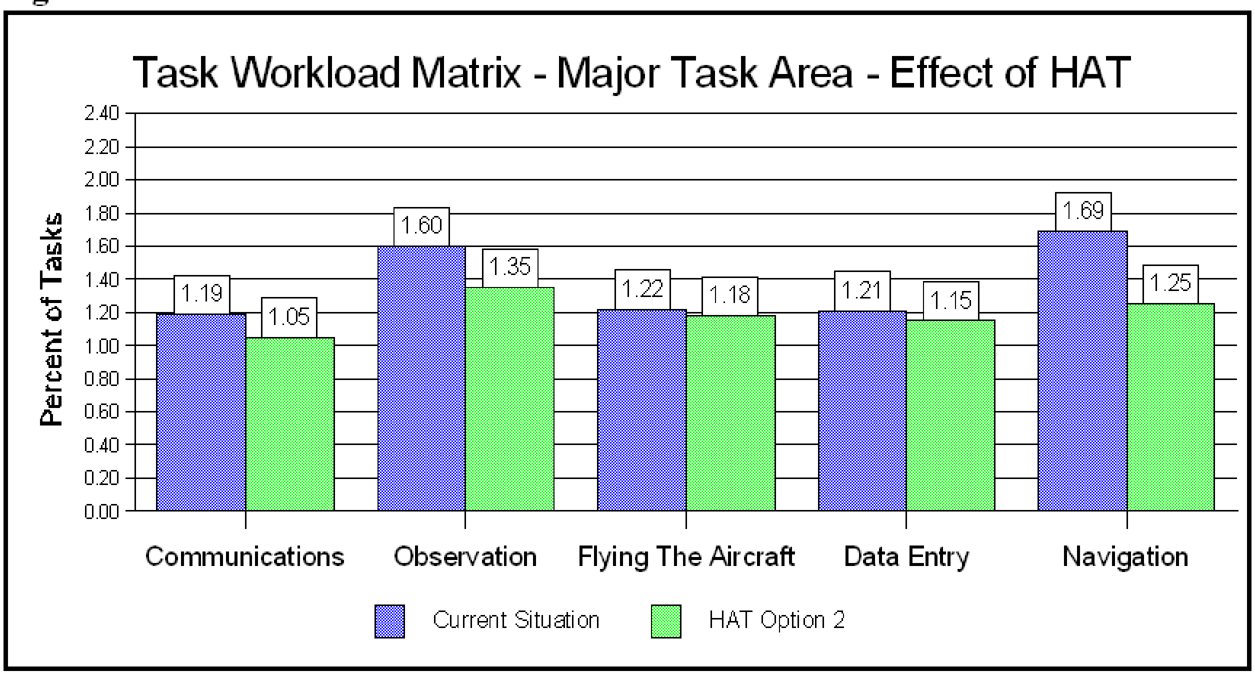
Respondents to the TARMS User Survey indicated that when leadplanes operated on fires with no ATGS present and with helicopter operations active, tasks relating to the management of helicopter operations were frequently placed on the helicopter pilot. This lack of supervision has both safety and efficiency implications. Also, if additional helicopter operations are required, the re-acquisition of information related to these tasks is difficult and adds to the workload of all participants.

Summary Of The Observations And Findings In The Evaluation Of Organizational And Human-aiding Technology Options

The TARMS User Survey and preliminary findings of the National Aerial Firefighting Safety and Efficiency Project (1996) identified communications as a significant problem. Human-aiding technology has the potential to significantly reduce verbal communications by providing common mental models of the environment which will aid in improving situational and geographical awareness. A shared picture is worth a thousand words.

Both the TARMS Field Survey and the Task Workload Matrix (Figures 13 and 14) identified high workloads as common to high-tempo aerial firefighting operations. In most cases, the successful implementation of human-aiding technology both within and outside aerial firefighting aircraft will either reduce workload, or have a positive effect on workload and on geographic and situational awareness. Both should have a positive affect on safety and efficiency. Figure 13 suggests that the workload associated with all aerial fire fighting tasks will

Figure 13



be reduced with the introduction of the minimum level of HAT discussed earlier in this report.

Figure 14

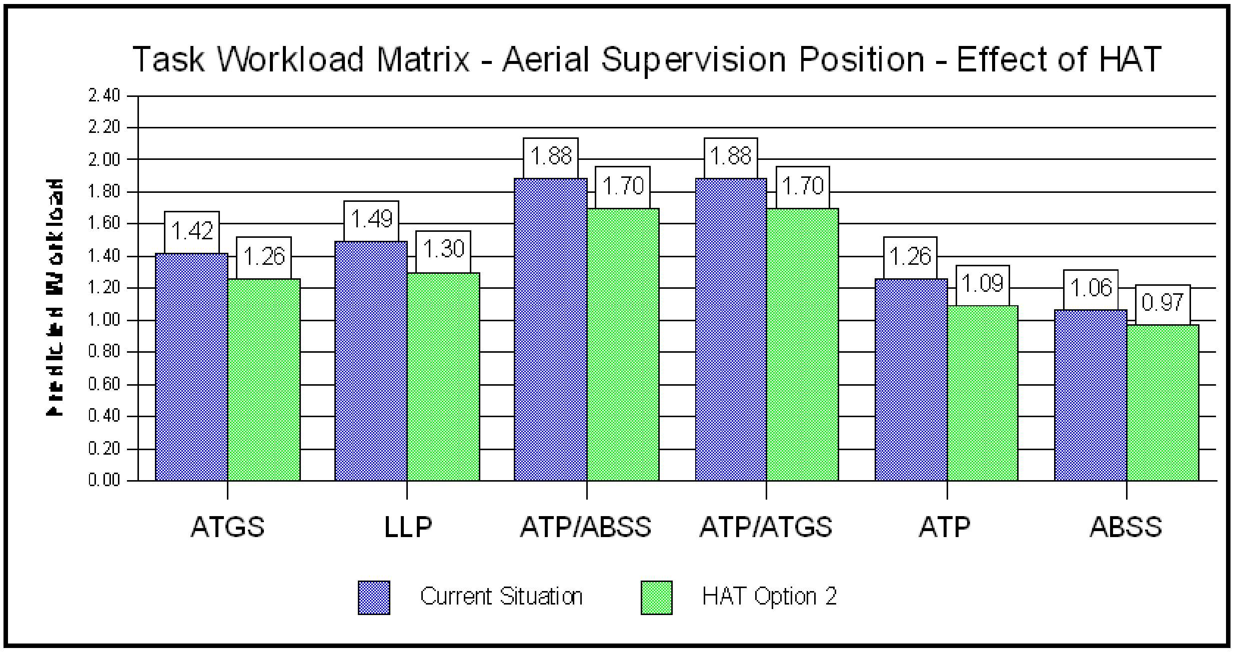
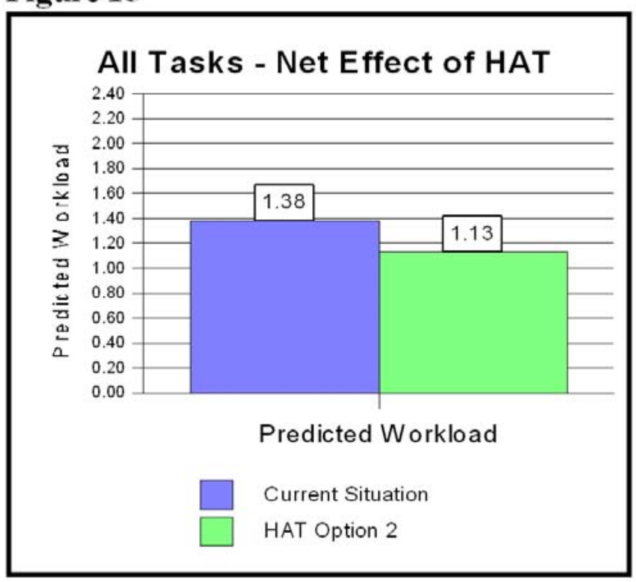


Figure 15



A large body of research on pilot workload and performance in aviation and supervisory control tasks suggests that when workload is in the high range, aerial firefighters (ATGSs and pilots) will start prioritizing tasks, resulting in the shedding (discarding) of some tasks and/or inadequately completing some (Hart & Sheridan (1984), Battiste and Hart, (1985). As displayed in Figure 15, implementation of human-aiding technology as defined in HAT Option 2 level can result in a reduction in workload of 18%. An 18% average reduction in workload may reduce a high workload situation to a more comfortable and manageable level where all tasks can be accomplished in an acceptable manner.

The data in Figure 14 which is summarized in Figure 15 suggests that the workload of current and proposed aerial firefighting supervisors will be reduced with the introduction of HAT into the flight deck and ground environment.

The following statements summarize conclusions by the study committee on the value of human-aiding technology applied to the mission of aerial firefighting.

In both the initial/extended attack and in the large-fire environments, lack of real-time information, particularly during high-tempo operations, hinders all personnel's ability to make the best decision based upon all required information.

Given the tempo, complexity, and rapidly-changing environments common to aerial firefighting tasks, decision-support tools are needed to improve the transfer of information between users. Human-aiding technology furnishes decision-support tools by providing:

- A shared mental model of fire, navigation, topographic, and traffic information distributed in real time.

- Real-time information distributed immediately to aerial and ground firefighters for tactical application and planning purposes

Human-aiding technology can improve situational and geographical awareness as demonstrated by uses in the commercial airline, general aviation, and military flight domains.

Past experience with flight deck technology in both the commercial airline and military sectors, as well as scientific research and various published papers (FAA, 1996) indicate that any successful implementation of technology in the aerial firefighting domain will be dependent upon as a minimum:

- In-depth human factors research and engineering in the domain (i.e., aerial firefighting), particularly with regard to the user-machine interface

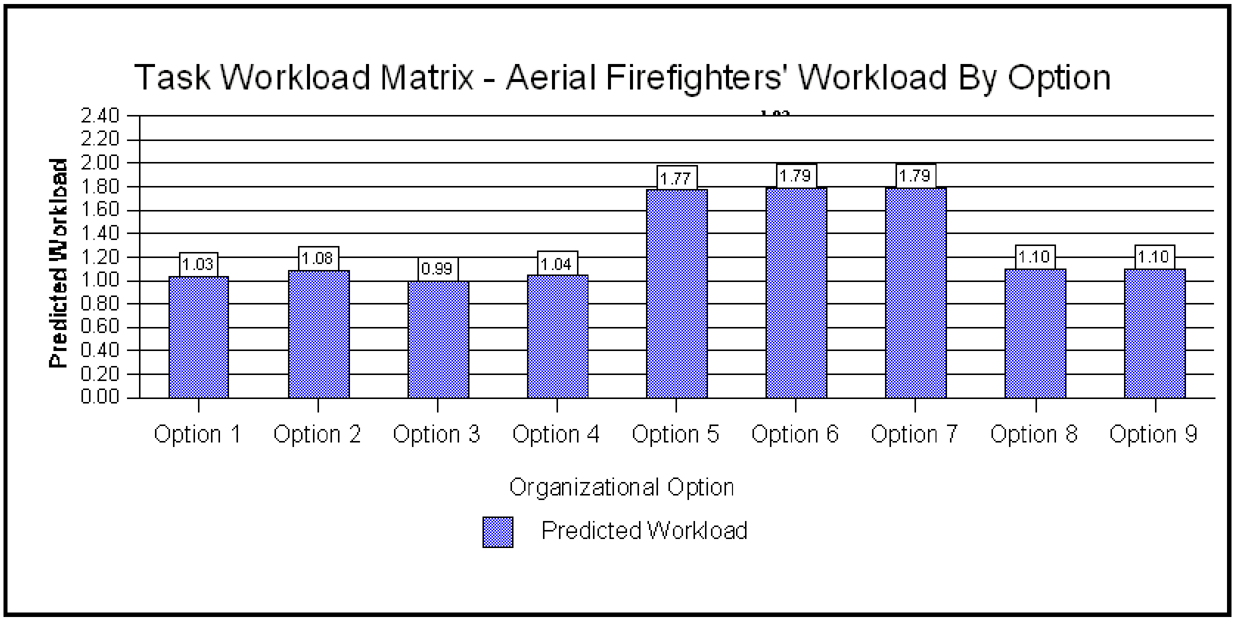
- A requirements phase wherein users define desired system components and suggest human-machine interfaces to design engineers.

- Comprehensive training in the use of human-aiding technology.

Technology that was formerly available only to commercial airlines or the military is now becoming more readily available, often with open, non-proprietary architecture and at extremely reduced costs (Battiste, 1996). Observation of trends in the commercial airline and military avionics industries indicates that any implementation of human-aiding technology must have open architecture, non-proprietary hardware and software, interoperability, and other characteristics that contribute to cheaper initial and life cycle costs.

Figure 16 summarizes the Task Workload Matrix for All Aerial Firefighters staffed within an organizational option.

Figure 16



The economic value to a leadplane was displayed in Step 2 to be a minimum of $8,500,000. The leadplane also provides for increased safety for the mission of dropping fire retardant from fixed wing airtankers, particularly in congested areas and on fires with multiple airtankers involved in dropping. For these reasons, the committee ceased further consideration of Organizational Options 3 and 4.

The workload for a single person/single aircraft Organizational Options 5, 6 and 7 is the highest. This workload is so high that tasks most likely are being shed or not accomplished fully. This conclusion is based information contained in the TARMS User Survey and from the individuals doing the task workload ratings. The evaluation criteria "to have workload reduced without a commensurate loss in task accomplishment" is not met in Organizational Options 5, 6 and 7. For these reasons, the committee ceased further consideration of Organizational Options 5, 6 and 7.

For the rest of this discussion, data will be presented to compare and contrast the Organizational Options left. These would be Options 1 and 2 (Current Organization with leadplane) with Options 8 and 9 (potential future organizations). These four Organizational Options are the only fully staffed Options.

When Organizational Options 1 and 2 are compared, the total workload increases from Option 1 to Option 2. The data in Figure 12 (Task Workload Matrix-Aerial Firefighters Workload Roles and Responsibilities) explains this increase in total workload with an experienced ATGS aircraft pilot (Option 2 = 0.69) versus an inexperienced ATGS aircraft pilot (Option 1 = 0.44). This increase in workload for the experienced ATGS Aircraft Pilot is based on his experience allowing him/her to assume additional responsibility for some tasks. Note the commensurate reduction in the ATGS' workload with an experienced ATGS Aircraft Pilot (Option 1 = 1.44, Option 2 = 1.33). Also note there is no change in the Leadplane Pilot's workload. Based on these data and data discussed earlier in the Report, Organizational Option 2 is preferred over Organizational Option 1.

Now data from Organizational Option 2, the preferred current organization with leadplane, will be compared with data from Organizational Options 8 and 9, potential proposed future organizations. A comparison of the combined workload of these three Organizational Options from Figure 16 shows that the workload is approximately the same (Option 2 = 1.08, Option 8 = 1.10, and Option 9 = 1.10). The apparent workload reduction in Organizational Option 2 is a result if a regression towards the means of the three individual workload values (ATGS, ATGS Aircraft Pilot and Leadplane Pilot) in this Option.

The data in Figure 12 (Task Workload Matrix-Aerial Firefighters Workload Roles and Responsibilities) displays data which will allow for a more in-depth understanding of these ratings. The Table below summarizes the data from the Figure 12.

Table 8 - Comparison of Workload Ratings Based on Roles and Responsibilities

Organizational Option	ATGS or ABSS	ATGS and Leadplane Pilot or ATP
Option 2	1.33	1.21 + 0.69 = 1.90
Option 8	1.03	1.17
Option 9	1.01	1.19

The workload for the ATGS is reduced by 23% (1.33 to 1.03) from Organizational Option 2 to Organizational Option 8. The workload for the ATGS or ABSS is reduced by 24% from Organizational Option 2 to Organizational Option 9. The percent reductions in combined workload from Organizational Option 2 for the ATGS Aircraft Pilot and the Leadplane Pilot to the workload for the ATP in Organizational Options 8 and 9 is 38% and 37% respectively. The workloads for the ATGS Aircraft Pilot and the Leadplane Pilot in Organizational Option 2 were added to reflect the combined workload which is occurring.

Observation of trends in the commercial airline and military avionics industries indicates that any implementation of human-aiding technology must have open architecture, non-proprietary hardware and software, interoperability, and other characteristics that contribute to cheaper initial and life cycle costs.

Recall that the evaluation criteria for organizations and human-aiding technology is as follows:

- Based on an assessment of workload for tasks to be performed, the evaluation will display the relative change in workload from the current situation, Organizational Options 1-5 and Human-aiding Technology Option 1. This comparison will be made in a manner where there is not a commensurate loss in task accomplishment.

Based on the workload ratings, Organizational Options 8 and 9 provide the most reduction with no commensurate loss in task accomplishment. These two Organizational Options offer the opportunity for better integration of the ATGS and leadplane roles, responsibilities and workload as both individuals are performing in these positions in the same aircraft. These two Organizational Options require one less airplane and one less pilot (ATGS aircraft pilot). Table 14 shows the significance of fire occurrence episodes and the correlation with large fire occurrence. The flexibility of having both the ATGS and leadplane roles and responsibilities in the same aircraft can be very significant when attempting to provide aerial supervision on days within episodes.

The predicted workload for the ATGS in Organizational Options 8 and the ABSS in Organizational Options 9 are about the same. The difference between these two Organizational Options is in the roles and responsibilities of the ATGS versus the ABSS. Recall that the ABSS is responsible for tactical supervision of <u>all</u> fire operations, both ground and air. This supervisory responsibility for ground operations will be maintained <u>until transferred to ground personnel.</u> It is the opinion of the committee that the implementation of the ABSS concept needs further study at this time.

Refer to Figure 10 and Figures I-1-4 (Appendix I), which displays the Task Workload Matrix ratings for Communications, Observation, Data Entry, Flying the Aircraft and Navigation Task respectively. Note that the tasks are more balanced between these major task areas in Organizational Option 8 versus 9.

In summary, the committee found:

- The task workload associated Organizational Options 8 and 9 was consistent with current task workload levels and the mission could be accomplished with one less person (ATGS aircraft pilot) and one less aircraft. The potential benefits of Organizational Option 8 were highest of all Organizational Options.

- Organizational Option 9 (ABSS) appear to have high value but further study is needed.

- Workload was highest in all single crew configurations (Organizational Options 5, 6 and 7).
- Overall workload was reduced by 18% with the use of Human-aiding Technology Option 1. All aerial firefighting tasks were reduced with this technology with the magnitude of reduction differing by major task area, task type, and phases of flight.

Potential Economic Value of Human-aiding Technology

Human-aiding technology as defined in Human-aiding Technology Options 2 and 3 configurations has the potential to reduce flight time costs spent in holding areas by airtankers and other aircraft, to reduce flight time spent looking for targets described inaccurately frequently by helicopters, and to improve accuracy of fire retardant drops.

The potential saving just for airtankers operations can be estimated. If implementation of HAT Option 1 or 2 produced just a 5% reduction in flight time spent by airtankers, the savings would be about $700,000 per year based on airtanker use data from 1987 - 1997. Application to helicopter operations would increase this estimated savings. Through no analytical study has been completed to verify potential economic savings, it does appear that savings are possible and attainable through efficiency goal setting during implementation of adopted recommendations.

Training Objectives and Potential for Change

All Organizational and Human-aiding Technology Options presented are based on an assumption that personnel involved in aerial firefighting receive adequate training to support performance at an optimal level of proficiency. This applies to all personnel who may participate in the high-risk environment of aerial firefighting, including the CWN ATGS or Air Tactical Pilot. The only variation will be in the breadth and depth of the training provided.

The Objective

The objective of training is to elicit a desired, consistent, and predictable response from different individuals when presented with like situations or stimuli as perceived from a “data set.”

The Theory

Training is the conditioning of an individual to respond in a predictable and appropriate manner to a given set of circumstances (or stimuli). Aerial firefighters formulate responses from a "set” of stimuli rather than a single stimulus or condition. Background information learned in the classroom allows a trainee to prioritize and weight the stimuli (or circumstances) and to develop an appropriate model and plan of action based on the information presented in the “data set.”

If correctly presented by the instructor, observation on-the-job and/or simulation of the working environment will allow the candidate to formulate and confirm the correct response to the data set presented and hence react with an appropriate response. Merely providing information in a lecture or reading format to students does not constitute a definition of training because it does not evoke a response, and conditioning does not occur. Providing information about a subject does weight elements of a data set and, while one may assume a particular response from the information provided, individuals will respond differently because conditioning (training) has not occurred.

As an example, consider each item of information presented to students to be a tool in a mechanic’s tool box. If individuals are picked at random, provide them with a complete 'tool box,' and ask them to repair a "widget”, the individuals may use the same tools differently or different tools to perform the same task. But whether they are successful in accomplishing the task safely and efficiently will still be in question because they have only been provided the required "tools" to accomplish the task. They have not been instructed (or conditioned) as to how those tools relate to the solution of the task.

Application of the Theory To Aerial Firefighters

Training will determine the effectiveness and level of performance attained by each candidate as a subject expert. It should be emphasized that training crews together with an emphasis on crew resource management (CRM) elements will be necessary to implement any Organizational and Human-Aiding Options.

The time needed to train aviators and aerial firefighters to an acceptable level of operational proficiency in the proposed ASM environment can be accomplished in a shorter span of time because a considerable quantity of the knowledge required for either task has been acquired while performing other jobs. These individuals, unlike a novice who must start from the beginning, both have a rich and varied background in aviation and/or ground firefighting.

The ATGS will have evolved from the ground firefighting arena and will have an extensive fire background from that experience. Similarly, the aviator will bring an extensive aviation background to the team. Desired "overlap" of roles which enhance the knowledge of ATGS personnel of aviation and enhance the knowledge of ATP personnel of fire management can be achieved through continuing education at a later date, when candidates have become comfortable with their primary roles.

Training Curriculum

Since most courses have been designed for the fire community (with aviation in mind) and not specifically for aviation, nearly all material presented is primarily relevant to and focused upon what the ground firefighter needs to know. The A "model" for many firefighter courses which address aviation topics is that of an individual on the ground. Yet this approach is applied to what is essentially an aviation operation, with little input by subject matter experts from the aviation community. There are also significant gaps in ground firefighter training (from basic firefighter to Operations Section Chief) regarding aviation and what the ground firefighter needs to know.

The same holds for the primary aviation courses. These courses often do not contain subject matter that is key and primary to the jobs of an aerial firefighter. They do not contain information relevant to the issues identified by TARMS, particularly in the area of verbal communications. They also do not address other issues critical to an aerial firefighter such as an ATGS: appropriate drop speeds, flight characteristics, of airtankers (also applies to lead plane pilot training), air traffic management and structure, etc. Though these may be addressed in the current lead plane and ATGS training, they are not addressed to the extent necessary.

As an example, S-378 Air Tactical Group Supervisor addresses radio communications hardware and frequencies in depth. It also addresses the terminology that is used in the environment. However, the course has no examples or exercises that would support the ATGS' future ability to communicate effectively and precisely. A case could be made that S-378 is the one course most in need of simulation exercises throughout the course. The latest version has one computer-based simulator, but it is an optional exercise and not required for completion. The course does not contain material that instructs and conditions ATGS candidates to perform the job effectively.

Many of the fire courses required for leadplane pilots contain only A ”elements” which are directly related to the leadplane role in fire suppression. Much of the material relates only to the primary function of leading airtankers. However, flight characteristics of airtankers are not addressed.

While the leadplane training program requires that specific trainers be designated, the Air Tactical Group Supervisor program does not. A structured cadre approach could allow for changing of performance by changing the training program to elicit the desired behavior. Centralized cadre training also offers the advantage that a reasonable number of aircraft can be equipped to accommodate training, and remain with the cadre. With a designated complement of training aircraft, the remainder of the fleet needs only to respond to the tactical mission. This philosophy will allow the selection of aircraft based on single mission objectives, and may reduce total fleet cost.

Immersed simulation in the aerial firefighting training process can offer many advantages in terms of expanding response repertoires, establishing standards, and comparing candidate responses to established or developing standards. It also provides the opportunity to test proposed procedures and extreme situations in a non-hazardous environments. While stand-up instruction can be effective as an introduction to training material in high-risk, high-tempo jobs such as the leadplane pilot or ATGS, immersed simulation (i.e., full cockpit simulators) is the only proven and effective method that consistently elicits desired responses.

One of the main reasons that immersed simulation has been so readily adopted by the commercial and business aviation community is the ability to simulate emergency procedures and develop conditioned responses in pilots. Scenarios can be developed and intensified according to the students progress and abilities, making training much more effective and comprehensive.

Immersed simulation can aid training of candidates in two distinct ways. It can provide the vehicle to allow stimulus response training of usual or anticipated fire scenarios' without respect to the type of fires that actually exist during the training season. Therefore every candidate can experience the full range of "normal" fire activity in the training scenario, and simultaneously be monitored for correctness of response during the training session. We could be assured for the first time that when given a defined set of circumstances, the candidate will respond in an appropriate and predictable manner.

Secondly, immersed simulation is important in training for "emergency" situations. The most important aspect of any emergency condition is time. Given ample time to deal with the offending condition, the scenario ceases to exist as a true emergency. In an emergency, correct responses of each of the participating players and the time it takes to formulate the responses will determine the success or failure of the response. The difference between success and failure will depend largely on the structure and definition of each player's role, or the degree of coordination and cooperation between the participants in formulating a timely response.

As with commercial pilot simulation, fire and aircraft situations for the pilot could be taken beyond what could be safely presented in "live"situations, allowing candidates to experience scenarios that would be too dangerous to replicate in on-scene training, but that are critical to his/her knowledge and behavior in an emergency.

Similarly, ATGS training could replicate the high intensity and quick responses necessary in the urban interface situation, where numerous aircraft approaching and departing, chaotic communications, and live/property at higher risk than usual are the norm rather than the exception. All too often under the present system, recently-qualified ATGSs find themselves in situations for which their training and experience has left them unprepared.

Simulation training can also be conducted at any time of year and under all weather conditions, making it unnecessary to limit training to summer months or to very active fire years. Simulation would be extremely valuable in eliminating the spring training "crunch." Despite relatively high up-front development costs, it can reduce travel and per diem costs when parts of the simulator are conducted remotely with the employee at his or her duty station.

Immersed simulation can be extremely valuable in teaching individuals their respective roles and responsibilities (to predetermine the structure and organization). When faced with a condition that does not allow for normal time frames of development and solution, they are able to respond successfully due to the previous simulator experience. Individuals can know in advance, their respective roles and responsibilities for timely solution to emergency or novel situations.

Aircraft Options

To test the ranking criteria evaluating process, the following ground rules for a level paying field were established. It is again noted, that these ground rules were established before any aircraft were identified for the testing process.

Approved Flight Manuals/Pilot Operating Handbooks

Only approved flight manuals were used to determine the performance of the potential aircraft. For aircraft in development, if an approved flight manual was not available, then the aircraft eliminated from further consideration since performance projections could not be verified.

Operational Weight

To evaluate and compare the aircraft for this study, a weight was established which realistically depicts the mission which is to be flown. Selection of the gross weight of the aircraft or maximum fuel capacity associated weights for the evaluation does not fulfill this requirement as some of the aircraft will not be flown at their gross weights. For example, the Beech King Air 350 has a passenger capacity of 17 but as a aerial supervision platform aircraft will most likely carry 2 people on a mission. Similarly, other aircraft are designed for niche markets and sacrifice payload for range by installing larger fuel tanks. To establish a suitable weight, consideration was given to the number of flight crew personnel, required flight duration, basic weight of the aircraft, and the required flight crew associated gear (charts, maps, books, etc.).

Currently, leadplanes operate in approximately 4 hour shifts. While ATGS personnel may operate for longer periods, the minimum limiting factor is the requirements for the aircraft operating as a leadplane. Hence, the weight of four hours of fuel (no reserves) will be used. While fuel reserves would be necessary in actual mission performance, the four hour assumption is valid for comparison purposes. The flight crew shall consist of a pilot, and one passenger. The average weight of these personnel shall be 200 lbs per person. The associated personnel gear shall be established at 50 lbs per person. Therefore, the operational weight for this study will be defined as:

Operational Weight = Basic Empty Weight of the Aircraft (Std Wt + Optional Equipment)
+ 400 lbs (Flight Crew, 2 * 200 lbs)
+ 100 lbs (Flight Crew Gear, 2 * 50 lbs)
+ 4 hours of fuel

Operational Day Conditions

In the National Airtanker Study and in the USDA Forest Service Large Airtanker Contract, aircraft performance is specified at ISA + 30°F. As the lead or ATGS aircraft, the platform must operate in this same environment. Hence, these conditions will be required for this evaluation. Additionally based on information obtained during the National Airtanker Study and a survey from leadplane pilots, an acceptable definition for the altitude in evaluating the performance is 5000 feet.

To complete the testing of criteria evaluation process, the five aircraft identified as passing the must have criteria will be examined against the ranking criteria. The following represents the results of the test.

Evaluation of Specific Mission Needs

The values shown In Table 9a for the subjective evaluation performed by the pilots and ATGS are the arithmetic average of the scores provided by the evaluators. To provide for ranking of the aircraft with their criteria, a method was adopted where the aircraft with the minimum value received a score of one and the aircraft with the highest value received a score of ten. For criteria where lower is better, for example stall speed, the aircraft with the lowest value received a score ten and the aircraft with the highest value received a score of one. Where criteria had established minimums or maximums aircraft beyond those values were dropped from consideration, even though they appear in the ranking. As a result, the following table shows the individual criteria rating, a weighted sum and a weighted rating summary ranking. An important note here is that the weights identified by the team when the criteria were developed are also shown. For example, among all the criteria for Specific Mission Needs Visibility Outwards is the most important. The weighted sum for a candidate aircraft is the sum of the individual element rating scores times the weight in that criteria element, all divided by the sum of the weights. Mathematically represented by:

$$\text{Weighted Sum} = \frac{\Sigma\,[\text{Criteria}_i * \text{Weight}_i]}{\Sigma\,\text{Weight}_i}$$

The Weighted Rating is similar to that which was done for the individual aircraft characteristic values. The aircraft with the lowest weighted sum was assigned a value of one and the aircraft with the highest weighted sum was assigned the value of ten. All other aircraft were rank ordered within the range of one to ten. Hence, applying the above method to the measured values for the Specific Mission Requirements results in the following table.

Table 9a - SPECIFIC MISSION NEEDS - Criteria Values

Evaluation Criteria	Baron 58P	KA C90	OV-10A	OV-10D	KA200/200C
Aircraft Visibility Outwards	2.00	3.17	1.00	1.00	3.50
Complexity of Flight in Lead Role	1.75	1.00	1.00	1.00	1.75
Minimum Control Airspeed	81	92	84	78	86
Flight Crew Capacity/Arrangement*	6/S	6/S	2/I	2/I	15/S
Single Engine Best Rate of Climb	300	510	500	715	780
Flight Deck Design	8	16	8	8	24
Aircraft Visibility of Being Seen	77	100	95	95	113

* - The first number is the people capacity and the second value (letter) indicates side by side seating on the flight desk (S) or inline seating (I) on the flight desk.

Table 9b - SPECIFIC MISSION NEEDS - Ranking						
Evaluation Criteria	Wt.	Baron 58P	KA C90	OV-10A	OV-10D	KA200 200C
Aircraft Visibility Outwards	10.0	4	2	10	10	1
Complexity of Flight in Lead Role	7.7	1	10	10	10	1
Minimum Control Airspeed	4.7	8	1	6	10	5
Flight Crew Capacity/Arrangement	4.6	7	7	8	8	7
Single Engine Best Rate of Climb	4.2	1	6	5	9	10
Flight Deck Design	4.2	1	6	1	1	10
Aircraft Visibility of Being Seen	1.9	1	7	6	6	10
Weighted Sum		4	5	7	8	5
Weighted Ranking		1	4	8	10	3

As can be seen by a review of Table 9b above, the performance and characteristics of the OV-10D rank the highest for this category of criteria.

Evaluation of Aircraft Performance

In analyzing the Performance Criteria, the OV-10A is found to not meet the minimum single engine service ceiling of 10000 feet. This is unacceptable since in some geographic areas the location of the fire or where aerial supervision would take place, may require the aircraft to climb above 10000 feet to clear the terrain to return to base or an alternate location. In an engine out situation, the most direct route to a safe landing is the most desirable. This results in the A model of the OV-10 to be dropped from further consideration as a future leadplane.

In a similar fashion as that done for the Specific Mission Needs, the above aircraft values were converted into a ranking. The results of that ranking are shown below. Again the OV-10D's performance and characteristics is found to rank the highest.

Table 10a - AIRCRAFT PERFORMANCE - Criteria Values					
Evaluation Criteria	Baron 58P	KA C90	OV-10A	OV-10D	KA200 200C
Rate of Climb (All Engines)	1613	2083	2650	3020	2497
Stall Speed	78	71	73	73	83
Responsiveness	2.00	1.07	1.00	1.00	1.57
Maximum Cruise Speed	190	207	205	250	263
Maneuvering Speed	170	169	190	190	181
Single Engine Best Rate of Climb Speed & Single Engine Service Ceiling	115 13000	104 15050	110 8500	110 12500	121 15000
Airframe Strength	4.10	6.70	6.61	6.61	3.10
Fuel Endurance	7.7	4.4	7.0	7.0	5.1
Accelerate and Stop on Takeoff	4050	3900	2000	2000	4150

Table 10b - AIRCRAFT PERFORMANCE - Rankings						
Evaluation Criteria	Wt.	Baron 58P	KA C90	OV-10A	OV-10D	KA200 200C
Rate of Climb (All Engines)	10.0	1	4	8	10	7
Stall Speed	8.1	5	10	9	9	1
Responsiveness	7.7	1	9	10	10	5
Maximum Cruise Speed	5.8	1	3	3	9	10
Maneuvering Speed	5.5	5.5	5.3	10	10	8
Single Engine Best Rate of Climb Speed & Single Engine Service Ceiling	4.5	6	10	4	7	6
Airframe Strength	3.5	3	10	10	10	1
Fuel Endurance	2.6	10	1	8	8	3
Accelerate and Stop on Takeoff	0.3	10	10	10	10	10
Weighted Sum		4	6	7	9	5
Weighted Ranking		1	5	7	10	4

Evaluation of Ergonomics

The analysis of Ergonomics did not find any aircraft to be excluded from further evaluation. The values of the analysis are presented below and followed by the same ranking implementation applied to the previous two criteria categories. In this category the King Air 90 and 200/200C were found to rank the best.

Table 11a - ERGONOMICS - Criteria Values

Evaluation Criteria	Baron 58P	King Air C90	OV-10A	OV-10D	King Air 200/200C
Workspace Width / Height	42/50	54/57	38/56	38/56	54/57
Pressurization	Yes	Yes	No	No	Yes
Seat Comfort	3	3	2	2	3

Table 11b - ERGONOMICS - Rankings

Evaluation Criteria	Wt.	Baron 58P	King Air C90	OV-10A	OV-10D	King Air 200/200C
Workspace Weight / Height	10.0	3	10	1	1	10
Pressurization	8.5	10	10	7	7	10
Seat Comfort	3.1	10	10	1	1	10
Weighted Sum		7	10	3	3	10
Weighted Ranking		6	10	1	1	10

Evaluation of Cost

The analysis of Cost also did not result in the exclusion of any additional aircraft. The values and ranking tables are presented below. In this category, the Beech 58P Baron was found to rank the best. The monthly availability costs was based on the indicated fixed costs developed by Conklin & deDecker Associates, Inc. The monthly availability includes hull and liability insurances, recurrent training, aircraft modernization, refurbishment, and depreciation and are valid for comparative purposes. Actual experienced costs may vary and in fact for the current agency-owned aircraft, they may be low.

Table 12a - COST - Criteria Values

Evaluation Criteria	Baron 58P	King Air C90	OV-10A	OV-10D	King Air 200/200C
Monthly Availability (Dollars)	$1,372	$19,266	$5,096	$5,096	$27,697
Annual Availability (Dollars)	$16,464	$231,192	$61,152	$61,152	$332,364
Flight Rate ($/Flight Hour)	$230	$367	$458	$473	$423
Annual Flight Rate (Dollars For Flight 200 hrs)	$46,000	$73,400	$91,600	$94,600	$84,600
Annual Total Cost (Dollars)	$62,464	$304,592	$152,572	$155,752	$416,964

Table 12b - COST - Rankings

Evaluation Criteria	Wt.	Baron 58P	KA C90	OV-10A	OV-10D	KA200 200C
Annual Availability	N/A	10	4	9	9	1
Annual Flight Rate	N/A	10	5	2	1	3
Annual Total Cost	10.0	10	4	8	8	1
Weighted Sum		10	4	8	8	1
Weighted Ranking		10	4	8	8	1

Summary of Test of Evaluation Using Ranked Criteria

Table 13 presents a summary of the aircraft weighted sums from the above charts by category. For Specific Mission Needs, the driving criteria for the category are Visibility Outwards and Complexity of Flight in the Lead role; for Aircraft Performance, the driving criteria are the All Engine Rate of Climb, Stall Speed, and Responsiveness; and for Ergonomics, the key criteria are Work Space and Pressurization. Of the aircraft which passed the Must Have Criteria, the OV-10D was found to attain the highest degree of criteria characteristics. It is important to note that this aircraft did not attain the best standings in each of the criteria categories, and that the weighting used provided relative importance of the categories, i.e. aircraft characteristics related to Specific Mission Needs are of import to and aircraft than Ergonomics and Cost.

Table 13 - RANKED CRITERIA SUMMARY - Criteria Values and Rankings

Evaluation Criteria	Wt.	Baron 58P	King Air C90	OV-10A	OV-10D	King Air 200/200C
Specific Mission Needs	10.0	3.6	5.1	7.4	8.4	4.7
Aircraft Performance	7.8	3.8	6.3	7.3	9.0	5.3
Ergonomics	3.9	6.9	10.0	3.4	3.4	10.0
Cost	3.3	10.0	3.9	7.7	7.6	1.0
Weighted Sum		5.0	6.1	6.8	7.7	5.2
Weighted Ranking		1.0	4.7	7.0	10.0	1.9
Summary of Category Ranking		**Baron 58P**	**King Air C90**	**OV-10A**	**OV-10D**	**King Air 200/200C**
Specific Mission Needs		1.0	3.9	8.3	10.0	3.2
Aircraft Performance		1.0	5.4	7.0	10.0	3.7
Ergonomics		5.8	10.0	1.0	1.0	10.0
Cost		10.0	3.9	7.7	7.6	1.0

In summary, the criteria and evaluation methodology developed perform well in their ability to screen aircraft from continued evaluation, and to rank those which remain in a prioritized mission and safety based method. The weighting on the ranking criteria establishes the appropriate criteria importance to be able to separate good aircraft from better aircraft through the emphasis on Specific Mission Needs over Performance, Ergonomics and Cost; Visibility and Ease of Flight over stall speed, etc.

Use of this method in the selection of replacement Aerial Supervision Aircraft must recognize that by its nature the method comparative. The characteristics of the OV-10D to the evaluation criteria provide the benchmark for future use of the method. Without considering this, the application of the method to different aircraft will provide different results which may not represent the best solution. Hence, in seeking aircraft solutions from industry, an appropriate specification in the solicitation must be accomplished to insure that the key criteria are emphasized (visibility, ease of flight, etc.).

Analysis To Support Determination Of Numbers and Locations for ASM Aircraft

As noted in Step 2, the NFMAS database for this analysis was the same database used in the National (Large) Airtanker Study, Phase 2 (NATS2). This database includes all National Forests in the California, Northwest, Northern, Rocky Mountain and Southwestern Geographic Areas. This data base also includes all but two BLM Districts in the California, Northwest, Northern, Rocky Mountain and Southwestern Geographic Areas. One BIA unit is included in the Northwest Geographic Area. This extensive data base provides a large data set by which inferences can be made as to effects on lands not presented.

Analysis Of Expected Dispatch Frequency Based On NFMAS

Analysis was completed using the NFMAS database to determine the expected number of dispatches by fire size class for leadplanes and ATGS aircraft. For leadplanes, two runs were done. One run assumed that a leadplane was dispatched whenever an airtanker was dispatched. This run represents a “worst case scenario” from a dispatch workload standpoint. A second run was completed where a leadplane was dispatched only when two or more airtankers were dispatched. This second run emulates what would occur under current agency policy as described in Forest Service Manual (FSM) 5700 and BLM Manual 9400 respectively and summarized in the Interagency Leadplane Operations Guide (ILOG). The number of expected leadplane dispatches per year is summarized in Table 14 in the columns titled Fires With at Least One Airtanker and Fires With At Least Two Airtankers.

Analysis of Episodes

The National Airtanker Study, Phase 1, (NATS1) displays on pages 44 and 45 graphs of fires per day for the year 1994 in the Great Basin, Northwest and Northern Geographic Areas. Superimposed on these graphs are the number of fires greater than 100 acres size by day. Figures A-1 and A-2 display an this information for the Northwest Geographic Area as an example which is mirror throughout the United States.Note in Figure 14 the relationship between the total number of 100 acre and larger fires per day and the days when a large number of fire happened on that day. These days are referred to as an “EpiDay” and a series of these EpiDays form a fire occurrence episode. Staffing of leadplanes and ATGS aircraft during episodes is critical. Table 14 displays information on fire occurrence and expected dispatch needs for the aerial tactical and leadplane missions. Column 1 gives the annual average number of fires for the Federal agencies (USDA-FS, USDI-BLM, USDI-BIA, USDI-FWS and USDI-NPS) from 1980- 1997. For Alaska, it is for all ownerships protected by the Alaska Fire Service and is for 1985-1997. Columns 2 - 5 provide the percent of all fires and of fires in the D size class (100-299 acres) or greater that occur during fire occurrence episodes. On EpiDays, the average daily fire occurrence is displayed in column 4 and increase to the level noted in column 5. This increase is frequently at a magnitude of three to four fold. Column 6 provides the percent of the total fire season days that are within fire occurrence episodes. Note than in most Geographic Areas, this percent is relatively low indicating a high percent of fires (columns 2 and 3) on a small percent of days.

Figure 17

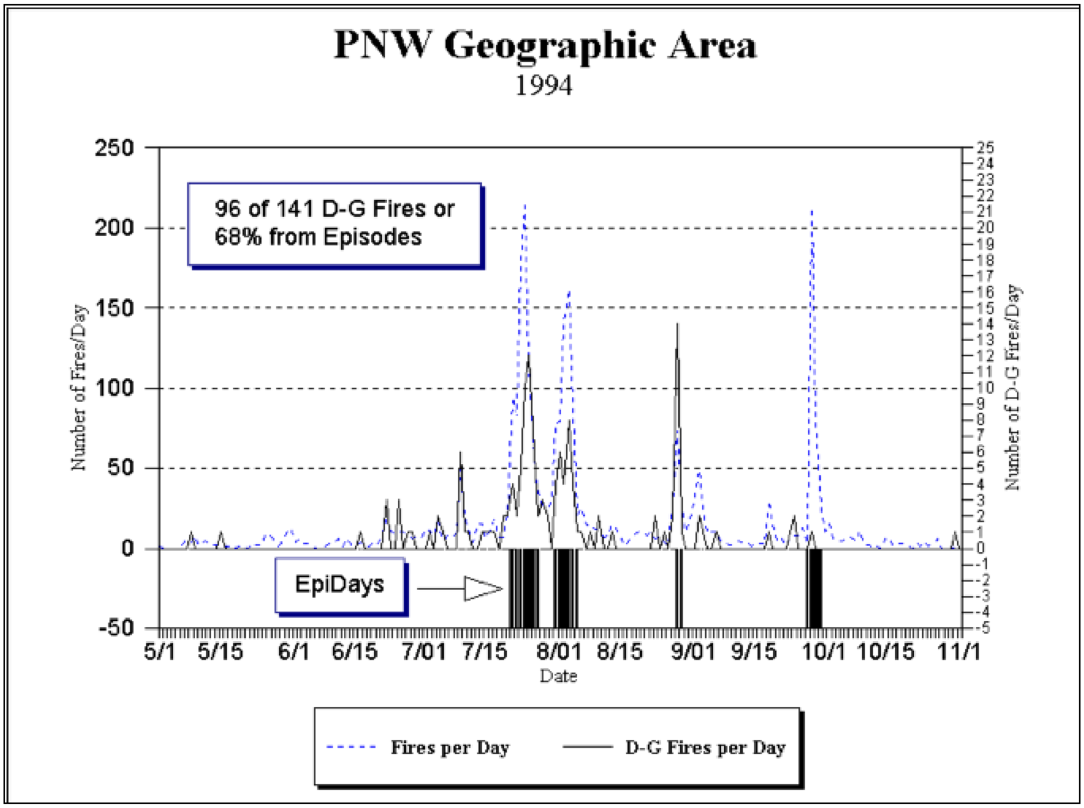


Figure 18

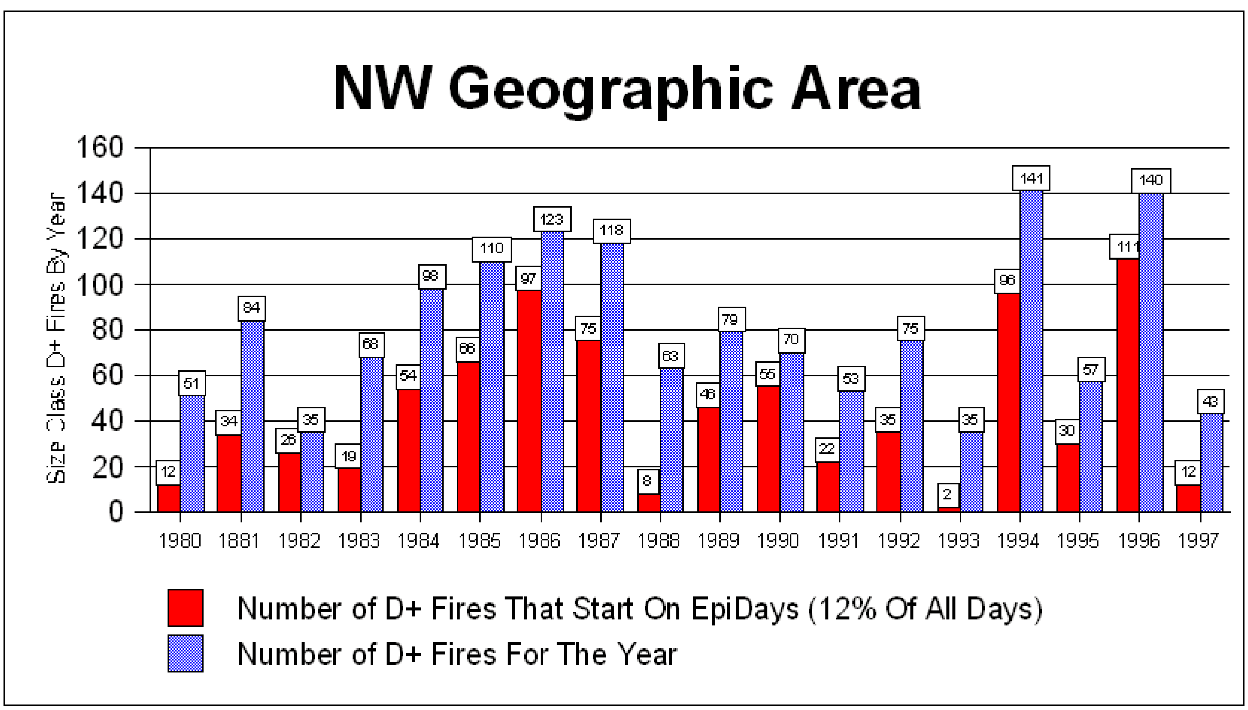


Table 14 - FIRE OCCURRENCE, AIR ATTACK, AND LEADPLANE DISPATCHES BASED ON NATS2 NFMAS DATABASE

Geographic Area	Annual Number of Fires	Percent of Fires From Episodes *		Average Number Of Fires **		Days In Episodes	At Least 1 Airtanker Dispatched To		At Least 2 Airtankers Dispatched To		ATGS*** Required At		Air Attack Dispatches per EpiDay		Leadplane Dispatches per EpiDay ****	
	Number	All Fires	D+ Fires	Per Avg Day	Per Epi-Day	Percent	All Fires	Epi-Day Fires	All Fires	Epi-Day Fires	All Fires	Epi-Day Fires	Avg	Max	Avg	Max
Column ID --->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Alaska	216	47%	60%	3	14	6%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
California	3082	32%	22%	13	58	13%	987	30%	427	27%	1639	30%	29	282	7-17	92-182
Eastern	1049	41%	48%	7	14	27%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Great Basin	2322	60%	63%	14	33	39%	786	59%	444	60%	1635	60%	23	205	6-11	60-155
Northern	1950	44%	39%	11	38	21%	263	39%	87	40%	933	38%	16	129	2-5	21-45
Northwest	2096	42%	44%	13	67	12%	332	41%	118	42%	810	42%	25	165	4-10	32-88
Rocky Mt.	1645	40%	37%	8	23	26%	747	37%	275	35%	116	36%	2	19	3-10	24-58
Southern	2098	47%	49%	8	14	33%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Southwest	3657	52%	54%	15	42	41%	730	50%	1349	50%	1095	50%	12	76	4-8	30-53

N/A Indicates Data Not Available At This Time
* An Episode is defined as a period of days where the daily fire frequency or fire frequency over three consecutive days is at a defined level for a Geographic Area.
** An EpiDay is a day when the daily fire frequency for a Geographic Area exceeds a defined number which is unique by Geographic Area.
*** It was assumed that an ATGS would be required on a wildland fire if there were two or more aircraft or four or more ground units dispatched to the fire.
**** The low value of the range is when two or more airtankers are dispatched to a fire. The high value is when only one or more airtankers are dispatched

Based on Agency policy and the committee's professional judgement, the number of air attack (ATGS) dispatches was determined based on the assumption that an ATGS was needed on a fire if there where three or more aircraft or if there were four or more ground firefighting units dispatched to a fire. Columns 7 - 12 provide information on the number of fires and the percent of fires that would require either leadplane or ATGS services based on these assumptions. The data in columns 7 and 8 assumes a leadplane is sent with each airtanker dispatch and provides a "worst case" demand estimate. Data in columns 9 and 10 assumes a leadplane is sent only when two or more airtankers are dispatched. The actual dispatch demand is most likely between these two values.

Based on analysis from the NFMAS database and this fire occurrence data, the average and maximum number of leadplane and air attack (ATGS) dispatches per EpiDay was then determined and are displayed in the last columns 13 - 16 of Table 14.

Examination of the data provides a general conclusion that in all Geographic Areas, a high percent of fires occur on a relatively low percent of the days (EpiDay). A relatively high percent of fires in the D size class (100-299 acres) and larger start as a result of the workload peak created during these fire occurrence episodes. These large fires are responsible for the majority of the suppression costs incurred by the Federal wildland fire management agencies. Responding to the expected dispatch demand for leadplane and aerial tactical supervision services during these fire occurrence episodes will challenge the National mobility concept for resources to be as wide-ranging as possible.

Potential Economic Value of Aerial Supervision

To the committee's knowledge, no studies have been done that quantify the change in fireline production efficiency by ground-based firefighting resources based on the presence or absence of aerial supervision. To test the sensitivity of acres burned and expected annual FFF+NVC to changes in fireline production efficiency, runs were made using the IIAA.

When an Air Tactical Group Supervisor (ATGS) is present over a wildland fire, communication to ground-based firefighters of the fire's location, current and expected fire behavior and the location of geographic features that have a influence in the development of strategy and/or tactics can increase the efficiency and safety of these firefighters.

An analysis was done with the IIAA and using the Forest Service and BLM units in the NFMAS database. Given the staffing of organizational options and if there is a 10% resultant increase in ground firefighter fireline production when an ATGS is present, the expected acres burned and annual FFF+NVC for each Organizational Option was determined and is displayed in Table 15. These estimates are conservative since not all users of aerial supervision services are not represented by the NFMAS data base. Given this limitation, they are nevertheless valid though for comparative purposes between Organizational Options.

Table 15 - Estimated Potential Economic Benefit of Organizational Options						
		Options 1,2	Options 3,4	Options 5,6,7	Options 8,9	Option 10
Diff. From Option 10	FFF+NVC	$30,485,446	$24,262,813	$5,946,440	$30,485,446	$0
	Acres Burned	46124	37038	7102	46124	0
Total	FFF+NVC	$252,124,502	$258,347,135	$276,663,508	$252,124,502	$282,609,948
	Acres Burned	402,463	411,549	441,485	402,463	448,587
California	FFF+NVC	$128,272,967	$128,590,665	$141,832,278	$128,272,967	$143,822,846
	Acres Burned	73,559	73,723	83,220	73,559	84,823
Great Basin	FFF+NVC	$54,564,684	$55,371,408	$56,557,652	$54,564,684	$56,792,792
	Acres Burned	202,966	203,907	214,668	202,966	215,142
Northern	FFF+NVC	$6,590,498	$6,631,044	$6,905,702	$6,590,498	$6,963,671
	Acres Burned	32,203	32,237	32,953	32,203	32,999
Northwest	FFF+NVC	$33,798,050	$36,665,573	$41,097,827	$33,798,050	$42,678,690
	Acres Burned	43,999	47,732	53,502	43,999	55,560
Rocky Mountain	FFF+NVC	$9,147,925	$9,194,099	$9,753,720	$9,147,925	$9,598,607
	Acres Burned	17,705	17,970	22,011	17,705	20,869
Southwest	FFF+NVC	$19,750,378	$21,894,346	$20,516,329	$19,750,378	$22,753,342
	Acres Burned	32,031	35,980	35,131	32,031	39,194

STEP 5: DEVELOP RECOMMENDATIONS TO ADDRESS THE GOALS AND OBJECTIVES AND RISK MITIGATION STRATEGY

The major sections within this Step are as follows:

- General Recommendations
- Aerial Supervision Organization Recommendations
- Human-aiding Technology Recommendations
- Aircraft Recommendations
- National Shared Forces Studies Recommendation
- Risk Mitigation for Organizational and Human-aiding Technology Recommendations

These recommendations were generated to address characteristics and issues within the leadplane and ATGS programs where changes could enhance performance and efficiency. These changes are in the areas of management and operations, communications, personnel, aircraft resource management, airspace coordination, safety and organization. The following recommendations are made to support (1) the determination of the best aerial firefighting structure and organization to direct and manage fire suppression resources; 2) the identification of the best aviation platform that will support that organization; 3) the identification of components of human-aiding technology that will best support the organization in the identified platform; and (4) training that will effectively implement (1) through (3).

The preferred organization, platform, and technology will perform in the wildland fire environment by meeting task criteria for the identified aerial firefighting missions and operations. All recommendations are based on safety, efficiency, and effectiveness selection criteria.

General Recommendations

1. The Committee recommends the establishment of an Implementation Team to oversee implementation of recommendations. This team will provide coordination and direction to Subject Area Groups developing implementation plans for Organizational, Human-Aiding Technology and Aircraft recommendations. The Implementation Team should provide benefit/cost analysis where necessary. Provide a group and charter by 10/01/98 to implement Recommendations 2-19.

2. The Committee recommends that known and proven training protocols be used in order to accomplish the training objectives. The National Aerial Firefighter Academy's (NAFA) approach is advocated and its expansion encouraged. The Committee recommends immersed simulation training for aerial supervisors supplemented by traditional classroom instruction. The committee supports cooperative efforts between the NWCG Training Working Team, the NAFA cadre, NASA and industry to accomplish these goals. This committee's members are willing to assist in any way possible to create a training curriculum to meet the needs of new or existing positions.

Aerial Supervision Organization Recommendations

3. The Committee recommends implementation of Organizational Option 8. (Aerial Supervision Module with an Air Tactical Group Supervisor and Air Tactical Pilot). The committee recommends no changes in the Helicopter Coordinator and Airtanker Coordinator positions.

   The Aerial Supervision Module (ASM) with an Air Tactical Group Supervisor and Air Tactical Pilot is the result of the recognition that if a person with extensive fire management training and experience is teamed with a person with extensive aviation/flight training and experience in the same aircraft, specific benefits can be realized. Training can be accomplished quickly because each individual is working within a domain in which they have an extensive background. Efficiencies are realized for most fires in the initial and extended attack mode because the mission can be accomplished with fewer aircraft on scene.

   In this configuration, the aviation and fire experts arrive at the same time on the wildland fire allowing for concurrent development of the size up, the strategy and tactics and the joint risk assessment. This should lead to a more efficient operation with a greater attention to safety and detail.

   Crew member fatigue can be minimized by operating as a Team. For fires that require two modules for supervision, modules can be switched periodically to rest the flight crew carrying the greatest workload. Frequency congestion can be reduced because the Leadplane/Air Tactical dialog will be accomplished with normal voice communication within the aircraft or via intercom communication. Either way, those communications occur within the module and do not utilize fire frequencies.

4. The Committee recommends for Initial Attack/Extended Attack, the staffing of 41 Aerial Supervision Modules (ASM). Forty-one represents the total number that are recommended for the California, Great Basin, Northern and Northwest Geographic Areas. The fire seasons with these Geographic Areas frequently coincide. This staffing is designed to fulfill the aerial supervision needs for Initial Attack and Extended. These modules would be mobile nationally and respond to staffing needs within all Geographic Areas.

   Table 16 displays the recommended number of ASM modules to federally staff within each geographic area during fire season. Also displayed in Table 16 are four columns from Table 14 containing data on the expected average and maximum of ATGS and leadplane dispatches during the highest fire occurrence periods (EpiDays). These numbers should be reviewed and adjusted during the implementation phase. This recommendation is based on analysis from the NFMAS data base, analysis of the character and frequency of episodes by geographic area and the professional judgement by the committee and management personnel in each Geographic Area.

Table 16 - Number Of ASM Modules To Staff Within Each Geographic Area					
		Air Attack Dispatches per EpiDay		Air Attack Dispatches per EpiDay	
	Number of ASMs	Average	Maximum	Average	Maximum
Alaska	3	N/A	N/A	N/A	N/A
California	12	29	282	7-17	92-182
Eastern	5	N/A	N/A	N/A	N/A
Great Basin	12	23	205	6-11	60–115
Northern	8	16	129	2-5	21-45
Northwest	9	25	165	4-10	32-88
Rocky Mt.	4	2	19	3-10	24-58
Southern	7	N/A	N/A	N/A	N/A
Southwest	8	12	76	4-8	30-53
N/A Indicates Data Not Available At This Time					

Use of analysis from the NFMAS database and episodes provides a conservative estimate of the number of ASM modules that should be staffed. As was noted in the section on episodes and as shown in Table 14, the staffing of the “dispatch workload peaks” during fire occurrence episodes is critical. It is during these episodes that firefighter safety has the greatest potential to be compromised when the likelihood of extended attack and large fire suppression will occur. Mobility of ASM aircraft and modules between geographic areas assists in supplying aerial supervision resources during these peak demand periods.

5. The Committee recommends the establishment of a Subject Matter Expert Group to implement the Aerial Supervision Module organization. Key components are: Staffing, Training, Human Factors, Standard Operating Procedures, and Qualifications.

6. The Committee recommends Crew Resource Management training as necessary to realize the added safety margin envisioned with the "module" concept. This crew training will be further enhanced with the development of a immersed simulator based training. Immersed simulation training will provide training advantages in terms of expanding repertoires, establishing and maintaining standards, and to provide training for situations too dangerous to do “live". To maintain consistency, this training needs to be accomplished by a dedicated training cadre.

   Instruction on components of the task of leading fixed wing airtankers should be considered for any aerial supervision position with the responsibility for the dropping of retardant from fixed wing airtankers. Not all candidates will be military trained so classes in theory and mechanics of “proximity” flight, performance and operational information about each different airtanker, low level instructional information, and human factors instructional information should also be considered as part of the aviators necessary training curriculum.

7. The Committee recommends the role of Airborne Suppression Supervisor (ABSS) versus the role of Air Tactical Group Supervisor (ATGS) be referred to NWCG for further review and evaluation.

8. The Committee recommends that ASM modules be additional resources available to Incident Management Teams.

   In examining the requirements for large fire aerial supervision, three roles emerged; 1) the role of the Incident Management Team's (IMT) ATGS; 2) the role of the ASM; and 3) the traditional role of the leadplane. The mix of using these roles depends on the complexity, size of the fire and other factors. In very complex terrain or on large or complex fires, the IMT's ATGS could assign divisions of the fire to one or more ASM's. Alternately, for less complex fires where the IMT's ATGS has responsibility for all divisions, the ASM or leadplane can fill the role of a leadplane to aid in the dropping of retardant from fixed wing airtankers.

9. The Committee recommends a cadre of "call-when-needed" Air Tactical Group Supervisors be maintained and certified to operate in the ASM environment.

<u>Human-Aiding Technology Recommendations</u>

In the implementation of Recommendations 10-13, human-aiding technology tools should be functionally integrated and cross-linked. For all factors of cost, training, and human factors, it is highly advantageous to have only one "black box" on the flight deck rather than two or three. The functionality of FLIR, aircraft position reporting, TCAS, and air-to-air and air-to-ground data link can be effectively and economically integrated into one on-board system and display. To determine the true impact of these technologies on the users though, a formal task analysis should be conducted, and the human-aiding technology should be installed and tested on a limited basis prior to installation in the fleet.

Collectively, Recommendations 10-13 provide for <u>an integrated systems approach</u> to hardware, software, and the human-machine interfaces.

Through the implementation of these human-aiding technology recommendations, wildland fire management can be facilitated by better real time information provided by technology. Identification of known flight and ground hazards will be consistent and real time. Increased hazard awareness and a safer environment will result. Critical fire intelligence will be real time. The potential exists for aerial supervision and ground based personnel to have the same information for deployment of ground and air resources. Information provided will have improved accuracy, provide for a safer fire environment for firefighters, will aid in more effective use of retardant and water drops and will enhance resource utilization. A major benefit will be a significant reduction of voice radio transmissions allowing more efficient use of existing radio frequencies. The real benefit in implementing these recommendations will be more reliable information provided in a timely fashion to support the decision-making process, resulting in an increase in safety and efficiency.

10. The Committee recommends the technology defined in HAT Option 2 be installed on all exclusive-use contract helicopters and airtankers and On-Call contract ASM aircraft.

11. The Committee recommends the technology defined in HAT Option 2 be available in a portable configuration for quick installation on any aircraft.

12. The Committee recommends the technology defined in HAT Option 4 (HAT Option 2 plus TCAS and FLIR) be installed on all ASM aircraft.

13. The Committee recommends the implementation of automated flight following by dispatch and coordination centers in a manner that will be consistent and integrated with HAT systems. The potential to furnish the entire array of HAT products (fire scene information, FLIR, etc.) to the ground and remote locations such as dispatch centers will be examined.

14. The Committee recommends that consideration should be given, as soon as the software/hardware defined in HAT Option 2 is mature, to including this technology requirement in CWN/BOA/rental agreements.

15. The Committee recommends that previous aerial firefighting and other-domain research and testing on hardware/software interfaces, human-machine relationships, installations, and developed communications protocols be utilized. Immediate opportunities exist for a partnership among agency Equipment and Development Centers, agency telecommunications personnel, academia, NASA, FAA, and private industry.

<u>Aircraft Recommendations</u>

16. The Committee recommends the procurement of an aircraft that supports the full potential of ASM.

    The evaluation process included the development of criteria and their associated importance (weighting) before identification of aircraft or any systematic re-evaluation of ground rules. All criteria are rooted in the characteristics needed to support the aerial supervision mission and role of the aircraft. The acquisition process should consider the characteristics of the benchmark aircraft as specified in Step 4.

17. The Committee recommends that 41 aircraft be procured to support the national ASM organization. Implementation processes should determine additional needs for spare aircraft and an adequate parts supply source.

    The procurement of a single aircraft type is most desirable. The history in both the Forest Service and BLM has shown that operational impacts are negligible or non-existent using a single aircraft. Also, the cost savings of training, maintenance, and operations far out weigh any minor impacts.

18. The Committee recommends the establishment of a Supplemental National fleet of aircraft for ATGS support to large fire and overload situations that occur under fire occurrence episodal conditions. These aircraft can be On-Call contract or agency owned, and must have an appropriate mix of fixed and rotor wing. The appropriate number for this fleet will be determined during implementation.

    These aircraft will support the aerial supervision requirements of large fires being managed by an Incident Management Team as well as to provide aircraft to support workload overload situations. This National program will provide support for management of large fires and multiple fire occurrence episodes with appropriate resources and preparedness.

19. The Committee recommends for large fire and specific local areas, that rotor wing aircraft are acceptable platforms for either ASM, ATGS or traditional HLCO roles.

    The need for speed is based on the national mobility concept for the fleet to support initial and extended attack. However, in considering large fire support and some local geographically dense areas, speed is not as important. In large fire support, there is ability to adequately plan and execute to achieve the most effective and efficient operation. Also in some local geographic areas, the historical record shows a average dispatch distance of less than 50 miles. At this short distance, the difference in arrival times to the fire between slow and fast aircraft does not make much difference.

National Shared Forces Studies Recommendation

The National Study of Type I and II Helicopters To Support Large Fire Suppression recommended the staffing of Type I and Type II helicopters with management modules to provide support to large fire suppression. The Type II component of this recommendation is currently being staffed and is noted in the following diagram as "7 Nat Eff Heli" or seven national efficiency helicopters.

The National (Large) Airtanker Study, Phase 1, recommended staffing 38 large airtankers to support initial and extended attack of wildland fires. Information presented in the study documented a need for three additional airtankers to "swell" the total fleet based on the demand to support large fire suppression.

```
        |<----------IA/EA-------->|<---------Large Fire Suppression---------->|
        |<--Ag./Coop.-->|<--Pvt.->|<----Ag./Coop.---->|<--Pvt.-->|<---Mil.--->|
Eff.
Helis.  |<----Forest Analysis---->|<-7 Nat Eff Heli-->|<--Pvt.-->|<---Mil.--->|
Study

NATS    |<--38 Large Airtankers-->|<--3 Added/NATS2-->|<--Pvt.-->|<---MAFFS-->|
Studies
                                  |<-----------LP/ASM for Lead--------------->|
TARMS   |<-------41 ASM's-------->|<-- ATGS-CWN A/C-->|<-ATGS/CWN or Mil A/C->|
```

The use of the military and call-when-aircraft from other sources when demand reaches a very high percentile of supply was not considered but information on when use can be expected is displayed. It is recognized that other resources are needed when private vendor sources for large airtankers are fully committed. Use of the military is an integral part of the total airtanker support during these events.

20. The Committee recommends that study goals and processes based on the National Shared Forces Task Force Report be acknowledged as a continuing model for future studies. The process, which defines a clear Charter implemented by a highly qualified and motivated team supported both through leadership and budget, has provided quality analysis and reports yielding tangible results in policy and in the field on wildland fires.

Risk Mitigation Strategy For Organizational and Human-aiding Technology Recommendations

It is recognized that there are risks associated with implementation of Organizational Option 8 and Human-aiding Technology Option 2. The organizational and human-aiding technology recommendations embody a risk mitigation strategy to these identified concerns and risks in the aerial fire fighting operation.

This section is not an in-depth risk assessment of the Organizational and Human-aiding Technology Options. However, it does provide a broad risk mitigation analysis and strategy that will allow the implementation team to focus on those issues associated with the Organizational Human-aiding Technology Options that are considered most critical for a successful implementation of both.

Table 17 - Measures Defined To Mitigate Concerns Associated With Implementation of Organizational and Human-aided Technology Recommendations

Concerns and Risks	Potential Consequences	Mitigation Measures
Exposure of two persons rather than one to accident in low-level flight	Two fatalities or serious injury rather than one	With a two person flight crew, one crew member can remain eyes out during this critical phase of flight, while the other monitors critical flight instruments. This sharing of task, both inside and outside of the aircraft should increase crew situational awareness, thus mitigating the risk.
Task work overload of the flight crew (Organizational Option 8) while performing all aerial supervision tasks	Lower priority task are shed (ignored); therefore some critical task may not be accomplished or a return to a previously-ignored “lower” priority task may be difficult (reacquisition of information)	Shared workload for communications, air traffic management and collision avoidance, etc. should result in a reduction of accidents in the low-level environment
Airsickness by non-pilot crew member during low-level flight (ATGS)	Distraction to pilot; ATGS unable to perform	Screening of ATGS candidates.

Table 17 - Measures Defined To Mitigate Concerns Associated With Implementation of Organizational and Human-aided Technology Recommendations		
Concerns and Risks	**Potential Consequences**	**Mitigation Measures**
Leads of airtankers performed when a lead is not needed	Aircraft conducting join-up and formation flights when not needed	Through improved training, communication protocols, and terminology a shift in the emphasis from "lead every time" to leading airtankers only when necessary (visibility, terrain, winds, when requested by airtanker) will result in a reduced exposure of the ASM module to hazardous flight regimes
Implementation of Organizational Option 8 may require frequent shifts from low-level to high-level altitude	Physical hazard of ASM aircraft changing altitudes frequently: potential airspace conflicts	If this shift becomes frequently necessary, the initial ASM should order an additional ASM. Shift in emphasis from "lead every time" to leading airtankers only when necessary (visibility, terrain, winds, when requested by airtanker) will result in fewer requirements to change altitudes. The ASM will be the only air supervision aircraft on station, thus reducing the potential for a conflict during altitude changes. The transition to support air tanker leads would occur during times of minimum traffic density. The potential to change altitude frequently may be reduced overall with the introduction of Human-aiding Technology Option 2 which supports target identification and marking.
Organizational Option 8 may require frequent shifts from the leadplane role to the ATGS role and back frequently	The ASM can not perform adequately in both roles.	During most initial attack operations there should be sufficient time to perform both functions. For those instances when the ASM cannot perform both roles adequately, a second module should be ordered. Training in ASM roles/responsibilities and the team concept must be implemented.
There can be an incompatibility between the team members (ATP and ATGS) while performing tasks on the flight deck	Conflict in selection of mission priorities	Initial screening of ATP and ATGS candidates for job to be performed; CRM training

Table 17 - Measures Defined To Mitigate Concerns Associated With Implementation of Organizational and Human-aided Technology Recommendations		
Concerns and Risks	**Potential Consequences**	**Mitigation Measures**
New roles and missions can create uncertainty and confusion on the mission.	Uncertainty and confusion	Training and simulations by all tactical aerial fire fighting participants is critical
Training in roles and responsibilities un-funded or inadequately funded.	Uncertainty and confusion	Management plan for implementation must have a fully staffed training curriculum identified
Use of the technology in Human-aiding Technlogy Option 2 in a VFR flight regime can be a "heads-down distraction."	Accident or near mid-airs	Intensive research and testing prior to implementation; design by users; ease of HAT operation; displays are properly placed; passive use by tactical pilots with active use by ATGS; training
Use of the tools contained in Human-aiding Technology Option 2 can be an additional task in an already workload-intensive environment	Task overload	Intensive research and testing prior to implementation; design by users; ease of HAT operation; displays are properly placed; passive use by tactical pilots with active use by ATGS; training

STEP 6: CONCERNS AND OPPORTUNITIES GENERATED BY THIS STUDY

The National Aerial Firefighting Safety and Efficiency Test conducted as a partnership between the BLM and the NASA is a true example of multi-agency cooperation that should be fostered and encouraged. The experience, skill and knowledge base within NASA and other government agencies should be sought and used where appropriate to support future activities of the wildland firefighting agencies.

Concerns and Opportunities For Implementation of Proposed ASM Organization.

There are several major issues that would need resolution if the ASM organization (Air Tactical Pilot and Air Tactical Group Supervisor in the same aircraft) were adopted. The Implementation Group as recommended in Step 5 - Recommendations should consider the following.

- Implementation time line (phased-in versus "overnight" change) is an issue that needs to be thoroughly examined. There are positive and negative effects associated with each.

- Changes to Incident Command System (ICS) terminology and roles/responsibilities descriptions will need to be developed and implemented.

- Changes to Incident Command System (ICS) procedures and protocols should be examined in depth.

- Human factors issues of changing roles should be addressed

- Resistance to change will be an issue that agencies need to address in a forthright and positive manner. Concern by employees about their job status and future should be addressed in a timely manner.

- Implementation issues with respect to centralized management including training, funding and dispatch control of ASMs and airtankers (as recommended in NATS2) at NICC and/or Geographic Area Coordination Centers should be examined.

- Due to the long-term "team" concept of the ASM, there is an opportunity to hire Permanent-Full-Time Air Tactical Pilots and ATGSs, utilizing them for co-lateral duties in the off-season in areas such as fire planning, prescribed fire, training, etc.

- When two ASMs are on scene with one performing the leadplane roles and responsibilities of the leadplane and one performing the aerial tactical roles and responsibilities, delineation of authority must be clear.

- As Organizational Options were developed, it became clear that standard duties and training for a (Wildland Fire) Detection Position were non-existent. Primary duties for this locally controlled and staffed resource include aerial reconnaissance, locating and plotting wildland fires, and providing information to assist in the management of the wildland fire.

Concerns and Opportunities With Respect To Procedure

- Numerous policy issues need to be resolved, including but not limited to: Flight Time/Duty Day requirements and relief requirements; Forest Service policy on non-flight crew flying under 500' AGL; Forest Service/FAA Exemption for dropping retardants in congested areas; and revision of the current Interagency Leadplane Operations Guide and the Aerial Tactical Group Supervisor's Guide.

- During NFMAS analysis certification, a review of proposed staffing of ATGS personnel and aircraft within each fire program alternative should occur to insure adequate staffing of this resource.

Concerns and Opportunities With Respect To Training

- Include in Air Tactical Pilot's and ATGS's training curriculum key topics on the task of leading fixed wing airtankers. These include the theory and mechanics of "proximity" flight, performance and operational information for different airtankers, low level instructional information, and human factors concerns.

- Opportunities should be explored to work with established flight simulation companies to develop simulator training for ATPs and non-pilot aerial firefighter positions (ATGS/HLCO).

- With the continued utilization of call-when-needed Type 2 and 3 helicopters to support initial attack, pilot knowledge of fire management strategy and tactics may not be adequate requiring increases in training. Adequate supervision will also increase efficiency and effectiveness.

<u>Concerns and Opportunities For Implementation Of Human-Aiding Technology.</u>

- The TARMS User Survey identified radio frequency use and management as a major problem. A study should be conducted to identify the specific problems and recommend strategy for resolution. Implementation of Human-Aiding Technology Option 2 and its potential to alleviate frequency management problems should be included in this study.

- As an interim measure prior to full Human-Aiding Technology implementation, there is an opportunity to proceed with recommendations on ATGS aircraft radio communications configuration and aircraft typing from the National ATGS Steering Group, Reno, Dec 1996.

- The decision support tools of human-aiding technology implementation, if provided in a timely manner, can be quite valuable to ground-based personnel in the efficient and safe implementation of tactics and strategy.

- As a result of this study, different or dissimilar aircraft and mission tools (HAT) may be introduced into future or existing platforms. It is extremely important that proper consideration be given to specific training for any new or unfamiliar device or system that will become part of the operational firefighting environment.

- Implementation efforts should maintain an awareness of FAA Free Flight/Flight 2000 Initiative and next-generation air traffic management goals and objectives.. Of particular concern are the areas of data link, aircraft position reporting and tracking capability, and air-air and air-ground information exchange.

- Explore opportunities to utilize Remotely Piloted Aerial Vehicles for surveillance of fires and utilization as airborne repeater sites. This could be of particular benefit at night. As part of the TARMS process, companies responded to a Request For Information (RFI); and several indicated a willingness to demonstrate and test this capability.

- Explore possibility with the Department of Defense for use of AWACS during large, complex, area-wide situations (ie; Yellowstone in 1988 and Florida in 1998).

<u>Concerns and Opportunities For Large Fire Support</u>

- With the increase in the use of Type 1 and 2 helicopter for large fire support, significant increases in safety, efficiency and effectiveness can be realized with the staffing and appropriate use of the Helicopter Coordinator (HLCO) position.

Bibliography

Battiste, Vernol. 1996. National Aerial Firefighting Safety and Efficiency Project, Update. Presented at the National Interagency Fire Center, Boise, ID.

Battiste, V. and Hart, S. G. 1985. Predicted Versus Experienced Workload and Performance on a Supervisory Control Task. Proceedings of the Third Biannual Symposium on Aviation Psychology. Ohio State University. Columbus. Ohio. Pages 255-262.

Battiste, V., & Downs, M., 1992. Development of An Electronic Chart Display System (ECD) With Global Positioning Satellite (GPS) Data. In the Proceedings of IEEE/AIAA 11th Digital Avionics Systems Conference, (pp. 423-427), Seattle, WA.

Bushey, Chuck. 1997. Wildland Fire/Aircraft Firefighter Fatalities in the United States Compared With Ground Based Firefighter Fatalities. A paper presented at the Canada/US Wildland Fire Safety Summit, Rossland, British Columbia, Canada, September 29 - October 2, 1997. To be published in the Proceedings of the Summit by the International Association of Wildland Fire, Fairfield, Washington.

Collins, A. M. and Gentner, D. 1986. How People Construct Mental Models. In D. Holland & N. Quinn (Eds.), Cultural Models in Language and Thought, Cambridge University Press.

Federal Aviation Administration. 1996. Federal Aviation Administration Human Factors Team Report. "The Interfaces Between Flight Crews and Modern Flight Deck Systems. June 18, 1996

Federal Aviation Administration. 1997. Flight 2000 Initial Program Plan. July, 1997.

Flightfax. 1991. Report of Army Aircraft Accidents. December, 1991.Volume 20, #2.

Flightfax. 1994. Report of Army Aircraft Accidents. March, 1994. Volume 22, #6.

Flightfax. 1994. Report of Army Aircraft Accidents. April, 1994. Volume 22, #7.

Federal Aviation Administration. 1996. Flight Management System - Air Traffic Management Next Generation (FANG) Operational Concept," Prepared by the FMS-ATM Next Generation (FANG) Team, Under the direction of the Federal Aviation Administration, Boeing Commercial Airline Group per Cooperative Research and Development Agreement 93-CRDA-0034, February 1996**;**

Federal Aviation Administration. 1995. Final Report of RTCA Task Force 3: Free Flight Implementation, October, 1995.

Hart, S. G. and Sheridan, T. B. 1984. Pilot Workload, Performance, and Aircraft Control Automation. In proceedings of the AGARD Symposium on Human Factors Considerations in High Performance Aircraft. Williamsburg, VA.

Jackson, Paul, Editor in Chief. 1997. Jane's All The World's Aircraft.

Kieras, D. and Bovair, S. 1984. The Role Of Mental Models In Learning To Operate A Device. Cognitive Science, Volume 8, Pages 255-273.

Linde, C., & Shively, R. J. (1988). Field Study of Communication and Workload in Police Helicopters: Implications for AI Cockpit Design.. Proceedings of the Human Factors Society 32nd Annual Meeting, 237-241.

Linde, C. (1988). Who's In Charge Here? Cooperative Work and Authority Negotiation In Police Helicopter Missions. Paper Presented at the Second Annual ACM Conference on Computer Supported Collaborative Work, Portland, OR.

McDaniel, James I., Chang, George C. Chang, Livack, Gary S. and McDaniel, James I. 1996. Emerging Cockpit Technologies for Free Flight: Situational Awareness for Safety; Automatic Dependent Surveillance-Broadcast, Air-to-Air Data Link, and Weatherlink.

NAFSEP. 1998. National Aerial Firefighting Safety and Efficiency Project. Final Report. Preparation in progress.

National Transportation Safety Board. 1990. A Review Of Flight Crew Involved Major Accidents of United States Air Carriers, 1978 - 1990. National Transportation Safety Board: Washington, DC; NTSP/SS-94/01; PB94-917001.

Norman, Donald A. 1990. The Design of Everyday Things. Doubleday: New York, New York.

Polson, P. G. & Kieras, D. 1985. A Quantitative Model Of The Learning And Performance Of Text Editing Knowledge. Proceedings of the CHI 1985 Conference on Human Factors in Computing, San Francisco, Ca.

RTCA Select Committee on Free Flight Implementation. 1997. A Joint Government/Industry Operational Concept fir the Evolution of Free Flight. August, 1997.

Schumacher, R.M. 1988. Acquisition of Mental Models. Unpublished Thesis. University of Illinois.

Veillete, Patrick J. PhD. "A 20-Year Review of U.S. Forest Service Fixed-Wing Mishaps, 1976-1995. U.S. Forest Service Smokejumper Operations. Presented at the 9th International Symposium on Aviation Psychology, Ohio State University. April, 1997.

Wickens, C. D., Seagul, L. D. and Raby, M. 1998. Strategy Management of Pilot Workload. Submitted to the International Journal of Aviation Psychology.

Acronyms

ABSS - AirBorne Suppression Supervisor
ACAC - Area Command Aircraft Coordinator
AGL - Above Ground Level
ASM - Aerial Supervision Module
ATGS - Air Tactical Group Supervisor
ATP - Air Tactical Pilot
AWACS - AirBorne Warning and Control System
BLM - Bureau of Land Management
COTS - Commercial Off-The-Shelf
DOD - Department of Defense
FLIR - Forward Looking Infrared
FOD - Foreign Object Debris
GPS - Global Position System
HAT - Human-aiding Technology
ILOG - Interagency Leadplane Operations Guide
ISA - International Standard Atmosphere
KIAS - Knots Indicated Air Speed
KTAS - Knots True Air Speed
MAFFS - Military Aerial Firefighting System
METO - Maximum Power Except Takeoff
NASA - National Aeronautics and Space Administration
NATS - National Airtanker Study
NATS1 - National Airtanker Study, Phase 1
NATS2 - National Airtanker Study, Phase 2
NFMAS - National Fire Management Analysis System
OAS - Office of Aircraft Services
SEAT - Single Engine Airtanker
TARMS - Tactical Aerial Resource Management Study
TCAS - Traffic Collision Avoidance System
USDA - United States Department of Agriculture
USDI - United States Department of the Interior
USFS - United States Forest Service

List of Tables

List of Figures

APPENDICES

APPENDIX A. -	Committee Membership, Charter
APPENDIX B. -	Aircraft Identified For Consideration
APPENDIX C. -	Cooper-Harper Aircraft Handling Scoring Form and Evaluation Flight Cards
APPENDIX D. -	TARMS Vendor Questionnaire to Determine Current Air Attack Aircraft
APPENDIX E. -	TARMS User Survey Questionnaire to Aerial Resource Management Personnel
APPENDIX F. -	TARMS Survey Questionnaire to Determine Availability of Human-aiding Technology
APPENDIX G. -	Aerial Firefighting Tasks For Representative Fire Scenario
APPENDIX H. -	Aerial Firefighting Workload Evaluation Form (Example For One Mission Phase and the Current Organizational Options 1-5)
APPENDIX I. -	Additional Figures Based on the Task Workload Evaluation
APPENDIX J -	Detailed Descriptions Of Ranking Criteria Categories

APPENDIX A

Committee Membership, Charter

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CHARTER FOR TACTICAL AERIAL RESOURCE MANAGEMENT STUDY

The Tactical Aerial Resource Management Study (TARMS) is chartered by the National Fire Aviation Coordination Group (NFACG).

VISION

The Tactical Aerial Resource Management Study shall provide managers with information, guidance and support for National and Geographic Area decisions affecting the National Leadplane, Air Tactical Group Supervisor and Helicopter Coordinator programs.

MISSION

The Tactical Aerial Resource Management Study shall determine the most appropriate organization, staffing and aerial platforms necessary to safely and cost effectively manage and direct aerial fire suppression resources. Support and interrelationships to fire suppression will be obtained and evaluated. The outcome of Phase 2 of the National Airtanker Study and other relevant projects will be important considerations as well.

The goal will be to identify the best way or alternative ways to manage and direct aerial suppression resources, to determine preferred platforms and to make recommendations for improvement. It will be necessary to properly consider and evaluate the several aerial supervision management roles, missions and platforms.

Conventional decision analysis and problem solving techniques, supported as needed by routine computer software programs, will be utilized. There should be no major software development or application required. Options for aircraft acquisition will not be a part of this study and should not be a consideration during this process.

A completion date of December 1997 is desired.

GUIDING PRINCIPLES AND ASSUMPTIONS

The Tactical Aerial Resource Management Study shall be conducted interagency in scope with committee representation from the USDA-Forest Service and USDI-Bureau of Land Management. Coordination with State wildfire suppression agencies, USDI-National Park Service, Bureau of Indian Affairs, Fish and Wildlife Service and Office of Aircraft Services shall be through the federal geographic area representatives. The initiative for this study is a USDA-Forest Service effort to provide guidance for the timely replacement of their leadplane fleet.

CHARTER FOR TACTICAL AERIAL RESOURCE MANAGEMENT STUDY

Traditional methods of operation shall be examined and challenged where appropriate.

Benchmarks and time frames for the study will be developed as well as a study communications plan. The plan shall define actions to convey study progress and status to effected groups.

PRODUCT

At the completion of the study a written report will be prepared addressing the following:

A. Identification of aerial supervision missions and tasks such as:

   1. Required communications.
   2. Fire intelligence and tactical advice.
   3. Airtanker coordination and direction.
   4. Helicopter coordination and direction.
   5. Overall aircraft/airspace management.
   6. Requirements of urban interface versus wildfire incidents.
   7. Identify training requirements to facilitate accomplishment of the missions and tasks.
   8. Potential uses of human aiding technology.

B. Identify and evaluate alternative organizations and staffing to accomplish missions and tasks. Identify roles and responsibilities of the staff.

C. Identify and evaluate alternative aerial platforms to perform or support the roles identified above. This will include recommendations for the number of, type and locations of these resources.

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APPENDIX B

Aircraft Identified for Consideration

APPENDIX C

Cooper-Harper Aircraft Handling Scoring Forms and and Evaluation Flight cards

APPENDIX D

TARMS Vendor Questionnaire to Determine Current Air Attack Aircraft

December 15, 1996

[Vendor Name]
[Vendor Address]

The Tactical Aerial Resource Management Study (TARMS) is conducting a survey of all air tactical ("air attack") aircraft available under contract or rental agreement in the United States to Department of Interior (Office of Aircraft Services), US Forest Service, or State/Local agencies.

Your responses should include those aircraft that are or have been used with an Air Tactical Group Supervisor on board, regardless of installed avionics.

Note that you may include aircraft which do **not** have a multi-channel programmable radio wiring harness, but in which a NIFC Air Tactical Radio package is installed on an as-needed basis. However, please indicate such under Remarks.

If you have any questions regarding this survey, please contact your TARMS geographic area representative:

Steve Pedigo, Rocky Mountain (CO,NE,WY,SD,ND) Representative, 303-275-5750
Joe Bates, California Area Representative, 805-391-6065/6110
Keith Birch, Great Basin (NV, UT, S. ID) Area - Natl Forests Representative, 208-624-3011
Carson Berglund, Eastern Area Representative, 218-327-4436
Hugh Carson, Great Basin (NV, UT, S. ID) Area - DOI Representative, 702-785-6526
Wally Griffin, Alaska Area Representative, 907-356-5505
Mike Hopf, Northwest (ID,MT) Area Representative, 406-329-4915
Rex Mann, Southern Area Representative, 606-745-3123
Ward Monroe, Northwest (OR, WA) Area Representative, 541-883-6855
Hunter Wistrand, Southwest (NM, AZ, TX) Area Representative, 520-527-3550

/s/ Steve Pedigo

TARMS Chair

AIR ATTACK AIRCRAFT VENDOR SURVEY

Vendor Name:

Vendor Address:

Vendor Phone:

Vendor Fax:

E-Mail (if applic):

Please complete the attached table for all aircraft that are utilized for air attack services under Office of Aircraft Services, US Forest Service, or State/Local contract or rental agreement.

Please return surveys by January 31, 1997 to:

Paul Hefner
BLM-NIFC
3833 South Development Avenue
Boise, ID 83705-5354

BLM-National Office
PH: 208-387-5150
FX: 208-387-5179

NOTE: This survey is available to vendors in electronic mail format.

Make/ Model FAA Regis #	Desig Base	$$$ FT/ HR	GPS or Loran ?	Is a VENDOR OWNED multi-channel programmable FM Radio Installed?? If Yes, Make of Radio And How Many?	If no Vendor-Owned FM, Wiring Harness For Multi-Channel Program-mable FM Radio ?	Approved FM Radio Antenna(s) ?	How many 720-Chan. AM Radios ?	How many audio panels (mixer boxes) ?	ATGS Trainer Capability (ie, Avionics In Back Seat?)	Other capabilities (video, FLIR, etc.) If under exclusive use contract, indicate with what agency and location

REMARKS:

APPENDIX E

TARMS User Survey Questionnaire to Aerial Resource Management Personnel

December 9, 1996

TARMS Field Survey

The TARMS (Tactical Aerial Resource Management Study) is an interagency study that has been chartered to determine the most appropriate organization, staffing and aerial platforms necessary to safely and most effectively manage and direct aerial fire suppression resources.

The goal of this study is to identify the best way or alternative ways to manage and direct aerial suppression resources, to determine preferred platforms and to make recommendations for improvement.

Since the study is without sideboards (constraints) in considering solutions for the future of aerial resource management, aerial supervision resources (Leadplane, Air Tactical Group Supervisors, Helicopter Coordinator) duties will be examined for possible reorganization and/or realignment.

This field survey is seeking your participation in innovative ideas on organization, policy, technology, and any other facet of aerial resource management that you may have ideas on. We also are interested in your issues and problems, whether you have a solution or not.

In considering the questions that seek innovation, imagine or project what you think should happen, or how we should be organized in 15 to 20 years. For example, the use of Remotely Piloted Vehicles (RPVs) or Drones may have application in some phase of aerial supervision.

While this may not pass the reality test for some, we all can remember ideas from the past which by many were dismissed out of hand as being ridiculous: “If man were meant to fly, he would have been given wings”; “Television is just a fad. It will never catch on”; “The sound barrier cannot be broken”; “64k of computer memory is all that anyone will ever need”

The point being that you should break paradigms in thinking for the future.

The study members request that you provide your input by January 15, 1997. For ease of collating comments, the preferred method for responding is E-mail. Otherwise return it by regular mail to the person identified on the next page.

We thank you for your time and energy in responding.

s/ Steve Pedigo
Chair, Tactical Aerial Resource Management Study

TACTICAL AERIAL RESOURCE MANAGEMENT STUDY (TARMS) FIELD SURVEY

Return by January 15, 1997 via e-mail (preferred) or regular mail to the TARMS Member indicated in the cover letter. Use additional sheets as necessary.

Name (Optional):

Phone (Optional):

Unit/Company (Optional):

E-Mail (Optional):

7. Position(s) You Fill or Hold in Aerial Firefighting:

___ Air Tactical Supervisor ___ Air Attack Pilot ___ Helicopter Coordinator

___ Helicopter Pilot ___ Airtanker Pilot ___ Leadplane Pilot

___ Smokejumper Pilot ___ Smokejumper Spotter ___ Dispatcher

___ Other: ____

8. Outline the three most serious problems that you commonly encounter in your aerial firefighting job. With each problem, indicate what part of the "system" failed and describe how that part of the system should function.

9. In your opinion what are the strengths and weaknesses of the following aerial firefighting roles? This question may apply to the role itself and/or personnel commonly filling the role. It may apply to procedures, training, etc.

   If possible, for each role. number them with "1" being greatest strength and weakness, "2" being next greatest strength or weakness, etc. Use additional sheets if necessary.

3a. Leadplane:

   3a(1). Strengths:

   3a(2). Weaknesses:

3b. Air Tactical Group Supervisor

   3b(1). Strengths:

   3b(2). Weaknesses:

3c. Helicopter Coordinator

3c(1). Strengths:

3c(2). Weaknesses:

3d. Airtanker:

3d(1). Strengths:

3d(2). Weaknesses:

3e. Helicopter:

3e(1). Strengths:

3e(2). Weaknesses:

3f. Smokejumper:

3f(1). Strengths:

3f(2). Weaknesses:

3g. Other:

3g(1). Strengths:

3g(2). Weaknesses:

10. How could the current aerial firefighting organizational structure (air tactical, leadplane, helicopter coordinator, airtanker, helicopter) be improved and/or strengthened? Feel free to consider *combining, eliminating, or adding* new roles/positions.

11. What information, system, and/or "thing" would aid you in completing your job more safely and efficiently?

NOTE: Some of the following questions may not directly apply to your role in aerial firefighting. For example, questions relating to the 21st century leadplane or air tactical aircraft may not apply directly to you as an airtanker pilot, but may have some effect or bearing on the job you do, so answer if you wish. Questions such as 6e and 6f apply to all.

6a. What characteristics would you like to see in the next-generation (21st century) aerial platforms (aircraft) for leadplane and/or air attack?

6b. Considering your role in aerial fire suppression, what physical aspects of the aircraft (visibility, interior space, seat adjustment, etc.) either hinder, enhance, or otherwise effect you in the performance of your job?

6c. Considering your role in aerial fire suppression, what performance aspects of the aircraft (climb rate, cruise speed, stall speed, roll rate, gust penetration speed, etc.) either hinder, enhance, or otherwise effect you in the performance of your job?

6d. Are there any aircraft (fixed or rotor wing) that you would like to see considered as potential aerial platforms in this study?

6e. What improved or new additional functionality or systems should be designed into the next generation aerial firefighting aircraft/cockpit system.

6f. What tasks in your job would you like to see automated or given to someone else?

The following questions (6g-j) deal with specific parameters for air attack and leadplane aircraft and how they may relate to the performance of your role as an air attack or leadplane pilot in aerial resource management.

6g. Seating arrangement - For missions which require multiple crew members, is tandem (front/back) or side-by-side seating important for the performance of your job?

6h. Cabin Size - For the performance of your job, is the cabin size of aircraft you use adequate? Consider storage of personnel items (maps, flight bags, etc.), room to ability to manipulate items (fold/unfold maps). Additionally, identify the aircraft in which your issues exist.

6i. Cabin Noise - Does cabin noise interfere with the performance of your job? Identify specific noise sources if possible and the aircraft in which your issue exists.

6j. Visibility - Is there adequate visibility out the front, side or back of the aircraft you use for you to perform your job? Consider outside the cabin obstructions (wing placement - high or low, landing gear, engine nacelles). Identify the aircraft and your seat position with your comments.

7. Urban Interface. Comment on the issues and problems associated with aerial firefighting tasks in the urban interface environment (also list any improvements that could be made):

   7a. Workload:

   7b. Communications Load:

   7c. Navigation:

   7d. Airspace Coordination/Aircraft Separation:

   7e. Geographical Orientation:

   7f. Target Precision:

   7g. Interagency Impacts:

   7h. Training:

   7i. Other:

8. Please provide any other input or comments that you feel are important:

APPENDIX F

TARMS Survey To Determine Availability of Human-aiding Technology

December 18, 1996

To Whom It May Concern:

A Tactical Aerial Resource Management Study (TARMS) for the wildland aerial firefighting environment has been initiated by the United States Forest Service (FS) and the Bureau of Land Management (BLM).

The goals of TARMS are to identify the best way, or alternative ways, to manage and direct aerial suppression resources, to determine preferred platforms, and to make recommendations for improvement. The study will be completed by December, 1997, and will set the direction for management of aerial resources, beginning in 1999, for the next 20 years.

Human-aiding technologies, applied both within and outside the cockpit, will be examined for applicability to the aerial firefighting task. As part of this effort, we have identified some technologies and functionalities which we wish to explore. See Enclosure 1 for a list of these; however, do not feel limited to those specified.

We recognize that we may not be aware of all the products and technologies that have either been developed or that are emerging in the near-term. Therefore, we invite you to provide information that you believe to be appropriate to the aerial firefighting environment.

Commercial vendors, governmental agencies, and other interested persons are invited to submit information which may be appropriate to this environment. It is important to note that this study is only chartered to recommend the direction the agencies should take in the future. Procurement is not within our purview. Hence, all pricing information (unit/system price, volume discounts, etc.) will only be used to develop budgetary estimates for any study recommendations and not as price quotes, should any future purchases occur.

Information should be submitted to:

Hugh Carson, State Aviation Manager
Bureau of Land Management, Nevada State Office
Box 12000, 850 Harvard Way
Reno, NV 89520
Phone: 702-785-6526
Fax: 702-785-6649

A duplicate copy of information should be sent to Carl Bambarger, USDA-Forest Service, San Dimas Technology and Development Center, 444 East Bonita Avenue, San Dimas, CA 91773

If you have any questions or concerns, please contact Mr. Carson at the above address.

/s/ Steve Pedigo
Chair, TARMS

Enclosure 1

Potential aerial firefighting technologies and systems include but are not limited to:

- Forward-Looking Infrared (FLIR) (heat sensing, targeting)
- GPS (targeting, command/control, flight following)
- Heads-Up Displays (HUDs)
- Flight following (both on-incident and long-range)
- Advanced Navigational Display Systems (the NASA-Ames/USFS/BLM NAFSE Project includes moving topographic map, aircraft traffic portrayal, and drawing targets on the screen and transmitting them rather than verbally describing them)
- TCAS (Traffic Collision Avoidance Systems)
- GPWS (Ground Proximity Warning Systems)
- Videography
- Weather data collection system
- Simulators for training
- Laser and other systems for targeting drop areas
- 3-D Auditory Messaging
- Radio systems
- Voice/computer interactive technologies
- Uplink/downlink of data collected both in the air and on the ground (eg, to incident command, dispatch, etc.)
- Satellite communications

APPENDIX G

Aerial Firefighting Tasks For Representative Fire Scenario

Mission Phase: Before Takeoff			
No	**Task Area**	**Task**	**IMP**
1	Communications	From ATIS: Weather, local conditions, local takeoff policies	1
2	Communications	In-Cockpit: Pre mission brief	2
3	Communications	From Disp: Obtain Initial Info (Block 11 on Resource Order)	3
4	Communications	From Disp: Obtain local weather	1
5	Data Entry	In-Cockpit: Program/select radio frequencies	2
6	Data Entry	In-Cockpit: Enter GPS Coordinates for incident, other TFRs, etc.	2
7	Fly Aircraft	In-Cockpit: Perform pre-flight checklist	3
8	Fly Aircraft	In-Cockpit: Taxi	1

Mission Phase:Takeoff			
No	**Task Area**	**Task**	**IMP**
9	Communications	To ATC: Request takeoff clearance, priority handling	1
10	Communications	From ATC: Receive takeoff clearance, departure instructions	1
11	Communications	To Airtanker Base: Call "Rolling"	1
12	Fly Aircraft	In-Cockpit: Takeoff	2
13	Observation	In-Cockpit: Traffic separation	3

Mission Phase: Enroute			
No	**Task Area**	**Task**	**IMP**
14	Communications	In-Cockpit: Monitoring Radio - Fire Frequencies	2
15	Communications	From Disp: Receive additional information on fire, resources, and airspace (SUA/MTR/TFR)	2
16	Fly Aircraft	In-Cockpit: Attain level cruise	1
17	Navigation	In-Cockpit: Navigate to the fire	2
18	Observation	In-Cockpit: Traffic separation	2
19	Observation	In-Cockpit: Observe weather conditions	1
20	Communications	To Disp: Relay weather conditions	1
21	Communications	To Other Aircraft: Communicate on ETAs, arrival/approach corridors, etc.	2
22	Communications	To Ground: Communicate on ETAs, etc.	1
23	Communications	To Disp: Initiate and perform flight following check-ins	1
24	Communications	To ATC: Request clearance through SUA or Class B airspace	3

Mission Phase: 3 Minutes Out			
No	**Task Area**	**Task**	**IMP**
25	Communications	To IC: Establish contact	2
26	Communications	From Disp: Receive updated air resource information and arrival information	2
27	Fly Aircraft	In-Cockpit: Plan descent; configure aircraft for low-level operations	3
28	Navigate	In-Cockpit: Navigate to and then within fire airspace	3
29	Communications	To Other Aircraft: Establish contact and coordination	3
30	Communications	To Other Aircraft: Establish operating frequencies	3

Mission Phase: Arrival At Fire			
No	**Task Area**	**Task**	**IMP**
31	Fly Aircraft	In-Cockpit: Descend	3
32	Communications	To Disp: Notify of arrival	1
33	Communications	From IC or OPS: Receive initial briefing	3
34	Communications	To Ground: Establish contact and receive additional briefing(s)	2
35	Communications	From Relief ATGS or Lead: Receive transition briefing	3
36	Observation	In-Cockpit: Observe fire; perform initial size-up, environmental assessment, terrain assessment/flight risk. Determine airspace structure and need for Temporary Flight Restriction. Determine aircraft and other resource needs for the incident	3
37	Data Entry	In-Cockpit: Complete standard size-up form	1
38	Communications	To Ground: Assist ground resources in getting to the fire	2
39	Data Entry	In-Cockpit: Map fire, hazards, airspace structure, dip sites, etc.	2
40	Communications	To ATC: If within SUA or Class B airspace, establish coordination, corridors, de-confliction, TFR, etc.	3
41	Observation	In-Cockpit: Determine tactics/strategy for aerial resources	3
42	Communications	To IC or OPS: Discuss size-up and additional needs (resource, TFR, relief, etc.); advise/recommend strategy/tactics; establish airspace structure and determine tactics	3
43	Communications	To Disp: Relay size-up and, if necessary, resource order for additional aircraft	2
44	Communications	From Disp: Receive information (environmental concerns and constraints,	2
45	Communications	To/From Lead/ATGS: Relay tactics/strategy to lead or air attack	3
46	Communications	To Other Aircraft: Communicate airspace structure (entry/exit, holding)	3
47	Communications	To Other Aircraft: Discuss tactics with each aircraft	3
48	Communications	To IC or OPS: Recommend/implement ground resource tactics	2
49	Communications	To Other Aircraft: Implement flight following check-ins	2
50	Communications	From Disp: Receive updated air resource information and arrival information	2

Mission Phase: Arrival At Fire			
No	**Task Area**	**Task**	**IMP**
51	Communications	To On-Scene Aircraft: Relay updated air resource information and arrival information	2
52	Communications	From Disp: Receive ground resource information and arrival information	2
53	Data Entry	In-Cockpit: List aircraft and ground resource information: on-scene, enroute, ordered	2
54	Communications	To Dispatch or Tanker Base: Establish sequencing for airtankers	2
55	Observation	In-Cockpit: Track air resources	3
56	Observation	In-Cockpit: Maintain VFR Awareness: Own-ship and traffic	3
57	Communications	To Other Aircraft: Provide airspace management and traffic advisories to aircraft	3
58	Observation	In-Cockpit: Track ground resources	2
59	Communications	To ground: Provide directions for ingress to ground resources (crews, engines) and safety information	3
60	Observation	In-Cockpit: Perform fire behavior and fire spread assessment, developing long-range strategy and tactics	2

Mission Phase: On Station At Fire			
No	**Task Area**	**Task**	**IMP**
60	Observation	In-Cockpit: Perform fire behavior and fire spread assessment, developing long-range strategy and tactics	2
61	Observation	In-Cockpit: Perform periodic size-ups	2
62	Data Entry	In-Cockpit: Update map	2
63	Communications	To Disp: Relay updated size-ups and assessments	2
64	Communications	To IC or OPS: Relay updated size-ups and assessments	2
65	Communications	To Airtanker(s): Communicate holding or sequencing pattern(s) and/or area(s)	2
66	Communications	To Helicopters: Establish holding or sequencing pattern(s) and/or area(s)	3
67	Communications	To IC or OPS: Confirm target selection	3
68	Communications	To Ground: Clear the drop zone	3
69	Communications	To helicopters: Clear the drop zone and work in identified area or hold on ground	3
70	Communications	ATGS/Lead: Exchange information regarding drop locations, coverage levels, etc.	3
71	Communications	To Airtanker(s): Relay drop locations, coverage levels, etc.	3
72	Communications	To Airtanker(s): Position next airtanker to observe drop area while in orbit	2
73	Fly Aircraft	Lead: Fly the drop pattern	3
74	Communications	To Airtankers: Relay drop pattern concerns (hazards, winds, drift, terrain)	3

Mission Phase: On Station At Fire			
No	**Task Area**	**Task**	**IMP**
75	Communications	To Ground: Provide final run notification	3
76	Communications	From Ground: Receive confirmation target area is clear	3
77	Communications	To Airtanker From Lead: Describe join up procedure	3
78	Fly Aircraft	In-Cockpit: Lead joins up with airtanker	3
79	Communications	To Airtanker(s): Discuss and confirm escape route(s)	3
80	Fly Aircraft	In-Cockpit: Fly the lead	3
81	Observation	To Airtanker From Lead: Mark drop start point (wing-wag, smoke, verbal)	3
82	Communications	No lead: To Airtanker From ATGS: Discuss and confirm drop start point	3
83	Communications	To Airtanker From Lead: Communicate during lead (spacing, hazards, drift correction)	3
85	Observation	In-Cockpit: Observe airtanker drop	3
86	Observation	In-Cockpit: Confirm aircraft separation (see and avoid)	3
87	Communications	To Other Aircraft: Communicate aircraft separation (see and avoid)	3
88	Communications	From Ground: Receive feedback on drop effectiveness	2
89	Communications	To Airtanker: Provide feedback on drop	2
90	Communications	ATGS To/From Lead: Discuss last drop effectiveness and validate/adjust future tactics	2
91	Observation	In-Cockpit: Reassess airspace management plan (holding/sequencing, separation, entry/exit routes, escape routes)	2
92	Communications	To Other Aircraft: Communicate adjustments to airspace management plan	3
93	Communications	To Airtanker: Sequence next aircraft; adjust or align next target	3
94	Communications	From Airtanker: Report clear of area; receive instructions on load and return, load and hold, or release	2
95	Communications	To Helicopter: Confirm dip site locations	2
96	Communications	To Helicopter: Provide drop locations and instructions	3
97	Communications	From Ground: Receive feedback on helicopter drop	2
98	Communications	To Helicopter: Provide feedback on drop	2
99	Communications	To Helicopter: Discuss last drop effectiveness and validate/adjust future tactics	2
100	Communications	From Helibase: Request authorization to perform logistics support missions	2
101	Communications	To Helicopter: Relay medevac request with location for pickup	3
102	Communications	In-Cockpit: Discuss and establish aircraft systems status and flight patterns	2
103	Communications	In-Cockpit: Discuss effectiveness of tactical plan, drops, etc.	2
104	Fly Aircraft	ATGS Aircraft Pilot: Fly observation pattern	2
105	Data Entry	In-Cockpit: Establish new or modified airspace structure as necessary	3
106	Communications	To Disp: Relay modified TFR and frequency changes as necessary	3
107	Observation	In-Cockpit: Observe ground and wire hazards	3
108	Navigate	In-Cockpit: Avoid ground and aerial hazards	3
109	Observation	In-Cockpit: Maintain separation from other aircraft	3

Mission Phase: On Station At Fire			
No	**Task Area**	**Task**	**IMP**
110	Communications	To Other Aircraft: Inquire on remaining flight time	1
111	Data Entry	In-Cockpit: Track remaining flight time and duty day	2
112	Communications	To IC or OPS: Advise concerning ground forces production, assignments, etc.	2
113	Communications	To Disp: Schedule/approve non-participating aircraft (e.g., media)	3
114	Communications	To IC or OPS: Provide input to plan for next operational period plan	2
115	Communications	From Disp: Receive requests for release of aircraft to other incidents	1
116	Data Entry	In-Cockpit: Write down other-incident dispatch information	2
117	Communications	To Other Aircraft: Release aircraft to other locations or fires, providing dispatch information	2
118	Communications	To IC or OPS: Locate and adjust ground support (portatanks, etc.)	2

Mission Phase: Demobilization			
No	**Task Area**	**Task**	**IMP**
119	Communications	To IC or OPS: Advise concerning release of resources, RON, etc.	2
120	Communications	To Airtanker(s): Determine # of loads before cutoff; advise of "last load"	2
121	Communications	To Other Aircraft: Release resources and/or place on hold	2
122	Communications	To Helicopter(s): Establish Cutoff Times and RON locations	2
123	Communications	To Disp: Recommend and coordinate RON plan	2
124	Communications	From Disp: Relay RON plan	2

Mission Phase: Return To Base			
No	**Task Area**	**Task**	**IMP**
125	Fly the Aircraft	In-Cockpit: Configure aircraft for cruise flight	2
126	Navigate	In-Cockpit: Navigate to base	2
127	Communications	To Disp: Make position reports	2
128	Fly Aircraft	In-Cockpit: Configure aircraft for landing	2
129	Fly Aircraft	In-Cockpit: Land the aircraft	2

Mission Phase: Post Flight			
No	**Task Area**	**Task**	**IMP**
130	Data Entry	In-Cockpit: Complete flight costs	2

Mission Phase: Post Flight			
No	**Task Area**	**Task**	**IMP**
131	Communications	To IC or OPS: Communicate aircraft costs	2
132	Communications	To Disp: Relay flight time and duty day remaining	2
133	Communications	To Disp: Relay servicing and maintenance needs	2
134	Communications	To Other Aircraft: Debrief: show maps, frequencies, control lines, etc.	2
135	Communications	To Disp or OPS: Debrief: show maps, frequencies, control lines, etc.	2

APPENDIX H

Aerial Firefighting Workload Evaluation Form

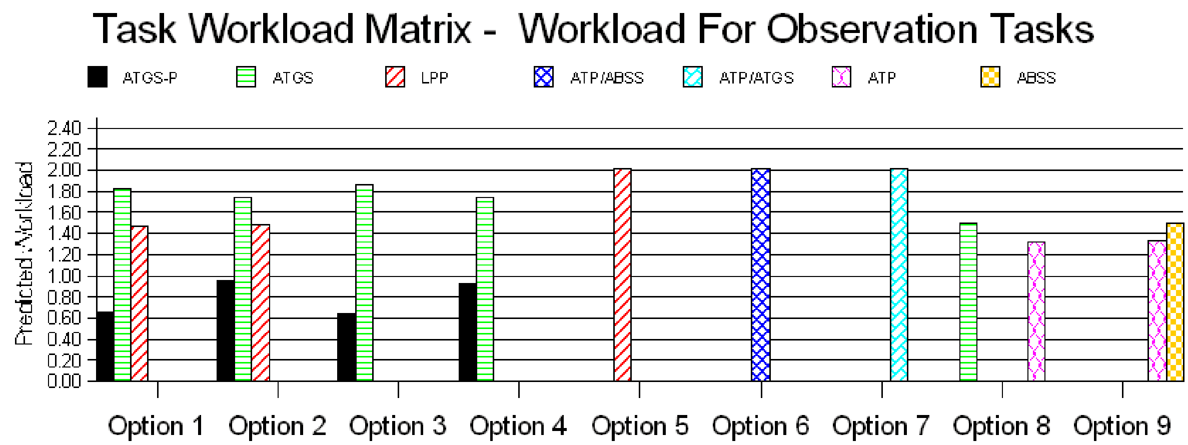
Mission Phase: BEFORE TAKEOFF

Task No	TASK AREA	TASK	IMP #	OPTION 1			OPTION 2			OPTION 3		OPTION 4		OPTION 5
				ATGS 1 Person in Aircraft INEXPER ATGS A/C PILOT ATP & ABSS Jobs Combined LP PRESENT NO HAT			ATGS 1 Person in Aircraft EXPER ATGS A/C PILOT ATP & ATGS Jobs Combined LP PRESENT NO HAT			ATGS 2 People in Aircraft INEXPER ATGS A/C PILOT ATGS and ATP NO LP NO HAT		ATGS 2 People in Aircraft EXP ATGS A/C PILOT ABSS and ATP NO LP NO HAT		NO ATGS NO ATGS A/C PILOT LP ONLY NO HAT
				ATGS	INEXP ATGS A/C PILOT	LP	ATGS	EXP ATGS A/C PILOT	LP	ATGS	INEXP ATGS A/C PILOT	ATGS	EXP ATGS A/C PILOT	EXP ATGS A/C PILOT / LP PILOT
1	Communications	From ATIS: Weather, local conditions, local takeoff policies	1											
2	Communications	In-Cockpit: Pre mission brief	2											
3	Communications	From Disp: Obtain Initial Info (Block 11 on Resource Order)	3											
4	Communications	From Disp: Obtain local weather	1											
5	Data Entry	In-Cockpit: Program/select radio frequencies	2											
6	Data Entry	In-Cockpit: Enter GPS Coordinates for incident, other TFRs, etc.	2											
7	Fly the aircraft	In-Cockpit: Perform pre-flight checklist	3											
8	Fly the aircraft	In-Cockpit: Taxi	1											

APPENDIX I

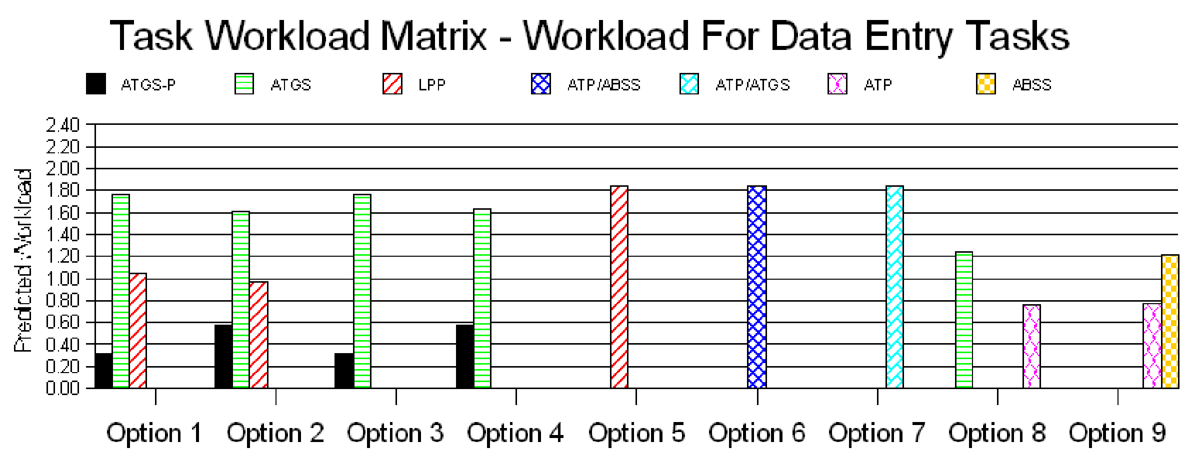
Additional Figures Based On The Task Workload Evaluation

Figure I-1



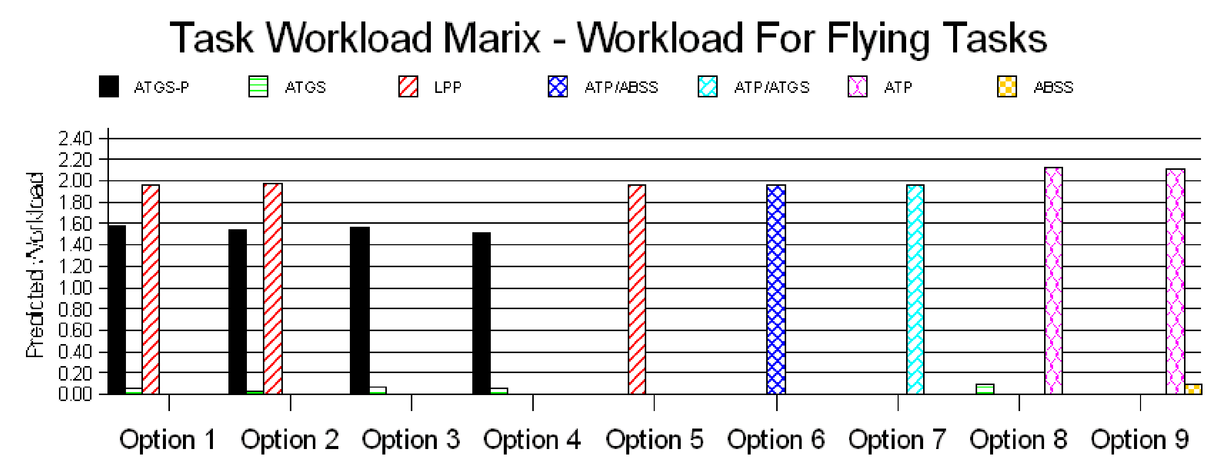
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
ATGS-P	0.66	0.96	0.64	0.92					
ATGS	1.82	1.74	1.86	1.74				1.5	
LPP	1.47	1.48			2.02				
ATP/ABSS						2.02			
ATP/ATGS							2.02		
ATP								1.32	1.34
ABSS									1.50

Figure I-2



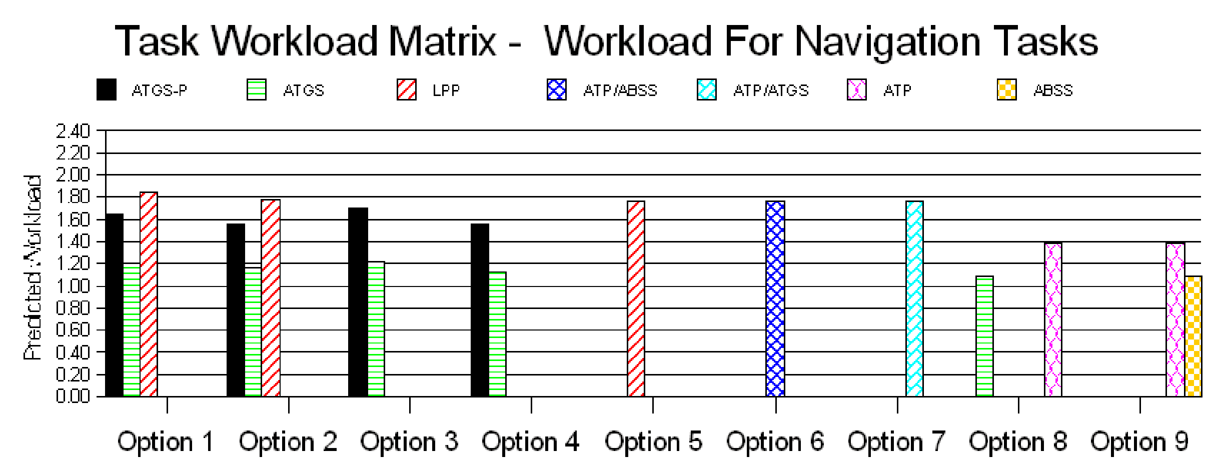
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
ATGS-P	0.31	0.58	0.31	0.58					
ATGS	1.76	1.61	1.76	1.63				1.24	
LPP	1.04	0.97			1.84				
ATP/ABSS						1.84			
ATP/ATGS							1.84		
ATP								0.76	0.77
ABSS									1.21

Figure I-3



	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
ATGS-P	1.58	1.54	1.57	1.51					
ATGS	0.05	0.03	0.07	0.06				0.1	
LPP	1.96	1.98			1.96				
ATP/ABSS						1.96			
ATP/ATGS							1.96		
ATP								2.12	2.11
ABSS									0.10

Figure I-4



	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
ATGS-P	1.64	1.56	1.70	1.56					
ATGS	1.20	1.16	1.22	1.13				1.08	
LPP	1.84	1.78			1.77				
ATP/ABSS						1.77			
ATP/ATGS							1.77		
ATP								1.39	1.38
ABSS									1.08

APPENDIX J

Detailed Descriptions Of Ranking Criteria Categories

Category: Specific Mission Needs

Criteria: Aircraft Visibility "Out the Window"

Parameters: Objective and Subjective Visibility

Criteria Weighting in Evaluation: 10.0

Mission Requirement: The airspace and environment in and around a fire is a visual one. The fire's perimeter, location of resources on the ground, aerial resources working the fire, inadvertent unauthorized aircraft incursions, etc. are all located through the visual sense. The aircraft to be used in aerial supervision must not hinder or increase the effort or workload of the pilot or ATGS in their ability to view the fire scene.

Parameter Development: Two methods will be used to evaluate this criteria for the candidate aircraft. The first method was developed for the evaluation of aircraft as airtankers. It was also used on several occasions to examine the visibility of some potential leadplanes in the past. The method is a laser transit system which is placed in the pilot's and co-pilot's seats. Measurements are taken which represent the unobstructed view (the view not obscured by wings, engine nacelles, etc.) through the windows. These measurements are then plotted and a representation of the visibility of the aircraft is made in squared degrees. The second method will be a subjective measure based on a modification of the Cooper-Harper Aircraft Handling Characteristics Scale, 1969 (see appendix E). During the flight evaluation, two pilots and one ATGS will evaluate the visibility based on the modified scale. These two methods will be used since each by themselves will not provide an adequate evaluation of the aircraft's visibility.

Platform Ranking: The rank ordered values from both methods will be averaged together. This resultant value will be ranked ordered with the other aircraft in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Specific Mission Needs

Criteria: Complexity of Flight During Lead Role

Parameters: 5,000 ft MSL, 2500 ft/min decent rate, 120 KIAS and 150 KIAS

Criteria Weighting in Evaluation: 7.7

Mission Requirement: In the lead role, retardant drops are made while maintaining a constant AGL altitude. The terrain over which these drops occur varies widely. The drop which is most demanding for pilot workload is the "down hill" (descent) drop. The leadplane must match the required airtanker drop speed and then maintain the speed during the lead role until the target is over flown. In a down hill (descent) drop, the aircraft has a natural tendency to gain speed. Therefore, the leadplane must be configured to maintain a constant speed while descending. Upon completion of the lead phase, the drop must be observed. This requires the aircraft to “clean-up,” speed-up, and bank while climbing. The observation of the drop is a “heads out” function. The workload to maintain safe flight while keeping attention outside must be considered and evaluated in the new platform.

Parameter Development: A measure of the complexity of the tasks in reconfiguring the platform after the lead phase of flight can be based on the number of aircraft controls which must be reconfigured. These controls include drag devices, high lift devices, and thrust adjustments. The deployment of the aircraft's landing gear shall not be an acceptable drag device. Additionally, the platform shall be capable of maintaining these speeds +/- 3 kts for 1 minute.

Airspeed: The lead role must match the needs of the airtanker. Airtankers can drop between 120 and 150 KIAS. Hence, the platform will be evaluated based on both speeds of 120 and 150 KIAS.

Decent Rate: 2,500 ft/min. Several Forest Service Leadplane pilots were consulted for the typical leadplane profile in mountainous terrain. The consensus was that to maintain adequate ground level clearance and drop heights without "push-over" maneuvers, that typical descent rates varied from 2,000 ft/min to 2,500 ft/min. Additionally, the Interagency Airtanker Board requirements for multi-engine airtankers requires:

> H. Descent. Aircraft is capable of descending at Board-approved operational gross weight along a 13 percent (7.41°) slope for 1 minute and leveling off at 3,000 ft pressure altitude in the drop configuration without exceeding maximum drop speed.

The FAA requirements under Part 171, Non-Federal Navigation Facilities states:

§171.265 Glide path performance requirements.

This section prescribes the performance requirements for glide path equipment components of the ISMLS. These requirements are based on the assumption that the aircraft is heading directly toward the facility.

(c) The glide path equipment must be capable of producing a radiated glide path from 3 to 9 degrees with respect to the horizontal. However, ISMLS glide path angles in excess of 3 degrees may be used to satisfy instrument approach procedures or to overcome an obstruction clearance problem, only in accordance with the criteria specified in Subpart C of Part 97 of this chapter.

Also in reviewing the glide angle for the speeds of 120 and 150 KTAS and various descend rates provides the following:

Descent Angle Comparison (degrees)

Descent Rate (fpm)	500	1000	1500	2000	2500
Airspeed (KTAS)					
120	2.4	4.7	7.0	9.3	11.6
150	1.9	3.8	5.6	7.5	9.3

In summary based on the above, there are sufficient documented requirements for a descent rate of 2000 fpm (IAB airtanker requirements). Additionally based on the FAA allowed descent angles and the leadplane pilots experience in mountainous terrain, a descent rate of 2500 fpm is an appropriate evaluation criteria.

Day Conditions: ISA +30F, 5,000 MSL is desirable, but maintaining adequate clearance and local conditions will prevail.

Platform Ranking: The average of the pilot evaluation scores for this element will be ranked ordered with the other aircraft in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Specific Mission Needs

Criteria: Minimum Control Airspeed

Parameters: Operational weight, 5,000 ft MSL, ISA + 30F

Criteria Weighting in Evaluation: 4.7

Mission Requirement: In the lead role, the aircraft is close to the ground and can be flying at speeds as low as 120 KIAS, the minimum airtanker drop speed.. While the loss of an engine is remote, the aircraft must have adequate margin between this speed and its minimum control airspeed.

Parameter Development: A value of 100 KIAS was selected based on professional judgement.

Platform Ranking: All option aircraft cost values will be ranked in descending order. The aircraft with the highest value will be assigned a value of one and the aircraft with the lowest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Specific Mission Needs

Criteria: Flight Crew Capacity and Arrangement

Parameters: Number of Seats and Configuration

Criteria Weighting in Evaluation: 4.6

Mission Requirement: The aircraft must be able to accommodate the defined flight crew and associated personnel gear within the cockpit area. The relative location of the flight crew shall be compatible with the mission and facilitate communications between them.

Parameter Development: The number of seats available in the aircraft as well as the orientation (side by side or in line) are the important features for this criteria. A minimum flight crew of 2 has been established. However, having a capacity of three is preferable since this allows for training opportunities during the fire season. A capacity of greater than 3 places provides no additional benefit to aerial supervision. The study committee was exempt from considering the aircraft for administrative transport. The ability to view the same targets at the same time without altering course or increasing bank angle is determined to have greater benefit for the aerial supervision role. This results in aircraft having in-line seating being preferred over side by side seating.

Platform Ranking:

Aircraft Seating No. and Arrangement	Weighted Value
3 or greater seats, in-line arrangement	10
2 seats, in-line arrangement	8
3 or greater seats, side by side arrangement	7
2 seats, side by side arrangement	5

Category: Specific Mission Needs

Criteria: Single Engine Best Rate of Climb

Parameters: Operational weight, 5,000 ft MSL, ISA + 30F, KIAS

Criteria Weighting in Evaluation: 4.2

Mission Requirement: Much of the leadplane role is performed in close proximity to the ground; and while the terrain varies across the country, mountainous terrain is very demanding on body the pilot and the aircraft. The climb performance, especially engine out for twin engine aircraft, is crucial while performing the leadplane role in this terrain. The strategic goals for aerial retardant may require retardant lines to be placed in the bottoms of canyons, at the base of mountains, and in other challenging locations for aircraft to operate into and out of. In the unlikely event of an engine loss, the aircraft must be capable of clearing the terrain.

Parameter Development: Single engine best rate of climb is established as the criteria for evaluating the aircraft in the event of an engine out occurrence. The single engine best rate of climb is associated with the airspeed of the aircraft and is based on the aerodynamics of the aircraft The maximum allowed value for this criteria is 120 KIAS, as identified in the must have criteria. The best rate of climb speed was selected over the best angle of climb speed for the following reasons:

- The best rate of climb speed is a higher speed than the best angle. Thus, it is a more demanding criteria.
- The slowest drop speed for an airtanker is 120 KIAS. If leading an airtanker at this speed and an engine failure occurs, the aircraft will instantly begin to slow down. Several seconds may pass while the pilot recognizes, evaluates and executes appropriate actions. During this time the aircraft will continue to slow. Since the best rate of climb speed is always higher than the best angle and the maximum allowed speed for the best rate of clime is 120 KIAS, the pilot can continue to slow to the best angle of climb speed, if terrain avoidance is required.
- Slowing down is more appropriate than being required to speed up to achieve an appropriate speed to avoid the terrain.

Day Conditions: 5,000 ft MSL, ISA+30F

Platform Ranking: This criteria only applies to multi-engine aircraft. During development of the criteria the study committee discussed the benefits and liabilities of single and multi-engine aircraft. All of the data reviewed does not show a clear answer regarding the safety of one over the other. The committee therefore decided upon the following. The data reviewed regarding single over multi-engine aircraft is not specific to the environment in which aerial supervision and the lead role are performed. The history of aircraft used in aerial supervision shows that engine loss is remote, but has happened (irrespective as to whether the engine was subsequently restarted). Hence, in consideration of the safety benefit provided to the flight crew in being able to continue flying and climb with the second engine, multi-engine aircraft will be provided additional consideration in the evaluations. This additional consideration is the value determined by the ranking among its peers for these two elements. Single engine aircraft will be given no value for these two elements.

Category: Specific Mission Needs

Criteria: Flight Deck Design (Panel Space)

Parameters: Panel size and configuration

Criteria Weighting in Evaluation: 4.2

Mission Requirement: The aerial supervision aircraft will operate for 15 to 20 years. This large investment must be made with consideration for future incorporation of new avionics. Additionally, this study will examine the introduction of automation into the flight deck for the crew. Since a solution for flight deck automation is not yet know, the amount of panel space beyond the standard avionics will be considered.

Parameter Development: Aircraft come equipped with a standard complement of avionics. These include traditional engine gages, flight instruments, dual navigation radios, dual communication radios, operating switches and levers for various aircraft systems. As a part of this study addition avionics equipment is being examined to be included as mission equipment. As this equipment is not yet identified, usable available space must be provided for this equipment. Hence, the excess available panel space will be measured in terms of placing a 3.5 inch standard altimeter in the open areas of the panel. The used panel space shall consider the standard complement of manufacturer supplied avionics.

Platform Ranking: All option aircraft performance values will be ranked in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Specific Mission Needs

Criteria: Aircraft Visibility of Being Seen

Parameters: Size and Configuration

Criteria Weighting in Evaluation: 1.9

Mission Requirement: As the aerial supervisor many instructions provided to and from other aircraft and ground personnel are in relation to each other's position. The ability to quickly visually find the candidate platform provides for greater efficiency of operations and can, at times, involve the safety of one or both of the personnel involved. Hence, the candidate aircraft must be evaluated for its ability to be seen.

Parameter Development: Visibility of the platform has three main attributes. The size, configuration, and the paint scheme. Since all aircraft can be painted to improve visibility, this criteria will focus on size and configuration. In its operational role, the aircraft will be viewed from all angles. To evaluate this criteria the sum of the length, span and height of non-rotating parts will be used to identify the size and configuration of the aircraft. Rotating parts are not considered since they are difficult to see.

Platform Ranking: All option aircraft performance values will be ranked in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Performance

Criteria: Rate of Climb (All Engines)

Parameters: Average from 0 to 10,000 ft MSL, ISA + 30F, Operational weight

Criteria Weighting in Evaluation: 10.0

Mission Requirement: Aerial supervision in the lead role occurs in many different topographical terrain. Of these the mountainous terrain is the most severe when considering the platforms rate of climb requirements. Retardant lines can be laid leading directly into the base of mountains, the bottom of box canyons, and many other areas where to climb is the only egress alternative. Hence, the aircraft must have an adequate rate of climb to assure that the mission and efficiency of leading the placement of retardant is not compromised. Additionally, many of the airports from which the platform will be dispatched are at the foot of hills or mountains. On dispatch, the aircraft must climb to an safe altitude to cross this terrain. The ability to climb while in route is far superior to climbing circles, and results in a quicker arrival time to the fire.

Parameter Development: The average altitude for the future bases from phase 2 of the National Airtanker Study is about 2,500 MSL, with over half of them above 5,000 MSL. The need to climb to altitudes approaching 10,000 ft is not uncommon in many geographic areas. The rate of climb will be the average rate of climb at Sea Level, 5,000 ft, and 10,000 ft with no flaps and gear retracted.

Day Conditions: ISA + 30F

Platform Ranking: All option aircraft performance values will be ranked in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Performance

Criteria: Stall Speed

Parameters: Landing configuration, power off, zero bank angle, operational weight, KIAS

Criteria Weighting in Evaluation: 8.1

Mission Requirement: Aerial supervision in the lead role requires the platform to operate at high angles of attack potentially approaching a stall condition. These conditions can occur at low air speeds or as accelerated stalls at higher airspeeds. The leadplane pull-up maneuver is a classic example for the Beech 58P Baron. During this maneuver the aircraft approaches an accelerated stall regime, but done properly the maneuver is safe. Since the mission requirement is fixed, a low stall speed represents an increase margin of safety.

Parameter Development: The mission requires the aircraft to be able to be going "down hill" in a high drag configuration, then pull up, and turn. The landing configuration data is close to this situation and is published in the pilot's handbook. Stall speed versus bank angle at a given weight is equal to the zero bank angle stall speed divided by the square root of the cosine of the bank angle. Therefore, a zero bank angle is representative of the performance of an aircraft. The weight should be the operational weight of the aircraft. The stall speed should be less than 90 KIAS since accepted tanker drop speeds are as low as 120 KIAS. The 25% margin is minimal considering the potential for bank angles and accelerated stalls.

Day Conditions: 5,000 ft MSL, ISA

Engine Power Setting: Power off. This value is generally available for different aircraft and will allow a valid comparisons between aircraft.

Platform Ranking: All option aircraft performance values will be ranked in descending order. The aircraft with the highest value will be assigned a value of one and the aircraft with the lowest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the high and low values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Performance

Criteria: Responsiveness

Parameters: Operational Weight

Criteria Weighting in Evaluation: 7.7

Mission Requirement: Aerial supervision in the leadplane role brings the aircraft in close proximity to the ground. In this environment, the fire causes convective air currents, the wind and the topography require constant and frequently quick flight control deflection to maintain an "on-line" path to the drop zone, avoid obstacles, and maintain aircraft separation. Additionally aborted drop runs may require the platform to accelerate to avoid an airtanker which may be overtaking the lead. The responsiveness of the platform to flight control and power setting changes provides a measure of safety to the flight crew and aircraft.

Parameter Development: The primary areas that are indicative of the response characteristics of an aircraft are its roll and pitch rates, acceleration, and deceleration. During development of the aircraft, costly flight testing and instrumentation are used by the aircraft company to validate this data. However, these data are not provided in standard approved flight manuals. Hence, the method to evaluate the aircraft's responsiveness was adapted from the Cooper/Harper Aircraft Handling Characteristics Scale, 1969. A flight evaluation program was developed together with a modified Handling Characteristics Scale, see appendix C for details. Two FS leadplane pilots were used to evaluate the aircraft and assign a score using the characteristics scale. There scores will be averaged together for ranking the aircraft's performance.

Day Conditions: 5,000 ft MSL, ISA is desirable, but maintaining adequate clearance and local conditions will prevail.

Platform Ranking: The average of all aircraft performance values from the flight evaluation sheets will be ranked ordered with the other aircraft in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Performance

Criteria: Maximum Cruise Speed

Parameters: Average 0 to 10,000 ft Altitude, ISA+ 30F, 75% Power, Operational Weight

Criteria Weighting in Evaluation: 5.8

Mission Requirement: The role of aerial supervision is to arrive on the scene of a fire, direct aerial assets, provide fire behavior information from the aerial view, and coordinate tactics with ground personnel and equipment. The conclusion of the National Airtanker Study was to upgrade the airtanker fleet from piston to turbine powered aircraft. The aircraft which are being pursued for the airtanker fleet all have speed capability of FAA limit below 10,000 feet of 250 KIAS. Since efficiency and effectiveness of retardant use is greatly improved with the role of the aerial supervision, the arrival of the platform ahead of the airtanker is required. Hence, the new platform must be capable arriving at the fire before the airtanker fleet.

Additionally on multiple fire occurrence days, aerial supervision can and does support multiple suppressions on a single flight. The locations of these ignitions can vary widely. The speed of the aircraft is paramount in providing adequate aerial supervision.

Parameter Development: The National Airtanker Study identified that the average dispatch of an airtanker is 100 nautical miles 90% of the time. The aerial supervision platform is assumed to be either be co-located or positioned at a similar distance away from the fire. Since the land management agencies cover terrain of varying altitudes (sea level to over 10,000 feet), an average of the platform's cruise speed between 0 to 10,000 will be used for evaluation. The average will be determined by taking the platform's speed capability at 0, 2,500, 5,000, 7,500 and 10,000 feet and dividing by five.

Engine Power Setting: A power setting of 75% for the maximum cruise speed is reasonable considering long term engine life, fuel economy, and time in route. Typically a cruise speed at 75% power is about 90% of the maximum level speed at maximum continuous power. Using 75% for the maximum cruise speed means that the aircraft can go faster, but there is a heavy fuel consumption penalty. Hence, a 75% power setting provides a reasonable fuel consumption and can be tolerated for a short flight of 100 nautical miles.

Platform Ranking: All option aircraft performance values will be ranked in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a 10. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Performance

Criteria: Maneuvering Speed

Parameters: Operational weight

Criteria Weighting in Evaluation: 5.5

Mission Requirement: The environment over a fire is extremely turbulent, both at altitude and while leading an airtanker. Course corrections are required continuously to maintain level flight or avoid terrain. At times, due to the local winds, the fire's convection column, or the topography full control deflection is required. When leading airtankers, the acceptable drop speed range for retardant is 120 to 150 KIAS. The aircraft in consideration must be capable of allowing full control deflection within the entire airtanker drop speed range.

Parameter Development: While leading airtankers, the pilot must match the speed of the airtanker making the drop. The leadplane platform must be capable of full control deflection at speeds up to the maximum allowable retardant drop speed, 150 KIAS. The pilot has enough workload to lead the airtanker, avoid the terrain, identify the target, and then observe the drop without having to concentrate on reducing control deflections (if the aircraft were so limited). Hence, the minimum maneuvering speed (full control deflection) shall be 150 KIAS.

Platform Ranking: All option aircraft performance values will be ranked in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Performance

Criteria: Single Engine Service Ceiling and Best Rate of Climb Speed

Parameters: 5,000 ft MSL, ISA+30F, Operational Weight

Criteria Weighting in Evaluation: 4.5

Mission Requirement: Much of the leadplane role is performed in close proximity to the ground; and while the terrain varies across the country, mountainous terrain is very demanding on body the pilot and the aircraft. The climb performance, especially engine out for twin engine aircraft, is crucial while performing the leadplane role in this terrain. The strategic goals for aerial retardant may require retardant lines to be placed in the bottoms of canyons, at the base of mountains, and in other challenging locations for aircraft to operate into and out of. In the unlikely event of an engine loss, the aircraft must be capable of clearing the terrain. Additionally, the aircraft is required to operate on one engine at a minimum altitude of 10,000 feet MSL. Fire can and do start in areas where the topography requires the aircraft to climb to altitude to clear the terrain to return to base or an alternate base.

Parameter Development: Single engine best rate of climb speed is established as the criteria for evaluating the aircraft in the event of an engine out occurrence. The maximum allowed value for this criteria is 120 KIAS, as identified in the must have criteria. The best rate of climb speed was selected over the best angle of climb speed for the following reasons:

- The best rate of climb speed is a higher speed than the best angle. Thus, it is a more demanding criteria.

- The slowest drop speed for an airtanker is 120 KIAS. If leading an airtanker at this speed and an engine failure occurs, the aircraft will instantly begin to slow down. Several seconds may pass while the pilot recognizes, evaluates and executes appropriate actions. During this time the aircraft will continue to slow. Since the best rate of climb speed is always higher than the best angle and the maximum allowed speed for the best rate of clime is 120 KIAS, the pilot can continue to slow to the best angle of climb speed, if terrain avoidance is required.

- Slowing down is more appropriate than being required to speed up to achieve an appropriate speed to avoid the terrain.

Day Conditions: 5,000 ft MSL, ISA+30F

Platform Ranking: This criteria only applies to multi-engine aircraft. During development of the criteria the study committee discussed the benefits and liabilities of single and multi-engine aircraft. All of the data reviewed does not show a clear answer regarding the safety of one over the other. The committee therefore decided upon the following. The data reviewed regarding single over multi-engine aircraft is not specific to the environment in which aerial supervision and the lead role are performed. The history of aircraft used in aerial supervision shows that engine loss is remote, but has happened (irrespective as to whether the engine was subsequently restarted). Hence, in consideration of the safety benefit provided to the flight crew in being able to continue flying and climb with the second engine, multi-engine aircraft will be provided additional consideration in the evaluations. This additional consideration is the value determined by the ranking among its peers for these two elements. Single engine aircraft will be given no value for these two elements.

Additionally, the ranking of these two elements will be averaged together before applying the criteria weighting factor.

Category: Performance

Criteria: Airframe Strength, G-Loading

Parameters: Operational weight

Criteria Weighting in Evaluation: 3.5

Mission Requirement: The flight environment above a fire is severe. Convective air currents caused by the fire, the winds, and the topography can result in violent wind shears. Aerial supervision in the leadplane role will subject the platform to these winds as well as potentially more severe conditions winds in close proximity to the terrain in the leadplane role. These violent winds impart high forces on the airframe. The platform must be capable of surviving this environment without damage or increased required inspection.

Parameter Development: The design G limit for the aircraft provides a measure of the structural strength of the aircraft. The minimum requirement is certification in the FAA normal category. Since the aircraft may be operated at weights considerably less than gross weight, the structural margin is improved. The effective margin is equal to the gross weight divided by the operational weight times the published structural limits.

Platform Ranking: All option aircraft performance values will be ranked in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Performance

Criteria: Fuel Endurance

Parameters: ISA, Operational weight but with full fuel, Manufacturer's recommended power setting for best economy, 5,000 Pressure Altitude

Criteria Weighting in Evaluation: 2.6

Mission Requirement: Aerial supervision in the from of Leadplanes are national assets and can be dispatched to support fire suppression activities from one end of the country to the other, including Alaska. Hence, the range capability of the aircraft is important in that stops for refueling add to the time to arrive at a fire.

Additionally, to provide adequate aerial suppression activities over a fire, the platform must be capable of loitering. Airtankers and other fire suppression aircraft are provided only "snap shots" views of the fire and its behavior, and/or only segments of the fire. The aerial supervision platform provides a continuous and uninterrupted aerial view of the fire from which the personnel in the platform develop tactics and strategic objectives in the fire’s suppression. Additionally, abrupt changes in fire behavior are seen early on; and changes to tactics and strategies can be re-evaluated quickly, while also providing information to ground personnel and equipment that can effect their safety.

Parameter Development: Aircraft are not typically designed to loiter. However, loiter can be equated to cruise. Hence, endurance will be the aircraft's maximum flight time at its best cruise. The cruise will be evaluated at the described operational weight, except that full fuel capacity will be used. As this is a comparison of aircraft, all considered platforms will be treated the same and assume no reserves of fuel.

Day Conditions: ISA, 5,000 MSL

Engine Power Setting: Manufactures recommend for best fuel economy at the day conditions listed above.

Platform Ranking: All option aircraft performance values will be ranked in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Performance

Criteria: Accelerate and Stop on Takeoff

Parameters: Operational weight, dry pavement, zero slope, no wind, 5,000 ft MSL, ISA+30F

Criteria Weighting in Evaluation: 0.3

Mission Requirement: The fire season for the US is over nine months long. The average elevation for 50% of the bases is above 5000 ft. Operations in support of fire typically peak in the summer months of July, August and September. During this period elevated air temperatures exist, resulting in high density altitude conditions. While engine failure is rare, candidate aircraft for this mission should provide the highest degree of safe operation. As a measure of safety, the platform in consideration must be able to accelerate and stop within the paved portion of the runways of the National Airtanker Study Phase 2 recommended airtanker bases.

Parameter Development: A review of the National Airtanker Study Phase 2 recommended airtanker bases that are in excess of 5000 feet MSL shows that the shortest runway exists at McCall, ID. This base is at 5020 feet MSL and the longest runway is 6162 feet. This base will provide a suitable measure for comparing the performance of candidate aircraft. However, the parameters for the evaluation will be elevation of 5000 feet MSL and a maximum runway length of 6000 feet.

Day Conditions: ISA +30F, 5000 feet MSL

Platform Ranking: All option aircraft whose ground distance was less than 6000 feet were scored a one which will result in a weighted value of 10. Aircraft which have a distance of greater than 6000 feet will score a 0 and result in a weighted value of 0.

Category: Ergonomics

Criteria: Flight Deck Working Space

Parameters: Cockpit room

Criteria Weighting in Evaluation: 10.0

Mission Requirement: In its role, the pilot and observer must perform their tasks in an environment without interfering with the others tasks. Efficiency, stress and safety are all improved with adequate room to meet these needs. Some of tasks that need to be performed include flying the aircraft;, moving to make observations; working communications equipment; and changing, laying out and reading charts and tables.

Parameter Development: Two methods were established to evaluate this criteria. One being an objective evaluation, and the other being subjective. The objective method was to record the physical dimensions of the flight deck with the seat in various positions. The subjective method was based on personnel performing simulated tasks while seated in the aircraft. An evaluation form was developed based on a modified Cooper-Harper Aircraft Handling Characteristics Scale, 1969. The scale is provided in appendix E of this document.

Platform Ranking: The subjective scores will be average together and combined with the measured seat position data. This value will then be ranked ordered with the other aircraft in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Ergonomics

Criteria: Pressurization

Parameters: N/A

Criteria Weighting in Evaluation: 8.5

Mission Requirement: While flying in the vicinity of the fire, the aircraft will seldom need to fly above 10,000 ft MSL. Oxygen is not required for the flight crew until above 12,500 ft MSL. However at altitudes above 6,000 ft MSL and ambient temperatures over a fire, greater than ambient oxygen improves crew performance, especially on extended flights. Additionally, safety is improved due to reduced crew stress and fatigue.

Parameter Development: Supplemental oxygen can be provided to the flight crew in several forms. Pressurization is preferred, as the crew are not required to wear additional equipment.

Platform Ranking:

Supplemental Oxygen System	Point Value	Weighted Value
Pressurization	2	10
Face Mask	1	7

Category: Ergonomics

Criteria: Seat Comfort

Parameters: Aircraft seat configuration and features

Criteria Weighting in Evaluation: 3.1

Mission Requirement: The role of the leadplane and ATGS requires them to remain on station over a fire for extended periods of time. Additionally, potential country wide dispatch can result in 8 hours or more of flying. A comfortable seat reduce flight crew fatigue.

Parameter Development: Seat comfort will be equated to the number of seat adjustments available to the pilot and co-pilot seats.

Platform Ranking: All option aircraft performance values will be ranked in ascending order. The aircraft with the lowest value will be assigned a value of one and the aircraft with the highest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Cost

Criteria: Aircraft Monthly Availability Rate

Parameters:

Criteria Weighting in Evaluation: N/A

Mission Requirement: Fiscal responsibility in the cost efficiency of ownership of an aircraft is required for this acquisition. Expenditure of the public's money must be based on prudent and justifiable rational.

Parameter Development: The monthly availability costs are based on the indicated fixed costs developed by Conklin & deDecker Associates, Inc. The monthly availability includes hull and liability insurances, recurrent training, aircraft modernization, refurbishment, and depreciation.

Platform Ranking: All option aircraft cost values will be ranked in descending order. The aircraft with the highest value will be assigned a value of one and the aircraft with the lowest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.

Category: Cost

Criteria: Aircraft Flight Rate

Parameters:

Criteria Weighting in Evaluation: N/A

Mission Requirement: Fiscal responsibility in the cost efficiency of ownership of an aircraft is required for this acquisition. Expenditure of the public's money must be based on prudent and justifiable rational..

Parameter Development: The aircraft flight rate is based on the direct operating costs of the aircraft developed by Conklin & deDecker Associates, Inc. These costs include fuel, lubricants, engine overhaul, airframe and avionic repairs, propeller (as appropriate), and thrust reverser (as appropriate).

Platform Ranking: All option aircraft cost values will be ranked in descending order. The aircraft with the highest value will be assigned a value of one and the aircraft with the lowest value will be assigned a ten. All other aircraft will be assigned values based on their position percentage between the low and high values. The value assigned will then be adjusted by the above identified weighting factor.