Helicopter Night Operations Study

Final Report
August 24, 2010

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Acknowledgements

This report was developed by Carl Bambarger, aviation program leader, San Dimas Technology and Development Center, and Fire Program Solutions LLC, in cooperation with PJKelly Consulting, LLC; Safe Fire Programs Inc.; and Janine Smith LLC (On Course Safety).

Tory Henderson, equipment and chemicals fire program manager, served as chair of the project steering committee and provided advice and council throughout the process.

The contributions made by members of the organizations listed below are very much appreciated and contributed substantially to the project team's knowledge regarding helicopter night operations. The following organizations hosted site visits from members of the project team:

- U.S. Immigration and Customs Enforcement, Riverside, CA.
- Los Angeles County Fire Department Air Operations.
- San Diego City Fire Department Air Operations.
- AirLink of St. Charles Medical Center, Bend, OR.
- U.S. Army Fort Rucker Aviation Training Center, Fort Rucker, AL.
    - U.S. Army Night Vision Facility.
    - U.S. Army Aeromedical Research Lab.
    - U.S. Army Combat Readiness Safety Center.
- U.S. Coast Guard Air Training Command, Mobile, AL.
- Oregon Army National Guard, Salem, OR.

David Luke, Night Flight Concepts, and Stephen Hatley, Night Readiness, LLC, made presentations to the steering committee, subject matter experts (experts), and project team.

The consultants appreciate the professionalism, integrity, and commitment to achieving improvements to the Forest Service aviation program by the experts and technical specialists who were assigned to the project team.

Executive Summary

In 1976, the Forest Service, U.S. Department of Agriculture, contracted for a Bell 212 helicopter with night operational capability utilizing night vision goggles. In 1977, a Los Angeles County helicopter and a Forest Service helicopter collided during night operations on a wildfire resulting in a fatality. The Forest Service continued contracting for two night-operations capable helicopters until 1983 when the program was discontinued due to limited use and program cost.

This report documents a helicopter night operations study including a programmatic risk assessment and definition of a quality assurance program for the use of helicopters at night to support wildland fire suppression operations. The scope of work was coordinated with the project steering committee by San Dimas Technology and Development Center.

The findings and recommendations for the use of helicopters during night operations are:

Findings

1. The agency can design, implement, and operate a safe helicopter night operations program. There are significant hazards, organizational challenges, and implementation considerations that need to be resolved to achieve implementation.

2. The missions of water and retardant dropping using a fixed tank with ground fill, aerial supervision, and aerial ignition with the plastic sphere dispenser can have potential benefit to the agency and an implementation plan for each should be pursued.

3. The mission of emergency medical transport (with hoist) is a mission the agency currently does not have. Further definition of this mission and the level of care provided should be addressed in the implementation plan and by the agency for its normal day operations. The entire medical mission needs to be further defined.

4. Support technology, such as night vision goggles and helicopter terrain awareness and warning system for helicopter night operations, has evolved to where operations can be conducted with a high degree of reliability and safety.

5. Forest Service fire and aviation managers have identified that the helicopter night operations missions may provide fire suppression benefits. However, no attempt was made to quantify these benefits during this study.

6. The amount of effort, expense, and organizational reprioritization to implement a helicopter night operations program will be substantial and will take years to implement the agency's first night-operational helicopter.

7. The agency lacks standards and guidelines for ground forces operating with helicopter night operations.

8. There is little corporate memory of the agency's helicopter night operations efforts in the late 1970s and early 1980s.

9. Nonrecurring startup costs will be significant.

10. Recurring multiyear organizational costs will be significant.

11. The Forest Service contracts for 99 percent of its helicopter services. The study reviewed many night helicopter operations and found that all of them are cooperator owned-and-operated services. Further, with the exception of the U.S. Army, the cooperators operate from a home base with a substantial knowledge of the terrain and hazards that they encounter within their designated area of operation.

12. The Forest Service helicopter program is based on all helicopters and pilots meeting the same standards. In addition, a total mobility concept is used with aircraft moving interchangeably throughout the United States. To implement helicopter night operations successfully, this total mobility program model may need to be modified.

13. The commitment required for a helicopter night operations program includes appropriate funding and staffing, not collateral duty functions. Without appropriate funding and staffing this program could result in a weakening of the overall helicopter program.

14. This risk assessment stands alone regarding the hazards and risk associated with night operations, but relies on prior risk assessments and their mitigating actions to apply to the aircraft and other system, e.g. aircraft performance, operation of the plastic sphere dispenser, etc.

Recommendations

1. The decision to proceed with any of the analyzed missions at night should be made at the Chief's level.

2. Identify a helicopter night operations program manager and project manager to lead this effort.

3. Develop a helicopter night operations implementation plan including information contained in this report.

4. Present the helicopter night operations implementation plan to the Chief's level for approval.

5. Develop operational standards and guidelines for ground personnel working with helicopter

night operations.

6. To ensure safe internal Forest Service program implementation, all 130 mitigation measures identified in the risk assessment need to be implemented. Additionally, integrate the appropriate mitigation measures from the prior risk Forest Service assessments.

7. Develop performance measures to implement and monitor in order to demonstrate a benefit based on program cost.

8. While the Forest Service develops its internal program, the agency could work with the southern California cooperator's program to achieve the Forest Service's needs for helicopter night operations.

Helicopter Night Operations Study

Introduction

This study documents missions that the Forest Service, U.S. Department of Agriculture, decided to analyze for use at night with the aid of night vision goggles (aided-flight). This study includes a programmatic risk assessment and definition of a quality assurance program for the use of helicopters at night to support wildland fire suppression operations. This study incorporates both risk assessment and quality assurance information resulting in unified findings and recommendations.

The scope of work was coordinated with the project steering committee by the San Dimas Technology and Development Center. The consultants used the safety management system as defined in the Federal Aviation Administration's Advisory Circular 120-92 (appendix I) and the 2009 Aviation Risk Management Workbook, (appendix C). The Aviation Risk Management Workbook is used as a point of departure for the risk assessment. This study does not duplicate an analysis of those hazards and mitigations, which are identified for the overall helicopter wildfire mission.

To develop the study, the Forest Service provided subject matter experts who identified helicopter missions to be studied further. The subject matter experts (experts) developed mission definitions and mission limitations. A programmatic risk assessment was completed that identified hazards and mitigation measures, projected costs for the mitigation measures, and rated the cost benefit of implementing the mitigation measure.

The experts included agency specialists with a wide variety of expertise at the national, regional and local levels including the following skills: forest air attack group supervisor, national emergency management specialist, national branch chief for aviation risk management and training systems, regional aviation officer, regional supervisory pilot, regional helicopter inspector pilot, national fire operations risk management specialist, and national helicopter operations specialist. In addition, there were nine site visits to locations that currently do night helicopter operations. These site visits provided a wide variety of information pertinent to flying missions at night.

A glossary of terms that are specific to aviation and night vision is included.

The Study

In 1976, the Forest Service contracted for a Bell 212 helicopter with night operational capability utilizing night vision goggles. In 1977, a Los Angeles County helicopter and a Forest Service helicopter collided during night operations on a wildfire resulting in a fatality. Los Angeles County suspended their night vision goggle program at that time. The Forest Service continued contracting for two night-operations capable helicopters until 1983, when the program was discontinued due to limited use and program cost. In 2001 Los Angeles County began building their night operations with night vision goggles and resumed night fire operations in 2005.

Currently in southern California, San Diego City, Orange County, Los Angles City, Los Angles County, Santa Barbara County, and Kern County are currently or preparing to operate 17 helicopters in a night operations mode.

This project was proposed in July 2008, by the Forest Service assistant fire director for operations, to be completed by the San Dimas Technology and Development Center. This project identified the primary firefighting operations that occur during the daytime that should be studied for continued use during the night by using night vision aiding technology. In identifying the feasibility of cross walking these functions to night operations, the initial assessment included use for fire initial attack and large fire support.

The Forest Service utilizes helicopters for a variety of daytime firefighting missions including:

- Personnel transport for fire suppression.
- Reconnaissance flights for gathering intelligence.
- Detection flights for wildfires.
- Aerial supervision (supervisory aerial platform).
- Retardant/water/foam/gel delivery.
- Helitack operations providing initial attack of wildfires.
- Rappeller operations providing rappelling to initial attack wildfires.
- Equipment and supply transport operations.
- Infrared imagery operations.
- Aerial ignition operations.
- Other fire suppression operations.

Night flight can be aided or unaided. These terms are defined as follows:

- Night-aided flight: Flying a night mission using night vision goggles.

- Night-unaided flight: Flying a night mission without using night vision goggles.

Missions performed at night using night vision goggles (night helicopter operations) are the focus of this project.

Currently, the Forest Service has no helicopters, helicopter pilots, or crews trained, equipped, qualified, or current to accomplish night firefighting missions. Occasionally, emergency night flights have been authorized.

The following discussion provides a context to understand the scope and scale of the Forest Service's helicopter program and its comparison to the U.S. Army aviation program. The U.S. Army statistics for aviation Class A-C flight accidents averaged over the period of 2000 to 2009 was 9.53 accidents per 100,000 hours of flight time. All Army helicopters are equipped and qualified for night flight operations. Hence the accident statistics apply to the entire fleet.

Twenty-eight percent of all U.S. Army accidents have occurred using night-aided equipment, such as night vision goggles. The 10-year average of U.S. Army aviation Class A-C accidents involving night-aided operations is 15.54 accidents per 100,000 hours, twice the day operations rate of 7.74 per 100,000. U.S. Army night-aided flight makes up 17 percent of all Army aviation flight hours.

The Forest Service contracts for 99 percent of its helicopter flight hours for an average of 39,924 flight hours per year. The Forest Service accident rate from 2000 to 2009 is 7.26 per 100,000 hours of flight time. This accident rate is solely based on daytime flight operations. This equates to one accident per every 13,775 hours or 2.89 accidents per year.

The Forest Service can project the following night-flight accident rate based on the U.S Army statistics with the assumption of utilizing five helicopters in night operations.

- Total flight time per year for five aircraft equals 500 hours or 100 hours per aircraft.
- Total day flight hours for five aircraft equals 413 hrs (82.60 percent) or 82.6 hours per aircraft.
- Night-aided flight hours for five aircraft equals 87 hours (17.4 percent) or 17.4 hours per aircraft.
- Night-aided accidents per 100,000 hours equals 15.54 or one accident per 6,435 hours.

Initial scoping for this project was performed and the report of that effort is contained in appendix D. The study was conducted in seven steps:

Step 1. Review history.
Step 2. Review current operations.
Step 3. Document currently available technology or technology that may be available soon.
Step 4. Define and quantify mission.
Step 5. Present alternatives and selection of course of action.
Step 6. Perform a risk assessment for candidate helicopter night missions.
Step 7. Complete report.

Step 1. Review History

A history of Forest Service helicopter night operations is provided in appendix E.

Step 2. Review Current Operations

Schedule site visits with organizations and personnel that currently perform night helicopter operations. Locations visited include:

- U.S. Immigration and Customs Enforcement, Riverside, CA – March 31, 2010.
- Los Angeles County Fire Department Air Operations, April 1, 2010.
- San Diego City Fire Department Air Operations, April 2, 2010.
- AirLink of St. Charles Medical Center, Bend, OR, April 28, 2010.
- U.S. Army Fort Rucker Aviation Training Center, Fort Rucker, AL, May 4 – 6, 2010.

    - U.S. Army Night Vision Facility, May 4th, 2010.
    - U.S. Army Aeromedical Research Lab, May 4th, 2010.
    - U.S. Army Combat Readiness Safety Center, May 5th, 2010.
- U.S. Coast Guard Air Training Command, Mobile, AL, May 6, 2010.
- Oregon Army National Guard, Salem, OR, May 11, 2010.

A summary of these site visits is provided in appendix F.

Step 3. Document Currently Available Technology or Technology That May Be Available Soon

A survey was performed regarding technology that could support night-aided flight. A detailed description of technology is contained in appendix G. A summary list follows:

General Equipment List

- Searchlight and spotlights.
- Radar altimeter.
- Night vision goggles.
- Moving map or electronic data manager.
- Traffic advisory system.
- Helicopter terrain awareness and warning system.
- TurboFlare© or similar (Landing zone marking and lighting device).
- Lip light and finger light.

Mission Specific Equipment

- Imaging and laser system. (This is a one-system camera with laser, infrared and electronic data system.)
- Gyro-stabilized, high-magnification sensor systems.
- Digital and analog wireless communication systems.
- Integration with other avionics to form a total system solution.
- Hoist.

Emerging Technologies Available to the Civilian Market

- Heads-up display systems (monocles).
- Synthetic vision.
- Smartpad and Smartphone flight data applications.

Step 4. Mission Definition and Quantification

The project steering committee directed the group of experts to analyze the potential helicopter night operations missions that could be conducted and to rank them in order of priority. The highest priority missions were to be those with the greatest potential to produce firefighting benefits. The committee determined that the analysis would proceed as follows.

Missions Carried Forward For Further Evaluation

The experts selected the following missions for further evaluation:

- Water and retardant dropping using a fixed tank with ground fill.
- Aerial supervision.
- Emergency medical transport (hoist).
- Aerial ignition with plastic sphere dispenser.

Missions not Considered for Further Evaluation

Those missions that presented significant hazards, which in the opinion of the experts could not be mitigated, were not considered for further evaluation. Also dismissed were missions that in the opinion of the experts had either low potential benefit or which were perceived to be extremely difficult to implement. The following missions were dismissed from further consideration:

- All missions that require cargo to be slung under the helicopter.
    - Missions such as water dropping with a bucket, aerial ignition with a flying drip torch, and supply transport in a cargo net slung under the helicopter.

- Personnel transport fire suppression and helitack operations.
    - Personnel transport missions on wildland fires are often flown to unimproved and unlit landing sites. These missions would have infrequent use and a high implementation cost.

- Reconnaissance, detection, and infrared imagery flights.
    - There are alternative methods to accomplishing these missions, which are simpler, safer, and less expensive to conduct.

- Rappelling.
    - Rappelling is a complex daytime operation for initial attack on wildland fires.

- Equipment and supply transportation.
    - Advantages gained by the occasional delivery of cargo at night are seen as minimal.
    - Missions would have only infrequent use entailing high risk and at an extremely high cost to implement.
    - Alternative ground methods of transport would exist in most cases.

The experts defined global mission limitations as well as flightcrew, aircraft, and support requirements. These limitations are global because they apply to more than one mission.

Global Mission Limitations as well as Flightcrew, Aircraft, and Support Requirements

Mission Limitations in Addition to Day Operations

- Known, approved, and dedicated landing sites for the number of aircraft desired.

- Essential support equipment and personnel are briefed, in place, and operational before darkness.
- Availability of aircraft approved and properly equipped for the night mission.
- Recommend to use only exclusive use approved cooperator helicopters or Forest Service owned.
- Heliport meets Category B requirements for takeoff minimums.
- Mission launch only if illumination is greater than to-be-defined ambient light conditions.
- Need to establish weather minimums (recommend 1,000 foot ceiling with 3-mile visibility).
- Need to obtain Air Force weather forecast for determination of illumination and thermal data.
- No vertical reference missions.

Flight Crew Requirements

- Meet Federal Acquisition Regulation, Part 61.
- Establish agency standards.
- Define where two or more crewmembers are needed based on the mission.
- Define training and currency requirements.
- Meet carding requirements for mission.
- Train and qualify all crewmembers in the use of night vision goggles.
- Require mission specific crew resource management training (includes mission pilot and crewmembers).
- Develop and implement an inadvertent instrument meteorological conditions plan.
- Ensure pilots have completed an approved mountain flying course.

Aircraft Requirements

- Meet technical standard order C-164.
- Aircraft avoidance system.
- Moving map technology that incorporates known hazards.
- Explore helicopter terrain avoidance technology.
- Public address/siren system.
- Additional night-aiding technology and specification to be determined (goggles, spotlights, lip lights and finger lights).
- Develop a minimum performance specification for Type 1 and 2 helicopters.

Support Requirements

- Require aerial supervision with technology to adequately support the operation for two or more aircraft.
- Agency ground support personnel trained and equipped for night operations.
- Helibase night lighting and support equipment.
- Identify any additional training needs for aerial supervision and equipment.
- Heliport meets Category B requirements for takeoff minimums.
- Maintain night-aiding technology at a Part 141 facility.
- Need for aviation life support equipment requirements.

- Need to staff a national night operation specialist.
- Expand flight and maintenance crew staffing to support 15-hour flight coverage during a 24-hour period.
- Adjust crew duty day and flight time to reflect 24-hour period operation.
- Develop a continual evaluation process. Provide life cycle planning to recommend night-aided mission related equipment.
- Obtain Air Force weather forecast for determination of illumination and thermal data.
- Develop personal protective equipment with identification marking requirements.
- Develop standard ground signaling methods.
- Develop training on standardized protocols when working with night operation.
- Ensure ground night communications center staffing (dispatch, incident command post, and incident helibase).
- Establish and maintain confirmed communications at location where air-to-ground flight following is maintained (example is 15-minute check-in).
- Have adequate day sleeping facilities.

In addition to the global limitations, the experts provided a description, limitations, flight crew requirements, aircraft requirements, and support requirements for each specific mission.

Water and Retardant Dropping Using a Fixed Tank with Ground Fill

<u>Mission description</u>

- Aiding in suppression of fires by applying water and retardant to the fire or fuels in the proximity of the fire.

<u>Mission limitations in addition to day operations</u>

- Location, size, and type of water source.
- Temporary flight restriction in place.
- Limited to Type 1 and 2 helicopters (need to add technical specification).
- Helicopter tank ground fill operations only at controlled sites.
- No water dropping operations using a slung vessel.

<u>Flight crew requirements</u>

- Require water-ditching training for all flightcrew members.

<u>Aircraft requirements</u>

- No additional, see global mission limitations.

<u>Support requirements</u>

- No additional, see global mission limitations.

Aerial Supervision

<u>Mission description</u>

- Manages incident airspace and controls incident air traffic.
- Conduct risk management for resources.
- Coordinate, assign, and evaluate the use of aerial resources in support of incident objectives.
- Collaborate with ground personnel to develop and implement tactical missions.

Mission limitations
- Exclude noncrewmembers from this mission.
- Mission to be accomplished at least 500 feet above vegetation.
- No lead plane mission by aerial supervision aircraft.

Flight crew requirements
- Air tactical group supervisor or helicopter coordinator on board.

Aircraft requirements
- Fuel capacity, which defines the length of the time before refuel.

Support requirements
- No additional, see global mission limitations.

Remarks
- Helicopter is not the only way to accomplish this mission.
- When the air tactical group supervisor's aircraft requires refueling, reduce the number of helicopters working to one.

Emergency Medical Transport

This mission is not currently defined and authorized by the Forest Service for day or night implementation. This prospective mission is important to consider as part of the agency's desire to provide more rapid medical transport capability to firefighters deployed in remote areas.

Mission description
- Transportation of injured personnel from the location of the injured person(s) to advanced life support.
- Transport adequately trained, certified, and equipped medical personnel.
- For transportation of personnel with life threatening injuries.

Mission limitations
- No short haul.
- No emergency helicopter extraction.

Flight crew requirements
- Two night-vision-goggle qualified crewmembers on board. (Note: The medical personnel are not considered a crewmember.)

Aircraft requirements

- Type 2 aircraft for transport of the injured person by litter.
- Hoist.

Support requirements

- No additional, see global mission limitations.

Remarks

- Need to have requirements integrated into the medical plan for the incident.

Aerial Ignition with Plastic Sphere Dispenser

Mission description

- Provide ignition of fuels by aerial ignition techniques.

Mission limitations

- Normal crewmember compliment and all are night-vision-goggle qualified.

Flight crew requirements

- None additional.

Aircraft requirements

- Aircraft has a bubble window on the right side (both sides need bubble windows).
- Need adequate lighting in the back.

Support requirements

- None additional, see global mission limitations.

Remarks

- None.

Step 5. Presentation of Alternatives and Selection of Course of Action

The project steering committee reviewed the experts' analysis and decided that four missions should be subjected to an in-depth safety management systems risk assessment. The missions, in descending priority are:

1. Water and retardant dropping using a fixed tank with ground fill.
2. Aerial supervision.
3. Emergency medical transport (with hoist).
4. Aerial ignition with plastic sphere dispenser.

Step 6. Perform a Risk Assessment for Candidate Helicopter Night Missions

Risk assessment identifies hazards and develops mitigation measures, benefits, and costs. This risk assessment does not duplicate other assessments, but builds upon them in the specific area of night aided fire operations. For example, this risk assessment does not repeat the risk and mitigating actions associated with low level flight (the hazard posed by helicopters hovering in the height velocity curve in the event of an engine failure) found in the helicopter rappel risk assessment. This assessment assumes the appropriate actions have been completed and that the risk and mitigation associated with this set of missions is applied to the aircraft here as lessons learned. The three prior risk assessments that apply are:

- Independent Risk Assessment for Personnel Transport in Type I Helicopters, May 13, 2009
- Programmatic Risk Assessment and Quality Assurance Evaluation for Aerial Ignition Using the Plastic Sphere Dispenser, April 10, 2010
- Programmatic Risk Assessment and Quality Assurance Evaluation for Helicopter Rappelling, March 1, 2010

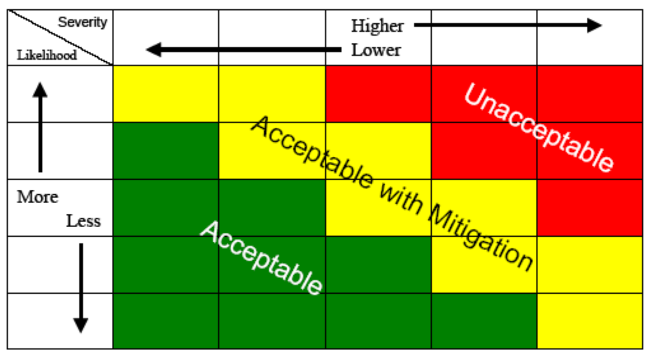
Systems, Hazards, and Mitigation Measures

The consultants designed a risk assessment process based upon the principles of safety management systems as described in Federal Aviation Administration Circular 120-92 (appendix I).

The Circular states that:

"(5) Risk Acceptance. In the development of its independent risk assessment criteria, aviation service providers are expected to develop risk acceptance procedures, including acceptance criteria and designation of authority and responsibility for risk management decisionmaking. The acceptability of risk can be evaluated using a risk matrix, such as the one illustrated in figure 1. The example matrix shows three areas of acceptability. Risk matrices may be color coded; unacceptable (red), acceptable (green), and acceptable with mitigation (yellow).

Figure 1. From FAA Circular 120-92, page 15.



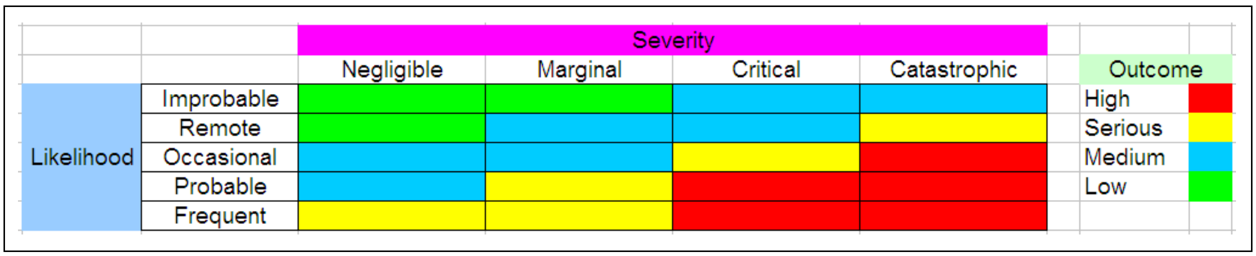
"(a) Unacceptable (Red). Where combinations of severity and likelihood cause risk to fall into the red area. The risk would be assessed as unacceptable and further work would be required to design an intervention to eliminate that associated hazard or to control the factors that lead to higher risk likelihood or severity.

"(b) Acceptable (Green). Where the assessed risk falls into the green area, it may be accepted risk to as low as practicable regardless of whether or not the assessment shows that it can be accepted as is. This is a fundamental principle of continuous improvement.

"(c) Acceptable with mitigation (Yellow). Where the independent risk assessment falls into the yellow area, the risk may be accepted under the defined conditions of mitigation."

The Forest Service, in the 2009 Aviation Risk Management Workbook, did not establish risk thresholds including risk acceptance and management processes as described in section 5 (a), (b), and (c) of the Federal Aviation Administration Circular 120-92. The process used to develop the hazards and mitigation measures together with the ratings of each premitigation and postmitigation compared the likelihood and severity rating to obtain an outcome of low, medium, serious, or high (figure 2). The process did not establish within these four outcome values which values were unacceptable, acceptable with mitigation, or acceptable without mitigation.

Figure 2. Outcome matrix from Forest Service 2008 Systems Safety Aviation Guide and 2009 Aviation Risk Management Workbook



In this project, the consultants utilized a similar process as used by the Forest Service in preparing the 2008 Systems Safety Aviation Guide and 2009 Aviation Risk Management Workbook, but with modifications. The key modification was the development of an additional rating matrix for the benefit-to-cost of the mitigation measures.

As used by the Forest Service in the 2008 Systems Safety Aviation Guide and the 2009 Aviation Risk Management Workbook, all hazards appear to be classified as section 5 (c), Federal Aviation Administration Circular 120-92, acceptable with mitigation. In this independent risk assessment, the consultants followed the same procedure. The consultants assume the Forest Service might utilize an additional process such as a program review to determine which hazards fall within the categories of section 5 (a), (b), and (c) from Federal Aviation Administration Circular 120-92.

The rankings are made in relationship to each other and do not propose benchmarks, such as acceptable, unacceptable, or acceptable with mitigation.

Identification of Systems and Subsystems
Using the helicopter section of the 2009 Aviation Risk Management Workbook as a reference, the experts identified five systems. They further identified 24 subsystems some of which appear in more than one system.

<u>A - Helicopter Aircraft Night</u>

- Capabilities subsystem.

- Visibility subsystem.
- Inspection subsystem.
- Equipment subsystem.
- Maintenance subsystem.

F - Helicopter Facilities Night

- Communications subsystem.
- Environment subsystem.

P - Helicopter Personnel Night

- Utilization subsystem.
- Policy subsystem.
- Training subsystem.
- Human factors subsystem.

T - Helicopter Technology Night

- Utilization subsystem.
- Maintenance subsystem.
- Human factors subsystem.

H - Helicopter Operations Night

- Mission subsystem.
- Management decisions subsystem.
- Utilization subsystem.
- Environment subsystem.
- Communications subsystem.
- Training subsystem.
- Water and retardant dropping using a fixed tank with ground fill subsystem.
- Aerial supervision subsystem.
- Hoist for emergency medical transport subsystem.
- Aerial ignition with plastic sphere dispenser subsystem.

Hazards and mitigation measures were defined within each of the categories. A listing of these measures is provided in appendix B.

Evaluation of Hazards and Mitigation Measures

The identification of hazards and mitigation measures for helicopter night operations was developed using a process similar to the one described in the 2008 Systems Safety Aviation Guide, Tab 5, System Safety Assessment – Helicopters and the 2009 Aviation Risk Management Workbook, Helicopters.

Evaluation Model Description

The consultants facilitated a workshop to identify hazards and mitigation measures as well as provide a risk rating for each hazard and mitigation measure. Six subject matter experts and three technical experts attended this workshop (appendix A). The consultants facilitated a process where the experts developed an evaluation and rating matrix. One item classified was the probability (likelihood) of a hazard resulting in an accident. The second item classified was the severity (consequences) of a hazard. Each was classified premitigation and postmitigation.

Figure 3. Rating matrix for rating hazards premitigation and postmitigation.

							Severity						
							No effect no damage	No lost time injury Minor damage	Loss time injury Damage ≤ 3 days	Serious injury Major Damage	Death Loss of Aircraft		
							Very Low	Low	Moderate	High	Extreme		
		Flights	Hrs	Probability			1	3	9	12	15	Rating	
Prob. or Sign.	10 yrs	2500	5000	**Very Low**		1	2	4	10	13	16	Extreme	
	2 yr	500	1000	**Low**		2	3	5	11	14	17	High	
	4 mo	250	500	**Moderate**		3	4	6	12	15	18	Moderate	
	1 wk	15	30	**High**		4	5	7	13	16	19	Low	
	daily	2	4	**Extreme**		5	6	8	14	17	20	Very Low	

The classifications and the resultant rating matrix is shown in figure 3. The experts assigned a numeric value to each classification. The sum of these two numbers became the score for each combination of probability and severity. The experts structured the scores into five rating classes shown in figure 4.

Figure 4. Scores defining the ratings.

Score	Rating	
15-20	Extreme	
12-14	High	
7-11	Moderate	
5-6	Low	
2-4	Very Low	

Next, the experts were asked to develop estimates for the costs to implement each mitigation measure. Some measures can be implemented with minimal-to-no cost and some measures might require millions of dollars. The benefit of implementing a mitigation measure was determined by the reduction of risk-rating classes that was achieved. For example, if the mitigation measure resulted in a reduction of three or four risk rating classes, the benefit was classified as substantial improvement or very high. The classifications and the rating matrix is shown in figure 5.

Figure 5. Rating matrix for costs and benefits premitigation and postmitigation.

					Severity Levels Reduced					
					0	1	2	3 or 4		
					Benefit					
					No Improvement	Moderate Improvement	Significant Improvement	Substancial Improvement		
					Low	Moderate	High	Very High		
					1	3	6	8	Rating	
Cost	**>$1,000,000**	Very High		1	2	4	7	9	Best	
	$100,000 - $1,000,000	High		2	3	5	8	10	Better	
	$10,000-$100,000	Moderate		3	4	6	9	11	Good	
	<$10,000	Low		4	5	7	10	12	Minimal	

The experts assigned a numeric value to each classification. The sum of these two numbers became the score for each combination of benefit and cost. The experts structured the scores in four rating classes as shown in figure 6.

Figure 6. Scores defining the ratings.

Score	B/C Rating
10-12	Best
7-9	Better
4-6	Good
2-3	Minimal

Rating of Hazards and Mitigation Measures with Benefits and Costs

A listing of the hazards and mitigation measures follow in tables 1 through 5, including ratings for premitigation, postmitigation, and benefit/cost.

Table 1 - Aircraft Night

Aircraft System														
			Pre-mitigation					Post-mitigation			Benefit-Cost		
Sub-System	ID	Hazards	Prob	Severity	Rating	ID	Mitigation	Prob	Severity	Rating	Cost	Benefit	Rating
Capability	A1	Aircraft lighting not certified for night operations	High	High	Extreme	A1M1	Develop and implement specifications for interior and exterior aircraft lighting modifications, which are compatible with class B night vision equipment.	Very Low	Moderate	Moderate	Moderate	High	Better
						A1M2	*Only use aircraft that are modified for night vision goggle operations using manufacturer's authorized modifications or supplemental type certificate.*	Low	Moderate	Moderate	Moderate	High	Better
Visibility	A2	Aircraft impacting terrain or other obstacles at night due to lack of incorporating available technology. Increased cockpit workload based on night operations diverting the pilot's attention.	High	High	Extreme	A2M1	Review and implement available technology to provide the pilot with situational awareness.	Low	Moderate	Moderate	Very High	High	Better
						A2M2	Investigate current and future integrated cockpit and night vision goggle technology to reduce pilot workload for situational awareness.	Low	Moderate	Moderate	Low	High	Best
						A2M3	Utilize and procure an ergonomic specialist to review cockpit configuration, pilot workload and survivability.	Low	Low	Low	Moderate	Very High	Best
						A2M4	Develop and integrate simulator system consistent with applicable technology for pilot training.	Very Low	Very Low	Very Low	High	Very High	Best
	A3	Inability to distinguish between specific aircraft at night may result in the misidentification of aircraft at or around landing zones	High	High	Extreme	A3M1	Investigate and implement as appropriate the expansion of automated flight following technology for the cockpit and the ground, which would identify specific aircraft in the fire airspace and assist with airspace de-confliction.	Low	Moderate	Moderate	Very High	High	Better
						A3M2	Incorporate existing automated flight following technology into operational planning with shorter aircraft reporting duration.	Very Low	Low	Low	Low	Very High	Best
	A4	Current technology does not identify individual aircraft to personnel in the command aircraft.	High	High	Extreme	A4M1	Investigate and implement as appropriate external aircraft identification application.	Low	Low	Low	Low	Very High	Best
						A4M2	Investigate and design a command aircraft (fixed wing, rotor wing or ground based) module that incorporates existing identification technology for a multiple person crew.	Very Low	Low	Very Low	Moderate	Very High	Best
	A5	Reduced pilot visual acuity and field of view when operating at night	High	High	Extreme	A5M1	Utilize night vision goggle and thermal technology.	Low	Moderate	Moderate	Very High	High	Better
						A5M2	Ensure initial and recurrent training addresses night vision equipment utilization and techniques.	Low	Moderate	Moderate	Moderate	High	Better
						A5M3	Implement available night vision goggle calibration and focusing technology before each operational period.	Low	Moderate	Moderate	Low	High	Best
	A6	Inability to distinguish color of objects at night.	Moderate	Moderate	High	A6M1	Have personnel review, educate and change operations that rely on recognition of color during the day.	Low	Low	Low	Low	High	Best
	A7	Inability to identify changing meteorological and illumination conditions.	High	High	Extreme	A7M1	Educate and equip fire weather meteorologists to support the night flying mission. System will report the forecast to the pilot.	Low	Moderate	Moderate	Moderate	High	Better
						A7M2	Educate pilot to recognize indicators of changing weather conditions when using night vision goggle.	Low	Low	Low	Low	Very High	Best
						A7M3	Implement broadcast weather and illumination updates. (i.e. automated surface observation system)	Low	Low	Low	High	Very High	Best
						A7M4	Educate ground personnel to relay to pilots any changing weather conditions	Low	Low	Low	Low	Very High	Best

Table 1 - Aircraft Night

Aircraft System														
			Pre-mitigation				Mitigation	Post-mitigation			Benefit-Cost		
Sub-System	ID	Hazards	Prob	Severity	Rating	ID		Prob	Severity	Rating	Cost	Benefit	Rating
Inspection	A8	Untrained maintenance, avionics and pilot inspectors for the night operations resulting in loss of mission or aircraft.	High	Extreme	Extreme	A8M1	Require maintenance, avionics and pilot inspectors to become qualified and attend approved manufacturer's training.	Low	Low	Low	High	Very High	Best
						A8M2	Develop a specification for night operations equipment maintenance.	Low	Low	Low	Low	Very High	Best
						A8M3	Develop the qualifications, certification and carding system for the maintenance, avionics and pilot inspectors.	Low	Low	Low	Low	Very High	Best
	A9	There is no program or process to support an aviation life support equipment program resulting in loss of mission capability.	High	High	Extreme	A9M1	Review current organizational staffing levels and add night operations maintenance and avionics inspector positions as needed to build the aviation life support equipment staff.	Low	Low	Low	High	Very High	Best
	A10	There is no quality assurance program for additional night operations projects. No Forest Service standards exist to inspect or measure agency or vendor audits.	Extreme	Extreme	Extreme	A10M1	Establish a quality assurance program for night operations.	Low	Moderate	Moderate	High	High	Better
						A10M2	Develop standards based on industry best practices.	Low	Moderate	Moderate	Low	High	Best
						A10M3	Charter a Forest Service night operations working group.	Low	Moderate	Moderate	Low	High	Best
						A10M4	Charter a night operation work group under the national interagency aviation committee task group.	Low	Moderate	Moderate	Low	High	Best
						A10M5	Ensure the quality assurance program addresses maintenance, inspection and equipment subsystems.	Low	Low	Low	Low	Very High	Best
	A11	The flight crew is more likely to miss a preflight item at night.	Moderate	Moderate	High	A11M1	Incorporate night preflight checklist items in training and require the use of defined procedures and equipment.	Low	Low	Low	Low	High	Best
Equipment	A12	Aircraft used in night operations not modified with the proper equipment.	High	High	Extreme	A12M1	Do not use aircraft that are not equipped to Forest Service standards.	Very Low	Low	Very Low	Low	Very High	Best
	A13	Introduction of hoist operations at night without prior implementation during the day.	Extreme	Extreme	Extreme	A13M1	The agency needs to perform and implement a detailed risk assessment and program planning on this mission.	Low	Moderate	Moderate	High	High	Better
						A13M2	Develop and implement hoist program during day concurrently with a night program.	Low	Moderate	Moderate	Very High	High	Better
	A14	Difficulty to identify cockpit switchology during normal and emergency operations.	High	High	Extreme	A14M1	The agency must identify and implement the complexity of the mission to determine the crew composition.	Low	Moderate	Moderate	Low	High	Best
						A14M2	Implement crew resource management training to include night operations.	Low	Moderate	Moderate	Moderate	High	Better
						A14M3	Provide specifications on standardized equipment layout in the cockpit.	Low	Low	Low	Low	Very High	Best
						A14M4	Incorporate a helicopter evaluation board for night operations. (Similar to smokejumper aircraft screening and evaluation board).	Low	Low	Low	High	Very High	Best
Maintenance	A15	Due to time compression, maintenance items may be missed or not done correctly. Lack of available time to perform aircraft maintenance during 24-hour operations.	High	High	Extreme	A15M1	Program design should ensure adequate staffing and appropriate time allotted.	Low	Low	Low	High	Very High	Best
						A15M2	Managers will ensure adequate staffing and time to perform scheduled maintenance.	Low	Low	Low	Low	Very High	Best

Table 2 - Facilities Night

Facilities System

Sub-System	ID	Hazards	Pre-mitigation Prob	Pre-mitigation Severity	Pre-mitigation Rating	ID	Mitigation	Post-mitigation Prob	Post-mitigation Severity	Post-mitigation Rating	Benefit-Cost Cost	Benefit-Cost Benefit	Benefit-Cost Rating
Communications	F1	Non-essential communication diverts pilot attention in the increased workload of the night operations	High	Low	Moderate	F1M1	Define and implement opportunities where technology or equipment can replace verbal communication.	Moderate	Low	Low	Moderate	Moderate	Good
						F1M2	Incorporate and reinforce brevity in verbal radio communications during training and briefings.	Low	Low	Low	Low	Moderate	Better
	F2	Marshalling ground procedures are different between the day and night	High	Moderate	High	F2M1	Develop and implement nighttime procedures.	Low	Low	Low	Low	High	Best
	F3	Lack of technology for air traffic separation at night in the absence of aerial supervision.	Moderate	Extreme	Extreme	F3M1	Designate egress and ingress routes, check points.	Low	Moderate	Moderate	Low	High	Best
						F3M2	Ensure automated flight following technology is available to helibase personnel	Low	Moderate	Moderate	Very High	High	Better
Environment	F4	Permanent and temporary helibase facilities are not compliant with night operations (Note: Need for Class B - takeoff minimums).	High	High	Extreme	F4M1	*Develop and implement night operations facility standards including lighting.*	Low	Moderate	Moderate	Low	High	Best
	F5	Lack of adequate sleeping facilities for crews staffed at night and resting in the daytime.	High	Moderate	High	F5M1	Ensure and implement proper environmentally controlled crew rest facilities.	Low	Low	Low	Low	High	Best
	F6	Lack of familiarity of the base if not seen during the daytime.	High	Moderate	High	F6M1	Require flight crews to see the helibase and fly the incident during the day. This activity will not affect the duty day.	Low	Low	Low	Low	High	Best
	F7	Inability to see night flying critters and animals in the landing zone.	Low	Moderate	Moderate	F7M1	Brief pilot of possible presence of owls, bats, migratory bird paths, etc. prior to flying.	Low	Moderate	Moderate	Low	Low	Good
						F7M2	Brief ground personnel on the need for security at the landing zone.	Very Low	Low	Very Low	Low	High	Best

Table 3 - Technology Night

Technology System

Sub-System	ID	Hazards	Pre-mitigation Prob	Pre-mitigation Severity	Pre-mitigation Rating	ID	Mitigation	Post-mitigation Prob	Post-mitigation Severity	Post-mitigation Rating	Benefit-Cost Cost	Benefit-Cost Benefit	Benefit-Cost Rating
Utilization	T1	Automated flight following is currently not a supported system within the agency or National Wildfire Coordinating Group.	Moderate	Moderate	High	T1M1	Make the existing automated flight following application an agency corporate application or locate a new one.	Low	Low	Low	Very High	High	Better
	T2	Inability to identify ground target.	High	Moderate	High	T2M1	Investigate, develop and implement technology and tactics for air and ground such as infrared and laser technology. Ensure all equipment is eye safe.	Low	Low	Low	High	High	Better
	T3	Inadequate execution of night technology life cycle replacement.	High	Low	Moderate	T3M1	Develop and implement a life cycle equipment program for both government and vendors.	Low	Low	Low	Low	Moderate	Better
	T4	Inappropriate or excessive weight of hardware in the helicopter.	Moderate	Low	Low	T4M1	Do a benefit versus weight and complexity analysis for all hardware.	Low	Low	Low	Low	Low	Good
	T5	New technology may not be compatible with legacy equipment.	Moderate	Moderate	High	T5M1	Ensure new equipment is engineered for compatibility with legacy equipment.	Low	Low	Low	Low	High	Best
	T6	NVG provide limited depth perception.	Extreme	Moderate	High	T6M1	Develop and implement techniques used by other agencies to perform this activity.	Low	Low	Low	Low	High	Best
Maintenance	T7	Inadequate execution of maintenance and preflight of night vision goggles	Moderate	High	Extreme	T7M1	Ensure that quality assurance and safety personnel are in place to review and improve maintenance processes and procedures.	Low	Moderate	Moderate	Very High	High	Better
Human Factors	T8	The current level of fatalities in helicopter crashes is from human error. Night operations will increase exposure to the flight crew.	High	High	Extreme	T8M1	Implement unmanned aerial system as appropriate.	Low	Low	Low	Very High	Very High	Better
						T8M2	Implement pre-mission electronic operational risk analysis (iPAD™).	Low	Moderate	Moderate	Low	High	Best

Table 4 - Personnel Night

Personnel System														
			Pre-mitigation				Mitigation	Post-mitigation			Benefit-Cost		
Sub-System	ID	Hazards	Prob	Severity	Rating	ID		Prob	Severity	Rating	Cost	Benefit	Rating
Utilization	P1	Understaffing and under managing night mission operations. Inability to retain experienced and qualified personnel for night missions.	High	High	Extreme	P1M1	Define and implement the night operations program to address the mission, staffing, retention, organization, procedures, logistics, support, policy, training, facilities and operational control.	Low	Moderate	Moderate	Very High	High	Better
						P1M2	Assign a National night operations project leader.	Low	Low	Low	Very High	Very High	Better
	P2	Lack of coordination and standardization with other agency cooperators.	High	High	Extreme	P2M1	Assign a National night operations project leader to coordinate interagency personnel and cooperators. Position will take the lead for Forest Service night operations working group.	Low	Moderate	Moderate	Moderate	High	Better
	P3	Lack of knowledgeable and experienced night operations government contract administrators.	High	Moderate	High	P3M1	Staff and train night operations government contract administrators.	Low	Low	Low	High	High	Better
						P3M2	Do a needs analysis to determine the adequate number of night operations government contract administrators.	Low	Low	Low	Low	High	Best
	P4	Vendor personnel lacks experience in night firefighting in mountainous terrain.	High	High	Extreme	P4M1	Develop a standard for night operations and firefighting operations.	Low	Moderate	Moderate	Low	High	Best
	P5	Lack of vendor knowledge and experience with night vision contract specifications.	High	High	Extreme	P5M1	Specifications, which fully define the night vision equipment requirements, need to be developed and transmitted to vendors.	Low	Low	Low	Low	Very High	Best
	P6	The helicopter contract does not require a SMS program for the vendor. The Federal Aviation Administration requires a system safety managment program for vendors starting in 2012.	Extreme	Moderate	High	P6M1	Develop and incorporate a safety management system specification in all contracts.	Low	Moderate	Moderate	Low	Moderate	Better
	P7	Operational protocols are not standardized and adhered to for nighttime operations at and around landing zones.	High	High	Extreme	P7M1	Develop and implement standards and protocols for interagency and cooperator operations.	Low	Moderate	Moderate	High	High	Better
						P7M2	Ensure interagency and cooperators are involved with agency working groups and committees.	Low	Low	Low	Low	Very High	Best
Policy	P8	Not adhering to night operations policy results in hazardous practices.	High	High	Extreme	P8M1	Assign supervision and oversight to ensure compliance during night operations.	Low	Moderate	Moderate	Low	High	Best
						P8M2	Brief and monitor compliance by overhead teams	Low	Moderate	Moderate	Low	High	Best
						P8M3	Incident personnel must perform an operational risk assessment on night operations.	Low	Low	Low	Low	Very High	Best
	P9	Night operations is not listed in the helicopter pilot practical test standards.	Extreme	High	Extreme	P9M1	Task Washington Office to develop practical test standard.	Low	Moderate	Moderate	Low	High	Best
	P10	The current visual flight rule requirement of 1500 hours is not adequate for the complexity of the night mission.	High	Moderate	High	P10M1	Explore industry minimum pilot flight time standards for night operations and establish agency minimum flight time requirements for night vision goggle missions.	Low	Low	Low	Low	High	Best
Training	P11	Lack of management support for maintaining a high level night vision goggle competency.	High	High	Extreme	P11M1	Provide adequate management support for maintaining a high level of night vision goggle competency.	Low	Moderate	Moderate	Low	High	Best
	P12	Staffing with unqualified or non-current personnel.	High	High	Extreme	P12M1	Staff all systems with qualified and current personnel.	Low	Moderate	Moderate	Low	High	Best
	P13	Primary and relief flight crews as well as crewmembers (contract/government mix) that have not worked with each other at night.	High	Moderate	High	P13M1	Ensure flight crews and crewmembers have trained and operated together.	Low	Moderate	Moderate	Low	Moderate	Better

Table 4 - Personnel Night

Personnel System													
			Pre-mitigation					Post-mitigation			Benefit-Cost		
Sub-System	ID	Hazards	Prob	Severity	Rating	ID	Mitigation	Prob	Severity	Rating	Cost	Benefit	Rating
Training	P14	Lack of a night simulation exercise facility.	Extreme	Moderate	High	P14M1	Develop and integrate nighttime simulation system for flight crew, crewmembers and incident management personnel.	Low	Low	Low	High	High	Better
						P14M2	Ensure the simulation and the simulator keeps pace with new technology.	Low	Low	Low	Moderate	High	Better
	P15	Inconsistent night vision goggle training and inspection by vendors.	High	High	Extreme	P15M1	Develop a training standard and implement in contracts.	Low	Moderate	Moderate	Low	High	Best
Human Factors	P16	Disruption of circadian cycle for personnel performing night operations.	High	High	Extreme	P16M1	Develop standards and procedures to ensure well-rested night operations personnel. Develop and implement standards and procedures.	Low	Moderate	Moderate	Low	High	Best
						P16M2	Gather and apply latest research on fatigue related to aviation operations.	Low	Moderate	Moderate	Low	High	Best
	P17	Pilot's overreliance on the use of technology and improper interface with automation.	Moderate	High	Extreme	P17M1	Ensure automation airmanship training is taken by flight crews.	Low	Moderate	Moderate	Low	High	Best
	P18	Pilot's lack of familiarity of local operating terrain increases risk of controlled flight into terrain and other operating procedures.	High	High	Extreme	P18M1	Develop and implement National electronic based flight hazard maps. (See F6M1).	Low	Moderate	Moderate	Very High	High	Better
	P19	The inability for a VFR-rated pilot to perform a night inadvertent instrument meteorological condition recovery or brownout recovery.	High	High	Extreme	P19M1	Require all night operations pilots to be commercial/ATP instrument rated and trained in brownout and whiteout conditions.	Low	Moderate	Moderate	Low	High	Best
	P20	Vendor/pilot accepts unnecessary additional risk for monetary gain.	High	High	Extreme	P20M1	Nighttime air operations personnel continually re-evaluate decisions at the appropriate level. Apply risk management principles from Interagency Helicopter Operations Guide Chapter 3.	Low	Moderate	Moderate	Low	High	Best

Table 5 - Operations Night

Operations System

Sub-System	ID	Hazards	Pre-mitigation Prob	Pre-mitigation Severity	Pre-mitigation Rating	ID	Mitigation	Post-mitigation Prob	Post-mitigation Severity	Post-mitigation Rating	Benefit~Cost Cost	Benefit~Cost Benefit	Benefit~Cost Rating
Mission	H1	Low-level military, homeland security and law enforcement night operations encroaching on fire operations.	Moderate	Moderate	High	H1M1	Educate the community about Forest Service intent to conduct night operations.	Low	Moderate	Moderate	Low	Moderate	Better
						H1M2	Ensure the use of temporary flight restrictions where appropriate.	Low	Moderate	Moderate	Low	Moderate	Better
						H1M3	Reaffirm dispatcher and airspace coordinator's responsibility to de-conflict military training routes.	Low	Moderate	Moderate	Low	Moderate	Better
Management Decisions	H2	Implementation of the night operations program without establishment of standards.	Extreme	Extreme	Extreme	H2M1	Establish and follow policy, guidelines and direction prior to implementation.	Low	Moderate	Moderate	Low	High	Best
	H3	Lack of definition and direction of use of night operations capability in non-wildfire missions.	High	High	Extreme	H3M1	Ensure that all missions are clearly defined and approved by management prior to implementation (mission creep). Collaborate with other program managers such as law enforcement.	Low	Moderate	Moderate	Low	High	Best
Utilization	H4	Under utilization of helicopter due to excessive risk avoidance leads to a reduction in competency, proficiency and program degradation.	High	High	Extreme	H4M1	Utilize program when appropriate criteria has been met.	Low	Moderate	Moderate	Low	High	Best
						H4M2	Define an effectiveness measures program.	Low	Low	Low	Low	Very High	Best
						H4M3	Implement a routine proficiency training program.	Low	Moderate	Moderate	High	High	Better
Environment	H5	Inadequate ambient light illumination to see and avoid obstacles.	Extreme	High	Extreme	H5M1	Establish minimum illumination value and night weather minimums for night operations.	Low	Moderate	Moderate	Low	High	Best
Communications	H6	Lack of effective communication of the Chief's intent and strategy for night operations.	High	Moderate	High	H6M1	Develop a communications and marketing plan for distribution to the field.	Low	Low	Low	Low	High	Best
Training	H7	Lack of training of incident command personnel on how to use night operations.	High	High	Extreme	H7M1	Ensure incident command personnel receive training on the requirements and best practices of night operations.	Low	Moderate	Moderate	Moderate	High	Better
	H8	Transition by pilot from night vision goggles to night unaided flight profiles	Moderate	Moderate	High	H8M1	Ensure training specification incorporates transition from aided to unaided environment.	Low	Moderate	Moderate	Low	Moderate	Better
	H9	Night visual illusions may result in controlled flight into terrain .	Moderate	High	Extreme	H9M1	Educate the flight crewmembers on the night visual illusions.	Low	Moderate	Moderate	Low	High	Best
Water and Retardanr Dropping Using a Fixed Tank with Ground Fill	H10	Impacting ground personnel with the drop.	Moderate	Low	Low	H10M1	Develop procedures such as dry runs, utilization of sirens, ensuring the drop zone is clear, etc. to ensure ground personnel will not be impacted.	Low	Low	Low	Low	Low	Good
						H10M2	Investigate and implement as appropriate illumination equipment for ground personnel and add to the aviation life support equipment handbook.	Low	Low	Low	High	Low	Minimal
	H11	Use of non-standardized equipment (tanks, includes cooperators and military, different couplings, etc.).	Moderate	Low	Low	H11M1	Define and implement standards for all water and retardant equipment.	Very Low	Very Low	Very Low	Low	Moderate	Better
						H11M2	Communicate standards to cooperators and military	Very Low	Very Low	Very Low	Low	Moderate	Better
	H012	Overloading the aircraft with water or retardant from ground filling.	Moderate	Moderate	High	H12M1	Investigate and implement equipment and procedures associated with tank filling.	Low	Low	Low	Moderate	High	Better
	H13	Increased number of landing and takeoffs.	High	Moderate	High	H13M1	Utilize approved helibases and helispots.	Low	Moderate	Moderate	Low	Moderate	Better

Table 5 - Operations Night

Operations System														
			Pre-mitigation					Post-mitigation			Benefit-Cost		
Sub-System	ID	Hazards	Prob	Severity	Rating	ID	Mitigation	Prob	Severity	Rating	Cost	Benefit	Rating
Water and Retardanr Dropping Using a Fixed Tank with Ground Fill	H14	*Failure of ground facilities to keep up with the turn rate for the helicopter can create an airspace coordination issue.*	Moderate	Moderate	High	H14M1	Each helicopter will have its own assigned pad.	Low	Low	Low	Low	High	Best
						H14M2	Establish fill capabilities at each pad.	Low	Low	Low	Moderate	High	Better
						H14M3	Identify the maximum number of helicopters from a helibase or helispot for nighttime ground fill operations.	Low	Low	Low	Low	High	Best
	H15	Increase traffic to the ground support system (Transferred Risk)	High	Moderate	High	H15M1	Establish a transportation plan for ground support vehicles.	Low	Moderate	Moderate	Low	Moderate	Better
						H15M2	Attempt to locate helibases and helispots to where hydrants or water sources can be used to eliminate water tender traffic.	Low	Low	Low	Low	High	Best
	H16	Increased workload for single pilot operations at night	High	High	Extreme	H16M1	Ensure the aerial supervisor is night vision goggle qualified.	Low	Moderate	Moderate	High	High	Better
Aerial Supervision (Fixed Wing)	H17	Increased difficulty of emergency landing of aircraft at night	Moderate	High	Extreme	H17M1	Utilize multi-engine airplane.	Low	Low	Low	Low	Very High	Best
	H18	Increased difficulty to locate ground resources and identify targets.	High	Moderate	High	H18M1	Consider use of a helicopter.	Low	Low	Low	Low	High	Best
Aerial Supervision (Rotor Wing)	H19	Limited fuel load can affect other tactical missions.	Moderate	Low	Low	H19M1	Use of auxiliary tanks on the helicopter.	Low	Low	Low	Moderate	Low	Good
Hoist for Emergency Medical Transport	H20	Inability to see vegetation that could snag the basket.	Moderate	High	Extreme	H20M1	Utilize a crewmember monitoring the hoist to talk to the pilot.	Low	Moderate	Moderate	Low	High	Best
						H20M2	Develop and implement techniques used by other agencies to perform this activity.	Low	Moderate	Moderate	Low	High	Best
						H20M3	Utilize a light to illuminate the scene.	Low	Moderate	Moderate	High	High	Better
	H21	The difficulty to maintain a stabilized hover causing drift.	High	High	Extreme	H21M1	Utilize current technology to assist stabilizing hover operations.	Low	Moderate	Moderate	High	High	Better
						H21M2	Establish and meet a currency and proficiency requirement.	Low	Moderate	Moderate	High	High	Better
						H21M3	Utilize specialized crew resource management for this mission.	Low	Moderate	Moderate	Low	High	Best
	H22	Vegetation and ground objects dislodged by rotor wash.	Moderate	Moderate	High	H22M1	Ensure proper training of ground personnel to hazards and site preparation.	Low	Moderate	Moderate	Low	Moderate	Better
						H22M2	Minimize the number of ground personnel under the aircraft and down slope.	Low	Moderate	Moderate	Low	Moderate	Better
	H23	Pilot engaged in emergency response and losing situational awareness.	Moderate	High	Extreme	H23M1	Analyze emergency medical services accident and lessons learned and develop a training program to include crew resource managment.	Low	Moderate	Moderate	Low	High	Best
	H24	A conscious decision abandoning the go/no go checklist because of an emergency mission.	Moderate	High	Extreme	H24M1	Develop a mission specific go/no go checklist. Train to the mission.	Low	Moderate	Moderate	Low	High	Best
	H25	There is a potential overutilization of the mission due to over triage of injured person. Transferred Risk: Relying on the EMT tool resulting in the placement of personnel in riskier places.	High	Moderate	High	H25M1	Develop and implement a national standard for levels of emergency medical service response.	Moderate	Moderate	High	Moderate	Low	Good

Table 5 - Operations Night

Operations System														
			Pre-mitigation				Mitigation	Post-mitigation			Benefit-Cost		
Sub-System	ID	Hazards	Prob	Severity	Rating	ID		Prob	Severity	Rating	Cost	Benefit	Rating
Aerial Ignition with Plastic Sphere Dispenser	H26	The potential for a sphere to land outside the fireline is higher at night.	Moderate	Low	Low	H26M1	Utilize technology to identify the fireline.	Low	Low	Low	Low	Low	Good
						H26M2	Utilize ground personnel to fire out the perimeter.	Low	Low	Low	Low	Low	Good
	H27	Inadequate lighting in the back of the helicopter to support the duties of the plastic sphere dispenser operator.	High	Low	Moderate	H27M1	Provide adequate and compatible lighting.	Low	Low	Low	Low	Moderate	Better
	H28	The current training requirements for the plastic sphere dispenser operator and firing boss may not be adequate for night operation	High	Moderate	High	H28M1	Define the minimum requirements for night operations.	Low	Low	Low	Low	High	Best
						H28M2	Ensure plastic sphere dispenser operator and firing boss are trained to night operations standards.	Low	Low	Low	High	High	Better
	H29	Inability to maintain security of the burn project area.	Moderate	Moderate	High	H29M1	Prior to ignition, utilize the public address system and radio to announce the mission intention.	Low	Low	Low	Low	High	Best
						H29M2	Confirm with ground personnel that the target area is clear.	Low	Low	Low	Low	High	Best
						H29M3	Ensure that the briefing discusses burnout operations.	Low	Low	Low	Low	High	Best

Table 6 summarizes the number of post-mitigation ratings by rating class.

Table 6. Summary of number of hazards and mitigation measures by rating.

System	Number of Hazards	Number of Mitigation Measures	Number of Mitigation Measures Rated Postmitigation				
			Very Low	Low	Moderate	High	Extreme
Aircraft	15	37	3	17	17	0	0
Facilities	7	10	1	5	4	0	0
Personnel	20	27	0	9	18	0	0
Technology	8	9	0	7	2	0	0
Operations	29	47	2	20	24	1	0
Total	79	130	6	58	65	1	0

Considerations for Implementing Mitigation Measures

Risk cannot be eliminated entirely even when highly effective mitigation measures are used. After these mitigation measures are designed but before the system is placed back online, an assessment must be made determining whether the mitigation measures are likely to be effective and/or if they introduce new hazards to the system. Residual risk is defined as the risk remaining after mitigation is implemented. Substitute risk is defined as any hazard that is introduced by a mitigation effort. Implementation considerations include a discussion of the following:

- Ease of introduction; i.e., will this measure be difficult to introduce?
- Acceptance; i.e., will users and management accept this measure?
- Durability; i.e., will this measure stand the test of time?
- Enforceability; i.e., will the measure be implemented?
- Expanded effect; i.e., could implementation of this measure change standards?
- Time to implement from time of adoption; i.e., it could be an immediate implementation (1 month or less), short-term (1 to 6 months), long-term period (6 months to 1 year) or extended period (greater than 1 year).

Effectiveness of the mitigation measure is addressed in the comparison of premitigation and postmitigation ratings. In table 7, each mitigation measure is listed with residual risk, substitute risk, and implementation considerations.

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
<u>Aircraft Night System</u>			
A1M1	Develop and implement specifications for interior and exterior aircraft lighting modifications, which are compatible with class B night vision equipment.	None anticipated	None anticipated
A1M2	Only use aircraft that are modified for night vision goggle operations using manufacturer's authorized modifications or supplemental type certificate.	None anticipated	None anticipated
A2M1	Review and implement available technology to provide the pilot with situational awareness.	Introduction of new technology/automation may introduce new errors	Automation airmanship training
A2M2	Investigate current and future integrated cockpit and night vision goggle technology to reduce pilot workload for situational awareness.	Technology/automation may introduce new errors. Implement change management.	Automation airmanship training and change management training
A2M3	Utilize and procure an ergonomic specialist to review cockpit configuration, pilot workload and survivability.	None anticipated	None anticipated
A2M4	Develop and integrate simulator system consistent with applicable technology for pilot training.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
A3M1	Investigate and implement as appropriate the expansion of automated flight following technology for the cockpit and the ground, which would identify specific aircraft in the fire airspace and assist with airspace de-confliction.	None anticipated	None anticipated
A3M2	Incorporate existing automated flight following technology into operational planning with shorter aircraft reporting duration.	None anticipated	None anticipated
A4M1	Investigate and implement as appropriate external aircraft identification application.	None anticipated	None anticipated
A4M2	Investigate and design a command aircraft (fixed wing, rotor wing or ground based) module that incorporates existing identification technology for a multiple person crew.	None anticipated	None anticipated
A5M1	Utilize night vision goggles and thermal technology.	Technology limitations	Proper and continuous training
A5M2	Ensure initial and recurrent training addresses night vision equipment utilization and techniques.	None anticipated	None anticipated
A5M3	Implement available night vision goggle calibration and focusing technology before each operational period.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
A6M1	Have personnel review, educate and change operations that rely on recognition of color during the day.	None anticipated	None anticipated
A7M1	Educate and equip fire weather meteorologists to support the night flying mission. System will report the forecast to the pilot.	None anticipated	None anticipated
A7M2	Educate pilot to recognize indicators of changing weather conditions when using night vision goggles.	None anticipated	None anticipated
A7M3	Implement broadcast weather and illumination updates. (i.e., automated surface observation system)	None anticipated	None anticipated
A7M4	Educate ground personnel to relay to pilots any changing weather conditions	None anticipated	None anticipated
A8M1	Require maintenance, avionics and pilot inspectors to become qualified and attend approved manufacturer's training.	None anticipated	None anticipated
A8M2	Develop a specification for night operations equipment maintenance.	None anticipated	None anticipated
A8M3	Develop the qualifications, certification and carding system for the maintenance, avionics, and pilot inspectors.	Develop quality assurance process to ensure inspectors remain current and proficient	Essential number of flight hours for familiarization, training, mission involvement

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
A9M1	Review current organizational staffing levels and add night operations maintenance and avionics inspector positions as needed to build the aviation life support equipment staff.	Fatigue: None. Aviation positions require proper oversight for duty cycle management.	Ensure proper/appropriate rest locations, times, work cycles
A10M1	Establish a quality assurance program for night operations.	None anticipated	None anticipated
A10M2	Develop standards based on industry best practices.	None anticipated	None anticipated
A10M3	Charter a Forest Service night operations working group.	None anticipated	None anticipated
A10M4	Charter a night operations working group under the national interagency aviation committee task group.	None anticipated	None anticipated
A10M5	Ensure the quality assurance program addresses maintenance, inspection, and equipment subsystems.	None anticipated	None anticipated
A11M1	Incorporate night preflight checklist items in training and require the use of defined procedures and equipment.	None anticipated	None anticipated
A12M1	Do not use aircraft that are not equipped to Forest Service standards.	None anticipated	None anticipated
A13M1	The agency needs to perform and implement a detailed risk assessment and program planning on this mission.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
A13M2	Develop and implement hoist program during day concurrently with a night program.	New program to the agency, cooperators or existing rescue units may be called upon to fill this requirement.	Ensure rescue resource meets all Forest Service standards for safety, training, and operations.
A14M1	The agency must identify and implement the complexity of the mission to determine the crew composition.	An unfamiliar area of operation requiring a "testing" phase to develop standards.	Build best practices standards from military, agencies and organizations currently conducting night operations.
A14M2	Implement crew resource management training to include night operations.	None anticipated	None anticipated
A14M3	Provide specifications on standardized equipment layout in the cockpit.	None anticipated	None anticipated
A14M4	Incorporate a helicopter evaluation board for night operations. (Similar to smokejumper aircraft screening and evaluation board).	None anticipated	None anticipated
A15M1	Program design should ensure adequate staffing and appropriate time allotted.	None anticipated	None anticipated
A15M2	Managers will ensure adequate staffing and time to perform scheduled maintenance.	None anticipated	None anticipated
<u>Facilities Night System</u>			
F1M1	Define and implement opportunities where technology or equipment can replace verbal communication.	Communication errors	Clear, simple, and thorough training on nonverbal communications, technology, and equipment

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
F1M2	Incorporate and reinforce brevity in verbal radio communications during training and briefings.	None anticipated	None anticipated
F2M1	Develop and implement nighttime procedures.	None anticipated	None anticipated
F3M1	Designate egress and ingress routes, check points.	None anticipated	None anticipated
F3M2	Ensure automated flight following technology is available to helibase personnel.	None anticipated	None anticipated
F4M1	Develop and implement night operations facility standards including lighting.	None anticipated	None anticipated
F5M1	Ensure and implement proper environmentally controlled crew rest facilities.	None anticipated	None anticipated
F6M1	Require flight crews to see the helibase and fly the incident during the day. This activity shall not affect the duty day.	None anticipated	None anticipated
F7M1	Brief pilot of possible presence of owls, bats, migratory bird paths, etc. prior to flying.	None anticipated	None anticipated
F7M2	Brief ground personnel on the need for security at the landing zone.	Unknown security personnel may present a risk to the aircraft.	Ensure security is reputable and reliable.

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
Personnel Night System			
P1M1	Define and implement the night operations program to address the mission, staffing, retention, organization, procedures, logistics, support, policy, training, facilities, and operational control.	Implementing the program without fully developing the program.	Assign minimum milestones as required checkpoints prior to implementation.
P1M2	Assign a national night operations project leader.	None anticipated	None anticipated
P2M1	Assign a national night operations project leader to coordinate interagency personnel and cooperators. Position will take the lead for Forest Service night operations working group.	None anticipated	None anticipated
P3M1	Staff and train night operations government contract administrators.	None anticipated	None anticipated
P3M2	Do a needs analysis to determine the adequate number of night operations government contract administrators.	None anticipated	None anticipated
P4M1	Develop a standard for night operations and firefighting operations.	None anticipated	None anticipated
P5M1	Specifications, which fully define the night vision equipment requirements, need to be developed and transmitted to vendors.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
P6M1	Develop and incorporate a safety management system specification in all contracts.	None anticipated	None anticipated
P7M1	Develop and implement standards and protocols for interagency and cooperator operations.	None anticipated	None anticipated
P7M2	Ensure interagency and cooperators are involved with agency working groups and committees.	None anticipated	None anticipated
P8M1	Assign supervision and oversight to ensure compliance during night operations.	None anticipated	None anticipated
P8M2	Brief and monitor compliance by overhead teams.	None anticipated	None anticipated
P8M3	Incident personnel must perform an operational risk assessment on night operations.	Incident personnel filling out paperwork without fully developing the risk assessment	Ensure incident personnel understand the importance of the operational risk assessment process.
P9M1	Task Washington Office to develop practical test standard.	None anticipated	None anticipated
P10M1	Explore industry minimum pilot flight time standards for night operations and establish agency minimum flight time requirements for night vision goggle missions.	Industry minimums may be inadequate.	Develop standards based on proficiency and performance by utilizing continuous reviews.
P11M1	Provide adequate management support for maintaining a high level of night vision goggle competency.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
P12M1	Staff all systems with qualified and current personnel.	None anticipated	None anticipated
P13M1	Ensure flight crews and crewmembers have trained and operated together.	None anticipated	None anticipated
P14M1	Develop and integrate nighttime simulation system for flight crew, crewmembers, and incident management personnel.	None anticipated	None anticipated
P14M2	Ensure the simulation and the simulator keeps pace with new technology.	None anticipated	None anticipated
P15M1	Develop a training standard and implement in contracts.	None anticipated	None anticipated
P16M1	Develop standards and procedures to ensure well-rested night operations personnel. Develop and implement standards and procedures.	None anticipated	None anticipated
P16M2	Gather and apply latest research on fatigue related to aviation operations.	None anticipated	None anticipated
P17M1	Ensure automation airmanship training is taken by flight crews.	None anticipated	None anticipated
P18M1	Develop and implement national electronic based flight hazard maps. (See F6M1).	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
P19M1	Require all night operations pilots to be commercial/airline transport pilot instrument rated and trained in brownout and whiteout conditions.	None anticipated	None anticipated
P20M1	Nighttime air operations personnel continually re-evaluate decisions at the appropriate level. Apply risk management principles from Interagency Helicopter Operations Guide Chapter 3.	None anticipated	None anticipated
<u>Technology Night System</u>			
T1M1	Make the existing automated flight following application an agency corporate application or locate a new one.	None anticipated	None anticipated
T2M1	Investigate, develop and implement technology and tactics for air and ground such as infrared and laser technology. Ensure all equipment is eye safe.	None anticipated	None anticipated
T3M1	Develop and implement a life cycle equipment program for both government and vendors.	None anticipated	None anticipated
T4M1	Do a benefit versus weight and complexity analysis for all hardware.	None anticipated	None anticipated
T5M1	Ensure new equipment is engineered for compatibility with legacy equipment.	If not compatible?	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
T6M1	Develop and implement techniques used by other agencies to perform this activity.	None anticipated	None anticipated
T7M1	Ensure that quality assurance and safety personnel are in place to review and improve maintenance processes and procedures.	None anticipated	None anticipated
T8M1	Implement unmanned aerial system as appropriate.	Unmanned aerial system program will create significant change in current processes.	Implement change management to incorporate unmanned aerial system.
T8M2	Implement pre-mission electronic operational risk analysis for handheld computing devices, e.g. iPAD™.	None anticipated	None anticipated
Helicopter Operations Night			
H1M1	Educate the community about Forest Service intent to conduct night operations.	None anticipated	None anticipated
H1M2	Ensure the use of temporary flight restrictions where appropriate.	None anticipated	None anticipated
H1M3	Reaffirm dispatcher and airspace coordinator's responsibility to deconflict military training routes.	None anticipated	None anticipated
H2M1	Establish and follow policy, guidelines and direction prior to implementation.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
H3M1	Ensure that all missions are clearly defined and approved by management prior to implementation (mission creep). Collaborate with other program managers such as law enforcement.	None anticipated	None anticipated
H4M1	Utilize program when appropriate criteria has been met.	None anticipated	None anticipated
H4M2	Define an effectiveness measures program.	None anticipated	None anticipated
H4M3	Implement a routine proficiency training program.	None anticipated	None anticipated
H5M1	Establish minimum illumination value and night weather minimums for night operations.	None anticipated	None anticipated
H6M1	Develop a communications and marketing plan for distribution to the field.	None anticipated	None anticipated
H7M1	Ensure incident command personnel receive training on the requirements and best practices of night operations.	None anticipated	None anticipated
H8M1	Ensure training specification incorporates transition from aided to unaided environment.	None anticipated	None anticipated
H9M1	Educate the flight crewmembers on the night visual illusions.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
H10M1	Develop procedures, such as dry runs, utilization of sirens, ensuring the drop zone is clear, etc. to ensure ground personnel will not be impacted.	None anticipated	None anticipated
H10M2	Investigate and implement as appropriate illumination equipment for ground personnel and add to the aviation life support equipment handbook.	None anticipated	None anticipated
H11M1	Define and implement standards for all water and retardant equipment.	None anticipated	None anticipated
H11M2	Communicate standards to cooperators and military.	Even when briefed, cooperators and military may revert to their own standard operating procedures.	Ensure managers of a/c are fully familiar with helicopter night operations standard operating procedures.
H12M1	Investigate and implement equipment and procedures associated with tank filling.	None anticipated	None anticipated
H13M1	Utilize approved helibases and helispots.	None anticipated	None anticipated
H14M1	Each helicopter will have its own assigned pad.	None anticipated	None anticipated
H14M2	Establish fill capabilities at each pad.	None anticipated	None anticipated
H14M3	Identify the maximum number of helicopters from a helibase or helispot for nighttime ground fill operations.	None anticipated	None anticipated
H15M1	Establish a transportation plan for ground support vehicles.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
H15M2	Attempt to locate helibases and helispots to where hydrants or water sources can be used to eliminate water tender traffic.	None anticipated	None anticipated
H16M1	Ensure the aerial supervisor is night vision goggle qualified.	None anticipated	None anticipated
H17M1	Utilize multi-engine airplane.	None anticipated	None anticipated
H18M1	Consider use of a helicopter.	None anticipated	None anticipated
H19M1	Use of auxiliary tanks on the helicopter.	Weight compromise	Utilize appropriate and fully capable airframe.
H20M1	Utilize a crewmember monitoring the hoist to talk to the pilot.	None anticipated	None anticipated
H20M2	Develop and implement techniques used by other agencies to perform this activity.	Other agency assumes risk but Forest Service is responsible party	Close oversight of outside agency operations
H20M3	Utilize a light to illuminate the scene.	May impact night vision for ground and air personnel if used inappropriately.	Strict standards for use of external light sources.
H21M1	Utilize current technology to assist stabilizing hover operations.	None anticipated	None anticipated
H21M2	Establish and meet a currency and proficiency requirement.	None anticipated	None anticipated
H21M3	Utilize specialized crew resource management for this mission.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
H22M1	Ensure proper training of ground personnel to hazards and site preparation.	None anticipated	None anticipated
H22M2	Minimize the number of ground personnel under the aircraft and down slope.	Ground personnel in these locations are at risk.	Strict standards to control ground personnel location in relation to helicopter and drops.
H23M1	Analyze emergency medical services accident and lessons learned and develop a training program to include crew resource management.	None anticipated	None anticipated
H24M1	Develop a mission specific go/no go checklist. Train to the mission.	None anticipated	None anticipated
H25M1	Develop and implement a national standard for levels of emergency medical services response.	Overreliance of the use of emergency medical technicians can result in the placement of personnel in riskier locations.	Develop chain of approval
H26M1	Utilize technology to identify the fireline.	None anticipated	None anticipated
H26M2	Utilize ground personnel to fire out the perimeter.	Slower movement to safe zones due to night activities.	Well established standard operating procedures and minimize distance to safe areas.
H27M1	Provide adequate and compatible lighting.	None anticipated	None anticipated
H28M1	Define the minimum requirements for night operations.	None anticipated	None anticipated

Table 7. Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Substitute or Transferred Risk	Implementation Considerations
H28M2	Ensure plastic sphere dispenser operator and firing boss are trained to night operations standards.	None anticipated	None anticipated
H29M1	Prior to ignition, utilize the public address system and radio to announce the mission intention.	None anticipated	None anticipated
H29M2	Confirm with ground personnel that the target area is clear.	None anticipated	None anticipated
H29M3	Ensure that the briefing discusses burnout operations.	None anticipated	None anticipated

Quality Assurance

Quality assurance, as a primary pillar of the safety management system, has been employed in conjunction with the risk management process throughout this review. This safety assurance method bolsters risk management by assuring that the quality of mission implementation, as intended by the agency, is carried out at its highest possible level.

The Federal Aviation Administration has described quality assurance as follows:

Quality assurance is designed to validate factual information to ensure that aviation operations perform as intended and accomplish the intended outcome. The expectation of this process is that the organization will monitor, measure, and evaluate the performance and effectiveness of all risk controls as well as ensure regulatory (policy) compliance. The purpose of a safety management system is to identify, document, monitor and control hazards in the operation (FAA Advisory Circular 120-9) (appendix I).

With the organizational and programmatic operations under an assurance process that seeks continual improvement, the National Transportation Safety Board has recently taken on the issue of an assurance program that will address the individual at every level. In an attempt to raise the bar of individual professionalism, the Board has begun a process to lead organizations to address continual improvement and monitoring at the individual level. Just as programs are reviewed, analyzed, and improved, the organization can only be as good as the professionalism and ethical fabric of the individual. With the human at the core of all organizational activities, addressing self-awareness, individual error, emotional intelligence, individual professional improvement and ethics education is just as critical in safety assurance of a program as any other aspect defined by the Federal Aviation Administration.

The Forest Service Office of Aviation Risk Management and Training has been leading the agency's aviation programs into implementation of the safety management system. This approach to daily operations and safety of all aviation programs is actively moving ahead of a forthcoming implementation required by the Federal Aviation Administration.

As the agency continues to implement this organizational system, it is essential that the quality assurance aspect of the safety management system is developed and performs at the highest level. The Federal Aviation Administration has developed a detailed safety management system assurance process, which is the framework used for this helicopter night operations quality assurance proposal.

The Federal Aviation Administration has stated that the safety management system assurance guide as well as the safety management system framework is not regulatory at this time although operators are encouraged to establish additional or more stringent requirements. With this in mind and with the agency already well on its way to building a robust safety management system, this helicopter night operations quality assurance process builds upon the current agency quality assurance practices and weaves them into a comprehensive strategy based upon the Federal Aviation Administration's quality assurance foundational framework.

The agency has a solid history of quality assurance processes implemented throughout each program. These processes have served the agency well and provide some program assurance aspects that Federal Aviation Administration and other international organizations identify as necessary implementation processes. The concern with the current agency assurance processes for the existing programs is that it does not fall into an all encompassing quality assurance standardized program and does not capture findings on a national scale. This often leaves lessons learned confined to regions or even more locally. Without cross-regional communication, the national program could become disjointed in quality assurance implementation. This could result in lost information and a degraded ability to capture critical areas of concern. In order to build a strong system for helicopter night operations, it is important to determine from those with extensive agency experience where quality-assurance efforts are lacking.

At a meeting in Missoula, Montana, the agency experts for the helicopter night operations project provided feedback. Twelve comments were made that would improve the quality assurance system:

1. Develop a quality assurance checklist from the strategic program risk assessments.

2. Implement a comprehensive set of standards and metrics for helicopter night operations program performance.

3. Implement a comprehensive set of standards and metrics for aviation personnel performance.

4. Designate a national quality assurance team for internal evaluations and standards reviews.

5. Offer or bolster the reporting system (SAFECOM and SAFENET) capabilities to better incorporate cooperators and vendors and call-when-needed contractors.

6. Ensure consistent and standardized information gathering and trending from the reporting system by program on a national level.

7. Ensure a centralized repository and management of the repository for the reporting system.

8. Conduct online surveys to evaluate safety culture and aviation program support.

9. Conduct after action reviews following each season gathering lessons learned and ensure that the findings are distributed nationally back to the end user.

10. Conduct an online survey for each program following each season to monitor compliance and performance.

11. Ensure proper staffing to fully support a robust quality assurance program.

12. Ensure that a quality assurance program will have full support by upper level management to ensure reviews, findings, and recommendations are fortified.

In order to eliminate gaps and ensure that quality assurance findings produce the ability to better understand the health of a program, developing a solid process for the helicopter night operations program is essential. Based on the Federal Aviation Administration's guidance, quality assurance will ensure a continuously successful implementation of this entirely new program for the agency and help shore up the current agency quality assurance processes. In looking at achieving a higher level beyond the Federal Aviation Administration basic quality assurance framework, this report incorporates the National Transportation Safety Board's recent push to raise awareness in developing and reinforcing professionalism for aviation safety.

Framed by the Federal Aviation Administration's Safety Management System Assurance Guide dated July 15, 2009, revision 2, the helicopter night operations quality assurance plan should contain the following elements.

Continuous Monitoring
The agency should monitor operational data, including products and services received from contractors, to identify hazards, measure the effectiveness of safety risk controls, and assess system performance.

Internal Audits by Operational Departments
The agency should perform regularly scheduled internal audits of its operational processes, including those performed by contractors, to determine the performance and effectiveness of risk controls.

Internal Evaluation
The agency should conduct internal evaluations of the safety management system and operational processes at planned intervals to determine that the safety management system and programs conform to the objectives and expectations.

External Auditing of the Safety Management System
The agency should include the results of audits performed by oversight and outside organizations in its analysis of data.

Investigations
The agency should establish procedures to collect data and investigate incidents, accidents, and instances of potential regulatory noncompliance that occur to identify potential new hazards or risk control failures.

Employee Reporting and Feedback System
The agency should establish and maintain a confidential employee safety reporting and feedback system. The data obtained from this system should be monitored to identify emerging hazards and to assess performance of risk controls in the operational systems.

Analysis of Data
The agency should analyze the data described in safety management system framework processes to assess the risk control's performance and effectiveness in the organization's operational processes and the safety management system and to identify root causes of deficiencies and potential new hazards.

System Assessment
The agency should assess the risk controls' performance and effectiveness, conformance with safety management system requirements, and the objectives of the safety policy.

Preventive/Corrective Action
The agency should take action to eliminate the causes of nonconformance, identified during analysis to prevent recurrence.

Management Review
The agency should conduct regular reviews of the safety management system, including outputs of safety risk management, safety assurance, and lessons learned. The agency should assess the performance and effectiveness of the agency's operational processes and the need for improvements.

Management of Change
The agency should assess risk for changes within the organization that may affect established processes and services by new system designs, changes to existing system designs, new operations/procedures or modified operations/procedures.

Continual Improvement
The agency should promote continual improvement of its safety management system through recurring application of safety risk management, safety assurance, and disseminating safety lessons learned to all personnel.

The agency should use the following methods for quality assurance:

- Incident reporting system (SAFECOM and SAFENET).
- Annual accident/incident reviews reports.
- Annual trending analysis reports.
- Program surveys.
- Program working groups.
- Regional base reviews.
- Include quality assurance in policies and guides.

- Programmatic and operational risk assessments.
- Lessons learned review.
- Simulation exercises.
- Recurrent training.
- Aviation safety assistance team reviews.
- Fire and aviation safety team reviews.
- Operational briefings.
- After action reviews.
- Contract prework sessions.
- Contract compliance inspections.
- Vendor performance evaluations.
- Contractor solicitation evaluations.

The detailed and standardized approach developed by the Federal Aviation Administration for safety assurance addresses many of the concerns raised by the agency helicopter night operations project experts. When a detailed quality assurance progression is applied as part of the safety management system, the helicopter night operations program as well as all aviation programs nationally, will benefit by preventing porous lines of communication and information sharing. Findings by quality assurance teams will be captured and addressed throughout the entire program and system, not limited to a specific operational area.

Findings, Conclusions, and Recommendations

This section includes findings, conclusions, and recommendations for use of helicopters for night operations.

Findings

1. The agency can design, implement, and operate a safe helicopter night operations program. There are significant hazards, organizational challenges, and implementation considerations that need to be resolved.

2. The missions of water and retardant dropping using a fixed tank with ground fill, aerial supervision, and aerial ignition with the plastic sphere dispenser can have potential benefit to the agency and an implementation plan for each should be pursued.

3. The mission of emergency medical transport (with hoist) is a mission the agency currently does not have. Further definition of this mission and the level of care provided should be addressed in the implementation plan and by the agency for its normal day operations. The entire medical mission needs to be further defined.

4. Support technology, such as night vision goggles, helicopter terrain awareness, and warning system for helicopter night operations has evolved such that operations can be conducted with a high degree of reliability and safety.

5. Forest Service fire and aviation managers have identified that the helicopter night operations missions may provide fire suppression benefits. However, no attempt was made to quantify these benefits during this study.

6. The amount of effort, expense, and organizational reprioritization to implement a helicopter night operations program will be substantial and will take multiple years to implement the agency's first night-operational helicopter.

7. The agency lacks standards and guidelines for ground forces operating with helicopter night operations.

8. There is little corporate memory of the agency's helicopter night operations efforts in the late 1970s and early 1980s.

9. Nonrecurring startup costs will be significant.

10. Recurring multiyear organizational costs will be significant.

11. The Forest Service contracts for 99 percent of its helicopter services. The study reviewed many night helicopter operations and found that all of them are cooperator owned and operated services. Further, with the exception of the U.S. Army, the cooperators operate from a home base with a substantial knowledge of the terrain and hazards that they encounter within their designated area of operation.

12. The Forest Service helicopter program is based on all helicopters and pilots meeting the same standards. In addition, a total mobility concept is used with aircraft moving interchangeably throughout the United States. To implement helicopter night operations successfully, this total mobility program model may need to be modified.

13. The commitment required for a helicopter night operations program includes appropriate funding and staffing, not collateral duty functions. Without this commitment the addition of this program could result in a weakening of the overall helicopter program.

14. This risk assessment stands alone regarding the hazards and risk associated with night operations, but relies on prior risk assessments and their mitigating actions to apply to the aircraft and other system, e.g. aircraft performance, operation of the plastic sphere dispenser, etc.

Conclusions

This study has reviewed current night aided helicopter operations with the U.S. Army, U.S. Border Patrol, U.S. Coast Guard and several local agencies responsible for wildland suppression; reviewed the Forest Service historical program information and operations from the 1970s and 1980s; examined current and emerging technologies associated with night vision capability;

examined the accident history from the last 10 years of the US Army; and performed a risk assessment on helicopter night operations. The results of these investigations show that night operations in support of wildland fire suppression can be completed safely.

The implementation of a night aided program requires a significant investment in terms of both development time and funding. Examining the program at Los Angeles County Fire, they began reinvestigating night aided operations in 2001 and became operational for wildland fire operations in 2005. It is anticipated that a Forest Service night aided operations program implementation will require a substantial development process as well, while building on the efforts of others. Obtaining night operations capability quicker may necessitate the use of cooperators.

The amount of night aided missions performed annually by the local agencies in support of wildland fire is a small percentage (between 4 percent and 8 percent) of their annual accumulated helicopter fleet hours. Emergency medical service (transport) is a major mission for these agencies. Emergency medical service, other than associated with an incident, is not a Forest Service mission.

The accident history of the U.S. Army for night aided operations represents a mature program. The U.S. Army has operated helicopters with night vision technology for over 30 years.

Recommendations

1. The decision to proceed with any of the analyzed missions at night should be made at the Chief's level.

2. Identify a helicopter night operations program manager and project manager to lead this effort.

3. Develop a helicopter night operations implementation plan including information contained in this report.

4. Present the helicopter night operations implementation plan to the Chief's level for approval.

5. Develop operational standards and guidelines for ground personnel working with helicopter night operations.

6. To ensure safe internal Forest Service program implementation, all 130 mitigation measures identified in the risk assessment need to be implemented resulting in an acceptable level of risk. Additionally, integrate the appropriate mitigation measures from the prior risk Forest Service assessments.

7. Develop performance measures to implement and monitor in order to demonstrate a benefit based on the cost of the program.

8. While the Forest Service develops its internal program, the agency could work with the southern California cooperator's program to achieve Forest Service's needs for helicopter night operations.

Glossary

Aerial Supervisor – A general term referring to the airborne supervisor over a wildfire. This is most often an Aerial Tactical Group Supervisor, but may be helicopter coordinator.

Automation Airmanship Training – The concept of applying a rigorous set of skills to the automated flight deck which allows crews to control the information, act on it systematically, and optimize safety while minimizing risk in an increasingly complex environment

Blooming – Momentary loss of the night vision image due to intensifier tube overloading by a bright light source. When such a bright light source comes into the night vision device's view, the entire night vision scene becomes much brighter, "whiting out" objects within the field of view.

Brownout – As a helicopter approaches to land or take off from a dusty area, the downwash from the rotor system creates a dust cloud that often engulfs the aircraft and makes it difficult for the pilot to see.

Category B Takeoff and Landing Requirements – Category B requirements for takeoff and landing are a combination of the aircraft's performance to clear a fifty foot obstacle and the location of that obstacle. The creation of helispots for use in night vision operations must provide the clearing of obstacles that are compatible with the aircraft performance in use to clear 50 foot obstacles.

Circadian Cycle or Rhythm – Cyclical variations in physical, mental, and behavioral functions of people. The cycle is internally based and has a recurring period of about 24 hours, responding primarily to light and darkness.

Change Management Training – Change management is a structured approach to transitioning individuals, teams, and organizations from a current state to a desired future state.

Class B Night Vision Lighting – Class B lighting components are those lighting components that are compatible with NVIS using 665-nm minus-blue objective lens. Class B lighting allows red and yellow colors in cockpit displays, but the consequence is reduced GEN III NVIS sensitivity to the outside visual scene.

Crew Resource Management Training – Crew resource management training addresses the challenge of optimizing the human/machine interface and accompanying interpersonal activities of an aircraft flight crew. The training include team building and maintenance, information transfer, problem solving, decisionmaking, maintaining situation awareness, and dealing with automated systems. Crew resource management training is comprised of three components: initial indoctrination/awareness; recurrent practice and feedback; and continual reinforcement.

Kneeboard – A small clip board often used by aviators that straps to the thigh of the pilot and contains flight information and is an easy location for notes and other information the pilot needs to write down throughout a flight.

Ergonomic Specialist – Ergonomics deals with the interaction of technological and work situations with the human being. The basic human sciences involved are anatomy, physiology and psychology. These sciences are applied by the ergonomist towards two main objectives: the most productive use of human capabilities, and the maintenance of human health and well-being.

FIRESCOPE –FIrefighting REsources of Southern California Organized for Potential Emergencies. By legislative action, the FIRESCOPE Board of Directors and the Office of Emergency Services Fire and Rescue Service Advisory Committee were consolidated into a working partnership on September 10, 1986. This consolidation represents all facets of local, rural, and metropolitan fire departments, the California Department of Forestry and Fire Protection, and federal fire agencies.

Firing Boss – The firing boss reports to the prescribed fire burn boss and is responsible for supervising and directing ground and/or aerial ignition operations according to established standards in the prescribed fire plan. Prior to 2006, this position was called aerial ignition specialist.

Flight Hazard Maps – A map depicting pre-identified ground structures/obstacles that pose a hazard to low level flight.

Gated System – When the power supply is auto-gated, it means the system is turning itself on and off at a very rapid rate. This, combined with a thin film attached to the microchannel plate (an ion barrier) reduces blooming. While blooming can be noticeably less on systems with a thin film layer, systems with thicker film layers can be perfectly acceptable depending on the end user's application.

Halo Effect – The viewer, using night vision goggles, sees a halo effect around visible light sources. When such a bright light source comes into the night vision device's view, the entire night vision scenes, or parts of it, become much brighter.

Hazard – Any existing or potential condition that can lead to injury, illness, or death to people; damage to or loss of a system, equipment, or property; damage to the environment. A hazard is a condition that is a prerequisite to an accident or incident.

Helicopter Coordinator – A position which provides aerial supervision to helicopters over wildland fires.

Hoist Program – Part of an emergency medical services program or search and rescue program which usually provides day, night and night vision goggle operations and full search and rescue capabilities to include rescue hoist missions operated from a rotor-wing aircraft.

Instrument Flight Rules – These are regulations and procedures for flying aircraft by referring only to the aircraft instrument panel for navigation. Even if nothing can be seen outside the cockpit windows, an IFR-rated pilot can fly while looking only at the instrument panel. IFR-rated pilots are authorized to fly through clouds.

Instrument Meteorological Conditions – This is an aviation flight category that describes weather conditions that normally require pilots to fly primarily by reference to instruments, and therefore under instrument flight rules, rather than by outside visual references under visual flight rules. Typically, this means flying in clouds, bad weather or at night.

Inadvertent Instrument Meteorological Condition Recovery – A procedure pre-identified and trained to (1) prevent entering into a condition where this recovery is required and (2) provide a plan and a detailed process to successfully transition to instrument flight and recover to the nearest appropriate airport if these conditions cannot be avoided.

Instrument Approach – Generally designed such that a pilot of an aircraft in instrument meteorological conditions, by the means of radio, GPS or inertial navigation system navigation with no assistance from air traffic control, can navigate to the airport, hold in the vicinity of the airport if required, then fly to a position from which he or she can obtain sufficient visual reference of the runway for a safe landing to be made, or execute a missed approach if the visibility is below the minimums required to execute a safe landing. The approach is defined and published in this way so that aircraft can land if they suffer from radio failure; it also allows instrument approaches to be made procedurally at airports where air traffic control does not use radar or in the case of radar failure.

Manufacturer's Authorized Modifications – Often generated by concerns or complaints in the field regarding a deficiency or product improvement issue on the design or operation of a part or parts of an aircraft or other piece of equipment. These concerns are either directly communicated to the original equipment manufacturer or go through a process by the Federal Aviation Administration. Changes made to the original design by the original equipment manufacturer are then issued in a Service Bulletin and parts changes to the maintenance manual. The information is initially disseminated by a Service Bulletin or Alert Service Bulletins and is issued by the original equipment manufacturer. Sometimes the Federal Aviation Administration will feel that a mandatory compliance is needed and will issue an airworthiness directive. The airworthiness directive’s typically will direct the owner to the manufacture's service bulletin.

Minimum Illumination Value – A low level of available ambient light necessary for night vision goggles to work on the principle of magnifying the amount of received photons from various natural sources such as starlight or moonlight or other light sources such as cities. Moonlight is a significant contribution to the value of night illumination. The ratio of the area illuminated by direct sunlight to the moon’s total area is the fraction of the moon's surface illuminated; multiplied by 100, it is the percent illuminated. At New Moon the percent illuminated is 0; at First and Last Quarters it is 50%; and at Full Moon it is 100%. During the crescent phases the percent illuminated is between 0 and 50% and during gibbous phases it is between 50% and 100%. The lower the available illumination from the moon, the lower the illumination value for night vision goggles.

Mitigate – To moderate (a quality or condition) in force or intensity; alleviate.

Night-aided Flight – Flying a night mission with the use of night vision goggles.

Night Visual Illusions – Information in visible light sources is often ambiguous, and to correctly interpret the properties of many scenes, the visual system must make additional assumptions about the scene and the sources of light. A side effect of these assumptions is that our visual perception cannot always be trusted; visually-perceived imagery can be deceptive or misleading. As a result, there are situations where what is perceived is not necessarily real. These misperceptions are often referred to as illusions. Gregory (1997) identifies two classes of illusions: those with a physical cause and those due to the misapplication of knowledge. Physical illusions are those due to the disturbance of light between objects and the eyes, or due to the disturbance of sensory signals of eye (also known as physiological illusions). Cognitive illusions are due to misapplied knowledge employed by the brain to interpret or read sensory signals. For cognitive illusions, it is useful to distinguish specific knowledge of objects from general knowledge embodied as rules (Gregory, 1997). Illusions generally occur at night in both the unaided and aided (night vision goggle) modes of flight.

Night Weather Minimums – A minimum standard requiring a specific weather ceiling combined with a horizontal visibility that must be reported by an aviation weather service in order for an aircraft to launch on a night flight. Standards differ between aided night flights and unaided night flights.

NV Technology – Night vision technologies can be broadly divided into three main categories:

- Image intensification – Image intensification technologies work on the principle of magnifying the amount of received photons from various natural sources such as starlight or moonlight. Examples of such technologies include night glasses and low light cameras.
- Active illumination – Active illumination technologies work on the principle of coupling imaging intensification technology with an active source of illumination in the near infrared or shortwave infrared band. Examples of such technologies include low light cameras.
- Thermal imaging – Thermal imaging technology works by detecting the temperature difference between the background and the foreground objects.

Operational Risk Analysis – A risk management tool that will assess accident/incident risk associated with a flight operation is designed to give safety managers and other users a quantitative assessment of specific risk for an operation, broken down into a variety of subgroups: by fleet, region, route, or even individual flight. This assessment is performed using a mathematical model, which synthesizes a variety of inputs, including information on crew, weather, management policy and procedures, airports, traffic flow, aircraft, and dispatch operations. The system will identify those elements that contribute most significantly to the calculated risk, and will be able in some cases to suggest possible interventions.

Practical Test Standard – The Federal Aviation Administration has standards for flight instructor certification practical tests for various aircraft categories. Federal Aviation Administration inspectors and designated pilot examiners shall conduct practical tests in compliance with these standards. Flight instructors and applicants should find these standards helpful during training and when preparing for the practical test.

Quality Assurance Program – Refers to processes for the systematic monitoring and evaluation of risk controls developed under the safety risk management of the various aspects of a project, service, or facility to ensure that standards of quality are being met throughout the life cycle of a system).

Residual Risk – The remaining safety risk that exists after all control techniques have been implemented or exhausted and all controls have been verified. Only verified controls can be used for the assessment of residual safety risk.

Risk – The composite of predicted severity and likelihood of the potential effect of a hazard in the worst credible system state.

Safety Management System – This is a structured, risk-based approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures.

Substitute Risk – The risk unintentionally created as a consequence of safety risk control(s).

Temporary Flight Restriction – These restrictions are in the form of a notice to airmen is a geographically-limited, short-term, airspace restriction, typically in the United States. Temporary flight restrictions often encompass major sporting events, natural disaster areas, air shows, space launches, and Presidential movements. Before the September 11, 2001 attacks, most temporary flight restrictions were in the interest of safety to flying aircraft with occasional small restrictions for Presidential movements. Since 9/11, temporary flight restrictions have been routinely used to restrict airspace for 30 nautical miles around the President, with a 10-nautical-mile (20 km) radius no-fly zone for non-scheduled flights.

Thermal Technology – Thermal imaging technology works by detecting the temperature difference between the background and the foreground objects.

Unmanned Aerial System – This is an aerial system that consists of the air vehicle, sensors/payloads, command and control data links, the operator station, as well as the ground support equipment required for launch/recovery, operations, and maintenance. Other terms that have been used are drones, pilotless aircraft, and unmanned aerial vehicles.

U.S. Army Class A Aviation Accident – An Army accident in which the resulting total cost of property damage is $2 million or more; an Army aircraft or missile is destroyed, missing, or abandoned; or an injury and/or occupational illness results in a fatality or permanent total disability. Note that unmanned aircraft systems (UAS) accidents are classified based on the cost to repair or replace the UAS. A destroyed, missing, or abandoned UAS will not constitute a Class A accident unless replacement or repair cost exceeds $2 million or more.

U.S. Army Class B Aviation Accident – An Army accident in which the resulting total cost of property damage is $500,000 or more, but less than $2 million; an injury and/or occupational illness results in permanent partial disability, or when 3 or more personnel are hospitalized as inpatients as the result of a single occurrence.

U.S. Army Class C Aviation Accident – An Army accident in which the resulting total cost of property damage is $50,000 or more, but less than $500,000; a nonfatal injury or occupational illness that causes 1 or more days away from work or training beyond the day or shift on which it occurred or disability at any time (that does not meet the definition of Class A or B and is a lost time case).

Visual Flight Rules – These rules are often used for sight-seeing flights, aerial photography, or lift services for parachute jumping. Pilots flying under visual flight rules are not permitted to fly through clouds. Under visual flight rules, the pilot is primarily responsible for navigation, obstacle clearance and maintaining separation from other aircraft using the see-and-avoid concept.

Appendixes

Appendix A – Project Team Members

Appendix B – Hazards and Mitigation Measures Developed by Subject Matter Experts

Appendix C – 2009 Systems Safety Aviation Guide, Helicopter System

Appendix D – Study Plan (Scoping)

Appendix E – History

Appendix F – Overview of Site Visits

Appendix G – Night Vision Aiding Equipment

Appendix H – U.S. Army Accidents during Night Aided Operations

Appendix I – Federal Aviation Administration (FAA) Advisory Circular 120-92

Appendix A

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Appendix B

Hazards and Mitigation Measures Developed by Subject Matter Experts

Hazards and Mitigation Measures
Helicopter Night Operations

A-Aircraft System

Capabilities Subsystem

A1 – Aircraft lighting not certified for night operations

> *A1M1 – Develop and implement specifications for interior and exterior aircraft lighting modifications, which are compatible with class B night vision equipment.*
>
> *A1M2 – Only use aircraft that are modified for NVG operations using manufacturer's authorized modifications or supplemental type certificate.*

Visibility Subsystem

A2 – Aircraft impacting terrain or other obstacles at night due to lack of incorporating available technology. Increased cockpit workload based on night operations diverting the pilot's attention.

> *A2M1– Review and implement available technology to provide the pilot with situational awareness.*
>
> *A2M2 – Investigate current and future integrated cockpit and NV technology to reduce pilot workload for situational awareness.*
>
> *A2M3 – Utilize and procure an ergonomic specialist to review cockpit configuration, pilot workload, and survivability.*
>
> *A2M4 – Develop and integrate simulator system consistent with applicable technology for pilot training.*

A3 – Inability to distinguish between specific aircraft at night may result in the misidentification of aircraft at or around landing zones

> *A3M1 – Investigate and implement as appropriate the expansion of automated flight following technology for the cockpit and the ground, which would identify specific aircraft in the fire airspace and assist with airspace de-confliction.*
>
> *A3M2 – Incorporate existing automated flight following technology into operational planning with shorter aircraft reporting duration.*

A4 – Current technology does not identify individual aircraft to personnel in the command aircraft.

A4M1 – Investigate and implement as appropriate external aircraft identification application.

A4M2 – Investigate and design a command aircraft (fixed wing, rotor wing or ground based) module that incorporates existing identification technology for a multiple person crew.

A5 – Reduced pilot visual acuity and field of view when operating at night.

A5M1 – Utilize NVG and thermal technology.

A5M2– Ensure initial and recurrent training addresses night vision equipment utilization and techniques.

A5M3 – Implement available NVG calibration and focusing technology before each operational period.

A6 – Inability to distinguish color of objects at night.

A6M1 – Have personnel review, educate and change operations that rely on recognition of color during the day.

A7 – Inability to identify changing meteorological and illumination conditions.

A7M1 – Educate and equip fire weather meteorologists to support the night flying mission. System will report the forecast to the pilot.

A7M2 – Educate pilot to recognize indicators of changing weather conditions when using NVG.

A7M3 – Implement broadcast weather and illumination updates. (i.e., automated surface observation system)

A7M4 – Educate ground personnel to relay to pilots any changing weather conditions.

<u>Inspection Subsystem</u>

A8 – Untrained maintenance, avionics and pilot inspectors for the night operations resulting in loss of mission or aircraft.

A8M1 – Require maintenance, avionics and pilot inspectors to become qualified and attend approved manufacturer's training.

A8M2 – Develop a specification for night operations equipment maintenance.

A8M3 – Develop the qualifications, certification, and carding system for the maintenance, avionics, and pilot inspectors.

A9 – There is no quality assurance program for additional night operations projects. No Forest Service standards exist to inspect or measure agency or vendor audits.

A9M1 – Review current organizational staffing levels and add night operations maintenance and avionics inspector positions as needed to build the aviation life support equipment staff.

A10 – There is no quality assurance program for assuming additional night operations projects. No Forest Service standards exist to inspect or measure against when doing agency or vendor audits.

A10M1 – Establish a quality assurance program for night operations.

A10M2 – Develop standards based on industry best practices.

A10M3 – Charter a Forest Service night operations working group.

A10M4 – Charter a night operation work group under the national interagency aviation committee task group.

A10M5 - Ensure the quality assurance program addresses maintenance, inspection and equipment subsystems.

A11 – The flight crew is more likely to miss a preflight item at night

A11M1 – Incorporate night preflight checklist items in training and require the use of defined procedures and equipment.

<u>Equipment Subsystem</u>

A12 – Aircraft used in night operations not modified with the proper equipment

A12M1 – Do not use aircraft that are not equipped to Forest Service standards.

A13 – Introduction of hoist operations at night without prior implementation during the day

A13M1 – The agency needs to perform and implement a detailed risk assessment and program planning on this mission.

A13M2 – Develop and implement hoist program during day concurrently with a night program.

A14 – Difficulty to identify cockpit switchology during normal and emergency operations

A14M1 – The agency must identify and implement the complexity of the mission to determine the crew composition.

A14M2 – Implement crew resource managment training to include night operations.

A14M3–- Provide specifications on standardized equipment layout in the cockpit.

A14M4 – Incorporate a helicopter evaluation board for night operations. (Similar to Smokejumper aircraft screening and evaluation board)

Maintenance Subsystem
A15 – Due to time compression, maintenance items may be missed or not done correctly. Lack of available time to perform aircraft maintenance during 24-hour operations.

A15M1 – Program design should ensure adequate staffing and appropriate time allotted.

A15M2 – Managers will ensure adequate staffing and time to perform scheduled maintenance.

Helicopter System – Facilities Night

Communications Subsystem
F1 – Nonessential communication diverts pilot attention in the increased workload of the night operations

F1M1 – Define and implement opportunities where technology or equipment can replace verbal communication.

F1M2 – Incorporate and reinforce brevity in verbal radio communications during training and briefings.

F2 – Marshalling ground procedures are different between the day and night.

F2M1 – Develop and implement nighttime procedures.

F3 – Lack of technology for air traffic separation at night in the absence of aerial supervision.

F3M1 – Designate egress and ingress routes, check points.

F3M2 – Ensure automated flight following technology is available to helibase personnel.

<u>Environment Subsystem</u>
F4 – Permanent and temporary helibase facilities are not compliant with night operations (Note: Need for Class B – takeoff minimums).

F4M1 – Develop and implement night operations facility standards including lighting.

F5 –Lack of adequate sleeping facilities for crews staffed at night and resting in the daytime.

F5M1 – Ensure and implement proper environmentally controlled crew rest facilities.

F6 – Lack of familiarity of the base if not seen during the daytime.

F6M1 – Require flight crews to see the helibase and fly the incident during the day. This activity will not affect the duty day.

F7 – Inability to see night flying critters and animals in the landing zone.

F7M1 – Brief pilot of possible presence of owls, bats, migratory bird paths, etc. prior to flying.

F7M2 – Brief ground personnel on the need for security at the landing zone.

<u>Helicopter System – Personnel</u>

<u>Utilization Subsystem</u>
P1 – Understaffing and under managing night mission operations. Inability to retain experienced and qualified personnel for night missions.

P1M1 – Define and implement the night operations program to address the mission, staffing, retention, organization, procedures, logistics, support, policy, training, facilities, and operational control.

P1M2 – Assign a national night operations project leader.

P2 – Lack of coordination and standardization with other agency cooperators.

P2M1 – Assign a national night operations project leader to coordinate interagency personnel and cooperators. Position will take the lead for Forest Service night operations working group.

P3 – Lack of knowledgeable and experienced night operations government contract administrators.

P3M1 – Staff and train night operations government contract administrators.

P3M2 – Do a needs analysis to determine the adequate number of night operations government contract administrators.

P4 – Vendor personnel lacks experience in night firefighting in mountainous terrain.

P4M1 – Develop a standard for night operations and firefighting operations.

P5 – Lack of vendor knowledge and experience with night vision contract specifications.

P5M1 – Specifications, which fully define the night vision equipment requirements, need to be developed and transmitted to vendors.

P6 – The helicopter contract does not require a safety management system program for the vendor. The Federal Aviation Administration requires a safety management system program for vendors starting in 2012.

P6M1 – Develop and incorporate a safety management system specification in all contracts.

P7 – Operational protocols are not standardized and adhered to for nighttime operations at and around landing zones.

P7M1 – Develop and implement standards and protocols for interagency and cooperator operations.

P7M2 – Ensure interagency and cooperators are involved with agency working groups and committees.

<u>Policy Subsystem</u>

P8 – Not adhering to night operations policy results in hazardous practices.

P8M1 – Assign supervision and oversight to ensure compliance during night operations.

P8M2 – Brief and monitor compliance by overhead teams.

P8M3 – Incident personnel must perform an operational risk assessment on night operations.

P9 – Night operations is not listed in the helicopter pilot practical test standards.

P9M1 – Task Washington Office to develop practical test standard.

P10 – The current visual flight rule requirement of 1500 hours is not adequate for the complexity of the night mission.

P10M1 – Explore industry minimum pilot flight time standards for night operations and establish agency minimum flight time requirements for night vision goggle missions.

<u>Training Subsystem</u>

P11 – Lack of appropriate management support for maintaining a high level night vision goggle competency.

P11M1 – Provide management support for maintaining a high level of night vision goggle competency.

P12 – Staffing with unqualified or non-current personnel.

P12M1 – Staff all systems with qualified and current personnel.

P13 – Primary and relief flight crews as well as crewmembers (contract/government mix) that have not worked with each other at night.

P13M1 – Ensure flight crews and crewmembers have trained and operated together.

P14 – Lack of a night simulation exercise facility.

P14M1 – Develop and integrate nighttime simulation system for flight crew, crewmembers, and incident management personnel.

P14M2 – Ensure the simulation and the simulator keeps pace with new technology.

P15 – Inconsistent night vision goggle training and inspection by vendors.

P15M1 – Develop a training standard and implement in contracts.

<u>Human Factors Subsystem</u>

P16 – Disruption of circadian cycle for personnel performing night operations.

P16M1 – Develop standards and procedures to ensure well-rested night operations personnel. Develop and implement standards and procedures.

P16M2 – Gather and apply latest research on fatigue related to aviation operations.

P17 – Pilot's overreliance on the use of technology and improper interface with automation.

P17M1 – Ensure automation airmanship training is taken by flight crews.

P18 – Pilot's lack of familiarity of local operating terrain increases risk of controlled flight into terrain and other operating procedures.

P18M1 – Develop and implement national electronic based flight hazard maps. (See F6M1).

P19 – The inability for a visual flight rule-rated pilot to perform a night inadvertent instrument meteorological condition recovery or brownout recovery.

P19M1 – Require all night operations pilots to be commercial/airline transport pilot instrument rated and trained in brownout and whiteout conditions.

P20 – Vendor/pilot accepts unnecessary additional risk for monetary gain.

P20M1 – Nighttime air operations personnel continually reevaluate decisions at the appropriate level. Apply risk management principles from Interagency Helicopter Operations Guide Chapter 3.

Helicopter System - Technology

Utilization Subsystem
T1 – Automated flight following is currently not a supported system within the agency or National Wildfire Coordinating Group.

T1M1 – Make the existing automated flight following application an agency corporate application or locate a new one.

T2 – Inability to identify ground target.

T2M1 – Investigate, develop, and implement technology and tactics for air and ground, such as infrared and laser technology. Ensure all equipment is eye safe.

T3 – Inadequate execution of night technology life cycle replacement.

T3M1 – Develop and implement a life cycle equipment program for both government and vendors.

T4 – Inappropriate or excessive weight of hardware in the helicopter.

T4M1 – Do a benefit versus weight and complexity analysis for all hardware.

T5 – New technology may not be compatible with legacy equipment.

T5M1 – Ensure new equipment is engineered for compatibility with legacy equipment.

T6 – NVG provide limited depth perception.

T6M1 – Develop and implement techniques used by other agencies to perform this activity.

Maintenance Subsystem
T7 – Inadequate execution of maintenance and preflight of night vision goggles.

T7M1 – Ensure that quality assurance and safety personnel are in place to review and improve maintenance processes and procedures.

Human Factors Subsystem
T8 – The current level of fatalities in helicopter crashes is from human error. Night operations will increase exposure to the flight crew.

T8M1 – Implement unmanned aerial system as appropriate.

T8M2 – Implement pre-mission electronic operational risk analysis for handheld computing devices, e.g. iPAD™.

Helicopter System - Operations

Mission Subsystem
H1 – Low-level military, Homeland security, and law enforcement night operations encroaching on fire operations.

H1M1 – Educate the community about Forest Service intent to conduct night operations.

H1M2 – Ensure the use of temporary flight restrictions where appropriate.

H1M3 – Reaffirm dispatcher and airspace coordinator's responsibility to de-conflict military training routes.

Management Decisions Subsystem
H2 – Implementation of the night operations program without establishment of standards.

H2M1 – Establish and follow policy, guidelines and direction prior to implementation.

H3 – Lack of definition and direction of use of night operations capability in non-wildfire missions.

H3M1 – Ensure that all missions are clearly defined and approved by management prior to implementation (mission creep). Collaborate with other program managers, such as law enforcement.

<u>Utilization Subsystem</u>
H4 – Under utilization of helicopter due to excessive risk avoidance leads to a reduction in competency, proficiency, and program degradation.

H4M1 – Utilize program when appropriate criteria have been met.

H4M2 – Define an effectiveness measures program.

H4M3 – Implement a routine proficiency training program.

<u>Environment Subsystem</u>
H5 – Inadequate ambient light illumination to see and avoid obstacles.

H5M1 – Establish minimum illumination value and night weather minimums for night operations.

<u>Communications Subsystem</u>
H6 – Lack of effective communication of the Chief's intent and strategy for night operations.

H6M1 – Develop a communications and marketing plan for distribution to the field.

<u>Training Subsystem</u>
H7 – Lack of training of incident command personnel on how to use night operations.

H7M1 – Ensure incident command personnel receive training on the requirements and best practices of night operations.

H8 – Transition by pilot from night vision goggles to night unaided flight profiles.

H8M1 – Ensure training specification incorporates transition from aided to unaided environment.

H9 – Night visual illusions may result in controlled flight into terrain.

H9M1 – Educate the flight crewmembers on the night visual illusions.

<u>Water and Retardant Dropping Using a Fixed Tank with Ground Fill Subsystem</u>
H10 – Impacting ground personnel with the drop.

H10M1 – Develop procedures, such as dry runs, utilization of sirens, ensuring the drop zone is clear, etc. to ensure ground personnel will not be impacted.

H10M2 – Investigate and implement as appropriate illumination equipment for ground personnel and add to the aviation life support equipment handbook.

H11 – Use of non-standardized equipment (tanks, includes cooperators and military, different couplings, etc.).

H11M1 – Define and implement standards for all water and retardant equipment.

H11M2 – Communicate standards to cooperators and military.

H12 – Overloading the aircraft with water or retardant from ground filling.

H12M1 – Investigate and implement equipment and procedures associated with tank filling.

H13 – Increased number of landing and takeoffs.

H13M1 – Utilize approved helibases and helispots.

H14 – Failure of ground facilities to keep up with the turn rate for the helicopter can create an airspace coordination issue.

H14M1 – Each helicopter will have its own assigned pad.

H14M2 – Establish fill capabilities at each pad.

H14M3 – Identify the maximum number of helicopters from a helibase or helispot for nighttime ground fill operations.

H15 – Increase traffic to the ground support system (Transferred Risk).

H15M1 – Establish a transportation plan for ground support vehicles.

H15M2 – Attempt to locate helibases and helispots to where hydrants or water sources can be used to eliminate water tender traffic.

<u>Aerial Supervision Subsystem</u>
The aircraft will have a pilot and an aerial supervisor.

Fixed wing and Rotor Wing
H16 – Increased workload for single pilot operations at night.

H16M1 – Ensure the aerial supervisor is night vision goggle qualified.

Fixed Wing
H17 – Increased difficulty of emergency landing of aircraft at night.

H17M1 – Utilize multiengine airplane.

H18 – Increased difficulty to locate ground resources and identify targets.

H18M1 – Consider use of a helicopter.

Helicopter
H19 – Limited fuel load can affect other tactical missions.

H19M1 – Use of auxiliary tanks on the helicopter.

Hoist for Emergency Medical Transport Subsystem
H20 – Inability to see vegetation that could snag the basket.

H20M1 – Utilize a crewmember monitoring the hoist to talk to the pilot.

H20M2 – Develop and implement techniques used by other agencies to perform this activity.

H20M3 – Utilize a light to illuminate the scene.

H21 – The difficulty to maintain a stabilized hover causing drift.

H21M1 – Utilize current technology to assist stabilizing hover operations.

H21M2 – Establish and meet a currency and proficiency requirement.

H21M3 – Utilize specialized crew resource management for this mission.

H22 – Vegetation and ground objects dislodged by rotor wash.

H22M1 – Ensure proper training of ground personnel to hazards and site preparation.

H22M2 – Minimize the number of ground personnel under the aircraft and down slope.

H23 – Pilot engaged in emergency response and losing situational awareness.

H23M1 – Analyze emergency medical services accident and lessons learned and develop a training program to include crew resource management.

H24 – A conscious decision abandoning the go/no go checklist because of an emergency mission.

H24M1 – Develop and adhere to a mission specific go/no go checklist. Train to the mission.

H25 – There is a potential overutilization of the mission due to over triage of injured person

H25M1 – Develop and implement a national standard for levels of emergency medical services response.

Aerial Ignition with Plastic Sphere Dispenser Subsystem

H26 – The potential for a sphere to land outside the fireline is higher at night.

H26M1 – Utilize technology to identify the fireline.

H26M2 – Utilize ground personnel to fire out the perimeter.

H27 – Inadequate lighting in the back of the helicopter to support the duties of the plastic sphere dispenser operator.

H27M1 – Provide adequate and compatible lighting.

H28 – The current training requirements for the plastic sphere dispenser operator and firing boss may not be adequate for night operation.

H28M1 – Define the minimum requirements for night operations.

H28M2 – Ensure plastic sphere dispenser operator and firing boss are trained to night operations standards.

H29 – Inability to maintain security of the burn project area.

H29M1 – Prior to ignition, utilize the public address system and radio to announce the mission intention.

H29M2 – Confirm with ground personnel that the target area is clear.

H29M3 – Ensure that the briefing discusses burnout operations.

Appendix C

2009 Aviation Risk Management Workbook

System Safety Assessment - Helicopters

Helicopter System -Aircraft

		Pre-mitigation			Mitigation	Post-mitigation		
Sub-System	Hazards	Likelihood	Severity	Outcome		Likelihood	Severity	Outcome
Capabilities	High DA will overgross the aircraft	Occasional	Catastrophic	High	Use appropriate aircraft for mission. Conduct thorough pre-mission planning, load calculations, etc. Reinforce HHH Training.	Remote	Catastrophic	Serious
	AC not appropriate for mission. ICS Typing	Occasional	Critical	Serious	Ensure appropriate aircraft is ordered & utilized. Conduct thorough pre-mission planning, load calculations, etc.	Remote	Critical	Medium
	Mechanical failure - flight component	Remote	Catastrophic	Serious	Follow IHOG Policy Ch 14 Sched Maint, Pre & Post Flight, etc.	Remote	Catastrophic	Serious
	Equipment not well maintained & operational	Occasional	Critical	Serious	Follow IHOG Policy Ch 9. Ensure personnel receive adequate basic training.	Occasional	Marginal	Medium
Visibility	Lack of Hi Vis AC Markings	Occasional	Catastrophic	High	Identify paint schemes that are NOT highly visible & add that to the contract as NOT approved.	Improbable	Catastrophic	Medium
Inspection	Lack of standardization of Gov't Inspectors	Frequent	Critical	High	Recommend development & implement of Interagency Standardized inspection process. If one Agency does not approve an aircraft or contractor for operation other agencies should follow and accept that decision.	Occasional	Critical	Serious
	Level of Training for HEMGs on inspection process is inadequate	Frequent	Marginal	Serious	Develop training for HEMGs on MEL, maintenance buzz words (Watch-Outs). Act on opportunity for HEMGs to attend inspections.	Occasional	Marginal	Medium
Equipment	Personnel not proficient with equipment	Frequent	Marginal	Serious	Inspectors ensure Contractors (Pilots) are adequately trained & skilled with equipment provided. Ensure contract language requires equipment to be commensurate with current technology.	Occasional	Marginal	Medium
Maintenance	Maintenance in the field	Frequent	Critical	High	Fly aircraft to shop/hanger for maintenance whenever possible. Allow adequate time for mechanics to work in field. Provide light/power/water if possible.	Remote	Critical	Medium
	Lack of thorough documentation	Occasional	Critical	Serious	Develop training for HEMGs on MEL, maintenance buzz words (Watch-Outs). Enhance awareness through training for HEMGs on when to call MI for assistance with Contractor & maintaining equipment.	Remote	Critical	Medium
	Poor Communications between all parties (Contractor, GACC,CO, ACO, COR, PI, MI, HEMG)	Frequent	Critical	High	Enhance and integrate tracking of maintenance records AND Contract Evaluations of the a/c over the duration of the contract period in order to recognize issues-CWN & Ex Use. Hire additional Maintenance Inspectors to keep up with this increased workload.	Occasional	Critical	Serious

Helicopter System - Facilities (permanent and temporary)

Sub-System	Hazards	Pre-mitigation Likelihood	Pre-mitigation Severity	Pre-mitigation Outcome	Mitigation	Post-mitigation Likelihood	Post-mitigation Severity	Post-mitigation Outcome
Communications	Lack of adequate base station VHF & FM radios-Not able to adequately communicate to helicopters out working missions/projects with handheld radios.	Occasional	Critical	Serious	Provide all Ex Use crews with mounted FM & AM radios on chase trucks (NOT just handhelds). Utilize Ex Use crews more often on incidents because they have the support equipment. Helibase Commo trailers should be on a National Contract instead of Geographic Area in order to lower cost.	Remote	Critical	Medium
	Lack of adequate computers-not able to access necessary flight planning, ABS, and weather documents prior to missions.	Frequent	Critical	High	Have Cache computers available for Incident/Unit personnel to check out that are Intranet accessible. These computers should be able to access Internet as well for Weather updates, TFR information, filing of flight plans, completing electronic payment forms, etc. **Ensure ALL Ex Use bases have Internet as well as Intranet access in order to access critical WX, TFR & Flight Planning information.**	Remote	Critical	Medium
Environment	Haz Mat concerns/spills-Lack of adequate spill prevention/mitigation equipment on site and the knowledge to utilize it.	Frequent	Marginal	Serious	Provide permanent as well as temporary helibases with approved Haz Mat storage facilities/equipment. Solicit for National Contracts to provide portable haz mat storage facilities for Incidents	Remote	Marginal	Medium
Inspection/Evaluation	Lack of Accountability/Follow Up on Annual/Triennial Helibase Reviews	Probable	Marginal	Serious	Hold Management accountable to conduct follow up and remedy critical issues found in reviews and adhere to interagency and OSHA standards.	Remote	Negligible	Low

Helicopter System - Personnel (Government)

Sub-System	Hazards	Pre-mitigation Likelihood	Pre-mitigation Severity	Pre-mitigation Outcome	Mitigation	Post-mitigation Likelihood	Post-mitigation Severity	Post-mitigation Outcome
Utilization	Span of Control/Collateral Duties. Personnel are often tasked with multiple duties especially during the emergence of an incident. Focused on Task at hand & not able to provide adequate oversight.	Probable	Catastrophic	High	Ensure existing staffing, supervision and management policies & procedures are met. Place aviation resource needs at higher priority level in the resource ordering process. Need to ensure situation is recognized & ensure additional resources/supervision is ordered. Limit collateral duties in key supervisory positions. If unable to fill key positions operations will be shut down or limit use of aircraft until span of control issues are resolved.	Remote	Catastrophic	Serious
Policy	Operational and mission goals during all-hazard assignments may be unstated or unclear and may conflict with interagency standards and policy	Probable	Critical	High	Adequate in-brief and dissemination of Commander's intent. Clarification of scope of authority & policy in place. Adhere to interagency policy, procedures and guidelines (e.g., IHOG). If unable to perform duties utilizing interagency policy, perform a separate Risk Assessment with appropriate approval sign off. Ensure personnel are working within the scope of their employment. Implementation of Aviation Doctrine may further mitigate conflicts between direction and policy.	Occasional	Critical	Serious

Helicopter System - Personnel (Government) - Continued

Sub-System	Hazards	Pre-mitigation Likelihood	Pre-mitigation Severity	Pre-mitigation Outcome	Mitigation	Post-mitigation Likelihood	Post-mitigation Severity	Post-mitigation Outcome
Training	Unable to bring seasonals on early enough to provide all the required training prior to sending on incidents	Frequent	Critical	High	Ensure line officers are committed to providing adequate time and funding to develop personnel as necessary.	Occasional	Critical	Serious
Training	Lack of CRM	Probable	Critical	High	Provide adequate time for training and provide time for Modules to develop CRM prior to field season. Provide training in CRM for Modules annually. Brief/debrief, maintain positive attitude.	Occasional	Critical	Serious
Human Factors	Fatigue/burnout due to incident duration as well as year round All Risk incident support .	Probable	Critical	High	Adhere to work/rest guidelines. Monitor fatigue levels of crews. Rotate personnel and helicopter programs to manage fatigue and burnout. Manage number and duration of assignments. Ensure adequate time off and provide quality R & R while on assignments.	Occasional	Critical	Serious
Human Factors	Acceptance of high risk missions as normal.	Probable	Catastrophic	High	Review risk assessment & existing policy/procedures, brief/debrief with all personnel and utilize risk management tools to include Go-No-Go Checklists. Educate personnel on the hazards of normalization of risk and complacency. Mission decision made at appropriate level. Must have better communication and collaboration between Operations and Aviation.	Remote	Catastrophic	Serious
Human Factors	High workload for Maintenance Inspectors may compromise their ability to perform thorough inspections. Standard inspections criteria not followed consistently among agencies or regions	Probable	Critical	High	Increase amount of personnel available to perform the duties of Maintenance Inspector in proportion with span of control. Ensure inspection standards are developed and maintained by agencies.	Remote	Critical	Medium
Human Factors	Conflicting personalities resulting in hazardous attiitudes.	Occasional	Critical	Serious	If individuals cannot professionally resolve differences, managers and supervisors must intervene immediately. Brief/debrief, employ CRM, provide honest and objective feedback, maintain positive attitude. Maintain professionalism and mission focus at all times.	Remote	Critical	Medium

Helicopter System - Personnel (Contractors)

Sub-System	Hazards	Pre-mitigation Likelihood	Pre-mitigation Severity	Pre-mitigation Outcome	Mitigation	Post-mitigation Likelihood	Post-mitigation Severity	Post-mitigation Outcome
Training/Experience	Inadequate/falsification of documentation	Occasional	Catastrophic	High	Adhere to existing contract requirements requiring Contractors to validate pilots' experience and training. Ensure HIPs review pilots' experience records.	Remote	Catastrophic	Serious
Training/Experience	Lack of training in Firefighting strategy, tactics, terminology, basic ICS, frequency mgmt, etc.	Probable	Critical	High	Establish requirements for documentation of online training to meet basic, minimum level of knowledge for all contracts. Consider pilot academy.	Occasional	Critical	Serious
Training/Experience	Pilots unfamiliar and not proficient using and programming contract required radio and navigation equipment	Frequent	Marginal	Serious	Inspectors ensure Contractors (Pilots) are adequately trained & skilled in use and programming of avionics equipment. Ensure contract language requires equipment to be commensurate with current technology.	Occasional	Marginal	Medium
Pilot Experience & Capabilities	Low flight time/experienced pilots	Probable	Critical	High	Develop, implement and support a pilot mentoring program in appropriate contracts. Consider pilot academy.	Occasional	Critical	Serious

Helicopter System - Personnel (Contractors) - Continued

Sub-System	Hazards	Pre-mitigation Likelihood	Pre-mitigation Severity	Pre-mitigation Outcome	Mitigation	Post-mitigation Likelihood	Post-mitigation Severity	Post-mitigation Outcome
Human Factors	Fatigue	Probable	Critical	High	Managers work with company personnel to ensure adequate rest. Manage missions to be most effective with proper use of pilots & aircraft. Implement Phase Duty Limitations as appropriate.	Remote	Critical	Medium
Human Factors	Acceptance of high risk missions as normal.	Probable	Catastrophic	High	Conduct thorough risk assessments & brief/debrief. Pilot and Helicopter Manager train in CRM and work together on mission planning. Mission approval made at appropriate level.	Occasional	Catastrophic	High
Human Factors	Low CRM with crew rotations (multiple relief pilots)	Frequent	Critical	High	Ensure there incoming crews are thoroughly briefed. Practice CRM, conduct effective AARs, etc. Enforce contract language regarding relief pilot/personnel changes.	Occasional	Critical	Serious
Human Factors	Conflicting personalities	Occasional	Critical	Serious	Brief/debrief, CRM, honest feedback, maintain positive attitude and professionalism. Immediately take action. Notify Contracting Officer/Inspector Pilot. **Don't let problem persist.**	Remote	Critical	Medium
Human Factors	Sense of urgency/pressure/mission driven	Probable	Critical	High	Ensure Managers are not placing undue pressure on pilot. Thorough risk assessment & brief/debrief. Pilot training in CRM with the Helicopter Manager. Pilot participate in Mission development. Mission decision made at appropriate level.	Occasional	Critical	Serious
Human Factors	Pre-flight/Post-flight inspections not thorough	Occasional	Catastrophic	High	Managers ensure adequate **REVENUE** time for Inspections. Ensure Managers are briefed/trained on the contract & realize that Contractors do get paid for this time. Encourage Pilot/Mechanic to utilize time to complete Inspections.	Remote	Catastrophic	Serious

Helicopter System - Technology

Sub-System	Hazards	Pre-mitigation Likelihood	Pre-mitigation Severity	Pre-mitigation Outcome	Mitigation	Post-mitigation Likelihood	Post-mitigation Severity	Post-mitigation Outcome
Utilization	Lack of standardization of equipment	Frequent	Critical	High	Allow time for the pilot, mechanic, and Helicopter Manager to conduct thorough pre-use familiarization with cockpit layout and avionics equipment.	Remote	Critical	Medium
Utilization	Some pilots do not know how to operate radios, GPS, etc. Managers not familiar with equipment.	Probable	Critical	High	Train all personnel to be proficient in the use of avionics equipment on the helicopter as per contract requirements. Provide computer based or hands-on training for various models of GPS units and radios for helicopter managers.	Remote	Critical	Medium
Human Factors	Cockpit overload, pilots flying, programming radios/GPS, dropping water, talking on three different radios, etc.	Frequent	Critical	High	Experience, OJT w/experienced supervision (HIP or Chief Pilot), CRM-work with experienced Helicopter Manager. Ensure appropriate levels of aerial supervison are in place. Encourage pilots to speak up when starting to get overloaded. Discuss safety options with the pilot.	Occasional	Critical	Serious

Helicopter System - Operations

Sub-System	Hazards	Pre-mitigation Likelihood	Pre-mitigation Severity	Pre-mitigation Outcome	Mitigation	Post-mitigation Likelihood	Post-mitigation Severity	Post-mitigation Outcome
Missions	Multi tasking-Pilot, Helicopter Manager, Helibase Manager, Helitack Crew personnel, fueler.	Frequent	Critical	High	Ensure existing staffing, supervision and management policies & procedures are met. Order resources early when the need is anticipated. Dispatchers need to recognize aviation staffing is a critical safety priority. Limit collateral duties in key supervisory positions. If unable to fill key positions, operations will be shut down or use of aircraft will be limited until span of control issues are resolved.	Occasional	Critical	Serious
	Complexity beyond capabilities/experience of available resources	Probable	Critical	High	Disengage, reassess & realign objectives until appropriate level of supervision is present. Conduct risk analysis. Ensure situation is recognized & ensure appropriate supervision/resources are ordered. Provide OJT and conduct	Occasional	Critical	Serious
	Poor Aviation Strategy (poor risk vs. reward, heli-mopping, overuse-are there alternative ways of doing this)	Frequent	Catastrophic	High	Utilize safe and effective strategy & tactics. Involve pilot in mission planning. Conduct thorough risk assessment prior to mission. Brief/debrief. Seek appropriate level of approval for high risk missions, i.e. Helicopter Manager, IC, District Manager, Forest Supervisor, etc. Involve Aviation overhead with operational planning of strategies and tactics for the Appropriate Management Response. Avoid risk/exposure	Remote	Catastrophic	Serious
	Jurisdiction/Borders-Mid Air collision avoidance	Frequent	Catastrophic	High	Boundary Airspace Plan developed/utilized. Follow FTA procedures. Utilize airspace coordinator. **COMMUNICATE.** Establish TFRs as needed. See & Avoid. Utilization of TCAS. Make AFF a requirement on all aircraft contracts.	Remote	Catastrophic	Serious
	Low level flight profile-below 500', Special Use (recons, aerial survey, game count, mapping, etc)	Occasional	Catastrophic	High	Conduct thorough risk assessment training. Thorough risk assessment/mission plan/performance planning is completed and signed at the appropriate level. Minimize exposure time. Utilize Part 27 certificated T3 helicopters. Ensure that the appropriate PPE/ALSE is used and that the flight is limited to essential flightcrew members. Ensure aircraft and pilot are carded for the mission. Conduct high level recon prior to working below 500' AGL.	Remote	Catastrophic	Serious
	PASP/Go-NO-Go Checklist absent or not complete (Policy Deviation)	Occasional	Critical	Serious	Ensure PASP and risk assessment are completed and approved at appropriate level. Ensure Unit Aviation Managers and Forest Aviation Officers are involved in mission planning when necessary. PASP should be used as a briefing tool. Stress that on the "GO/NO-GO" checklist a "NO GO" halts the operation. Ensure that if there are multiple briefings that all information is given at the primary briefing.	Remote	Critical	Medium
Management Decisions	Incident Management Team strategies shift risk from ground operations to aviation operations.	Frequent	Catastrophic	High	Utilize safe and effective strategy & tactics. Involve Pilot in mission planning. Conduct thorough risk assessment prior to mission. Brief/debrief. Acquire appropriate-level approval signatures for high-risk complex missions; i.e. Helicopter Manager, IC, District Manager, Forest Supervisor, etc. Involve Aviation overhead with Operational planning of strategy and tactics for the Appropriate Management Response. Avoid risk/exposure transference.	Remote	Catastrophic	Serious

Helicopter System - Operations - Continued

Sub-System	Hazards	Pre-mitigation Likelihood	Pre-mitigation Severity	Pre-mitigation Outcome	Mitigation	Post-mitigation Likelihood	Post-mitigation Severity	Post-mitigation Outcome
Utilization	Inefficient or improper use of Aircraft for the assigned mission (wrong aircraft selected for a mission, flying without tactical/logistical objectives, etc.)	Frequent	Critical	High	Use only an appropriate aircraft for the mission. Conduct thorough pre-mission planning and load calculations. Ensure that tactical/logistical missions have clear, obtainable goals (i.e., Appropriate Aviation Management Response is used). Aircraft assigned should be based on performance and capabilities.	Occasional	Critical	Serious
Environment	Weather: Poor Visibility/Thunder storms/Hot-High DA/Turbulence	Frequent	Catastrophic	High	Obtain most current/accurate weather reports available. Conduct risk assessment & determine need to conduct mission. Wait until conditions improve. Follow policy on visibility, wind speed, updating load calcs, etc. Utilize part 27 certificated T3 helicopters or better. Establish trigger points to stop operations.	Remote	Catastrophic	Serious
	Mountainous Terrain	Frequent	Catastrophic	High	Ensure Pilot is trained, experienced & qualified/carded. Non-local flight crews obtain thorough briefing on local conditions before starting operations. Aircraft appropriate for the mission. Performance planning is completed for environmental conditions. Consider dual pilot operations or utilize a mentor pilot for low experience pilots.	Remote	Catastrophic	Serious
	Urban Interface: Wires, General Aviation Traffic, Major Airport Traffic, Communications, Congestion, High Complexity	Probable	Catastrophic	High	Conduct thorough briefings. Review/establish Interagency agreements. Provide preseason briefing for Media aircrews. Preplan dipsites, staging area, helispots, etc. Update aerial hazard maps. Establish TFRs & issue NOTAMs as appropriate. Require dipsite management. Order/utilize aerial supervision (HLCO). Perform Airspace deconfliction and coordination. Provide frequency and airspace management training. Complexity is managed at appropriate level.	Remote	Catastrophic	Serious
Communications	Lack of Compatibility (Banding/Frequencies)	Probable	Critical	High	Utilize Unified Command. Review/establish interagency agreements to reduce/eliminate compatibility issues. Continue education/training.	Remote	Critical	Medium
	Frequency management - lack of timely response for Incident Support to obtain additional frequencies.	Probable	Critical	High	Evaluate prior reviews and conduct additional national Interagency reviews of frequency management. Release frequencies back to NICC as soon as they are no longer needed. Encourage Dispatch offices to order additional frequencies early in emerging incidents.	Occasional	Critical	Serious
	Cockpit overload	Frequent	Critical	High	Encourage pilots to speak up when starting to get overloaded. Discuss safety options with the pilot. Practice division of workload and CRM on incidents and in simulations.	Occasional	Critical	Serious
	Inadequate briefing	Occasional	Critical	Serious	Stress to Managers & Pilots the need to slow down & ensure adequate briefings. Follow Policy and guidelines, use existing checklists (IHOG, IRPG, etc) as a minimum. Solicate feedback, reiterate information given, use of maps, IAPS, and frequency lists. Ensure AARs are being conducted and documented.	Remote	Critical	Medium

Helicopter System - Operations - Continued

Sub-System	Hazards	Pre-mitigation Likelihood	Pre-mitigation Severity	Pre-mitigation Outcome	Mitigation	Post-mitigation Likelihood	Post-mitigation Severity	Post-mitigation Outcome
Training	Lack of training for specialized missions i.e. rehab (Bale dropping, waddle placement), guzzler placement, etc.	Occasional	Critical	Serious	Consider and encourage using End Product Contracts. When end-product is not feasible, develop standardized description of how to sling unusual items. Develop a source list for approved equipment. Utilize PASPs. Utilize subject matter experts. Use "Tech Tips" to share information/procedures.	Remote	Critical	Medium
	Lack of standardized training with non-Federal cooperators (non-standard terminology, target description, resource capability & limitations)	Probable	Critical	High	Promote joint training with non-Federal cooperators. Ensure thorough briefings are conducted prior to starting operations. Check Incident Qualification cards.	Remote	Critical	Medium
Human Factors	Lack of Crew Resource Management (CRM)	Probable	Critical	High	Training, Brief/debrief, maintain positive attitude. Promote and attend formalized CRM training for contractors as well as agency employees. Include CRM training/topics at Helicopter Manager Workshops (RT-372). Include CRM as part of the training curriculum for S-372.	Occasional	Critical	Serious

Appendix D

Study Plan

Study Plan

Project Scope Established by the Steering Committee – January 8, 2010
The helicopter night operation project should identify the primary firefighting operations that occur during the daytime and determine if they can be continued during the night.

Specifically examine the delivery of wildland fire chemicals and water, crew transport, aerial ignition, rappel, helitak (initial attack), cargo delivery, medivac, and intelligence gathering.

In identifying the feasibility of cross walking these functions to night operations, the initial assessment should include for either initial attack or large fire or both.

After the initial preview, present to the steering committee the potential for the daytime operations to move into night operations with a general sense of complexity to implement or ease to implement. Once this has been presented, the primary focus for complete project development will occur.

Process
The recommended plan is to complete steps 1-4 below leading to the steering committee decision defined in step 5. Following this decision, steps 6 and 7 will be completed. The steps of the process follow.

Step 1 - Review history
Step 2 - Review current operations
Step 3 – Document currently available technology or technology that may be available soon
Step 4 - Mission definition and quantification
Step 5 - Presentation of alternatives and selection of course of action
Step 6 - Study risk and benefit/costs associated with helicopter night missions
Step 7 – Complete report

Details of the Process

Step 1 - Review History
- ✓ Research and document wildfire helicopter night operations
- ✓ Research and document the reason for Forest Service termination of wildfire helicopter night operations
- ✓ Research and document the equipment used
- ✓ Accident reports

Missions
Examples:
- Initial attack
- Personnel transportation
- Rappelling
- Water and retardant dropping
- Aerial ignition
- Intelligence gathering
- Tactical Infrared
- Cargo delivery
- Medivac

When: 1 month in
Travel: None
Results: Prepare prelim-history report

Step 2 - Review Current Operations
- ✓ Document programs and experiences for agencies conducting night helicopter operations
- ✓ Research and document the current contract helicopter rates – agency and commercial for day and night operations.

Information Sources and Subject Matter Expertise
Customs, Border Patrol, Military (Special Ops), Coast Guard, Los Angeles County, San Diego, Oregon Air Guard, Fort Lewis, Fort Rucker, Canada, Defense Advanced Research Projects Agency, Emergency Medical Services (Air Methods), PHI, National Aeronautics and Space Administration, Federal Aviation Administration

Key Contacts
Los Angeles County

Expertise
Night vision equipment
Interview skills
Current agency pilots
Drug enforcement folks

Key Items to Address
Mission
Technology used and/or discontinued included make, model and maker
Mitigation measure
Meteorological conditions during mission
Systems and systems integration
Managerial Factors
Aircraft modification requirements
Impact on fatigue
Pilot experience and training
Operations plan
Decision analysis to conduct night operations
Safety analysis
Return on investment benefits
Ground coordination/training
Consider cost of helicopter company's insurance rates
Contact San Diego on cost of maintaining proficiency and currency
Considering partnering to execute missions, which can mitigate the costs

When: 2 months in
Travel: Southern California (Los Angeles County, San Diego, Border Patrol), Salem (Oregon National Guard), Fort Rucker (U.S. Army) and Mobile (U.S. Coast Guard)
Results: Prepare prelim-current operations report, notebook with history and current operations

Step 3 – Document Currently Available Technology or Technology That May Be Available Soon

- ✓ Research and document commercially available equipment for night operations
- ✓ Document capability, cost (procurement and installation), available training

Information Sources and Subject Matter Expertise
Contact Missoula Technology and Development Center
National Aeronautical and Space Administration
Federal Aviation Agency
Helicopter Aviation International
Bill Waterbury to provide information on a camera researched in USFS R-3
Consider doing a request for info in the Federal Business Opportunities publication

Expertise
Involvement mainly in the equipment
Integration of technology into operations
Remote Sensing Applications Center

When: 3 months in
Travel: None
Results: Prepare prelim-current commercial technology report

Step 4 - Mission Definition and Quantification

- ✓ Define ground support needs for each night helicopter mission
- ✓ Define technology requirements for each night helicopter mission
- ✓ Define flight crew requirements including daily flight time limits
- ✓ Define the mission characteristics, parameters and technology for each night helicopter mission
- ✓ Considerations – contracting, development and maintenance of pilot skills
- ✓ Doctrine/Policy

<u>Missions</u>
Initial attack, extended attack and large fire support – needs appear to be different

Examples:

- Initial attack
- Personnel transportation (helispot to helispot)
- Rappelling
- Water and retardant dropping
  - Vertical reference and long line
- Aerial ignition
- Intelligence gathering
- Tactical Infrared
- Cargo delivery
- Medivac

<u>Subject Matter Expertise</u>
Vince Welbaum (National Helicopter Operations Specialist), Neal Hitchcock (National Deputy Fire Operations Officer) , Jeff Powers (Regional Helicopter Operations Specialist), Incident Commander, Helicopter Inspector Pilot, Tom Bates (Interagency Hotshot Crew Superintendent and ATGS) Air Operations Branch Director, Michael Peitz (Helicopter Pilot with night vision experience), Fire Behavior Analyst, Meteorologist

When: 4 month in
Travel: Meeting in Boise
Results: Prepare prelim-mission report (defined whom what, where and how) and recommendations of missions to pursue to a risk assessment

Step 5 - Presentation of alternatives and selection of course of action
Present to the steering committee the potential for the daytime operations to move into night operations with a general sense of complexity to implement or ease to implement. Obtain concurrence on missions from the committee and then proceed with risk assessment.

When: After meeting in Step 4 above
Travel: None
Results: Decisions from Steering Committee

Step 6 - Study Risk and Benefit/Costs Associated with Helicopter Night Missions
- ✓ Perform safety management system risk assessment identifying hazards, mitigation measures and costs to implement mitigation measures

When: 4.5 to 5 months in
Travel: Boise
Results: Prepare prelim-risk study report

Step 7 – Complete report

When: Complete at 6 months in
Travel: Boise
Results: Report

Appendix E

History of Helicopter Night Operations

Helicopter Night Operations:

A History of Technology and Forest Service Involvement

By Janine Smith

The Early Days

Agency interest and involvement in the evolution of helicopter night capabilities has been actively explored since 1963. The USDA, Forest Service, Aviation Management tasked the San Dimas Equipment Development Center to begin preliminary studies on the feasibility of helicopter operations at night to extend capabilities of forest fire control.

Over a three year period this department performed extensive studies and research into what was currently available at the time in night technology, navigational technology and supporting equipment that could be used in helicopters for firefighting missions. They initially looked to the military to see what equipment potentially supported their missions at night. Utilizing much larger aircraft than the Forest Service was interested in; the military was able to incorporate the most sophisticated navigational equipment for the times, which was beyond what would be rational for the smaller helicopters to incorporate in the fire environment.

The agency then examined what the civilian market had to offer in the way of night operations technology. In 1964 they conducted a series of test flights to evaluate efficient lighting and navigational equipment. By 1965 they had come up with some general guidelines for pilot qualification and training, helicopter equipment requirements, helispot equipment requirements, flight routes and emergency landing areas, visibility, terrain and finally physiological factors for flying at night. A brief look at those very early guidelines follows:

Pilot:

- Must have a desire and interest in flying at night
- Qualifications more stringent than for day flight operations
- Must receive extensive training in safe route selection, equipment and physiological factors

Helicopter:

- Controllable searchlight
- Air-net radio
- Altitude gyro (electric)
- Directional gyro (electric)
- A newly tested lightweight, low cost radar altimeter

Helispot:

- 100’ wide by 100-200’ long
- Amber lights marking boundaries, one chain (88 feet) apart
- Blue or green lights indicating center of pad
- Orientated for best use of terrain, winds, smoke, obstacles

- Required helispot marking kit which was contained in a fiberboard box:
  - 5 - route marker strobe lights
  - 14 - route marker (amber) lights
  - 16 - emergency landing area marker lights
  - 30 - 6-volt dry cell batteries
  - 6 - 3-foot diameter parachutes (to deliver kit to landing site if necessary)
  - 1 - Air-net radio

Flight routes:

- Must be selected by the pilot and flown during the day
- Routes are marked with beacons and emergency landing areas along the way
- Distance between helispots should be a short as possible

Visibility:

- Consider weather, topography, vegetative cover, smoke, and moonlight
- Terrain
- Flight routes must avoid dark canyons and smoke
- Requires careful planning
- Physiological factors
- 1965 Pacific Southwest Forest and Range Experiment station studied;
- Night vision
- Visual illusions
- Autokinesis
- Flicker and motion vertigo

In 1966, these findings and research information were published in the US Department of Agriculture’s Forest Service *Fire Control Notes* dated July of 1966 in Volume 27 No. 3. U.S. Department of Agriculture Forest Service Fire Control Notes, Vol. 27 #3, page 12 -13, July 1966, was the primary source for this early 1960’s information. This publication not only informed the entire agency of the study, but left a positive opinion that night operations capability was a possibility for future operations. It would require further testing and studies on many phases of night operations, but these later tests could potentially prove “another valuable application of helicopters in firefighting.”

Research and Implementation
By April of 1972 a meeting took place in Sacramento between the Forest Service and the California Department of Forestry and Fire Protection to discuss night electronic support systems. They particularly wanted to look at the newly developed helicopter mounted INFANT (Iroquois Night Fighter and Night Tracker) night-vision system being used by the military. The purpose of the meeting was to compare the INFANT system with the Fire-Scan (fixed-wing aircraft mounted), helicopter mounted forward looking infra-red (FLIR), and Mohawk (fixed-wing mounted infra-red) to determine capabilities in day, night, in smoke and without smoke to evaluate costs, reliability and availability of the system.

Developed by Hughes, this INFANT system, a very new technology, was a “night vision” or light gathering, image intensification electronic system. Mounted externally on the nose of the aircraft it weighed 445 pounds fully installed. The external system had two periscope-type scanners which could be operated either separately or in tandem and rotated both horizontally and vertically. It connected to both eye pieces and on a television screen inside the aircraft for tracking and navigation. Since it was a light gathering intensification system it was unable to penetrate smoke or clouds.

The Fire Scan system was a Forest Service infra-red unit mounted in a fixed-wing aircraft. It was used for fire detection and mapping and had the ability to penetrate smoke, although not clouds or fog. The imagery had to be reproduced on film and then would be manually delivered to the decision makers.

The Mohawk was a fixed-wing military aircraft with infra-red sensing equipment that was made available to civilian groups as was the INFANT system. It was a generation more advanced than the Forest Service Fire Scan system, and the imagery had the ability to be transmitted via video receivers on the ground.

In the eleven categories used for comparison, the INFANT system proved equally capable in most categories including costs and more capable in a few other categories. If smoke was a factor, the INFANT system rated poor to fair in all categories, but the group determined that the INFANT system had good potential, and thus began further exploration into imaging systems for the test program.

Even if the group was able to find a worthy technology that would allow them to launch the helicopter night operations mission, there was a very real concern over the reluctance of fire administrators to adopt the program. The following reasons were noted:

- The payoff to the fire boss was too low.
- The daytime use of the helicopter had such greater benefits to the fire boss that the equipment and pilot time and associated personnel were fully used during the daylight hours with no residual for night operations.

- Some special effort and training was required for night operations
- Equipment and manpower were not equipped for night-time operations to match the helicopter capability.
- Because of the contractual helicopter services, operators had some reluctance to fly at night.

Some of these concerns would prove not only to be an obstacle in implementing the night operations program, but would eventually be a primary reason the program was discontinued in the 1980's.

In the fall of 1972, the group began development of the proposed study plan for helicopter firefighting at night. As they developed the statement for Problem and Background portion of the report, they referenced the results of the devastating Coyote fire that occurred in Santa Barbara in 1964 destroying over 100 homes, 67,000 acres and costing taxpayers $20 million. This spurred some testing in southern California with 117 night helicopter flights over mountainous terrain that would simulate fire line operations. These tests indicated that flights carrying passengers and cargo could be conducted safely if (1) the night operation is well planned (2) the helicopter is in excellent condition (3) adequate lighting and guidance equipment are provided and used (4) the pilot and crew are well trained. They also considered the disastrous 1970 fire season that took place in California and Washington.

With this information at hand, the steering committee developed specific objectives, a work plan, personnel assignments, time schedules and costs. The objectives were to demonstrate and test helicopter navigational aids such as the INFANT and wide-angle FLIR systems, and to develop techniques and guidelines for integrating medium and large helicopters into conventional fire organizations. A month later this objectives list was expanded from two specific objectives to nine.

1. Determine applicability of both the INFANT and FLIR systems for night operations under variable condition of weather and smoke.

2. Establish limitation of use.

3. Determine pilot acceptance of night flight operations as compared to normal daylight operations.

4. Explore autorotation limitations, if any, as compared to daylight techniques required to stay within established height-velocity curve.

5. Determine capability to deliver equipment and cargo by landing, free-fall or heli-chuting.

6. Determine capability to deliver fire retardants on selected targets.

a. With aid of ground markers or lights.

b. Without ground markers.

c. With ground voice direction for both cases.

7. Explore potential of night reconnaissance for mapping and remote sensing.

8. Determine ability to perform other tasks such as laying hose, resupplying water and backfiring, as compared to daylight operations.

9. Report on other effects, which may be generated as a result of having nighttime air mobility.

A final objective was to evaluate effects on costs of 24-hour helicopter operations.

In December of 1972, the committee had made a formal request to the Commanding General, Headquarters Army Material Command for the loan of an INFANT surveillance system. It was for a period of one year and possibly extended to three years. The system included one AN/AS 132 Image Intensification System and one UH-1M Iroquois helicopter. The purpose of the request was for test and evaluation. Surprisingly, the request was denied. The correspondence from that time indicates the executive director of Helicopter Association of America (HAA) had influenced the Department of the Army, despite prior approval of the cooperative night firefighting research project by the HAA Forest Committee. The HAA membership concerns stemmed from a group of large operators who feared this loan would be the start of a Forest Service fleet. They also wanted to know who would perform the maintenance on the helicopter, and who would furnish the pilots?

The denial of the request was on the grounds the steering committee needed to provide an invitation for bid to commercial aviation operators. The committee did not provide an invitation for bid because the Department of the Army was the only operator of the system at that time. The Forest Service Washington Office had then contacted members of HAA to confirm that there were no commercial entities that had the ability to provide the steering committee with the system. The steering committee again explained the situation to the Army and was again denied stating the HAA Board of Directors reemphasized their position opposing the use of military equipment "whenever the application of such equipment represents possible interference with private enterprise."

The Department of the Army was being pulled in two different directions in this "battle" between the steering committee requests for the loan from the Army and the HAA Board and membership wanting commercial representation. However, the Army concluded their denial with this statement, which eventually opened the door for the test program, "We shall be happy to sit down and attempt to work out a way to cooperate with you and the U.S. Forest Service, as long as the vehicle which carries the test equipment be contracted from private industry."

This tug-of-war was eventually concluded with the compromise of utilizing the Army's INFANT system and UH-1M helicopter for a period of seven months from May through November, 1973. The INFANT system would then continue on a one year loan provided the aircraft was supplied by a commercial vendor.

By January of 1973, the night helicopter test group had come up with a list of seven missions that they believed would show "appreciable use, and reduction of acres burned". Through the development of medium and large helicopter night capability, the list of missions they believed would benefit fire operations were:

- Visual reconnaissance with a medium sized helicopter
- Infra-red mapping – medium helicopter
- Transportation to assemble and disperse overhead – medium helicopter
- Burning out operations (firing ignition devices from helicopter) – medium helicopter
- Emergency rescue missions – medium helicopter
- Transportation of men, equipment and supplies – medium and large helicopters
- Retardant dropping – medium and large helicopters

By February of that year Deputy Chief Arnold gave the approval to proceed with the "Helicopter Firefighting at Night" test project. A steering committee was developed and they had their first meeting on March 1, at which time Herb Shields was assigned as project leader and eight different funds allocated the initial $350,000 for the project. These funds came from the California Department of Forestry, Los Angeles County Fire Department, San Dimas Technology and Development Center, Aerospace Corporation, Rocky Mountain Research Station, Pacific Southwest Research Station, Oregon Department of Forestry, and a contingency fund.

The steering committee developed tasks for the research project:

- Visit sensor laboratories
- Obtain letters from the Federal Aviation Administration regarding Instrument Flight Rule requirements
- Visit military labs i.e., Army Night Vision Facility
- Contact fire agencies
- Develop new program options as needed
- Determine other support requirements such as a grant to Aerospace Corporations
- Complete arrangement for cooperative agreements between Pacific Southwest Station, California Department of Forestry and Fire Protection, and Los Angeles County
- Obtain security clearances for Roland Barton and Robert Weaver

During this same meeting the attendees developed a three-phase approach for fully implementing the night operations program.

Phase I – Began implementation in early fiscal year 1973 and included:
- Equipment selection
- Training and test
- Demonstration
- Fire Operations (bailed aircraft, agency piloted)

Phase II – Extended from mid-fiscal year 1973 through the end of 1974 and included:
- Engineered modifications
- Policy and tactic development
- Contractor training
- Fire operations (agency and contractor, piloted)

Phase III – Extended from mid-fiscal year 1974 through 1975
- Operationally proven equipment
- Established policy and tactics
- Operations implemented – contractor piloted

During the course of a survey conducted of military sources of night vision devices, the group was unexpectedly introduced to the AN/PVS-5 night vision goggles, which was a ground personnel night vision goggle system which Army aviators had been using and were very enthusiastic about. The group immediately added this technology to the mix of test equipment to be evaluated during their testing phase of the project.

During a steering committee meeting that took place August 24, 1973, the committee members worked out the future plans for the implementation of the night operations systems for FY '74. The plans included two UH-1M Iroquois helicopters acquired from Virginia and New Jersey to be fitted with the test technology systems. One was flown to Corpus Christi, Texas, to be fitted with the INFANT system; the other was to be flown to California for the installation of the FLIR. The aircraft were then to be taken to Yuma Proving Ground for two weeks of training for six test team pilots. These pilots were the backbone of the testing program for the night operations systems and would be trained in the night vision goggles, FLIR and the INFANT systems. Once the training was complete, the aircraft were to be moved back to California for the testing.

During another meeting, the committee members were presented with the technology. They reviewed a high quality video tape of the FLIR imagery, received an informative briefing on the INFANT system and following the adjournment of the meeting, the committee members were taken on a flight into Big Dalton Canyon with the Los Angeles County pilots. The pilots used only the night vision goggles for navigation during this flight and impressed the committee members with a landing in the dark canyon. The committee members came away from the flight with the realization that "goggles" would play a major role in future night helicopter tests and operations.

October closed with the all the meetings, memorandums, and research coming to reality as the two helicopters were received by the Forest Service. By November the aircraft were being fitted with the FLIR.

Between October 1972 and February 1974, the Helicopter Night Operations Project had progressed from circulating the study plan to fully implementing a training program with two UH-1M helicopters, acquiring two pair of night vision goggles, installing a FLIR system in one helicopter and the INFANT system in another. However, the aircraft with the INFANT system was in such bad condition that the Forest Service would not receive that aircraft until April of 1974. There was continued delay in receiving the second aircraft from the Army that was equipped with the INFANT system. The aircraft that was fitted with FLIR and had the pilots using NVGs, kept the project moving forward.

Once testing began with the FLIR and INFANT systems, the committee required extensive evaluation of the systems to determine their "capabilities envelope" based on the mission matrix. They were to operate aircraft during the 1974 fire season and record imagery from both day and night flights, and document the attributes and problems related to operating in the fire environment.
The following is a compressed timeline of the project activities:

- Huey (UH-1M) helicopter obtained on loan from US. Army (October, 1973).
- First night viewing of forest fire with night vision goggles occurred at Angeles National Forest (February 23, 1974).
- Project crew spent one week in Arizona conducting experimental flying and training of one Forest Service pilot and one BLM pilot (March, 1974).
- First water drops (10) made at night on a forest fire (Rock Fire) by Los Angeles County pilots (June 16, 1974).
- FLIR system in Army helicopter showed ability to provide fire spread information and navigational potential at night and under smoky or smoggy conditions (spring, 1974).
- Potential of portable instrument landing system and IR light demonstration under nocturnal conditions (summer, 1974).
- Trained pilots from Western Helicopters assumed responsibility for conducting tests with Army helicopter (July 1, 1974).

- Successful demonstration of night fire suppression capabilities made on Soboba Fire by Los Angeles County pilots with more than 50 drops of 330-gallons each (total of 16,000 gallons) were made between midnight and [0200] (August 28-29, 1974). Taken from Helicopter Night Operations Steering Committee meeting dated July 7, 1975 – the actual text says "between midnight and 2100 a.m." The bracketed information is an educated guess.

- Test team conducted 3,600 mile tour of the western US in an Army helicopter to demonstrate night navigational capability with NVGs and FLIR (October, 1974).

- Two night rescues were made in the San Gabriel Mountains by Los Angeles County pilots (winter, 1974).
- After more than 150 hours of useful flight time, UH-1M helicopter equipped with FLIR was returned to the Sacramento Army Depot (April, 1975).

- Lightweight FLIR system delivered to the Forest Service by Philco-Ford and will be installed in the Los Angeles County 204-B helicopter for operational testing (June, 1975).

- "Information for Flight Crews" draft of training syllabus developed and ready for evaluation (June, 1975).

As 1975 approached, the evaluation period and funding for the INFANT system was completing. The committee and test team were very impressed with the "stand-alone" capabilities of the night vision goggles. The decision was made not to further fund the study, not use the INFANT system, and to return the aircraft and system to the Army.

By summer of 1975, the project was transferring technical information knowledge and procedures learned during the research and development phase into operational plans and instructions phase. The conclusion of the testing and research phase of the project provided clear information on what technologies the project would move forward with. The five systems that were reviewed from the early stages of the project were:

- Starlight Scope
- INFANT (Iroquois Night Fighter and Tracker)
- FLIR (Forward Looking Infra-Red)
- NVG (Night Vision Goggles)
- TALAR (Portable Instrument Landing System)

In November, the committee decided to move ahead with the following equipment.

1. AN/PVS – 5 night vision goggles
    a. Magnifies available light up to 14,000 times
    b. Powered by 2.7 volt battery with a 12 – 18 hour life
    c. Images can be seen well up to 1000 meters
    d. Has a 40 degree field of view
    e. The initial cost for one pair of the night vision goggles was $15,000. They presently cost $10,400 and are in mass production.

2. FLIR (Forward Looking Infra-Red)
    a. Can penetrate smog, fog, smoke during night and daytime
    b. Has a 30 degree vertical and 40 degree lateral scan
    c. Video tape recorder for TV compatibility with time, date and narration superimposed
    d. Pure Infra-red with 8-13 mirror spectrum range
    e. Cost $75,000 prototype, not in production at this time

3. TALAR
    a. Portable Instrument Landing System
    b. Approximately one hour to set the system up
    c. $40,000 per system
    d. In production at this time
    e. Not compatible with existing aircraft VHF-UHF instrument landing systems

The goal was to have the project mission capable by the start of fire season 1976. To accomplish this, the list of items to be purchased totaled $404,000 and included:

Bell 212 (Contracted)	BLM	$220,000
Night vision goggles (three sets)	USFS	$45,000
IR Light	USFS	$3,000
FLIR (June 30, 1976)	USFS	$75,000
Fixed tank	USFS	$40,000
Instruction for TALAR with B-212	BLM	$5,000
B-212 Modifications	BLM	$1,000
Training of three pilots – 25 hours @ $275.00/hr		$6,875.00
Instructor Pilot from Los Angeles County Fire Department		$2,000

As the summer of 1976 approached, the committee had identified guidelines for the helicopter night flying operational fire season. They had developed personnel qualifications and training guidelines for pilots and helitack personnel, equipment guidelines, operations, scope, procedures and heliport requirements.

Pilots
Above the requirements outlined in 5712.12a, pilots must have one full fire season as a full time Forest Service contract pilot, a minimum of 50 hours of helicopter night flying experience, 5-10 hours of night vision goggle flying experience, have at least 45 minutes with three takeoffs and landings, pass an agency approved check ride and possess a Helicopter Pilot's Qualification Card reflecting night flying qualifications.

Helitack Personnel
Air Service Manager (Heliport) will possess a current Red Card rating of Air Service Manager (Heliport 2), at least one day's experience working with the type of helicopter to be used in the type of operation to be undertaken, undergo two hours of training and orientation.

Equipment
Helicopter will be fully equipped for night flying to include a toggle switch for instrument lights on/off, fixed metal drop tank, three pairs of AN/PVS-5 NIGHT VISION GOGGLEs, IR supplemental lighting, approved flight helmets with NIGHT VISION GOGGLE attachments, Heliport marking available, additional equipment as required, water trucks and pumps available.

Following the 1976 fire season, the Los Angeles County Fire Department had not flown on any fires at night and had focused primarily on the training of Arizona Helicopter's crew and the currency of their own pilots. The Rose Valley aircraft had flown two missions on the Sequoia National Forest and two missions on the Los Padres National Forest, which resulted in a total of 7.1 hours flown and 2,100 gallons of water dropped at night. Though it was in the very early stages of operations, the committee felt the program had been successful and requested the continuation of the program at Rose Valley. They also recommended adding a second helicopter to the Region if money and resources were available.

In January of 1977 there was a concern raised in a letter from Arizona Helicopters regarding better communications between the ground crew working directly with the aircraft and the pilots. Under certain conditions such as extremely dark and ground guide too far away, it is very easy to misinterpret the hand signals. They requested considering a ground helmet with receiver and transmitter internally.

The Accident
By 1977, both the USFS and Los Angeles County were flying operational missions at night. The accident involved one contracted USFS aircraft and one Los Angeles County aircraft on approach to the same helibase and resulted in a mid-air collision that killed a pilot from Los Angeles County. This accident significantly impacted the program. The Los Angeles County Fire Department withdrew from night operations altogether, and the US Forest Service took a large step back and re-evaluated the authority of the program, policies for the program and operational procedures.

Following the accident, San Dimas Equipment Development Center and the Steering Committee developed a more detailed Helicopter Night Flying Operations Policy effective as of November

1977. This replaced the previous guidelines and established a go/no-go checklist which was to be completed and personally signed off by the fire boss or deputy prior to each mission.

The policy was continually revised and improved by Region 5 management and the night vision goggle steering committee members and by March of 1978, the revised helicopter operations policy was created and separated into three sections:

I – Authority

A. Helicopter operations policy as approved by the Regional Forester will be in effect.
    a. Night operations steering committee will continue to function as responsible for recommendations until such the program is approved for full use regionally or nationwide.
B. Line officer authority will be in effect for all day and night helicopter operations.
C. Final operational decisions will be agreed upon by the air attack boss and the pilot.

II – Policy

A. Daytime go/no go operations checklist will be used on all extra period fires.
B. Night Helicopter go/no go operations checklist will be used in all single and multiple helicopter operations.
C. All night helicopter operations will require twin engine capabilities with two qualified night vision goggle pilots.
D. Day and night go/no go checklists will be revised and reviewed whenever changes occur.
    a. Night operations (included detailed operating procedures and minimums).
    b. Personnel qualifications and training (included detailed night flying procedures).
        i. Pilots
        ii. Helitack personnel
        iii. Helitack foreman and assistant foreman
        iv. Night air attack boss
        v. Fire boss and line boss
    c. Equipment (night flying operations)
        i. Listed mandatory equipment available
            1. Helicopter fully equipped for night flight
            2. Fixed drop tank
            3. Three pair AN/PVS-5 night vision goggle s
            4. Infra-red light
            5. Approved helmets with suitable night vision goggle attachments
            6. Cockpit warning horn to indicate doors open on drop tank

III – Operations

A. Day helicopter go/no go checklist
    a. Personnel
    b. Communications
    c. Briefings
    d. Landing areas
    e. General

f. Approval sheet

B. Night helicopter go/no go operations checklist
   a. Organization
   b. Heliport operations
      i. Landing and takeoff director
      ii. Parking tender
      iii. Radio operator
      iv. Person trained and equipped with night vision goggles
   c. Fire suppression
   d. Crash rescue
   e. General
   f. Helicopter operations go/no go approval sheet

As the Region 5 management team and steering committee worked together during this time, it was also decided that all night vision goggle and other equipment be transferred to the South Zone Air Unit. San Dimas was no longer funded for the night flying project so it was turned over to operational development which required the move to the South Zone Air Unit.

As the 1978 fire season passed, the night flying helicopter operations steering committee called another meeting requesting reports from the Rose Valley and Chantry Flat helicopter programs. The committee wanted their input regarding;

- Use
- Cost effectiveness
- Problems and/or effectiveness of
  - Equipment
  - Training
  - Personnel
  - Operations, including checklist
- Recommendations for changes in policy, checklist, etc.
- Any commendations of the program.

The reports provided valuable insights to the committee members as the program continued toward the 1979 season. Many of these recommendations progressed through the steering committee and moved forward to the Regional Forester as recommended changes in policy of procedures for the night flying mission. These recommendations included:

1. Add to mandatory equipment available six rechargeable 17-hour batteries and battery charger for communication system.

2. The Regional Forester should request San Dimas Equipment Development Center pursue the development of a positive identification system that can be used on night flying helicopters.

3. Request that each of the regional fire teams receive an update on the night flying helicopter program at their spring 1979 team meeting. The training can be provided by the South Zone Air Unit.

4. The South Zone Helicopter Specialist should be qualified to check ride contract pilots for night flying helicopter operations.

5. Request that the Regional Forester request that the national helicopter program specialist be qualified to check ride contract pilots. This is in addition to the South Zone Helicopter Pilot being qualified.

6. Change policy that will permit Forest Service pilots to train in single engine helicopter when using night vision goggles.

7. The North Zone Helicopter Program Manager and Helicopter Specialist should receive training in night flying helicopter operations so that they can evaluate use.

8. At night, fly trained helitack and helishot crews attached to the night helicopter from an approved helibase to a manned and approved helispot for:
    a. Point to point transportation
    b. Tactical fire support

9. The night flying helicopter steering committee should be dissolved. The duties of the committee should be turned over to the South Zone Air Unit, who will use the air technical committee and the South Zone Supervisors Board of Directors to make future recommendations to the Regional Forester.

10. Approval of changes to the helicopter checklists.

The purpose of the Night Flying Helicopter Steering Committee had completed it's task and this research team was ready to disband as it handed responsibilities off to an operational implementation team. Under this team, the night flying program continued to progress and successfully moved into the 1980's.

In 1980 the Los Padres National Forest utilized one Bell 212 helicopter out of the Rose Valley helibase and the Angeles National Forest operated a Bell 212 out of Tanbark helibase. They had a total of 12 pairs of night vision goggles, three of which were on loan to the Los Angeles County Fire Department. During the 1980 fire season, the two aircraft had an overwhelmingly successful year flying a total of 13 fires using the night vision goggles. Three fires were dual ship operations, 86 flight hours flown under night vision goggle and 125,000 gallons of water dropped by both aircraft under night vision goggle flight and no accidents or incidents took place during that season. The general consensus from the fire line officers was very favorable and the future of the program looked promising.

By 1982, an extensive night flying helicopter training program was developed that would incorporate classroom and field instruction for the night crews and ground personnel. The objective for this two-day multi-helicopter night training course was to provide training followed by demonstration of all personnel abilities which included:

1. Set up an operational helibase for night flying operations.

    a. Using large fire management guidelines
    b. Using helicopter operations checklists
    c. Using specialized night operational equipment

2. Operate specialized communications equipment and demonstrate procedures.

3. Organize and develop an emergency procedure plan for the helibase.

4. Install special standard lighting techniques for helibase and/or helispots.

5. Describe and perform in the position function designated.

6. Demonstrate duties and responsibilities of the night air attack supervisor in dual and single helicopter operations.

7. Prepare flight routes and flight following plans.

8. Plan and set up a retardant/water delivery operation for night helicopter use.

The training provided specific instruction to the different groups such as the night air attack supervisors, night helibase managers, and the night observers and included a planned prescribed burn to provide targets for the pilots during actual water drops.

Prescribed Fire Operations
By 1983 research had begun on night vision goggle/Helitorch evaluations. This evaluation was conducted by two pilots from Permian Aviation utilizing the Chantry Flat Bell 212. The goal of the evaluation was to determine if the co-pilot would be able to see the torch nozzle while in flight and if line pilots were capable of handling the torch under night vision goggle conditions.

The evaluation was completed and considered a total success, but not without some issues that needed to be worked out. These problems were identified and would require further evaluations and equipment modifications in order provide enough capability that this mission would be considered for night operations. One problem related to a greater degree of torch oscillation than they had experienced in the past. They weren't sure if it was pilot induced or the required longer length of the cable inducing the oscillations. Further testing would take place to answer these questions.

The second area of concern was the need to keep light levels to a minimum in the landing area which helped the pilots wearing the full faced PVS-5 night vision goggles, but it greatly hindered ground personnel's ability to see the torch well enough to assist the pilot during takeoff and landing. It was also difficult to examine the torch over during each load and to change the barrel. They tried taping several chemsticks to the torch frame, which helped some but was not producing enough light for good reference.

During this training, they also used the prototype flip-up (Penny-NVIS) goggles that were fabricated by Rob Harrison of San Dimas. The modification consisted of removing the tubes from the standard mask and mounting them on the helmet visor shield with an over-center device which allowed for the tubes to be placed in position for viewing or readily flipped-up out of the way. They also installed the battery packs on the rear of the helmet to power the tubes.

Several of the pilots were able to fly with the new flip-up goggles and without exception, preferred them to the standard system. They were very pleased with the results of the flip-up prototype and their plans were to move toward the third generation technology as quickly as possible. The third generation technology would provide greater capability of safely flying under lower light levels and would pay for itself by giving fire management people a more useable tool.

A couple of months later, the team reassembled for a third phase of the night vision goggle/Helitorch project conducted September 7, 1983 at the Garden Valley Helibase. Participating in the evaluation were Earl Palmer (Washington Office), Rob Harrison (Sand Dimas Equipment and Development Center), Ray Patnaude (Boise National Forest), Greg Conaway and Dennis Hulbert (South Zone Aviation Unit).

The purpose of this phase was to evaluate aircraft mounted lights, determine the cause of the torch oscillation, determine how much light is needed in the helibase area to give ground crews adequate lighting for ground operations, evaluate the ability of pilots to transition from a well lighted area to darkness and darkness to the lighted heliport. And finally to further evaluate the capabilities of the flip-up (Penny NVIS) goggles.

Following the test, the evaluation group's first recommendation was that two flood style lights be installed on all night vision goggle contract helicopters. These were 4" lights equipped with 150 watt elements mounted to the rear step of the helicopter which allowed the ground crew to easily see the torch and suspension cables.

A second recommendation was that pilots be talked off the ground by ground crew when transporting sling loads. When given directions from the ground crew by radio, the pilots were better able to slowly and carefully lift the torch from the surface nearly eliminating the tendency of the cables to twist.

Third, was to provide at least four, 500 watt flood lights for the convenience of the ground crew, provide four adjustable intensity marker lights for alignment during lift off and landing, and provide a portable visual approach slope indicator system at the helibases for use when sling loads are being transported.

Their final recommendation was to convert nine sets of Forest Service owned goggles to have the flip-up capability. This required nine new SPH-4 helmets which were requested prior to the start of the 1984 fire season.

During the final evaluation of the NVG/Helitorch night operations evaluation, a standard model 5400 helitorch with extended cables was used. The torch performed without problems, but when the modified 5400 helitorch was used, the torch misfired and tilted with the nozzle facing up during the return flight to the base.

With a few changes to the modified Helitorch, the team was ready to use the night/Helitorch operationally in conjunction with the South Zone Aviation Unit.

In November of 1984, the push to modify the PVS-5 night vision goggles to a flip-up version was well underway. Pilots had struggled with techniques to overcome the weight and fatigue caused by the full-face goggles, the lack of peripheral vision, inability to read the instruments, loss of visual cues during landing and relying heavily on verbal direction and information from the second pilot. Though the night operations were proceeding satisfactorily, flight crew complaints were well enough documented that the San Dimas Equipment Development Center was assigned to improve night vision goggles for firefighting operations. The intent of this assignment was to develop and implement a night vision goggle mount with the advantages of the recently developed Aviator Night Vision Imaging System marketed to the military by Hughes Optical Products, Inc.

The objectives of this development project were to utilize the existing generation II night vision goggle intensifier tubes owned by the Forest Service, provide improved peripheral vision, provide pilots the ability to read the instruments without removing or refocusing the goggles, provide quick removability and replacement for the pilot to easily transition from aided (using night vision goggles) to unaided (not using night vision goggles) flight. They also wanted to help reduce pilot fatigue by reducing the weight of the goggles and increase pilot acceptance of the equipment.

Several modifications were made, and the new “flip-up” style of night vision goggles performed satisfactorily, and after one full season of field use was ready for service-wide implementation. Though most of the objectives were met, the unresolved pilot complaints were the weight of the equipment (4.4 lbs), placement of the battery pack on the helmet and placement of the main switch. The cost of the mount was just under $500.

The End of a Program

Although the night operations program had proven capable and transitioned from a test and evaluation program to a successful operational program over an eight year period, the field operational portion of the program ended in 1983. Some non-operational testing occurred until 1985.

Although the program came to an end after nearly 10 years, it was a significant ground breaking venture into a fledgling mission capability in aviation. The procedures, evaluation, and operational use the program eventually provided was invaluable and proved, though with some difficult setbacks, that the mission really was viable and worth the effort. It has laid the groundwork for future programs.

Nearly all of the information in this report is taken directly from archived documents available through the San Dimas Technology and Development Center.

Appendix F

Overview of Site Visits

Site Visit Synopsis

During the course of the Helicopter Night Operations project, several site visits were conducted to gather information pertinent to flying missions at night. The following information is a synopsis from each site visit and includes Los Angeles County Fire Department Air Operations, San Diego City Fire Department Aviation Branch, Riverside Immigration and Customs Enforcement Aviation Branch, AirLink of St. Charles Medical Center, Emergency Medical Service, U.S. Army Aviation Training Center in Ft. Rucker, Alabama and the U.S. Coast Guard Air Mobility Command in Mobile, Alabama.

Riverside Immigration and Customs Enforcement (ICE), Riverside, California – March 31, 2010

ICE was selected for the purposes of gathering information from a federal agency (Department of Homeland Security) that had an extensive history of helicopter night operations in the low level flight regime. Specific information that was of importance from this visit focused on the technology used and currency requirements. The primary missions using night operations include air interdiction, drug trafficking, human border protection, search and rescue and resupply. ICE uses helicopter and fixed wing assets to include the Cessna Citation Jet, H-60 Blackhawk, Astar B-3, Hughes 500, Pilatis PC-12. ICE uses a minimum of 11 pieces of equipment to augment their missions, both day and night. Some key technologies used for the night missions are as follows:

- The forward-looking infrared (FLIR©) system is a primary system used in all of their aircraft. The infrared is capable of detecting images even in hazy and light smoke conditions.
- The SIRIUS XM provides weather data through WxWorx© over the XM satellites and WSI (Weather Services International, a company of The Weather Channel) InFlight. This uses excess capacity on Sirius's network.
- Terrain Collision Avoidance System is critical, especially in areas with dense air traffic.
- Helicopter Terrain Awareness and Warning System. These systems provide superior and potentially life-saving information for flight crews, even when flying in changing weather with poor visibility, in rough terrain, or at low altitudes.
- Moving map systems, though with their current version, the mapping system is less accurate in mountainous conditions.
- Night vision goggles.
- Public Announcement System.
- Spotlight equipment such as the Trakka-Beams for intensity and capability from higher altitudes.

- Radar altimeter as required by Federal Aviation Administration for night operations.

ICE generally flies all their night missions with two pilots; however the Astar B-3 is an aircraft approved for single pilot night vision goggle missions. Prior to each flight the pilots conduct a mission risk assessment on an aviation mission record form, which records the request, mission, assignments, risk assessment acceptance or decline with approving authority signature and special mission approval information. They consider risk factor areas covering operational, environmental, equipment and human factors. Following the mission, there is an after action report section of the aviation mission record and it is then kept on file.

The greatest detriment to night operations is the interruptions in circadian rhythms.

All initial training is conducted at the Customs Border Patrol headquarters in Oklahoma City and is a five-day training course. Recurrence training takes place locally and often times with vendors located near the Air Branch that provide the training service. To maintain proficiency, if pilots have flown night vision goggles within a six month period, they just need to fly with a night vision goggle current pilot, if greater than six months, they must fly with an night vision goggle instructor pilot. If it is more than two years since a pilot has flown with night vision goggles, they must return to Oklahoma City for the full course.

Los Angeles County Fire Department Air Operations, April 1, 2010
Los Angeles County is about 4,000 sq. miles in size and includes Catalina and San Clemente Islands. Its highest point is Mt. Baldwin at 10,064 feet, and over 500,000 acres are considered urban interface. The Los Angeles County fire department provides fire protection to 58 of the 88 cities in the county. It also staffs 22 contract stations for the California Department of Forestry and Fire Protection and covers 33 fire departments within its jurisdiction of over 10 million people.

Of the 802 wildfire events in the county in 2007, 387 involved air operations. A total of 2,652,920 gallons were dropped. Their philosophy is direct attack with water or foam whenever possible. The premise behind their air operation is risk vs. gain with no identifiable risk being taken and gain being clearly defined.

Los Angeles County has a multi-mission aviation fleet. Their missions include wildfire suppression, search and rescue and medical transport. They own and operate a fleet of four Blackhawks (S-70's) and five Bell 412's. All have a gated tank secured to the aircraft (LA tank) on them except for one 412 which is used for command and control – helicopter coordinator, the only aircraft equipped with infrared. They utilize night vision goggles accompanied with the Night Sun, a high-powered search light, and utilize both extensively in their night missions.

Their night firefighting missions include helicopter water dropping. In dropping water they most often land and fill the helicopter via fire engine or hydrant. They occasionally transport fire fighters from pre-identified lit heliport to lit heliport. They do not do off-site landings or initial attack at night. Most of their night work is either on extended attack or work on campaign fires. To support their night operation they have a network of 41 night capable heliports all with improved surfaces, (no dirt) and few obstacles on approach and departure. Each heliport can support two Blackhawks.

Los Angeles County Fire flew night vision goggles in the late 1970's until they had a fatality on a night fire mission involving a mid-air collision between a Forest Service contract helicopter and one of their own aircraft. They did continue to fly night unaided missions and eventually started using night vision goggles in 2000-2001 but the program was not fully implemented until 2005. They only fly single pilot in both aircraft types and all crewmembers are paramedics and captains within the fire department. Staffing the night missions is a significant consideration and challenge.

The technology primarily used for the night operations is the Pinnacle AN/AVS-9 night vision goggles, cameras with laser capabilities, mapping FLIR, spotlight and a radar altimeter. The minimum hiring standards for the air unit is 4000 hours, but all of their pilots have at least 8000 hours of flight time and they require extensive fire experience for all of their pilots. They utilize the aviation section of FIRESCOPE as an operating standard and operate 24-hour shifts.

The agency indicated that approximately 40 percent of their total helicopter fleet hours are night aided flying. Further the amount of night aided flying that is in support of wildland fire is approximately 4 to 6 percent of the total fleet hours. Emergency medical service (transport) is the preponderant mission during night aided operations.

The key to their effective and safe night operations is intimate knowledge of the areas in which they fly and high time pilots that measure the risk versus gain aspects of each mission.

<u>San Diego City Fire Department Air Operations, April 2, 2010</u>
The San Diego City Fire Department (SDCFD) has jurisdiction over approximately 400 square miles of operating area. When they began air operations, they started with a contract through Kachina Helicopters in 2002. In its last years this contract conducted night operations using NVGs and by 2005 the City of San Diego started their own in-house air operations program. The Chief Pilot for SDCFD was formerly the chief pilot for Kachina and had worked building the program for SDCFD prior to assuming his current position with SDCFD.

SDCFD operates one Bell 212 and one Bell 412 both with fixed belly tanks. Many of their operating concepts have come from Los Angeles County and they also utilize FIRESCOPE for operating guidance. They place a large emphasis on pilot experience, with a heavy emphasis on fire fighting experience, vertical reference and mountain operations. They have a 4000 hour minimum for a hiring standard, but mirror Los Angeles County in the fact that all of their pilots have at least 8000 hours of flight time.

Their missions include medical transport, hoist rescue, water dropping and occasional transport of firefighters from a lighted and pre-approved night heliports to another lighted and pre-approved heliport. All of their missions launch with three crewmembers, a single pilot, a flight paramedic and a fire captain who sits left seat and is able to size up and manage a fire from the air. The medic is a qualified helispot manager and if the mission is fire, the medic is dropped at the helispot to manage the aircraft and personnel. All night vision goggle helibases and fill-points are pre-approved by SDCFD trained personnel. There are 150 designated helispots throughout the city – all checked for local hazards, water sources and size. The main spots have information contained in a landing zone notebook with pictures of the locations and all pertinent information.

They operate one aircraft 24/7 from January 1 through July 1 for missions primarily consisting of search and rescue and medical transport. From July 1 through December 31, fire is the primary mission and they fully staff two aircraft 24/7. Utilizing the automated flight following system, they can keep track of the movements of their aircraft during missions launched at night. They follow the launch criteria defined in FIRESCOPE with a launch approval coming from the shift commander and the air operations battalion chief. These criteria are; lives threatened, structures are threatened, or high value infrastructure or resources are threatened. They spend as much time as necessary, up to a year, to train, familiarize and ensure proficiency in night vision goggle operations. They have raised their weather minimums for night operations from 700’ cloud ceiling and 2 miles horizontal visibility, defined by FIRESCOPE, to 1000’ ceiling and 3 miles visibility.

In the high wire environment, they require all three crewmembers to be on night vision goggles. The night vision goggle training is a huge investment and is the biggest commitment in undertaking a night operation with night vision goggles. Each pilot is sent to Flight Safety International for annual training and refresher.

They utilize FLIR, but have found it difficult to operate under single pilot crew configuration. They use external light sources extensively to help with the night missions and always perform good recons before conducting their missions. If possible, they perform day recons to familiarize themselves with a location prior to conducting night operations in the area.

When conducting water drops, they utilize sirens prior to dropping the water. Only one helicopter is allowed to drop water over a drop-zone at any one time. They do not conduct initial attack on fires at night and no ground crews are allowed in the area while water drops are being conducted.

The agency indicated that approximately 8 percent of their total 2009 helicopter fleet hours are night aided flying in support of wildland fire, and while their Emergency medical service (transport) response is increasing, 2009 was a lower fire occurrence year. Further, based on the mission risk parameters, many night fires missions receive reconnaissance, Infra-Red support, and the direction of ground resources and not direct suppression action. Their program guidance requires specific criteria to be met before allowing the dropping of water on the fire.

<u>AirLink of St. Charles Medical Center, Bend, OR, April 28, 2010</u>
This organization went through several significant changes around the time the flight department was considering the implementation of night vision goggles into their operations.

They were a branch of Air Methods until the hospital changed the contract to a company out of Shreveport, LA called Metro Aviation Incorporated. Not only were they changing parent companies, they were changing aircraft type and were very new into the implementation of night vision goggles.

AirLink (the Air Methods) began incorporating night vision goggles into their program in 2005, but they found it difficult to acquire night vision goggles due to the demand by the military at the time. The Federal Aviation Administration provided general guidance for night vision goggle implementation, but the organization went further to develop a training and operations manual specific to their organization. There were no EC 145 check airmen for the night vision goggle programs which was the aircraft they unit had just transitioned to, so the Federal Aviation Administration used one of their own check airmen and certified the chief pilot of AirLink to be the approved check airman for the EC 145 emergency medical service community.

The crew is made up of two medical crewmembers and a pilot, with each crewmember qualified on night vision goggles and all are required to be using aided flight (night vision goggles) during take-off to transition and landings. At least two crewmembers (pilot and one medical crewmember) must be aided unless the condition of the patient requires the attention of both medical personnel. This particular air unit has a close culture between the medical teams and the pilots. Crew resource management and cockpit communications is not only expected, but thoroughly trained and relied upon. Getting crews used to using the night vision goggles was a challenge, but the bigger challenge was getting them to really understand and respect the limitation of the night vision goggles. The other change in implementing the night vision goggles was getting the crews used to wearing helmets, a piece of equipment not formerly used in helicopter emergency medical services.

The helicopter terrain awareness and warning system and night vision goggle equipment are two critical pieces of equipment along with a spotlight/searchlight for night operations. night vision goggles have made an enormous difference in improving safety at night for helicopter emergency medical services.

Night vision goggle operations require caution under a number of situations. Night vision goggle operations allows for the pilot to somewhat see through smoke and weather, but can draw the pilot in to a point where visibility just shuts down. Pilots can easily find themselves in an inadvertent instrument meteorological condition. Night vision goggles can cause people to revert to flying and responding as if they were in daylight as visual acuity is very good with the latest versions of goggles. It is important to recognize that night vision goggles are more fatiguing to fly with requiring constant scanning, increased concentration and places extra weight on the head and neck, duty and flight times should be closely managed.

<u>U.S. Army Fort Rucker Aviation Training Center, Fort Rucker, Alabama, May 4 – 6, 2010</u>
This site visit incorporated three departments that provided information to the project, the Night Vision Facility, U.S. Army Aeromedical Research Lab, and Combat Readiness Safety Center.

The Night Vision Facility, May 4th, 2010

The visit to this facility focused specifically on issues pertaining to the night vision goggles themselves, such as improvements to night vision goggle technology since the U.S. Forest Service had used them in the 1970's and 1980's. The visual acuity is now 20/25 with the night vision goggles and the new gated system prevents outside light sources from diminishing the resolution of the goggles. The advantage to the gated system is that it maintains the resolution even with bright lights.

The information gained from the night vision goggle facility covered an array of topics. Their recommendation and advice was to ask about class A minus blue filters when considering buying night vision goggles directly from the manufacturer or from companies dealing in night vision devices since Class A performs better in low light. The AN/AVS 9 has class B and C filters which are more compatible with cockpit lighting. Consider Class B filters with Class A cockpit lighting (Mil-specification 3009 defines classification of cockpit lighting). Cockpit compatibility lighting should be tested to specifications after modifications are complete. Also ask about laser filters, but the laser threat is probably are not a concern to civilian flight.

The five hour requirement for training and currency is more than likely not sufficient for proficiency. Flying night vision goggles is more fatiguing, so consider using a ratio of flight time of 1.5 hours day being equivalent to 1 one hour of night vision goggle flight.

The anti-collision light can be a light hazard under night vision goggles, consider seeking approval from the Federal Aviation Administration to turn the anti-collision lights off under 50 feet for landing and take-off, but ensure pilots turn them back on when above 50 feet.

They do not recommend single pilot operations under night vision goggle or night unaided and they highly recommend inadvertent instrument meteorological conditions training. Use caution when flying during the "golden hour" which is the hour after the end of evening nautical twilight or one hour prior to before morning nautical twilight this is when the horizons produce enough light to affect the night vision goggles ability to perform well when flying toward those areas where the sun has set or is about to rise.

U.S. Army Aeromedical Research Lab, May 4th, 2010

This facility studies all types of mission equipment that affects the aviator or crewmember. They have a two-pronged approach to their research; accident injury and chronic performance decremence. They perform extensive studies with flight helmets and night vision goggles to find if there is an increase in neck injury during accident sequences or with long term use of the goggles. The night vision goggles breakaway from the flight helmet at 10Gs due to the design structure of the ball and socket attachment points to the helmet. They have not found any neck injuries that can be tied specifically to the wearing of night vision goggles unless they are improperly used. Some pilots have been known to tie the neck lanyard from the night vision goggles to the visor slide on the helmet. This permanently attaches the night vision goggles to the top of the head creating a potential for serious neck injury if an accident should occur.

Over long-term use, they have seen some stressing, fatiguing and tiring of the muscles and soft tissue and notice the reducing of response time after fatigue has set in. Nap of the earth flight requires more movement of the head, neck, eyes and level of focus or alertness. This seems to shorten the time when fatigue begins to set in during night vision goggle flight. Simulator studies have been conducted for vibration effects and the evidence of physical fatigue. Findings after two to four hours did not indicate evidence of a lot of physical fatigue. When physical fatigue did begin to occur from the increased weight on the head and neck, mental fatigue would also increase affecting flight performance.

The best helmet on the market today is the HG56P flight helmet due to the blunt impact protection it provides, energy absorbing ear cups and the lightweight of the helmet. Helmets are rated by the Association for Advancement of Automotive Medicine using the Abbreviated Injury Scale (AIS). This scale rates from the lowest impact of 0 (very survivable) to the highest impact rating of 6 (non-survivable). The SPF 4 typically scores in the 4 to 5 range while the HG56P scores 0 to 2.

Combat Readiness Safety Center, May 5th, 2010
The safety center provided information on the requirements for developing and implementing a night operations program. Historically there were operational and distortion issues with the night vision goggles, but with those issues resolved the center has no evidence that night vision goggles actually have created or increased accidents in the last 10 years.

Standards are very important when utilizing night vision goggles in a program. Every task must be standardized with a written protocol to achieve a required level of performance. Basic risk management should be implemented.

Successful implementation of an night vision goggle program requires extensive and consistent training for crew qualifications, performance, proficiency and currency. A dedication to a solid inadvertent instrument meteorological conditions training program is critical and the commitment to the training program by management is the key to success.

The Safety Center provided a report of accidents that took place at night from 2000 – 2010. Most of those years are during conflicts in Iraq and Afghanistan, so an increase in the number of events can be expected. The military rates accidents by severity in a classification system ranging from A to C.

- Class A accidents are the most severe with three qualifying factors
    - $1 million in damage, total destruction of the aircraft, and/or a fatality or total and permanent disability.

- Class B accidents

    - $200,000 up to $999,999 in damages, permanent partial disability, three or more people hospitalized.

- Class C accidents
    - $20,000 but less than $200,000, non-fatal injury causing loss of time at work, or just a loss of time at work.

The report provided consisted of 246 night accidents that had occurred in the 10 year period. 79 or 32% of all those events were rated as Class A accidents, 39 or 16% were Class B and 128 or 52% were Class C events.

- 51 – tree strike
- 12 – over-torque
- 14 – other collision
- 43 – controlled flight into terrain
- 11 – wire strike
- 7 – multi-aircraft event
- 30 – hard landing
- 12 – object strike
- 1 – bird strike
- 2 – foreign object debris

<u>U.S. Coast Guard Air Training Command, May 6, 2010</u>
The U.S. Coast Guard implemented the night vision goggle program in 1996 with a phased approach. This was a very measured way of adding this new technology into their already well established missions; Phase 1 allowed flight with night vision goggles only above 300 feet, Phase 2 allowed flight using night vision goggles below 300 feet, Phase 3 the night vision goggles could be used during take-off and landing and Phase 4 allowed all phases of flight with night vision goggles to include ship board operations and landings.

In training their aircrew and pilots they use the “crawl, walk, run” method where they have 21 training events from the most basic to the most complex rescue swimmer operations. They train these events when a pilot has completed Navy flight school and moves to Air Training Command for mission training. 40% of their budget goes toward training and they have a cadre of 23 instructors to perform quality assurance evaluations annually. Each year these teams of evaluators travel to each unit to conduct check rides, maintenance reviews, and safety reviews.

Luke Air Force Base provided the Coast Guard with exceptional help on training information. They had a civilian compile and build the Air Force information into a computer based training program that has proven to provide high quality and value to their training program.

Their crew compilation consists of three crewmembers (two pilots and a crew member) unless they are over-water which requires a rescue swimmer. They utilize two search lights and a Night

Sun during night missions and also use it to assist ground or boat missions in a supporting role. They have incorporated an incident reporting system, enhanced crew resource management and safety reviews within their safety program and quality assurance program.

Oregon Army National Guard (OANG), Salem, Oregon, May 11, 2010

The OANG is a unit familiar with both NVG flight and wildland firefighting missions, though not at the same time. They have been supporting fire missions for the state and federal government for many years and have a UH-60 Blackhawk modified with a 1000 gallon belly tank with snorkel to support the fire mission within the state.

The essential items for night flight are the use of hazards maps that are consistently updated, day recons of night flight routes, raising drop altitudes to ensure obstacle clearance at night, and a two pilot crew would be best if funding allows, though single pilot night vision goggle flight is not out of the question. If two pilots are not an option, a crewmember on the opposite side of the aircraft with night vision goggles would be advised for visibility, obstacle clearance and increased situational awareness.

Transitioning a high time single pilot into a dual pilot cockpit could be a challenge, which could create difficulties in communication and crew coordination. High time pilots revert to what they know and are familiar with, and in a critical situation requiring increased attention a pilot may stop communicating while handling the pressure event, mostly out of habit not necessarily intentionally disregarding the other pilot.

Inadvertent IMC training is important and basic instrument skills are critical for night flight. The OANG uses three crewmembers for fire operations (two pilots and a crew chief) and four crewmembers for night operations (two pilots and two crew chiefs or a crew chief and medic). Consideration for night operations should incorporate separate and appropriate sleep locations to include considerations for noise abatement, light management and temperature control.

These site visits were key in providing an extensive amount of information to the U.S. Forest Service's subject matter experts. The full list of information was incorporated into notebooks provided to each project member.

Appendix G

Night Vision Aiding Equipment

Night Vision Aiding Equipment

General Equipment List

Searchlight and Spotlights
Searchlights are powerful, totally controllable lights offering the pilot a large amount of illumination when needed for better visual enhancement of a dark area or object. The light is controlled with collective mounted switches, allowing the pilot to maneuver the light easily while flying the aircraft.

Radar Altimeter
A self contained, panel mounted instrument with the display and receiver-transmitter contained in one unit. It is a pulse type radar that utilizes two antennas for the transmit and receive functions. It transmits a short pulse and receives the reflected signal while the tracking system measures the time delay. The aircraft antennas point straight down and the signal bounces off the ground under the aircraft. The time delay is converted to a digital and analog readout in feet. Depending on the height above ground and the received signal level, the tracking circuitry controls the transmit power, pulse width, and receiver sensitivity. It will maintain the correct power and gain for reliable operations over all types of terrain.

Night Vision Goggles
The aviation night vision imaging system enables rotary-wing aviators to conduct and complete night operations during the darkest night of the year. Fitted with the latest tubes, the aviation night vision imaging system offers the best lowlight-level performance available and significantly reduced halo effects. The gated power supply in these tubes maintains system resolution even in the presence of bright lights, significantly expanding the capability to operate in changing light conditions. The objective lens focusing capabilities guarantees maximum image clarity under all conditions of flight. The lightweight binoculars can be fitted to a variety of aviator helmets and also has an optional clip-on power source which allows aviation night vision imaging system use without the helmet.

Moving Map or Electronic Data Manager
Both devices provides situational awareness of the operating area in the form of moving maps with Global Positioning System location, checklists, landing zone diagrams, manuals, charts and electronic notes on a cockpit display screen. The moving map system is typically integrated into the cockpit instrument panel, where the electronic data manager is typically a kneeboard device. The use of standard mission planning products, such as the Aviation Mission Planning System, the Portable Flight Planning Software and the FalconView mapping system, allows ease of use for that critical part of a mission. Operational features of the small, rugged electronic data manager include connectivity to a variety of networks, and the screen is both readable in bright sunlight conditions and compatible with the aviator's night vision imaging system and the night vision goggle system.

Traffic Advisory System

Interrogates other aircraft transponders within range and displays the surrounding traffic on any number of compatible display systems and provides audible alerts in the event of potential traffic conflict. Provides real-time traffic monitoring and advisories and can track up to 50 aircraft at a time displaying 9 of the nearest targets. The system is not radar-coverage limited or dependent on ground-based systems.

Helicopter Terrain Awareness and Warning System

The system provides superior and potentially life-saving information for flight crews, even when flying in changing weather with poor visibility, in rough terrain, or at low altitudes. It is a self-contained computer with three separate databases for second terrain, man-made obstacles and user-defined waypoints or obstacles. It has a built-in, high resolution terrain display with tremendous safety benefits for pilots. It accurately displays terrain contours and elevation changes on both sides of the aircraft and a pilot can select the range of coverage from 10 miles to one mile mode sensitivity. It is colorfully detailed, high-resolution and night-vision-goggle compatible.

TurboFlare (Landing Zone Marking and Lighting Device)

TurboFlare is one of several commercial portable landing zone markers. TurboFlare uses 20 extremely bright light emitting diodes to create a rotating, highly visible light source, effective even from great distances. The units are compact and can operate for over 17 hours on a charge. The batteries are re-chargeable and the available light colors are amber, orange, red, green, white and blue.

Lip Light and Finger Light

The lip light is a small light that attaches to the microphone boom of a flight helmet or headset. The finger light attaches to a finger and both are good for normal and emergency use. Both lights provide the pilot the ability to direct light where it is needed. Typically the pilot uses them when looking under the goggles, although the lights available in night vision goggle compatible versions. Another feature is a brightness memory where the light returns to the prior illumination level when re-activated. .

Mission Specific Equipment

Imaging and Laser System

This is a one-system camera with laser, infrared and electronic data system.

Gyrostabilized, high-magnification sensor systems

This system is effective in demanding environments, this is a multi-sensor payload that includes daylight and low-light cameras, infrared FLIR (forward-looking infrared) sensors, long focal length lenses, and laser rangefinders and designators.

Digital and analog wireless communication systems

This system combines superior imaging technology with digital and analog wireless transmission and reception to enable communication of high quality video images and data from moving vehicles to remote receiving stations.

Integration with other avionics to form a total system solution
Visual imaging can be integrated with radar, Global Positioning Systems, Inertial Navigation Systems, moving maps, communication encryption protocols, etc. to provide a turnkey package for real-time visual information.

Hoist
Hoist and winch technologies are used around the world for critical rescue missions and cargo handling by the U.S. and international coast guards, U.S. Army, foreign and domestic armed forces, and paramilitary forces, such as police, firefighters, medical evacuation crews, and other local municipalities. The rescue hoists have field proven success in high demand, extreme environment missions and have been instrumental in saving lives in several worldwide disaster relief efforts. Types of hoists include electric, hydraulic, internally-mounted and externally-mounted. There are two distinct types of technology: traditional level wind technology and translating drum cable management systems. Each hoist is designed to meet specific mission requirements, and the capabilities of the two design concepts are very different. Rescue hoists utilizing translating drum cable management systems were specially developed to meet the increased demands of the rescue community. They are designed for high usage, high fleet angle environments and aircraft whose primary mission is search and rescue. The translating drum cable management system allows for continuous duty operation and operation in unlimited fleet angles in unpredictable or extreme environments. The translating drum cable management system provides high reliability in the undesirable and often changing environments with minimal impact to the hoist or cable. Features include symmetrical braking to allow rapid controlled directional changes.

Emerging Technologies Available to the Civilian Market

Heads-Up Display Systems (monocles)
This technology offers a modular approach to giving pilots head-up/eyes-out capability. It combines mission-critical situational awareness with significant improvements in weight, cost, flexibility, simplicity and optical performance. The display clips on to any standard helmet, giving the pilot a "plug-and-play" capability. The features include a large exit pupil for pilot viewing and seamless transitions between day and night, increasing pilot situational awareness and mission capability. The sight is placed approximately 15 to 25 millimeters from the eye in day operating mode. Eye relief is a large 15 to 50 millimeters, allowing operations with pilot prescription glasses. In high ambient light conditions, a dark visor can be used to improve the contrast of the imagery. It is also compatible with night vision goggles. Operation at night can be achieved by simply clipping on the goggles and deploying in the normal manner. The sight is located in its own mount and position behind the goggle's eyepiece.

Synthetic Vision

This technology provides the pilot with increased situational awareness by displaying an artificial image of the world outside the aircraft. The technology combines topographical information held in an on-board database with various external sensors (i.e. radar, traffic avoidance, etc.) and a highly accurate aircraft position to provide a virtual 3-D image of the aircraft within its surrounding environment.

Flight Data Applications for Handheld Computing Devices (i.g. Smartpad and Smartphone)

As new mobile handheld computing devices become more available, companies are developing pilot flight applications. Some of these developments are combined software and hardware solutions while others are developing applications for commercial mobile computing devices such as iPhone and the iPad (e.g. ForeFlight Mobile HD). ForeFlight Mobile HD is the latest evolution of the Preflight Intelligence™ application for pilots, now optimized for the iPhone and the iPad. The application provides access to high quality weather, airport intelligence, service providers, flight planning, and much more.

Appendix H

U.S. Army Accidents during Night Aided Operations

U.S. Army Accidents during Night Aided Operations

This summary covers the latest available Army aviation accidents that occurred over a 10 year period from 2000 through 2009. Though the mission is certainly different from that of wildland firefighting, it reveals the challenging situations and human error issues facing low level helicopter operations, particularly at night.

The Army report covers only accidents that occurred during night aided operations and includes seven types of helicopters and 18 different models. It is important to keep in mind this report covers nearly eight years of wartime aviation operations so combines combat, non-combat, training, and test flights.

Over these 10 years the Army had a total of 1224 accidents (not including unmanned aerial system accidents) 241 or 20% of which were night aided accidents. The military classifies all accidents into three separate categories, which are based on a monetary value of the damage to the aircraft and the level of injuries to the people onboard. The classifications are as follows (https://safety.army.mil).

<u>Class A</u>
An Army accident in which the resulting total cost of property damage is $2,000,000 or more; an Army aircraft or missile is destroyed, missing, or abandoned; or an injury and/or occupational illness results in a fatality or permanent total disability. Note that unmanned aircraft systems accidents are classified based on the cost to repair or replace the unmanned aircraft system. A destroyed, missing, or abandoned unmanned aircraft system will not constitute a Class A accident unless replacement or repair cost exceeds $2,000,000 or more.

<u>Class B</u>
An Army accident in which the resulting total cost of property damage is $500,000 or more, but less than $2,000,000; an injury and/or occupational illness results in permanent partial disability, or when 3 or more personnel are hospitalized as inpatients as the result of a single occurrence.

<u>Class C</u>
An Army accident in which the resulting total cost of property damage is $50,000 or more, but less than $500,000; a nonfatal injury or occupational illness that causes 1 or more days away from work or training beyond the day or shift on which it occurred or disability at any time (that does not meet the definition of Class A or B and is a lost time case).

Of the 241 night aided accidents, 78 (32%) were Class A, 35 (15%) were Class B and 128 (53%) were Class C. The most prominent event type in all three categories was collisions. Though the Army broke collision types out into four different events (collision with ground or water, other collisions, multi-aircraft event and object strike) for the purpose of this report, those event types were combined. The results being that collisions make up 33% of all night aided accidents, 45% of Class A, 40% of Class B, 23% of Class C. The next most notable event type is tree strikes, which make up 20% of the night accidents; 15% of Class A, 17% of Class B, and 22% of Class C.

Table G-1 depicts the breakdown of event types per classification.

Table G-1

Event Type	**Class A**	**Class B**	**Class C**	**Total**	**Percentage**
Collisions	37	14	29	80	33%
Grnd/Wtr	29	8	5	42	37%
Object Strike	3	2	10	15	22%
Other	2	1	13	16	6%
Multi-aircraft event	3	3	2	8	3%
Tree Strike	12	6	28	46	19%
Hard Landing	4	8	19	31	13%
Over trq, spd, load, stress	1	2	16	19	8%
Wire Strike	5	0	5	10	4%
Engine Failure	5	3	2	10	4%
Aircraft System Failure	6	0	4	10	4%
Dropped Equipment/Load	1	0	7	8	3%
Fire/Explosion	2	1	2	5	2%
Airframe	0	0	5	5	2%
Mission Equipment	1	0	4	5	2%
Yaw/Spin	2	1	0	3	1%
Landing Gear	0	0	3	3	1%
Bird Strike	0	0	2	2	1%
Fuel Starvation	2	0	0	2	1%
Maintenance Failure	0	0	1	1	<1%
Total Night Added Accd.	78	35	128	241	
Total Army Aviation Accd.	223	163	838	1224	
% of Night vs Total Acc. Rate	35%	27%	15%	20%	

Tables G-2, G-3 and G-4 provide a good overview of events leading to night aided helicopter accidents, but to further breakdown the accidents reveals more information as to the circumstances leading up to the accident. The following chart breaks this down even further.

Table G-2

Class A			
	Operational Missions (53 or 68%)	Training Missions (25 or 32%))	Total (78)*
Contributing Factors			
Dust/Snow	13	7	20
Loss of SA	17	7	24
Poor Illum/Vis	8	3	11
IIMC	3	2	5
Mtc/Inspect Failure	3	-	3
Poor Crew Coord/Crew Resource Management	15	8	23
SOP/Standards Failure	11	6	17
Planning Error	11	3	14
Spatial Disorientation	4	2	6
Inexperience	6	3	9
Time/Mission Pressure	4	1	5
Poor Wx	6	2	8
Fatigue	4	-	4
Human Error			71
Material Failure			11
Environmental			16
* More than one factor may contribute to an accident. Numbers taken from redacted narratives and may not reveal full extent of information.			

Table G-3

Class B			
	Mission (28 or 80%)	**Training (7 or 20%))**	**Total* (35)**
Contributing Factor			
Dust/Snow	9	4	13
Loss of SA	11	4	15
Poor Illum/Vis	3	1	4
IIMC	-	-	-
Mtc/Inspect Failure	3	-	3
Poor Crew Coord/Crew Resource Management	4	1	5
SOP/Standards Failure	6	2	8
Planning Error	4	-	4
Spatial Disorientation	-	-	-
Inexperience	1	-	1
Time Pressure	-	-	-
Poor Wx	-	1	1
Fatigue	1	-	1
Human Error			29
Material Failure			3
Environmental			8
* More than one factor may contribute to an accident. Numbers taken from redacted narratives and may not reveal full extent of information.			

Table G-4

Class C			
Contributing Factor	**Operational Mission (70 or 55%)**	**Training Mission (52 or 41%)**	**Total (128)**
Dust/Snow	12	6	18
Loss of SA	31	28	59
Poor Illum/Vis	4	3	7
IIMC	-	-	-
Mtc/Inspect Failure	17	3	20
Poor Crew Coord/ Crew Resource Management	12	12	24
SOP/Standards Failure	15	5	20
Planning Error	4	4	8
Spatial Disorientation	-	-	-
Inexperience	2	5	7
Time Pressure	-	-	-
Poor Wx	2	-	2
Fatigue	1	-	1
Human Error			105
Material Failure			24
Environmental			9
* More than one factor may contribute to an accident. Numbers taken from redacted narratives and may not reveal full extent of information.			

Though environmental factors, maintenance and mechanical failures made their impact on the accident rates, the largest impact and number one concern for nearly all of the accidents in all three categories is Human Error which was established as a finding in 85% of all the accidents. Poor planning, loss of situational awareness, poor Crew Resource Management/Crew Coordination, poor or missed inspections and inexperience made many of these accidents avoidable.

The US Army mission is very different from the wildland fire mission, but the lessons gathered from the data provided can serve as a building block for addressing these areas of common failure as the Forest Service helicopter night operations program continues to move forward.

Appendix I

Federal Aviation Administration's (FAA) Advisory Circular 120-92

Advisory Circular

Subject: Introduction to Safety Management Systems for Air Operators

Date: 6/22/06

Initiated by: AFS-800

AC No: 120-92

1. PURPOSE.

a. This advisory circular (AC):

(1) Introduces the concept of a safety management system (SMS) to aviation service providers (for example, airlines, air taxi operators, corporate flight departments, and pilot schools).

(2) Provides guidance for SMS development by aviation service providers.

b. This AC is not mandatory and does not constitute a regulation. Development and implementation of an SMS is voluntary. While the Federal Aviation Administration (FAA) encourages each aviation service provider to develop and implement an SMS, these systems in no way substitute for regulatory compliance of other certificate requirements, where applicable.

2. APPLICABILITY. This AC applies to both certificated and non-certificated air operators that desire to develop and implement an SMS. An SMS is not currently required for U.S. certificate holders. However, the FAA views the requirements in Appendix 1 to this AC to be a minimum standard for an SMS developed by an aviation service provider.

3. RECOMMENDED READING MATERIAL. The following ACs may be of value to users of this AC if they desire to integrate any of the following programs with an SMS:

a. AC 120-59A, Air Carrier Internal Evaluation Programs.

b. AC 120-66, Aviation Safety Analysis Programs (ASAP).

c. AC 120-79, Developing and Implementing a Continuing Analysis and Surveillance System.

d. AC 120-82, Flight Operational Quality Assurance.

4. BACKGROUND. The modern aviation system is characterized by increasingly diverse and complex networks of business and governmental organizations. The rapidly changing aviation operational environment requires these organizations to adapt continuously to maintain their viability and relevance. The aviation system is also becoming increasingly global. Few business entities' markets, supplier networks, and operations are confined entirely within the boundaries of a single country. These characteristics of complexity, diversity, and change add to the importance of sound management of functions that are essential to safe operations. While safety efforts in the aviation system have been highly successful to date, the rapid increase in the volume and variety of aviation operations push the limitations of current safety strategies and practices. Along with this trend is the problem of decreasing resources to be applied by both business and government organizations. These processes have forced a fresh look at the safety strategies of the future. The best approach to problems of increased aviation activity and decreased resources is to bring safety efforts into the normal management framework of aviation operations. Just as businesses and government organizations must manage these factors effectively to accomplish their missions or to maintain business viability, they must likewise provide sound management of safety. This innovation in aviation system safety is best termed "Safety Management Systems" a term indicating that safety efforts are most effective when made part of business and government management of operations and oversight.

a. Safety Benefits of an SMS. An SMS is essentially a quality management approach to controlling risk. It also provides the organizational framework to support a sound safety culture. For general aviation operators, an SMS can form the core of the company's safety efforts. For certificated operators such as airlines, air taxi operators, and aviation training organizations, the SMS can also serve as an efficient means of interfacing with FAA certificate oversight offices. The SMS provides the company's management with a detailed roadmap for monitoring safety-related processes.

b. Business Benefits of an SMS. Development and implementation of an SMS can give the aviation service provider's management a structured set of tools to meet their legal responsibilities but they can also provide significant business benefits. The SMS incorporates internal evaluation and quality assurance concepts that can result in more structured management and continuous improvement of operational processes. The SMS outlined in this AC is designed to allow integration of safety efforts into the operator's business model and to integrate other systems such as quality, occupational safety, and environmental control systems that operators might already have in place or might be considering. Operators in other countries and in other industries who have integrated SMSs into their business models report that the added emphasis on process management and continuous improvement benefits them financially as well.

5. SMS PRINCIPLES.

a. Safety Management. Modern management and safety oversight practices are moving increasingly toward a systems approach that concentrates more on control of processes rather than efforts targeted toward extensive inspection and remedial actions on end products. One way of breaking down SMS concepts is to discuss briefly the three words that make it up: safety, management, and systems. Then we'll touch on another essential aspect of safety management; safety culture.

(1) Safety: Requirements Based on Risk Management. The objective of an SMS is to provide a structured management system to control risk in operations. Effective safety management must be based on characteristics of an operator's processes that affect safety.

Safety is defined in dictionaries in terms of absence of potential harm, an obviously impractical goal. However, risk, being described in terms of severity of consequences (how much harm) and likelihood (how likely we are of suffering harm) is a more tangible object of management. We can identify and analyze the factors that make us more or less likely to be involved in accidents of incidents as well as the relative severity of the outcomes. From here, we can use this knowledge to set system requirements and take steps to insure that they are met. Effective safety management is, therefore, risk management.

(2) Management: Safety Assurance Using Quality Management Techniques. In a recent set of working papers and guidance documents, the International Civil Aviation Organization (ICAO) emphasized that safety is a managerial process, shared by both the state (government regulators such as the FAA) and those who conduct aviation operations or produce products or services that support those operations.[1] This is compatible with the goals set forth for the FAA and industry in the Federal Aviation Act of 1958. The safety management process described in this AC starts with design and implementation of organizational processes and procedures to control risk in aviation operations. Once these controls are in place, quality management techniques can be used to provide a structured process for ensuring that they achieve their intended objectives and, where they fall short, to improve them. Safety management can, therefore, be thought of as quality management of safety related operational and support processes to achieve safety goals.

(3) Systems: Focusing on a Systems Approach. Systems can be described in terms of integrated networks of people and other resources performing activities that accomplish some mission or goal in a prescribed environment. Management of the system's activities involves planning, organizing, directing, and controlling these assets toward the organization's goals. Several important characteristics of systems and their underlying process are known as "process attributes" or "safety attributes.[2]" when they are applied to safety related operational and support processes. As in the previous discussion of quality, these process attributes must have safety requirements built in to their design if they are to result in desired safety outcomes. The attributes include:

(a) Responsibility and authority for accomplishment of required activities,

(b) Procedures to provide clear instructions for the members of the organization to follow,

(c) Controls which provide organizational and supervisory controls on the activities involved in processes to ensure they produce the correct outputs, and

(d) Measures of both the processes and their products.

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[1] ICAO Document 9734, Draft Safety Oversight Manual; ICAO Document 9859, Safety Management Manual, March 2006; and ICAO Working Paper from the ICAO Air Navigation Commission, Approval of Draft Report to Counsel on Amendment 30 to Annex 6, part 1.

[2] The six system characteristics, responsibility, authority, procedures, controls, process measures, and interfaces, are called "safety attributes" in the FAA's Air Transportation Oversight System (ATOS).

(e) An important aspect of systems management also is recognizing the important interrelationships or interfaces between individuals and organizations within the company as well as with contractors, vendors, customers, and other organizations with which the company does business.

b. Safety Culture: The Essential Human Component of Organizations. "An organization's culture consists of its values, beliefs, legends, rituals, mission goals, performance measures, and sense of responsibility to its employees, customers, and the community.[3]" The principles discussed above that make up the SMS functions will not achieve their goals unless the people that make up the organization function together in a manner that promotes safe operations. The organizational aspect that is related to safety is frequently called the "safety culture." The safety culture consists of psychological (how people think), behavioral (how people act), and organizational elements. The organizational elements are the things that are most under management control, the other two elements being outcomes of those efforts. For this reason, the SMS standard that is contained in Appendix 1 of this AC includes requirements for policies that will provide the framework for the SMS and requirements for organizational functions such as an effective employee safety reporting system and clear lines of communications both up and down the organizational chain regarding safety matters.

6. SYSTEM FUNCTIONS AND RELATIONSHIPS.

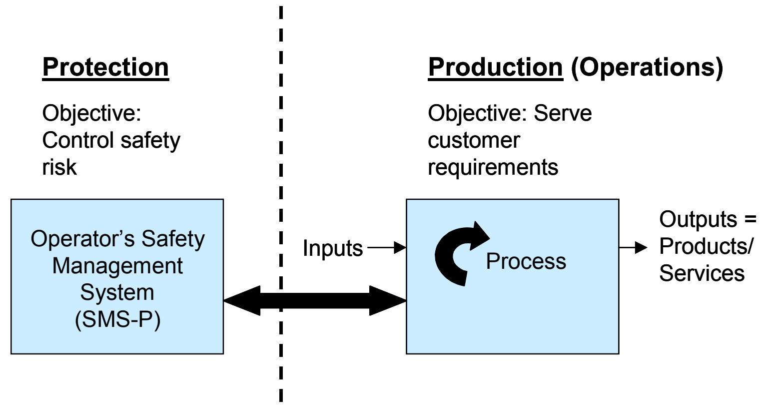
a. System Goals: Production and Protection. The global aviation system is really a "system of systems." Figure 1 depicts the relationship between the systems that are related to safety. The Figure depicts the relationships between the technical and management functions in the company that are related to providing customers with products or services and the functions that are related to controlling risk that is often a byproduct of the operations. The dichotomy between "production" and "protection" in the Figure, therefore, refers to the functions and requirements that are attendant to producing products or services (e.g. flight operations, flight training) and those that are involved in ensuring safety. As pointed out by Dr. James Reason, a prominent organizational safety researcher, these functions must be kept in harmony if the organization is to remain financially viable while controlling safety risk.[4]

NOTE: The depiction in Figure 1 refers to functional roles and not organizational structures. It is not meant to suggest that safety management is the sole responsibility of a "safety department" or "safety manager." In fact, the SMS standard stresses the role of those who manage the productive "line operational' processes in safety management.

[3] Manuele, Fred A. On the Practice of Safety. John Wiley & Sons, 2003, Hoboken, NJ.

[4] Reason, Dr. James. Managing the Risk of Organizational Accidents. Ashgate Publishing Limited, 1997, Aldershot, United Kingdom.

FIGURE 1. SYSTEM RELATIONSHIPS



(1) Production in Aviation Systems: Conducting Operations. The production system that produces the product or service that is the mission of the aviation service provider's organization. For operators, these services usually involve provision of transportation services but may also include providing additional services to other companies such as maintenance and flight crew training. One of the first tasks in effective risk management and safety assurance is for both the operator and an oversight organization to have a thorough understanding of the configuration and structure of this system and its processes. A significant number of hazards and risk factors exist from improper design of these processes or a poor fit between the system and its operational environment. In these cases, hazards to operational safety may be poorly understood and, therefore, inadequately controlled.

(2) Protection in Aviation Systems: Controlling Risk. Safety risk is a byproduct of activities related to production. The aviation service provider's customers and employees are, therefore, the potential direct victims of the consequences of failures in the safety system. It is a primary responsibility of the aviation service provider to identify hazards and to control risk in the processes they manage and their operational environment. The aviation service provider is primarily responsible for safety management. The aviation service provider's SMS (denoted as the SMS-P to differentiate it from the FAA's safety oversight system, later referred to as the SMS-O) provides a formal management system for the operator's management to fulfill this obligation.

b. Safety Management Systems for Certificated Organizations. As aviation service providers develop SMSs, a natural interaction between the safety management efforts of the FAA and those of aviation service providers also develops. This relationship can leverage the efforts of both parties to provide a more effective, efficient, and proactive approach to meeting safety requirements while at the same time increasing the flexibility of companies to tailor their safety management efforts to their individual business models. There are distinct roles, responsibilities, and relationships (the "three Rs") for both regulators (FAA) and aviation service providers in the "system of systems" that is involved in management of safety.

(1) Responsibilities of Certificated Operators and Aviation Service Providers. Operators who hold out to provide services in common carriage to the public have a special responsibility to provide their customers with safe, reliable transportation. Title 49 of the United

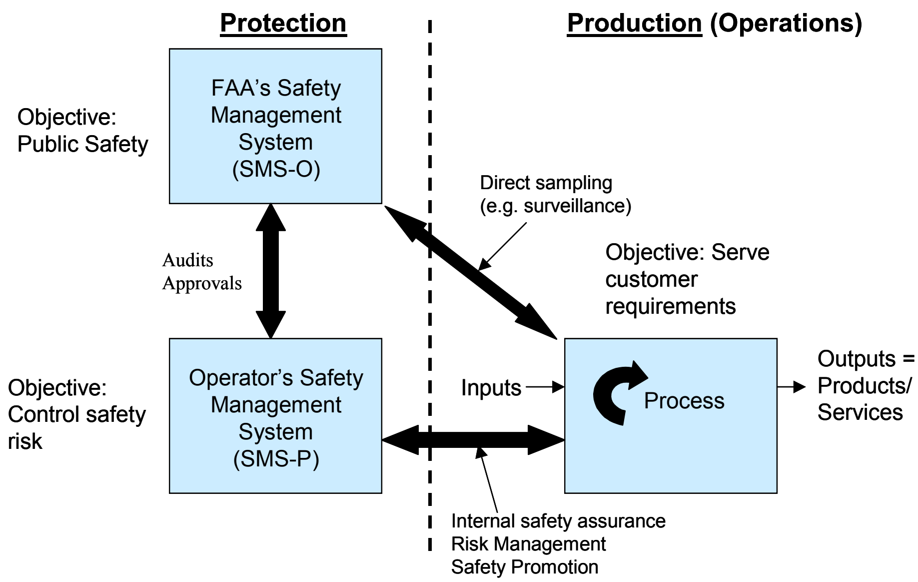
States Code, subtitle VII, chapter 447, section 44702 states, in part, that "When issuing a certificate under this chapter, the Administrator shall consider the duty of an air carrier to provide service with the highest possible degree of safety in the public interest and differences between air transportation and other air commerce…." This section of the public law makes management of safety a specific legal responsibility for air carrier management teams and, as such, is a fundamental principle of the FAA oversight doctrine. While this section applies specifically to air carriers, the FAA expects all certificated organizations to make safety a top priority and holds their managements accountable for doing so.

(2) Oversight Responsibilities of the FAA. United States Code Title 49 Subtitle VII Chapter 447 also prescribes roles and responsibilities of the FAA. The FAA is tasked with developing and implementing regulations and standards of other safety oversight activities that ensure operators apply those regulations and standards to the design and continuing operational safety of their organizations. These regulations and standards and the processes that apply them to certificate holders should be thought of as important safety risk controls, rather than just bureaucratic requirements.

(3) Oversight Systems. The other system on the "protection" side of the model in Figure 2 is the SMS-O, the system that is used by the regulator to provide oversight of the aviation service provider's operations. Traditional oversight of aviation service providers consists of activities such as certification, surveillance, investigation, and enforcement of regulations. The FAA is transitioning the traditional oversight process from a quality control approach with principal emphasis on surveillance of compliance with technical standards to a systems approach that stresses the systemic nature of aviation businesses and the larger system as a whole. While traditional oversight functions will continue to exist in future safety oversight systems, the primary means of safety oversight will shift more toward system safety methods and an emphasis on operator safety management. Moreover, the ability of the government to provide the resources that would be required to manage safety through intensive direct intervention in aviation service provider's activities is questionable at best.

(4) Relationships between Aviation Service Provider's SMS and Oversight. Figure 2 depicts the functional relationships between the productive processes in aviation service provider organizations, their safety management functions, and the functions of FAA oversight activities. On the "protection" side of the model depicted in Figure 2, two management systems exist: the aviation service provider's SMS (noted as SMS-P) and that of the oversight organization or regulator (noted as SMS-O).

FIGURE 2. SYSTEM RELATIONSHIPS. CERTIFICATED OPERATORS



(5) Voluntary Programs and the SMS. The FAA is seeking to increase the use of voluntary programs in the process of safety management, particularly use of the Aviation Safety Action Program (ASAP) and internal evaluation programs (IEP). Both of these programs have strong relationships to the functions of safety assurance and safety promotion in an SMS. Aviation service providers are encouraged to consider integrating these programs into a comprehensive approach to safety management.

c. Future Developments in Safety Management. A well-developed SMS and a strong relationship with the oversight system provide an excellent place from which to develop an integrated program between regulatory programs, voluntary programs, and the operator's own systems. The FAA Flight Standards Service is developing procedures to provide more effective interfaces in this process and to make both voluntary and regulatory programs more standardized and interoperable. These processes include improved, joint-use auditing tools and processes, procedures for information sharing and protection, and voluntary disclosure procedures. In the interim, certificated organizations should work closely with their certificate-holding district office (CHDO) or certificate management office (CMO) to build an SMS that will interface smoothly with regulatory oversight programs. For example, an SMS that incorporates the operator's continuing analysis and surveillance system (CASS — for certificated operators), an IEP, and an ASAP would allow the operator to derive the multiple benefits of these programs with a minimum of duplication. For operators that desire to implement Flight Operations Quality Assurance (FOQA) programs, these programs can also contribute to the safety assurance function.

7. THE SMS STANDARD: INTRODUCTION.

a. The Need for Safety Management Standards.

(1) Standardization. The FAA Associate Administrator for Aviation Safety (AVS) is interested in developing an integrated SMS in which business and governmental roles and relationships are well defined, requirements are based upon sound systems engineering and system safety principles, and both regulators and regulated industries participate in a unified safety effort. The SMS standard in appendix 1 of this AC provides functional requirements for an aviation safety SMS. It is similar in scope to internationally recognized standards for quality management, environmental protection, and occupational safety and health management.

(2) International Harmonization. ICAO, in a recent set of working papers, manuals, and proposals[5] for changes to key annexes to the ICAO Conventions, is revamping its standards and recommended practices to reflect a systems approach to safety management. This coincides with the FAA's move toward a systems approach for oversight over the past several years. Because of the many diverse relationships between organizations and the above stated global nature of the aviation system, it is critical that the functions of an SMS be standardized to the point that there is a common recognition of the meaning of SMS among all concerned, both domestically and internationally.

(3) Alignment with International Organization for Standardization (ISO) Standards. The SMS standard is written at the approximate scope and scale of the international standards for quality management (QMS) and management of environmental protection (EMS), ISO 9000-2000 and ISO 14001, respectively. The FAA also reviewed the British Standards Institute's standard for occupational health and safety management systems (OHSMS), which is based on ISO 14001. The clause structure of the aviation service provider SMS standard initially was developed to parallel ISO 14001, with the clauses then being arranged around the four building blocks discussed below under "The Four Pillars of Safety Management."

(4) Alignment with Other Industry Standards. The SMS standard was developed after an extensive review of documented SMS systems used by other countries around the world.[6] This review included literature reviews of regulations, policy documents, and advisory material, as well as interviews with both government and industry personnel who promulgated and used the systems. Existing management system standards from the International Standardization Organization (ISO) and the American National Standards Institute (ANSI) were reviewed cross-mapped.[7] The review also included consideration of third-party systems developed by user organizations such as the International Air Transport Association (IATA), the Medallion Foundation, and the International Business Aviation Council (IBAC)[8].

(5) Auditability. The SMS standard is designed to provide definitive functional requirements in a manner that can be audited by the organization's own personnel, regulators, or

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[5] Ibid. See footnote 1.

[6] The review included review of documents and interviews of government and industry personnel from Australia, Canada, New Zealand, and the United Kingdarom.

[7] A matrix showing the functional correlation between the SMS standard in Appendix 1 of this AC and existing standards for quality management, environmental control, and occupational safety and health management is included as Appendix 2.

[8] This preliminary literature review was conducted to compare content of the various programs and documents and did not assess any of the reviewed programs for completeness or assurance of regulatory compliance.

other third-party consultants. The language in the standard is, therefore, written in a requirements-oriented tone. To the maximum extent possible, each indexed statement defines a single requirement so that it can easily be used in audits of the system.

(6) Integration with Other Management Systems. While the SMS standard's stated scope is on product and service safety, the FAA recognizes that managers in real-world organizations may often, if not usually, be required to manage not only this aspect of safety, but also occupational safety and environmental protection, as well. Managers of these organizations typically are required to fit their activities into the framework of the organization's mission or commercial objectives and may operate under an integrated management system. The SMS standard therefore can be mapped to other existing standards covering these areas so that organizations may develop integrated management systems. Appendix 2 provides a cross-reference between the SMS standard presented in Appendix 1 and several other commonly used management standards.

b. Structure and Organization.

(1) Functional Orientation. The SMS Standard is written as a functional requirements document. It stresses "what" the organization must do rather than "how" it will be accomplished. The FAA feels that each of the functions detailed in the standard are essential for a comprehensive SMS. At the same time, the standard needs to be applicable to a wide variety of types and sizes of operators. Therefore, it is designed to allow operators to integrate safety management practices into their unique business models. Operators are not expected to configure their systems in the format of the standard or to duplicate existing programs that accomplish the same function. This was a further reason for using a similar scope, scale, and language to the ISO standards, which also are designed for broad application. The standard document contained in Appendix 1, therefore, attempts to strike a balance between flexibility of implementation and functional standardization of essential safety management processes.

(2) Four Pillars of Safety Management. The standard is organized around four basic building blocks of safety management. These four areas are essential for a safety-oriented management system, and derive from the SMS principles discussed earlier.

(a) Policy. All management systems must define policies, procedures, and organizational structures to accomplish their goals. Requirements for these elements are outlined in Appendix 1, par 4 which in turn provide the framework for SMS functional elements.

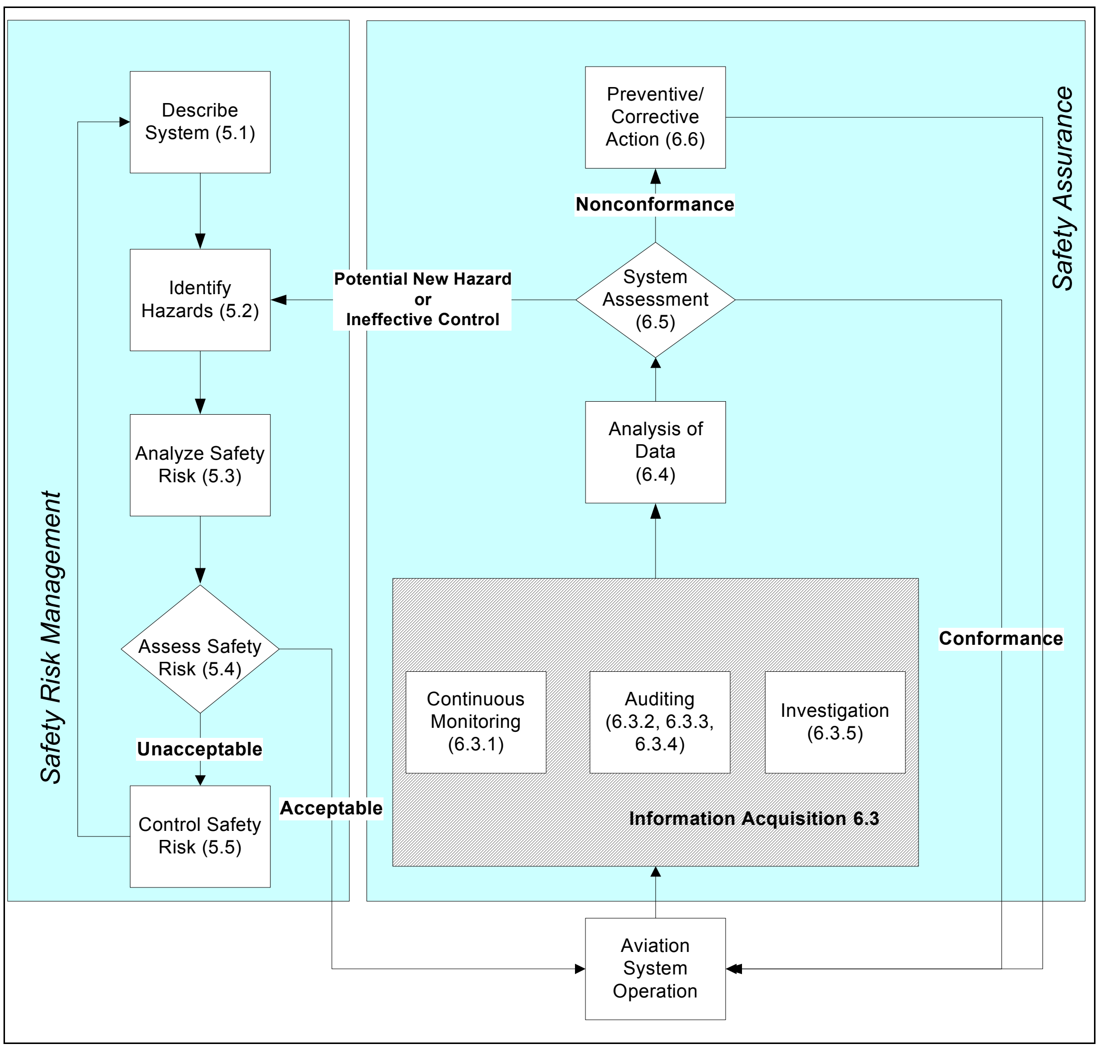
(b) Safety risk management. A formal system of hazard identification and safety risk management in Appendix 1, par. 5 is essential in controlling risk to acceptable levels. The safety risk management component of the SMS is based upon the system safety process model that is used in the system safety training course that is taught at the FAA Academy.

(c) Safety assurance. Once these controls are identified, the operator must ensure they are continuously practiced and continue to be effective in a changing environment. The safety assurance function in Appendix 1, par 6 provides for this using quality management concepts and processes.

(d) Safety promotion. Finally, the operator must promote safety as a core value with practices that support a sound safety culture. Appendix 1 par. 7 provides guidance for setting up these functions.

(3) Integration of Safety Risk Management and Safety Assurance. Figure 3 shows how the safety risk management and safety assurance processes are integrated in the SMS. The safety risk management process provides for initial identification of hazards and assessment of risk. Organizational risk controls are developed and, once they are determined to be capable of bringing the risk to an acceptable level, they are employed operationally. The safety assurance function takes over at this point to ensure that the risk controls are being practiced and they continue to achieve their intended objectives. This system also provides for assessment of the need for new controls because of changes in the operational environment.

FIGURE 3. SAFETY RISK MANAGEMENT AND SAFETY ASSURANCE PROCESSES[9]



[9] The numbers in the process blocks shown in Figure 3 refer to clause numbers in the SMS standard in Appendix 1 to this AC.

8. THE SMS STANDARD.

a. General Organization of the SMS Standard. The first part of the SMS functional requirements (SMS Standard) included as Appendix 1 of this AC follows the general organization of ISO 9000-2000 and ISO 14001. The first three clauses describe scope and applicability, references, and definitions. The following four clauses address each of the four pillars of SMS, as described previously in paragraph 7b(2).

b. Policy: Setting the Framework.

(1) Safety and Quality: Striking a Balance. As discussed above, the SMS standard uses quality management principles, but the requirements to be managed by the system are based on an objective assessment of safety risk, rather than customer satisfaction with products or other conventional commercial goals. However, management of process quality, with emphasis on those characteristics of those processes that affect safety, is an important aspect of safety management. The standard specifies that the aviation service provider should prescribe both quality and safety policies. The coverage of quality policies is limited in scope to quality in support of safety, although operators are encouraged to integrate their management systems as much as feasible. However, safety objectives should receive primacy where conflicts are identified.

(2) Roles, Responsibilities, and Relationships: The "Three Rs" of Safety Management. Figures 1 and 2 show the relationship between the productive processes of the aviation service provider as well as the joint protective processes of the regulator (FAA) in the form of an oversight system (SMS-O) and the aviation service provider's SMS (SMS-P). As before, it is important to recognize that the two aviation service provider systems shown (Protection and Production) are functional rather than departmental or organizational depictions. One of the principal roles of the oversight system (SMS-O) is to promulgate risk controls in the form of regulations, standards, and policies. It follows that regulatory compliance, in a manner that accomplishes the regulations' safety objectives, is also part of the aviation service provider's role in safety management.

(3) Importance of Executive Management Involvement. The standard specifies that top management is primarily responsible for safety management. Managements must plan, organize, direct, and control employees' activities and allocate resources to make safety controls effective. A key factor in both quality and safety management is top management's personal, material involvement in quality and safety activities. The standard also specifies that top management must further clearly delineate safety responsibilities throughout the organization. While it is true that top management must take overall responsibility for safe operations, it also is true that all members of the organization must know their responsibilities and be both empowered and involved with respect to safety.

(4) Procedures and Controls. Two key attributes of systems are procedures and controls. Policies must be translated into procedures in order for them to be applied and organizational controls must be in place to ensure that critical steps are accomplished as designed. Organizations must develop, document, and maintain procedures to carry out their safety policies and objectives. The standard also requires organizations to ensure that employees understand their roles. Moreover, supervisory controls must be used to monitor the accomplishment of the procedures.

c. Safety Risk Management: Setting Requirements for Safety Management. The safety risk management process is used to examine the operational functions of the company and their operational environment to identify hazards and to analyze associated risk. The safety risk management process follows the same sequence of steps as the system safety process model that is used in the FAA's System Safety training course at the FAA Academy. These are also the same general steps that are used in operational risk management programs within several of the military services.

(1) Systems and Task Analysis. Safety risk management begins with system design. This is true whether the system in question is a physical system, such as an aircraft, or an organizational system such as an operator, maintenance or training establishment. These systems consist of the organizational structures, processes, and procedures, as well as the people, equipment, and facilities used to accomplish the organization's mission. The system or task descriptions should completely explain the interactions among the hardware, software, people, and environment that make up the system in sufficient detail to identify hazards and perform risk analyses. While systems should be documented, no particular format or is required. System documentation would normally include the operator's manual system,[10] checklists, organizational charts, and personnel position descriptions. A suggested breakdown of operational and support processes for air operators includes:

(a) Flight operations;

(b) Dispatch/flight following;

(c) Maintenance and inspection;

(d) Cabin safety;

(e) Ground handling and servicing;

(f) Cargo handling; and

(g) Training.

NOTE: Long and excessively detailed system or task descriptions are not necessary as long as they are sufficiently detailed to perform hazard and risk analyses. While sophisticated process development tools and methods are available, simple brainstorming sessions with managers, supervisors, and other employees are often most effective.

(2) Hazard Identification. Hazards in the system and its operating environment must be identified, documented, and controlled. It also requires that the analysis process used to

[10] While manuals are required only for certificated operators and agencies, all operators are encouraged to develop a manuals as a means of documenting their policies and procedures.

define hazards consider all components of the system, based on the system description described above. The key question to ask during analysis of the system and its operation is "what if?" As with system and task descriptions, judgment is required to determine the adequate level of detail. While identification of every conceivable hazard would be impractical, aviation service providers are expected to exercise due diligence in identifying significant and reasonably foreseeable hazards related to their operations.

(3) Risk Analysis and Assessment. The standard's risk analysis and risk assessment clauses use a conventional breakdown of risk by its two components: likelihood of occurrence of an injurious mishap and severity of the mishap related to an identified hazard, should it occur. A common tool for risk decision-making and acceptance is a risk matrix similar to those in the U.S. Military Standard (MIL STD 882) and the ICAO Safety Management Manual[11]. Figure 4 shows an example of one such matrix. Operators should develop a matrix that best represents their operational environment. Separate matrices with different risk acceptance criteria may also be developed for long-term versus short-term operations.

(4) Severity and Likelihood Criteria. The definitions and final construction of the matrix is left to the aviation service provider's organization to design. The definitions of each level of severity and likelihood will be defined in terms that are realistic for the operational environment. This ensures each organization's decision tools are relevant to their operations and operational environment, recognizing the extensive diversity in this area. An example of severity and likelihood definitions is shown in Table 1 below. Each operator's specific definitions for severity and likelihood may be qualitative but quantitative measures are preferable, where possible.

TABLE 1. SAMPLE SEVERITY AND LIKELIHOOD CRITERIA[12]

Severity of Consequences			**Likelihood of Occurrence**		
Severity Level	Definition	Value	Likelihood Level	Definition	Value
Catastrophic	Equipment destroyed, multiple deaths	5	Frequent	Likely to occur many times	5
Hazardous	Large reduction in safety margins, physical distress or a workload such that operators cannot be relied upon to perform their tasks accurately or completely. Serious injury or death to a number of people.	4	Occasional	Likely to occur sometimes	4

[11] Available at: http://www.icao.int/fsix

[12] Adapted from ICAO Safety Management Manual (SMM). ICAO Doc 9859. Available at: http://www.icao.int/fsix

Severity of Consequences			Likelihood of Occurrence		
	Major equipment damage.				
Severity Level	Definition	Value	Likelihood Level	Definition	Value
Major	Significant reduction in safety margins, reduction in the ability of operators to cope with adverse operating conditions as a result of an increase in workload, or as result of conditions impairing their efficiency. Serious incident. Injury to persons.	3	Remote	Unlikely, but possible to occur	3
Minor	Nuisance. Operating limitations. Use of emergency procedures. Minor incident.	2	Improbable	Very unlikely to occur	2
Negligible	Little consequence	1	Extremely Improbable	Almost inconceivable that the event will occur	1

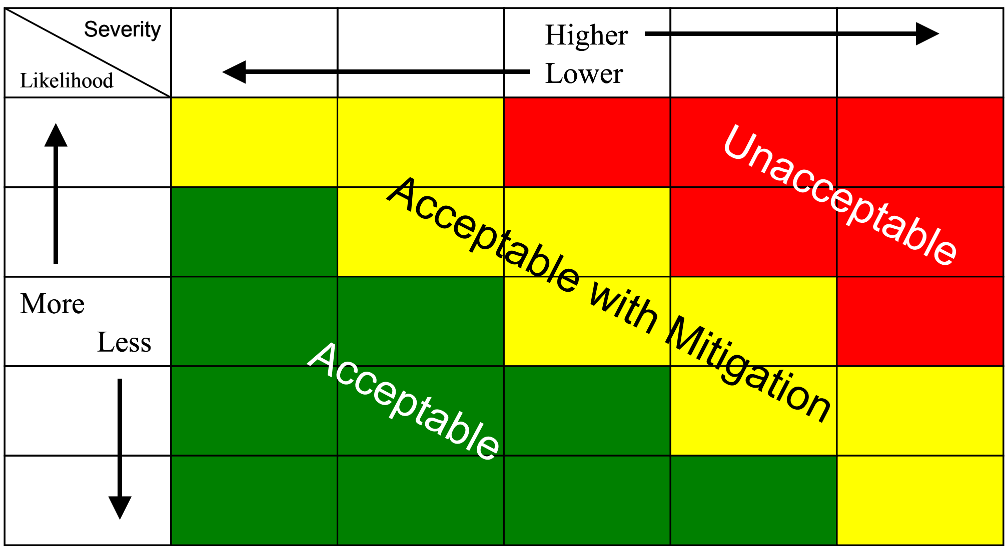
(5) Risk Acceptance. In the development of its risk assessment criteria, aviation service providers are expected to develop risk acceptance procedures, including acceptance criteria and designation of authority and responsibility for risk management decision making. The acceptability of risk can be evaluated using a risk matrix such as the one illustrated in Figure 4. The example matrix shows three areas of acceptability. Risk matrices may be color coded; unacceptable (red), acceptable (green), and acceptable with mitigation (yellow).

(a) Unacceptable (Red). Where combinations of severity and likelihood cause risk to fall into the red area, the risk would be assessed as unacceptable and further work would be required to design an intervention to eliminate that associated hazard or to control the factors that lead to higher risk likelihood or severity.

(b) Acceptable (Green). Where the assessed risk falls into the green area, it may be accepted without further action. The objective in risk management should always be to reduce risk to as low as practicable regardless of whether or not the assessment shows that it can be accepted as is. This is a fundamental principle of continuous improvement.

(c) Acceptable with Mitigation (Yellow). Where the risk assessment falls into the yellow area, the risk may be accepted under defined conditions of mitigation. An example of this situation would be an assessment of the impact of a non-operational aircraft component for inclusion on a Minimum Equipment List. Defining an Operational ("O") or Maintenance ("M") procedure in the MEL would constitute a mitigating action that could make an otherwise unacceptable risk acceptable, as long as the defined procedure was implemented. These situations may also require continued special emphasis in the safety assurance function.

FIGURE 4. SAFETY RISK MATRIX



(6) Other Risk Assessment Tools for Flight and Operational Risk Management. Other tools can also be used for flight or operational risk assessment such as the Controlled Flight into Terrain (CFIT), Approach and Landing Accident Reduction (ALAR), operational control, and ground operations risk assessment tools available from the Flight Safety Foundation (http://www.flightsafety.org/technical_initiatives.html) or the Medallion Foundation (http://www.medallionfoundation.org).

(7) Causal Analysis. Risk analyses should concentrate not only on assigning levels of severity and likelihood but on determining why these particular levels were selected. This is often called "root cause analysis," and is the first step in developing effective controls to reduce risk to lower levels. Several structured software systems are available to perform root cause analysis. However, in many cases, simple brainstorming sessions among the company's pilots, mechanics, or dispatchers other experienced subject matter experts is the most effective and affordable method of finding ways to reduce risk. This also has the advantage of involving employees who will ultimately be required to implement the controls developed.

(8) Controlling Risk. After hazards and risk are fully understood though the preceding steps, risk controls must be designed and implemented. These may be additional or changed procedures, new supervisory controls, addition of organizational, hardware, or software aids, changes to training, additional or modified equipment, changes to staffing arrangements, or any of a number of other system changes.

(9) Hierarchy of Controls. The process of selecting or designing controls should be approached in a structured manner. System safety technology and practice has provided a hierarchy or preferred order of control actions that range from most to least effective. Depending on the hazard under scrutiny and its complexity there may be more than one action or strategy that may be applied. Further, the controls may be applied at different times depending on the immediacy of the required action and the complexity of developing more effective controls. For example, it may be appropriate to post warnings while a more effective elimination of the hazard is developed. The hierarchy of controls is:

(a) Design the hazard out – modify the system (this includes hardware/software systems involving physical hazards as well as organizational systems).

(b) Physical guards or barriers – reduce exposure to the hazard or reduce the severity of consequences.

(c) Warnings, advisories, or signals of the hazard.

(d) Procedural changes to avoid the hazard or reduce likelihood or severity of associated risk

(e) Training to avoid the hazard or reduce the likelihood of an associated risk.

(10) Residual and Substitute Risk. It is seldom possible to entirely eliminate risk, even when highly effective controls are used. After these controls are designed but before the system is placed back on line, an assessment must be made of whether the controls are likely to be effective and/or if they introduce new hazards to the system. The latter condition is referred to as "substitute risk," a situation where "the cure is worse than the disease." The loop seen in Figure 3 back to the top of the diagram depicts the use of the preceding systems analysis, hazard identification, risk analysis, and risk assessment processes to determine if the modified system is acceptable.

(11) System Operation. When the controls are acceptable, the system is placed into operation. The next process, safety assurance, uses auditing, analysis, and review systems that are familiar from similar quality management systems. These processes are used to monitor the risk controls to ensure they continue to be implemented as designed and continue to be effective in a changing operational environment.

d. Safety Assurance: Managing the Requirements. The safety assurance function applies the processes of quality assurance and internal evaluation to the process of making sure that risk controls, once designed, continue to conform to their requirements and that they continue to be effective in maintaining risk within acceptable levels. These assurance and evaluation functions also provide a basis for continuous improvement.

(1) Relationship between Safety Risk Management, Safety Assurance, and Internal Evaluation. Quality assurance processes concentrate on proving, through collection and analysis of objective evidence, that process requirements have been met. In an SMS, the system's requirements are based on assessment of risk in the organization's operation or in the products that it produces, as discussed above. Quality assurance techniques, including internal auditing and evaluation, can be used to determine if risk controls that are designed into the operator's processes are being practiced and that they perform as designed. The process is, therefore, appropriately termed "safety assurance." If an operator already has an IEP, it should be reviewed to ensure that it conforms to the SMS safety assurance standards.[13]

> **NOTE: the safety assurance function does not need to be extensive or complex to be effective. Smaller organizations may find available tools such as the Internal Evaluation Program Audit tools produced by the Medallion Foundation (http://www.medallionfoundation.org) to be a good foundation for their organization's safety assurance processes.**

(2) Role of Other Management Systems. As discussed above, safety assurance uses many of the same practices as those used in quality management systems (QMS). In an SMS however the requirements being managed relate to ensuring risk controls, once designed and put into place, perform in a way that continues to meet their safety objectives. While operators may find it beneficial to integrate their management systems for these other areas, such as quality, employee health and safety, or environmental protection with the SMS, it is beyond the scope of the safety management standard to address these areas directly. Appendix 2 to this AC contains a table of cross-references between ISO standards and other recognized standards for quality (ISO 9000:2000), environmental protection (ISO 14001), and employee health and safety management (BSI OHSAS 18001). These are provided for convenience for organizations that desire to develop integrated management systems or that may already have existing systems in one or more of these areas.

(3) Information for Decisionmaking. Information for safety assurance comes from a variety of sources, including formal program auditing and evaluation, investigations of safety-related events, and continuous process monitoring of day-to-day activities and inputs from employees through employee reporting systems. While each of these types of information sources exist to some degree in every organization, the standard formalizes requirements for each. Specifications for these and other related safety assurance processes are left at a functional level, allowing individual organizations to tailor them to the scope and scale appropriate for their size and type of organization.

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[13] The safety assurance functions in the SMS standard contained in Appendix 1 were derived almost directly from ISO 9000-2000, the international quality management standard and the IEP development guidance in AC 120-59A.

(4) Internal Audits by Operating Departments. The primary responsibility for safety management rests with those who "own" the operator's technical processes. It is here where hazards are most directly encountered, where deficiencies in processes contribute to risk, and where direct supervisory control and resource allocation can mitigate the risk to acceptable levels. The standard specifies a responsibility for internal auditing of the operator's productive processes (the Production/Operation side of Figures 1 and 2). As with other requirements, the standard's auditing requirements are left at a functional level, allowing for a broad range of complexity, commensurate with the complexity of the organization.

(a) Line Management Responsibilities. Line managers of operational departments have the direct responsibility for quality control and for ensuring that the processes in their areas of responsibility function as designed. Moreover, line organizations are the domain technical experts in any organization and thus the most knowledgeable about the technical processes involved. Line managers of the operational departments should be given the responsibility for monitoring these processes and periodically assessing the status of risk controls though an internal auditing and evaluation program.

(b) Audit Programs and Tools. In order to promote system integration and a minimum of duplication, operators may want to consider using available technical system audit tools such as those provided by the Air Transportation Oversight System (ATOS)[14] or third party tools such as those in the IATA Operational Safety Audit (IOSA). This can be particularly advantageous if the operator is already involved with using these programs.

(5) Internal Evaluation. This function involves evaluation of the technical processes of the operator as well as the SMS-specific functions. Audits conducted for the purpose of this requirement must be conducted by persons or organizations that are functionally independent of the technical process being evaluated. A specialist safety or quality assurance department or another sub-organization as directed by top management may accomplish it. The internal evaluation function also requires auditing and evaluation of the safety management functions, policymaking, safety risk management, safety assurance, and safety promotion. These audits provide the management officials designated responsibility for the SMS to inventory the processes of the SMS itself.

NOTE: In very small organizations, the top management may elect to conduct the internal evaluation function themselves, in conjunction with the management review function.

(6) Integration of Regulatory and Voluntary Programs. The provisions of the SMS standard are not intended to duplicate the functions of required CASS (required for operators under part 121 or part 135 of Title 14 of the Code of Federal Regulations) (14 CFR) or IEPs. In fact, the FAA encourages an integrated approach where these programs are all part of a comprehensive SMS.

(7) External Audits. External audits of the SMS may be conducted by the regulator (FAA), code-share partners, customer organizations, or other third parties selected by the

[14] Available at: http://www.faa.gov/safety/programs_initiatives/oversight/atos/library/data_collection

operator. These audits not only provide a strong interface with the oversight system (SMS-O) but also a secondary assurance system. Organizations may elect to have third-party audits of their SMS from organizations such as the IATA or other consultant organizations.

(8) Analysis and Assessment. Audits and other information-gathering activities are useful to management only if the information is distilled into a meaningful form and conclusions are drawn to form a bottom line. Recall that the primary purpose of the safety assurance process is to assess the continued effectiveness of risk controls put into place by the safety risk management process. Where significant deviations to existing controls are discovered, the standard requires a structured, documented process for preventive and corrective action to place the controls back on track.

(9) Corrective Action and Followup. The safety assurance process should include procedures that ensure that corrective actions are developed in response to findings of audits and evaluations and to verify their timely and effective implementation. Organizational responsibility for the development and implementation of corrective actions should reside with the operational departments cited in audit and evaluation findings. If new hazards are discovered, the safety risk management process should be employed to determine if new risk controls should be developed.

(10) Monitoring the Environment. As part of the safety assurance function, the analysis and assessment functions must alert the organization to significant changes in the operating environment, possibly indicating a need for system change to maintain effective risk control. When this occurs, the results of the assessment start the safety risk management process, as depicted in Figure 3.

e. Safety Promotion: Supporting the Culture. An organizational safety effort cannot succeed by mandate or strictly though a mechanistic implementation of policy. As in the case of attitudes where individual people are concerned, organizational cultures set the tone that predisposes the organization’s behavior. An organization’s culture consists of the values, beliefs, mission, goals, and sense of responsibility held by the organization’s members. The culture fills in the blank spaces in the organization’s policies, procedures, and processes and provides a sense of purpose to safety efforts.

(1) Safety Cultures. Cultures consist of psychological (how people think and feel), behavioral (how people and groups act and perform) and structural (the programs, procedures, and organization of the enterprise) elements. Many of the processes specified in the policy, risk management, and assurance components of the SMS provide the framework for the structural element. However, the organization must also set in place processes that allow for communication among employees and with the organization’s management. The aviation service provider must make every effort to communicate its goals and objectives, as well as the current status of the organization’s activities and significant events. Likewise, the aviation service provider must supply a means of upward communication in an environment of openness.

(2) Communication: A Two Way Street. Dr. James Reason, among other current organizational system safety theorists, stresses the need for a “reporting culture” as an important aspect of safety culture. The organization must do what it can to cultivate the willingness of its members to contribute to the organization’s knowledge base. Dr. Reason further stresses the need for a "just culture," where employees have the confidence that, while they will be held accountable for their actions, the organization will treat them fairly.[15] The standard specifies that the aviation service provider must provide for a means of employee communication that allows for timely submission of reports on safety deficiencies without fear of reprisal. Many certificated operators already have invested in ASAP. ASAP is a collaborative, reporting, analysis, and problem solving effort among the FAA, operators, and employee unions. This program is another example of a voluntary program that could be integrated into the SMS, having a strong potential to contribute to the safety assurance and safety promotion.

(3) Organizational Learning. Another of Dr. Reason's principles of organizational safety culture is that of a "learning culture."[16] The information in reports, audits, investigation, and other data sources does no good if the organization does not learn from it. The standard also requires a means of analysis of this information and a linkage to the safety assurance process. The standard requires an analysis process, a preventive/corrective action process, and a path to the safety risk management process for the development of new safety controls, as environments change and new hazards are identified. It further requires that the organization provide training and information about risk controls and lessons learned.

9. CONTACT. For additional information or suggestions, please contact AFS-800 at (202) 267-8212, or AFS-900 at (703) 661-0526.

ORIGINAL SIGNED BY
John M. Allen (for)

James J. Ballough
Director, Flight Standards Service

[15] Reason. Managing the Risks of Organizational Accidents.

[16] Ibid.

APPENDIX 1. AIR OPERATOR SAFETY MANAGEMENT SYSTEM (SMS-P) STANDARD: FUNCTIONAL REQUIREMENTS

PURPOSE OF THIS APPENDIX. To provide a uniform standard for SMS development by aviation service providers.

1. Scope and Applicability

A) This Standard describes the requirements for a product/service provider's Safety Management System (SMS-P) in the air transportation system.

1) This standard is intended to address aviation safety related operational and support processes and activities rather than occupational safety, environmental protection, or customer service quality.

2) The requirements of this standard apply to Safety Management Systems developed and used by organizations that provide products and/or services in the air transportation system.

3) Operators and service providers are responsible for the safety of services or products contracted to or purchased from other organizations.

B) This document establishes the minimum acceptable requirements; oversight entities can establish more stringent requirements.

2. References

This Standard is in accordance with the following documents:

- Annex 6 to the Convention on International Civil Aviation, *Operation of Aircraft*
- International Civil Aviation Organization (ICAO) Document 9859, *ICAO Safety Management Manual*
- ICAO Document 9734, *Safety Oversight Manual*

3. Definitions

Accident – an unplanned event or series of events that results in death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.

Analysis – the process of identifying a question or issue to be addressed, modeling the issue, investigating model results, interpreting the results, and possibly making a recommendation. Analysis typically involves using scientific or mathematical methods for evaluation.

Assessment – process of measuring or judging the value or level of something.

Audit – scheduled, formal reviews and verifications to evaluate compliance with policy, standards, and/or contractual requirements. The starting point for an audit is the management and operations of the organization, and it moves outward to the organization's activities and products/services.

Internal audit – an audit conducted by, or on behalf of, the organization being audited.

External audit – an audit conducted by an entity outside of the organization being audited.

Aviation system – the functional operation/production system used by the service provider to produce the product/service (see Figure 1).

Complete – nothing has been omitted and the attributes stated are essential and appropriate to the level of detail.

Continuous monitoring – uninterrupted watchfulness over the system.

Corrective action – action to eliminate or mitigate the cause or reduce the effects of a detected nonconformity or other undesirable situation.

Correct – accurately reflects the item with an absence of ambiguity or error in its attributes.

Documentation – information or meaningful data and its supporting medium (e.g., paper, electronic, etc.). In this context it is distinct from records because it is the written description of policies, processes, procedures, objectives, requirements, authorities, responsibilities, or work instructions.

Evaluation – [ref. AC 120-59A] a functionally independent review of company policies, procedures, and systems. If accomplished by the company itself, the evaluation should be done by an element of the company other than the one performing the function being evaluated. The evaluation process builds on the concepts of auditing and inspection. An evaluation is an anticipatory process, and is designed to identify and correct potential findings before they occur. An evaluation is synonymous with the term systems audit.

Hazard – any existing or potential condition that can lead to injury, illness, or death to people; damage to or loss of a system, equipment, or property; or damage to the environment. A hazard is a condition that is a prerequisite to an accident or incident.

Incident – a near miss episode with minor consequences that could have resulted in greater loss. An unplanned event that could have resulted in an accident, or did result in minor damage, and indicates the existence of, though may not define, a hazard or hazardous condition.

Lessons learned – knowledge or understanding gained by experience, which may be positive, such as a successful test or mission, or negative, such as a mishap or failure. Lessons learned should be developed from information obtained from within, as well as outside of, the organization and/or industry.

Likelihood – the estimated probability or frequency, in quantitative or qualitative terms, of an occurrence related to the hazard.

Line management – management structure that operates the aviation system.

Nonconformity – non fulfillment of a requirement (ref. ISO 9000). This includes but is not limited to noncompliance with Federal regulations. It also includes company requirements, requirements of operator developed risk controls or operator specified policies and procedures.

Operational life cycle – period of time spanning from implementation of a product/service until it is no longer in use.

Oversight – a function that ensures the effective promulgation and implementation of the safety-related standards, requirements, regulations, and associated procedures. Safety oversight also ensures that the acceptable level of safety risk is not exceeded in the air transportation system. Safety oversight in the context of the safety management system will be conducted via oversight's safety management system (SMS-O).

Preventive action – action to eliminate or mitigate the cause or reduce the effects of a potential nonconformity or other undesirable situation.

Procedure – specified way to carry out an activity or a process.

Process – set of interrelated or interacting activities which transforms inputs into outputs.

Product/service – anything that might satisfy a want or need, which is offered in, or can be purchased in, the air transportation system. In this context, administrative or licensing fees paid to the government do not constitute a purchase.

Product/service provider – any entity that offers or sells a product/service to satisfy a want or need in the air transportation system. In this context, administrative or licensing fees paid to the government do not constitute a purchase. Examples of product/service providers include: aircraft and aircraft parts manufacturers; aircraft operators; maintainers of aircraft, avionics, and air traffic control equipment; educators in the air transportation system; etc. (Note: any entity that is a direct consumer of air navigation services and or operates in the U.S. airspace is included in this classification; examples include: general aviation, military aviation, and public use aircraft operators.)

Records – evidence of results achieved or activities performed. In this context it is distinct from documentation because records are the documentation of SMS outputs.

Residual safety risk – the remaining safety risk that exists after all control techniques have been implemented or exhausted, and all controls have been verified. Only verified controls can be used for the assessment of residual safety risk.

Risk – The composite of predicted severity and likelihood of the potential effect of a hazard in the worst credible system state.

Risk Control – refers to steps taken to eliminate hazards of to mitigate their effects by reducing severity and/or likelihood of risk associated with those hazards.

Safety assurance – SMS process management functions that systematically provide confidence that organizational products/services meet or exceed safety requirements.

Safety culture – the product of individual and group values, attitudes, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, the organization's management of safety. Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures.

Safety Management System (SMS) – the formal, top-down business-like approach to managing safety risk. It includes systematic procedures, practices, and policies for the management of safety (as described in this document it includes safety risk management, safety policy, safety assurance, and safety promotion).

Product/Service Provider Safety Management System (SMS-P) – the SMS owned and operated by a product/service provider.

Oversight Safety Management System (SMS-O) – the SMS owned and operated by an oversight entity.

Safety objectives.[17]– something sought or aimed for, related to safety.

NOTE 1: Safety objectives are generally based on the organization's safety policy.

NOTE 2: Safety objectives are generally specified for relevant functions and levels in the organization.

Safety planning[18] – part of safety management focused on setting safety objectives and specifying necessary operational processes and related resources to fulfill the quality objectives.

Safety risk – the composite of predicted severity and likelihood of the potential effect of a hazard.

Safety risk control – anything that reduces or mitigates the safety risk of a hazard. Safety risk controls must be written in requirements language, measurable, and monitored to ensure effectiveness.

Safety risk management (SRM) – a formal process within the SMS composed of describing the system, identifying the hazards, assessing the risk, analyzing the risk, and controlling the risk. The SRM process is embedded in the processes used to provide the product/service; it is not a separate/distinct process.

Safety promotion – a combination of safety culture, training, and data sharing activities that support the implementation and operation of an SMS in an organization

Severity – the consequence or impact of a hazard in terms of degree of loss or harm.

Substitute risk – risk unintentionally created as a consequence of safety risk control(s).

System – an integrated set of constituent elements that are combined in an operational or support environment to accomplish a defined objective. These elements include people, hardware, software, firmware, information, procedures, facilities, services, and other support facets.

Top Management – (ref. ISO 9000-2000 definition 3.2.7) the person or group of people who directs and controls an organization.

4. Policy

4.1. General Requirements

A) Safety management shall be included in the complete scope of the operator's systems including:

[17] Adapted from definition 3.2.5 in ISO 9000-2000 for "quality objectives."

[18] Adapted from definition 3.2.9 in ISO 9000-2000 for "quality planning."

1) flight operations;
2) dispatch/flight following;
3) maintenance and inspection;
4) cabin safety;
5) ground handling and servicing;
6) cargo handling; and
7) training.

B) SMS processes shall be:

1) documented;
2) monitored;
3) measured; and
4) analyzed.

C) SMS outputs shall be:

1) recorded;
2) monitored;
3) measured; and
4) analyzed.

D) The organization shall promote the growth of a positive safety culture (described in Sections 4.2 and 7.1).

4.2. Safety Policy

A) Top management shall define the organization's safety policy.

B) The safety policy shall:

1) include a commitment to implement an SMS;
2) include a commitment to continual improvement in the level of safety;
3) include a commitment to the management of safety risk;
4) include a commitment to comply with applicable regulatory requirements;
5) include a commitment to encourage employees to report safety issues without reprisal;
6) establish clear standards for acceptable behavior;
7) provide management guidance for setting safety objectives;
8) provide management guidance for reviewing safety objectives;
9) be documented;
10) be communicated to all employees and responsible parties;

11) be reviewed periodically to ensure it remains relevant and appropriate to the organization; and

12) identify responsibility of management and employees with respect to safety performance.

4.3. Quality Policy

Top management shall ensure that the organization's quality policy is consistent with the SMS.

4.4. Safety Planning

The organization shall establish and maintain a safety management plan to meet the safety objectives described in its safety policy.

4.5. Organizational Structure and Responsibilities

A) Top management shall have the ultimate responsibility for the SMS.

B) Top management shall provide resources essential to implement and maintain the SMS.

C) Top management shall appoint a member of management who, irrespective of other responsibilities, shall have responsibilities and authority that includes:

1) ensuring that process needed for the SMS are established, implemented and maintained

2) reporting to top management on the performance of the SMS and the need for improvement, and

3) ensuring the promotion of awareness of safety requirements throughout the organization.

D) Aviation safety-related positions, responsibilities, and authorities shall be:

1) defined;

2) documented; and

3) communicated throughout the organization.

4.6. Compliance with Legal and Other Requirements

A) The SMS shall incorporate a means of compliance with safety-related legal and regulatory requirements.

B) The organization shall establish and maintain a procedure to identify to current safety-related legal and regulatory requirements applicable to the SMS.

4.7. Procedures and Controls

A) The organization shall establish and maintain procedures with measurable criteria to accomplish the objectives of the safety policy[19].

B) The organization shall establish and maintain process controls to ensure procedures are followed for safety-related operations and activities.

4.8. Emergency Preparedness and Response

The organization shall establish procedures to:

1) identify the potential for accidents and incidents;
2) coordinate and plan the organization's response to accidents and incidents; and
3) execute periodic exercises of the organization's response.

4.9. Documentation and Records Management

A) General.

The organization shall establish and maintain information, in paper or electronic form, to describe:

1) safety policies;
2) safety objectives;
3) SMS requirements;
4) safety-related procedures and processes;
5) responsibilities and authorities for safety-related procedures and processes;
6) interaction/interfaces between safety-related procedures and processes; and
7) SMS outputs.

B) Documentation Management.

1) Documentation shall be:
   a) legible;
   b) dated (with dates of revisions);
   c) readily identifiable;
   d) maintained in an orderly manner; and
   e) retained for a specified period as determined by the organization (and approved by the oversight organization).

2) The organization shall establish and maintain procedures for controlling all documents required by this Standard to ensure that:

[19] Measures are not expected for each procedural step. However, measures and criteria should be of sufficient depth and level of detail to ascertain and track accomplishment of objectives. Criteria and measures can be expressed in either quantitative or qualitative terms.

a) they can be located;

b) they are periodically:

(1) reviewed,

(2) revised as necessary, and

(3) approved for adequacy by authorized personnel;

c) the current versions of relevant documents are available at all locations where operations essential to the effective functioning of the SMS are performed; and

d) obsolete documents are promptly removed from all points of use or otherwise assured against unintended use.

C) Records Management.

1) For SMS records, the organization shall establish and maintain procedures for their:

a) identification;

b) maintenance; and

c) disposition.

2) SMS records shall be:

a) legible;

b) identifiable; and

c) traceable to the activity involved.

3) SMS records shall be maintained in such a way that they are:

a) readily retrievable; and

b) protected against:

(1) damage,

(2) deterioration, or

(3) loss.

4) Record retention times shall be documented.

5. Safety Risk Management

A) SRM shall, at a minimum, include the following processes:

1) system and task analysis;

2) identify hazards;

3) analyze safety risk;

4) assess safety risk; and

5) control safety risk.

B) The SRM process shall be applied to:

1) initial designs of systems, organizations, and/or products;

2) the development of operational procedures;

3) hazards that are identified in the safety assurance functions (described in Section 6); and

4) planned changes to the operational processes to identify hazards associated with those changes.

C) The organization shall establish feedback loops between assurance functions described in Section 6 to evaluate the effectiveness of safety risk controls.

D) The organization shall define acceptable and unacceptable levels of safety risk (or safety risk objectives).

1) Descriptions shall be established for:

a) severity levels, and

b) likelihood levels.

2) The organization shall define levels of management that can make safety risk acceptance decisions.

3) The organization shall define acceptable risk for hazards that will exist in the short-term while safety risk control/mitigation plans are developed and executed.

E) The following shall not be implemented until the safety risk of each identified hazard is determined to be acceptable in:

1) new system designs;

2) changes to existing system designs;

3) new operations/procedures; and

4) modified operations/procedures.

F) The SRM process shall not preclude the organization from taking interim immediate action to mitigate existing safety risk.

5.1. System and Task Analysis

A) System and task descriptions shall be developed to the level of detail necessary to identify hazards.

B) System and task analyses should consider the following:

1) the system's interactions with other systems in the air transportation system (e.g. airports, air traffic control);

2) the system's functions for each area listed in para 4.1 A);

3) employee tasks required to accomplish the functions in 5.1 B) 2);

4) required human factors considerations of the system (e.g. cognitive, ergonomic, environmental, occupational health and safety) for:

a) operations, and

b) maintenance;

5) hardware components of the system;

6) software components of the system;

7) related procedures that define guidance for the operation and use of the system;

8) ambient environment;

9) operational environment;

10) maintenance environment;

11) contracted and purchased products and services;

12) the interactions between items in Section 5.1.B., 2 - 10 above; and

13) any assumptions made about:

a) the system,

b) system interactions, and

c) existing safety risk controls.

5.2. Identify Hazards

A) Hazards shall be:

1) identified for the entire scope of the system that is being evaluated as defined in the system description[20]; and

2) documented.

B) Hazard information shall be:

1) tracked, and

2) managed through the entire SRM process.

5.3. Analyze Safety Risk

The safety risk analysis process shall include:

1) existing safety risk controls;

2) triggering mechanisms; and;

3) safety risk of reasonably likely outcomes from the existence of a hazard, to include estimation of the:

a) likelihood; and

b) severity.

[20] While it is recognized that identification of every conceivable hazard is impractical, operators are expected to exercise due diligence in identifying and controlling significant and reasonably foreseeable hazards related to their operations.

5.4. Assess Safety Risk

A) Each hazard shall b e as sessed for its safety risk accep tability using the safety risk objectives described in Section 5D.

B) The organization shall define levels of management t hat c an ma ke s afety r isk acceptance decisions.

5.5. Control Safety Risk

A) Safety control/m itigation plans shall be defined for each hazard with unacceptable risk.

B) Safety risk controls shall be:

1) clearly described;
2) evaluated to ensure that the requirements have been met;
3) ready to be used in the operational environment for which they are intended; and
4) documented.

C) Substitute risk shall be evaluated in the creation of safety risk controls/mitigations.

6. Safety Assurance and Internal Evaluation

Figure 3 illustrates how Safety Assurance functions (described in Sections 6.2 – 6.6) are linked to the SRM process (described in Section 5).

6.1. General Requirements

The organization shall monitor heir systems and operations to:

1) identify new hazards;
2) measure the effectiveness of safety risk controls; and
3) ensure compliance with regulatory requirements.

6.2. System Description

The safety assurance function shall be based upon a com prehensive sy stem description as described in Section 5.1.

6.3. Information Acquisition

The organiz ation sh all colle ct th e data nec essary to dem onstrate th e ef fectiveness of the organization's:

1) Operational processes; and
2) the SMS.

6.3.1 Continuous Monitoring

A) The organization shall monitor operational data (e.g., duty logs, crew reports, work cards, process sheets, or reports from the employee safety feedback system specified in Section 7.1.5 to:

1) assess conformity with safety risk controls (described in Section 5);

2) measure the effectiveness of safety risk controls (described in Section 5);

3) assess system performance; and

4) identify hazards.

B) The organization shall monitor products and services received from subcontractors.

6.3.2 Internal Audits by Operational Departments

A) Line management of operational departments shall ensure that regular internal audits of safety-related functions of the organization's operational processes (production system) are conducted. This obligation shall extend to any subcontractors that they may use to accomplish those functions.

B) Line management shall ensure that regular audits are conducted to:

1) determine conformity with safety risk controls; and

2) assess performance of safety risk controls.

C) Planning of the audit program shall take into account:

1) safety significance of the processes to be audited; and

2) the results of previous audits.

D) The audit program shall include:

1) definition of the audit:

a) criteria,

b) scope,

c) frequency, and

d) methods;

2) the processes used to select the auditors;

3) the requirement that individuals shall not audit their own work;

4) documented procedures, which include:

a) the responsibilities; and

b) requirements for:

(1) planning audits,

(2) conducting audits,

(3) reporting results, and

(4) maintaining records; and

5) audits of contractors and vendors.

6.3.3 Internal Evaluation

A) The organization shall conduct internal eval uations of the operational processes and the SMS at planned intervals to determine that the SMS conforms to requirements.

B) Planning of the evaluation program shall take into account:

1) safety significance of processes to be audited; and

2) the results of previous audits.

C) The evaluation program shall include:

1) definition of the evaluation:

a) criteria;

b) scope;

c) frequency; and

d) methods;

2) the processes used to select the auditors;

3) the requirement that auditors shall not audit their own work;

4) documented procedures, which include:

a) the responsibilities, and

b) requirements for:

(1) planning audits,

(2) conducting audits,

(3) reporting results,

(4) and maintaining records; and

5) audits of contractors and vendors.

D) The program shall be under the direction of the m anagement offi cial described in Section 4.5.

E) The program shall include an evaluation of the program required described in Section 6.3.2.

F) The person or organization perform ing eval uations of operational departm ents m ust be functionally independent of the department being evaluated.

6.3.4 External Auditing of the SMS

A) The organization shall include the results of oversight organization audits in the analyses conducted as described in Section 6.4.

6.3.5 Investigat ion

A) The organization shall collect data on:

1) incidents, and

2) accidents.

B) The organization shall establish procedures to:

1) investigate accidents;

2) investigate incidents; and

3) investigate instances of potential regulatory non-compliance.

6.3.6 Em ployee Reporting and Feedback System.

A) The organization shall establish and m aintain a conf idential employee saf ety reporting and feedback system as in Section 7.1.5).

B) Employees shall be en couraged to use th e safety reporting and feedback system without reprisal as in Section 4.2 B) 5).

C) Data from t he safety reporting and feedback s ystem shall be m onitored to iden tify emerging hazards.

D) Data collected in the s afety repor ting a nd feedback system shall be included in analyses described in Section 6.4.

6.4. Analysis of Data

A) The organization shall analyze data the data described in Section 6.3 to dem onstrate the effectiveness of:

1) risk controls in the organization's operational processes, and

2) the SMS.

B) Through data analysis, the organization sh all evaluate where im provements can be made to the organization's:

1) operational processes, and

2) SMS.

6.5. System Assessment

A) The organization shall assess the performance of:

1) safety-related functions of operational processes against their requirements, and

2) the SMS against its requirements.

B) System assessments shall result in a finding of:

1) conformity with exis ting saf ety ris k c ontrol(s)/ SMS requirem ent(s) (including regulatory requirements);

2) nonconformity with existing safety risk control(s)/ SMS requirement(s) (including regulatory requirements); and

3) new hazard(s) found.

C) The SRM process will be utilized if the assessment indicates:

1) the identification of new hazards; or

2) the need for system changes.

D) The organization shall maintain records of assessments in accordance with the requirements of Section 4.9.

6.6. Preventive/Corrective Action

A) The organization shall develop, prioritize, and implement, as appropriate:

1) corrective actions for identified nonconformities with risk controls; and

2) preventive actions for identified potential nonconformities with risk controls actions.

B) Safety lessons learned shall be considered in the development of:

1) corrective actions; and

2) preventive actions.

C) The organization shall take necessary corrective action based on the findings of investigations.

D) The organization shall prioritize and implement corrective action(s) in a timely manner.

E) The organization shall prioritize and implement preventive action(s) in a timely manner.

F) Records shall be kept of the disposition and status of corrective and preventive actions per established record retention policy.

6.7. Management Reviews

A) Top management will conduct regular reviews of the SMS, including:

1) the outputs of SRM (Section 5);

2) the outputs of safety assurance (Section 6); and

3) lessons learned (Section 7.5).

B) Management reviews shall include assessing the need for changes to the organization's:

1) operational processes, and

2) SMS.

6.8 Continual Improvement

The organization shall continuously improve the effectiveness of the SMS and of safety risk controls through the use of the safety and quality policies, objectives, audit and evaluation results, analysis of data, corrective and preventive actions, and management reviews.

7. Safety Promotion

7.1. Safety Culture

Top management shall promote the growth of a positive safety culture through:

1) publication of senior management's stated commitment to safety to all employees;

2) visible demonstration of their commitment to the SMS;

3) communication of the safety responsibilities for the organization's personnel;

4) clear and regular communication of safety policy, goals, objectives, standards, and performance to all employees of the organization

5) an effective employee safety feedback system that provides confidentiality as is necessary;

6) use of a safety information system that provides an accessible efficient means to retrieve information; and

7) allocation of resources essential to implement and maintain the SMS.

7.2. Communication and Awareness

A) The organization shall communicate outputs of the SMS to its employees, as appropriate.

B) The organization shall provide access to the outputs of the SMS to its oversight organization, in accordance with established agreements and disclosure programs.

7.3. Personnel Requirements (Competence)

A) The organization shall document competency requirements for those positions identified in Section 4.5.D).

B) The organization shall ensure that those individuals in the positions identified in 4.5.D) meet those competency requirements.

7.4. Training

Training shall be developed for those individuals in the positions identified in 4.5.D).

1) Training shall include:

   a) initial training; and

   b) recurrent training.

2) Employees shall receive training commensurate with their:

a) Level of responsibility; and

b) impact on the safety of the organization's product or service.

3) To ensure training currency, it shall be periodically:

a) reviewed; and

b) updated.

7.5. Safety Lessons Learned

A) The organization shall develop safety lessons learned.

B) Lessons learned inform ation shall be used to prom ote continuous improvem ent of safety.

C) The organization shall communicate information on safety lessons learned.

APPENDIX 2. COMPARISON OF SMS-P STANDARD WITH OTHER STANDARDS

1. PURPOSE OF THIS APPENDIX.

a. The table below is provided to assist those organizations developing and implementing an SMS. It provides a link between existing standards and this standard. It includes links to the following:

(1) Quality Management Systems via International Standards Organization (ISO) 9001:2000 and the Aerospace Basic Quality System Standard (AS 9100) requirements;

(2) Environmental Management Systems via ISO 14001 requirements; and

(3) Occupational Safety and Health Management Systems via OHSAS 18001. (NOTE: OHSAS 18001 is an Occupation Health and Safety Assessment Series for health and safety management systems, which was created through a concerted effort from a number of the world's leading national standards bodies, certification bodies, and specialist consultancies.)

b. The table is intended to assist the developer in building on existing management systems to develop the SMS and/or integrating its SMS with these existing management systems.

2. SMS-P STANDARD COMPARED WITH OTHER STANDARDS.

Content (Standards)	SMS-P Standard	ISO 9001:2000/ AS 9100	ISO 14001	OHSAS 18001
Scope and application	1	1	1	1
References (Normative)	2	2	2	2
Definitions	3	3	3	3
Management system description	4	4	4	4
General requirements (and Responsibility/Authority (ISO 9000))	4.1	4.1, 5.5	4.1	4.1
Policy (safety, environmental, quality)	4.2, 4.3	5.1, 5.3, 8.5	4.2	4.2
Planning	4.4	5.4	4.3	4.3
Requirements (hazard/risk, environmental aspects, customer requirements)	5	5.2, 7.2.1, 7.2.2	4.3.1	4.3.1
Legal and other requirements, customer focus (ISO 9000)	4.6	5.2, 7.2.1	4.3.2	4.3.2
Objectives and targets	4.2.B), 5D.	5.4.1	4.3.3	4.3.3

Content (Standards)	SMS-P Standard	ISO 9001:2000/ AS 9100	ISO 14001	OHSAS 18001
Programs, action planning to meet targets, continual improvement	4.1.A), 4.4, 5.5	5.4.2, 8.5.1	4.3.4	4.3.4
Management responsibility and organizational structure	4.5	5, 6 (Resource mgmt.)	4.4.1	4.4.1
Training	7.3, 7.4	6.2.2	4.4.2	4.4.2
Communications	6.3.6, 7.2, 7.5	5.5.3, 7.2.3	4.4.3	4.4.3
Documentation and quality manual (ISO 9000)	4.9	4.2	4.4.4	4.4.4
Document and data control	4.9	4.2.3	4.4.5	4.4.5
Operational control and product realization	4.7	7	4.4.6	4.4.6
Emergency preparedness and response, control of nonconforming product (ISO 9000)	4.8	8.3	4.4.7	4.4.7
Performance measurement and monitoring	4.1, 6.3.1, 6.4, 6.5	8	4.5	4.5
Accidents, incidents, nonconformity, corrective and preventive action	6.3.5, 6.5, 6.6	8.3, 8.5.2, 8.5.3	4.5.2	4.5.2
Auditing	6.3.3 – 6.3.5	8.2.2	4.5.4	4.5.4
Management review	6.7	5.6	4.6	4.6
Continual Improvement	6.8	8.5.1	4.3.4	4.3.4