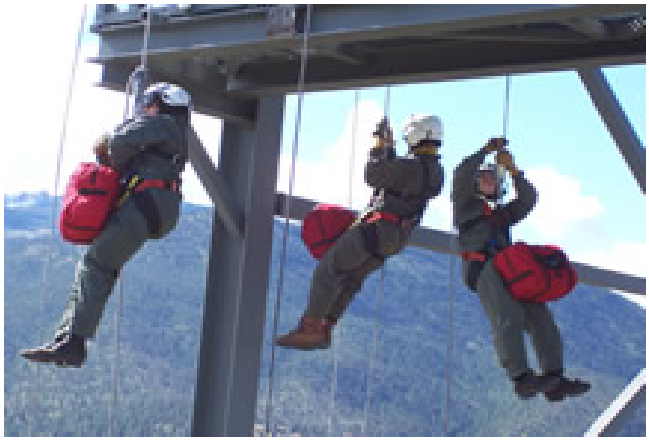
Programmatic Risk Assessment and Quality Assurance Evaluation For Helicopter Rappelling



Final Report

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Executive Summary

This report documents a risk assessment and quality assurance evaluation of the mission of helicopter rappelling in the wildland fire environment. This project was conducted by a team of consultants working in partnership with Forest Service aviation leaders, subject matter experts (SMEs) and rappel practitioners. The work began in August, 2009, and ended in March of 2010. Much of the report was developed with the consultants serving as facilitators and the agency subject matter experts providing the content information. The report, its conclusions and recommendations are solely the work of the consultants.

The consultants conclude that helicopter rappelling in the wildland fire environment does pose significant hazards. These hazards can be mitigated resulting in an acceptable level of risk. The findings and recommendations follow.

Finding 1 – SMS Policy Component: National Helicopter Program Management Structure
The national helicopter program management structure is not in alignment with the complexity of the current program.

Discussion
The helicopter program has evolved with mostly local and Regional guidance on many key program components. The helicopter rappelling program has evolved with very little national guidance on program development. National training and equipment guidance are considered with significant local variation, interpretation and adaptation.

Recommendation 1-1
Establish a National mission statement for the Helicopter program including Aviation Life Support Equipment.

Recommendation 1-2
Establish a National mission statement for the helicopter rappelling program.

Recommendation 1-3
Define and implement a National Helicopter and Helicopter Rappelling Program Management structure including Program Leadership and Quality Assurance Staff.

Recommendations1-4
Conduct a National Activity Review of the helicopter rappelling program.

Finding 2 - SMS Risk Management Component: Helicopter Rappelling Hazards And Mitigation Measures

U.S. Forest Service subject matter experts identified hazards and mitigation measures during the completion of the helicopter rappelling risk assessment.

Discussion

The hazards and mitigations were identified, evaluated and rated by experts including program leaders, managers, rappel spotters, pilots and safety specialists.

Recommendation 2-1

The Forest Service should identify elements of the rappel program that contain immitigable risk that are acceptable as a component of having a rappel program.

Recommendation 2-2

The Forest Service should prepare an action plan leading to implementation of the mitigation measures resulting in an acceptable level of program risk.

Finding 3 - SMS Quality Assurance Component: Implementation Of Policy Standards And Processes

The implementation of policy, standards and processes from the Interagency Helicopter Rappel Guide (IHRG) is high, but documentation standards are inconsistent.

Discussion

In order for a quality assurance process to be effective in its purpose within mission implementation, there must be consistent standards and processes throughout a program. Quality assurance within an organization is tasked to "monitor, measure, and evaluate the performance and effectiveness" of a program. This is not possible if the program to be measured varies in its implementation from one base to another.

Recommendation 3-1

Perform further review of program gaps is recommended for a proper conclusion as to what should and should not be required in documentation.

Recommendation 3-2

Clarify and define standards and procedures in the Interagency Helicopter Rappel Guide.

Recommendation 3-3

Rappel program reviews by the agency need to be standardized, documented, and complete.

Finding 4 - SMS Promotion Component: Agency Reporting Culture

The agency reporting culture does not provide comprehensive information on events that are needed to support management decisions.

Discussion

Many personnel perceive that the reporting system provides management a vehicle for punitive action. There is a stigma associated with the reporting system that continues to inhibit its use in the most beneficial way. The fully functional reporting system must attempt to assure complete confidentiality for the reporter. If the system provides any avenue for punitive action, management will lose the valuable opportunity to learn about the issues that could have the most profound effect upon the organization.

Recommendation 4-1

Augment the current system to ensure complete confidentiality.

Recommendation 4-2

Continuously market and campaign the importance of the reporting program to the field, to include vendors. Promote the use of the system by highlighting instances where reporting has been successful in preventing mishaps and negative consequences have not occurred.

Programmatic Risk Assessment and Quality Assurance Evaluation For Helicopter Rappelling

Introduction

This report documents a programmatic risk assessment (RA) and quality assurance (QA) evaluation for the mission of helicopter rappelling in the wildfire environment. The project, conducted under contract to the Forest Service (FS), was completed in March of 2010. This report incorporates both risk assessment and quality assurance information resulting in unified findings and recommendations.

The scope of work left the choice of methodology to the consultants. The consultants used the Safety Management System (SMS) as defined in the Federal Aviation Administration's (FAA) Advisory Circular 120-92 (Appendix J) and the 2009 US Forest Service – Department of the Interior Aviation Risk Management Workbook, (Appendix C). The 2009 Aviation Risk Management Workbook is used as a point of departure for this risk assessment. This programmatic risk assessment addresses the overall program and does not address all of the unique or problematic aspects of each aircraft used for helicopter rappelling. It also does not duplicate an analysis of those hazards and mitigations which are identified for the overall helicopter wildfire mission and which apply only incidentally to helicopter rappelling.

To develop the risk assessment, the Forest Service provided a dedicated and highly professional group of subject matter experts (SMEs) who identified hazards and mitigation measures, projected costs for the mitigations and rated the cost benefit of implementing the mitigations. The SMEs included agency specialists with a wide variety of expertise at the National, Regional and local levels including the following skills: Helicopter Program Manager, Helicopter Coordinator, Helicopter Pilot Inspector, Helicopter Operations Specialist, Rappel Check Spotter, Rappel Spotter and Aviation Risk Manager. Another SME was a current contract helicopter rappel pilot. In addition, there were four site visits to three Regions. These site visits were for the purpose of obtaining comments on the Helicopter Rappelling Risk Assessment contained in the 2009 Aviation Risk Management Workbook and to introduce the concept of quality assurance.

In 2009, a rappeller lost his life during a proficiency rappel in Northern California. This was the first fatality in the 37 year history of the rappelling program. The Deputy Chief directed that the Forest Service take unprecedented steps to standardize the Helicopter Rappelling Program. The consultants are aware of this work and have assisted with some phases of it. However, this report is completely independent of the standardization effort.

Study Plan

The intent of the risk assessment is for the subject matter experts to identify hazards and develop mitigation measures, benefits and costs. The intent of the quality assurance evaluation is to understand how program direction is being implemented in the field and to receive feedback from the practitioners on the adequacy of program guidance.

A notebook of key documents and statistics concerning helicopter rappelling was prepared for use by the SMEs. Topics addressed in the notebook include helicopter rappelling accident and incident and safety communications information mainly from the Aviation Safety Communiqué (SAFECOM) system. It also included rappelling history, analysis of flight statistics including failure rate comparisons between single and twin engine helicopters. Program documentation on comparable helicopter rappelling programs was included the Province of British Columbia, Province of Alberta and Travis County, Texas.

The risk assessment SMEs workshop brought together the data gathered from the site visits and information in the notebook and the considerable expertise of the team members. The initial task was the definition of hazards and the mitigation measures. Each hazard was rated was assigned a risk rating based on the probability of occurrence resulting in an accident and the severity of the consequences. The consultants developed a mathematical model to determine the risk rating. The SMEs initially reviewed the proposed model and indicated their belief that it would be effective.

A post mitigation risk rating was also determined for each mitigation measure using the same two criteria. Comparison of the two risk ratings provides a measure of relative effectiveness of the mitigation measure. This difference is called the benefit of the mitigation and when coupled with the cost of implementing the mitigation measure provided a benefit to cost rating.

An in depth quality assurance survey was prepared and completed by 97 members of the helicopter rappelling community. From the results of the risk assessment and the quality assurance evaluation, the consultants and the Forest Service advisors prepared recommendations for consideration by agency leadership.

Background

The helicopter rappelling program began in Region 6 in 1972 as a program evaluation and was approved by the Chief of the Forest Service as a nationally approved method for delivery for firefighters in 1976. This program was discontinued in 1983 as the cost of twin-engine helicopters, the only approved platform at that time, became prohibitive.

Helicopter rappelling returned to the Forest Service in 1986 in Region 3 utilizing light single engine helicopters. By 1991, helicopter rappelling was being done in Regions 3, 4, 5, and 6. By 1995, there were 32 helicopter rappel bases nationally.

With the advent of funds from the National Fire Plan in 2001, the helicopter rappel program grew. At 2009 program levels, there were 47 exclusive-use medium and light helicopters used as rappel platforms.

This growth and development has been managed almost exclusively at the regional level with the national role being limited to guidance through documents such as the Interagency Helicopter Rappel Guide (IHRG) and with national sponsorship of a helicopter rappel equipment position at the Missoula Technology Development Center. A more detailed history of the helicopter rappel program is provided in Appendix H.

Assumptions

This risk assessment and quality assurance evaluation focused upon the mission of the delivery of personnel using helicopter rappelling in the wildfire environment. Other helicopter firefighting missions are not addressed in this assessment.

This risk assessment considered but is not limited to the following issue areas:

- Environmental factors
- Terrain
- Special pilot skills
- Helicopter design and performance
- Ground support needs

The risk assessment specifically considered the most recent ten years of data regarding the Forest Services' experience. The 2009 Forest Service and Department of Interior Aviation Risk Management Workbook is used as a point of departure from which this risk assessment was performed.

The risk assessment was done with an awareness of the events regarding the 2009 fatal rappel accident in Northern California, but no information regarding the progress of the accident investigation nor any specific accident details were provided to the consultants.

The consultants assumed a "clean slate approach" and were not constrained by current methods, procedures or existing aviation contracts.

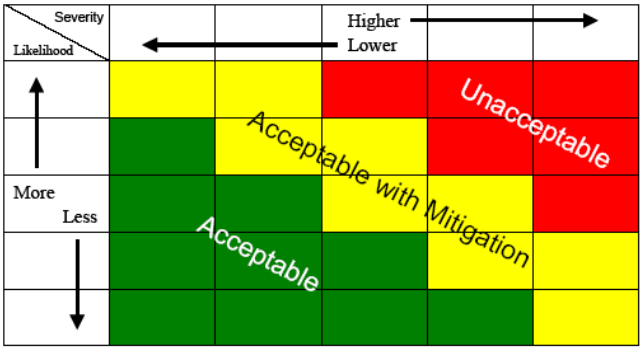
Systems, Hazards and Mitigation Measures

The consultants designed a risk assessment process based upon the principles of Safety Management Systems (SMS) as described in FAA Circular 120-92 (Appendix J).

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 decision-making. 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 2008 Systems Safety Aviation Guide and 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 FAA Circular 120-92. The process used to develop the hazards and mitigation measures together with the ratings of each pre-mitigation and post-mitigation 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 *

		Severity					
		Negligible	Marginal	Critical	Catastrophic		Outcome
Likelihood	Improbable						High
	Remote						Serious
	Occasional						Medium
	Probable						Low
	Frequent						

* - The 2008 Systems Safety Aviation Guide and the 2009 Aviation Risk Management Workbook did not display an Outcome matrix but the consultants were able to develop this matrix based on the outcome values.

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), FAA 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 FAA 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 SMEs identified three systems. They further identified 18 subsystems some of which appear in more than one system.

A-Aircraft System

- Performance, Capabilities, Limitations Subsystem
- Aircraft Equipment
- Configuration
- Aircraft Health

E-Rappel Equipment System

- Human Factors
- Cargo Delivery
- Rappel Equipment
- Management

O-Operations System

- Training
- Rappel Procedure
- Rappel Site Selection
- Management
- External Cargo Letdown
- Internal Cargo Letdown
- Emergency Procedures
- Reconfigure Offsite
- Configure at Helibase
- Large Fire Support

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

Evaluation of Hazards and Mitigation Measures

The identification of hazards and mitigation measures for helicopter rappelling 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 (SME) and three technical experts attended this workshop (Appendix A). The consultants facilitated a process where the SMEs 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 pre-mitigation and post-mitigation.

Figure 3 – Rating Matrix for Rating Hazards Pre-Mitigation and Post-Mitigation

							Negligible	Marginal 1	Marginal 2	Critical	Catastrophic		
							Severity						
							No effect no damage	**No lost time injury Minor dings**	**Loss time injury Damage < 3 days**	**Serious injury Replace Aircraft**	**Death Total the Aircraft**		
							Very Low	Low	Moderate	High	Extreme		
		Flights	Hrs				1	3	9	12	15	Rating	
Probability	**5 yr+**	325	650	**Very Low**		1	2	4	10	13	16	Extreme	
	1 yr	75	150	**Low**		2	3	5	11	14	17	High	
	3 mo	30	60	**Moderate**		3	4	6	12	15	18	Moderate	
	1 wk	10	20	**High**		4	5	7	13	16	19	Low	
	daily	1	2	**Extreme**		5	6	8	14	17	20	Very Low	

The classifications and the resultant rating matrix is shown in Figure 3. The SME assigned a numeric value to each classification. The sum of these two numbers became the score for each combination of probability and severity. The SMEs 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 SMEs 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 implementation of 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 resultant rating matrix is shown in Figure 5.

Figure 5 – Rating Matrix for Costs and Benefits Pre-Mitigation and Post-Mitigation

					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
Cost	>$501K	High		1	2	4	7	9
	$101K-$500K	Moderate		2	3	5	8	10
	$1 - $100K	Low		3	4	6	9	11
	0	Very Low		4	5	7	10	12

B/C Rating	
Best	
Better	
Good	
Minimal	

The SMEs assigned a numeric value to each classification. The sum of these two numbers became the score for each combination of benefit and cost. The SMEs 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	

<u>Rating of Hazards and Mitigation Measures With Benefits and Costs</u>

A listing of the hazards and mitigation measures follow, including ratings for pre-mitigation, post-mitigation and benefit/cost.

Table 1 - Aircraft System

			Pre-mitigation					Post-mitigation			Benefit~Cost		
Sub-System	ID	Hazards	Prob	Severity	Risk Rating	ID	Mitigation	Prob	Severity	Risk Rating	Cost	Benefit	B~C Rating
Performance, Capabilities, Limitations	A1	There is a lack of standard aircraft configuration by make and model of helicopters to perform the rappel mission.	Moderate	Moderate	High	A1M1	Develop National Rappel Helicopter Screening and Evaluation Board.	Low	Low	Low	Low	High	Better
						A1M2	Develop a standard configuration by make and model.	Very Low	Very Low	Very Low	Moderate	Very High	Best
						A1M3	Tech transfer the standard configuration to the field	Very Low	Low	Very Low	High	Very High	Better
	A2	Lack of adequate screening of aircraft to perform the rappel mission prior to award.	Moderate	Moderate	High	A2M1	Develop National Rappel Helicopter Screening and Evaluation Board.	Very Low	Low	Very Low	Very Low	Very High	Best
	A3	The aircraft are performing near limits of capabilities due to mission, payload, and environment with constantly changing conditions.	High	Low	Moderate	A3M1	Refine national rappel specifications template in the exhibit section of the contract. Utilize pilots, helicopter managers, helicopter operations specialists and rappel specialists when developing aircraft contract specifications and modifications.	High	Very Low	Low	Low	Moderate	Good
						A3M2	Ensure rappel operation begins with the helicopter operating within the maximum continuous parameters. (Start in the green arc.)	Moderate	Very Low	Very Low	Very Low	High	Best
						A3M3	Ensure strict compliance with flight manual and increased awareness training of aircraft performance for helicopter managers and proper mission planning (including downloading).	Moderate	Very Low	Very Low	Very Low	High	Best
						A3M4	Apply additional downloading to maintain safe operating parameters	Low	Low	Low	Very Low	Moderate	Better
	A4	There is a lack of a definition of a standard load of rappellers and equipment.	Moderate	Low	Low	A4M1	Develop a rappel mission statement so load parameters can be defined.	Low	Low	Low	Very Low	Low	Good
	A5	There is an inherent hazard posed by helicopters hovering in the height velocity curve in the event of an engine loss or loss of control.	Very Low	Extreme	Extreme	A5M1	Consider only use of twin-engine helicopters with one engine out flyaway capability when within the height velocity curve.	Very Low	Moderate	Moderate	High	High	Better
						A5M2	Consider only use of twin-engine helicopters.	Very Low	High	High	High	Moderate	Good
						A5M3	Single engine operations maintain adequate rotor clearance for emergency landings in the rappel zone.	Very Low	High	High	Very Low	Moderate	Better
Aircraft Equipment	A6	There is a lack of follow-up quality assurance on new rappel anchors.	Low	Moderate	Moderate	A6M1	Newly designed rappel anchors must be structurally field tested prior to use.	Very Low	Low	Very Low	Moderate (A1M2)	High	Better
						A6M2	Ensure follow-up quality assurance.	Very Low	Low	Very Low	High (O11M2)	High	Better
	A7	The spotter tether attachment point is not uniformly defined, tested and designed in some aircraft.	Low	High	High	A7M1	Ensure spotter tether attachment point is approved with proper and valid STCs, tested annually, installed correctly, and inspected at manufacturer's recommendations.	Very Low	High	High	Low (A1M1)	Low	Good
	A8	Aircraft modifications improperly installed and documented could impede the airworthiness of the aircraft.	Low	Moderate	Moderate	A8M1	Ensure thorough maintenance inspections, documented, verification of STC documentation and compliance, increased training for helicopter managers.	Very Low	Low	Very Low	Very Low	High	Best

Table 1 - Aircraft System

			Pre-mitigation					Post-mitigation			Benefit~Cost		
Sub-System	ID	Hazards	Prob	Severity	Risk Rating	ID	Mitigation	Prob	Severity	Risk Rating	Cost	Benefit	B~C Rating
Configuration	A9	With the doors off or doors open during flight, crash survivability is reduced.	Very Low	High	High	A9M1	Minimize doors off or open operation to essential missions only.	Very Low	Moderate	Moderate	Very Low	Moderate	Better
	A10	Items in an external basket are not properly secured.	Low	High	High	A10M1	Ensure security of external loads prior to mission.	Very Low	Very Low	Very Low	Very Low	Very High	Best
	A11	In some helicopters, no structural barrier exists between rappel operations and PIC resulting in exposure to the flight controls.	Moderate	Extreme	Extreme	A11M1	Restrict rappel and cargo letdown operations only to helicopters that have a structural barrier that provides a defined barrier that cannot be compromised between the rappel operations and the PIC.	Very Low	Very Low	Very Low	Very Low	Very High	Best
						A11M2	Ensure there is a physical barrier between the rappel operations area and the flight control operations area.	Very Low	Very Low	Very Low	Low	Very High	Best
Aircraft Health	A12	Undetected corrosion, stress crack, structural, limited, and/or unknown amount of aircraft health testing and monitoring being performed on current aircraft (fatigue, corrosion, airframe, etc.).	Low	Moderate	Moderate	A12M1	Ensure Maintenance Inspectors are conducting thorough reviews of aircraft maintenance logs.	Very Low	Low	Very Low	Very Low	High	Best

Table 2 - Rappel Equipment System

			Pre-mitigation					Post-mitigation			Benefit-Cost		
Sub-System	ID	Hazards	Prob	Severity	Risk Rating	ID	Mitigation	Prob	Severity	Risk Rating	Cost	Benefit	B-C Rating
Human Factors	E1	Rappel equipment damaged or marginalized due to improper use.	Low	Moderate	Moderate	E1M1	Use education, supervision and expert quality assurance for following equipment use standards.	Low	Low	Low	High (O1M2)	Moderate	Good
						E1M2	When in doubt about equipment's usage, retire it.	Very low	Low	Very Low	High (O1M2)	High	Better
	E2	Rappel equipment damaged or marginalized due to improper treatment.	Low	High	High	E2M1	Use education, supervision and expert quality assurance for following equipment treatment standards.	Very low	Low	Very Low	Very Low	Very High	Best
	E3	The use of non-approved equipment can compromise safety and reliability.	Low	Extreme	Extreme	E3M1	Maintain comprehensive and current list of approved rappel equipment.	Low	Moderate	Moderate	Very Low	High	Best
						E3M2	Maintain current equipment standards for rappel equipment.	Low	Moderate	Moderate	Very Low	High	Best
						E3M3	Only utilize approved rappelling equipment.	Very low	Low	Very Low	Very Low	Very High	Best
						E3M4	Design and implement a process for independent evaluation of equipment at individual rappel bases.	Very low	Low	Very Low	High (O1M3)	Very High	Better
Human Factors	E4	Equipment is not properly inspected or documented.	Low	High	High	E4M1	Use training and supervision to ensure that equipment inspection and documentation standards (IHRG) are followed.	Very low	Low	Very Low	High (O1M3)	Very High	Better
						E4M2	Design and implement a process for independent evaluation of equipment at individual rappel bases.	Low	Low	Low	High (O1M3)	High	Better
						E4M3	Implement and utilize rappeller records (RAPREC) database.	Very low	Low	Very Low	Low	Very High	Best
	E5	Equipment is improperly rigged for a rappeller and spotter.	Low	High	High	E5M1	Develop and implement standard processes and procedures to include quality assurance.	Low	Low	Low	High (O1M2)	High	Better
						E5M2	Perform proper training per the IHRG.	Very low	Low	Very Low	High (O1M3)	Very High	Better
						E5M3	Maintain currency and proficiency.	Very low	Low	Very Low	Very Low	Very High	Best
						E5M4	Develop and implement a span of control criteria for training, operations and program management.	Very low	Low	Very Low	Very Low	Very High	Best

Table 2 - Rappel Equipment System

			Pre-mitigation					Post-mitigation			Benefit~Cost		
Sub-System	ID	Hazards	Prob	Severity	Risk Rating	ID	Mitigation	Prob	Severity	Risk Rating	Cost	Benefit	B~C Rating
Human Factors	E6	Improper use during the testing phase or improper use of newly approved equipment.	Low	Moderate	Moderate	E6M1	Develop and implement field-testing protocols.	Very low	Low	Very Low	High (O1M3)	High	Better
						E6M2	Ensure equipment sent to the field for testing has adequate instructions for testing and use.	Low	Low	Low	Very Low	Moderate	Better
Cargo Delivery	E7	There is no national standard configuration, which results in potential confusion and mistakes as personnel move from base to base.	Moderate	Moderate	High	E7M1	Identify and establish model specific configuration(s) and procedures.	Low	Low	Low	Very Low	High	Best
	E8	Use of improper cargo restraint straps/cargo compartment netting (internal only) may fail due to over stressing.	Low	Moderate	Moderate	E8M1	Establish minimum standard for cargo restraint straps and protective netting.	Very low	Low	Very Low	Very Low	High	Best
Rappel Equipment	E9	The current descent control device does not have an auto locking brake (fail-safe) component in the event of an incapacitated rappeller.	Low	High	High	E9M1	Consider development, testing and implementation of an auto locking brake (fail-safe) component on the descent control device.	Very low	Moderate	Moderate	High	Moderate	Good
Management	E10	There is uncertain equipment quality control and limited quality assurance from the manufacturer, which can lead to defective descent devices including ropes and decent devices.	Moderate	High	Extreme	E10M1	Develop an agency quality assurance process targeted at manufacturer defects.	Low	Low	Low	High (O1M3)	Very High	Better
						E10M2	Ensure compliance within the agency quality assurance process for newly acquired equipment.	Low	Low	Low	High (O1M2)	Very High	Better

Table 3- Operations System

Sub-System	ID	Hazards	Pre-mitigation Prob	Pre-mitigation Severity	Pre-mitigation Risk Rating	ID	Mitigation	Post-mitigation Prob	Post-mitigation Severity	Post-mitigation Risk Rating	Benefit-Cost Cost	Benefit-Cost Benefit	Benefit-Cost B-C Rating
Training	O1	Training in rappel procedures and instructional systems are non-standard and inconsistent throughout the agency leading to an increased likelihood of procedural errors.	Moderate	High	Extreme	O1M1	Develop standard procedures and instructional systems.	Low	Low	Low	Moderate (O1M4)	Very High	Best
						O1M2	Transfer and implement the standard procedures and delivery systems in training.	Low	Low	Low	Moderate (O1M4)	Very High	Best
						O1M3	Utilize consolidated training as a method standardization and quality assurance regionally and nationally.	Very Low	Low	Very Low	High	Very High	Better
						O1M4	Develop and implement a train the trainer program and implement.	Very Low	Low	Very Low	Moderate	Very High	Best
	O2	Mishaps that occur during training on the ground are not being reported in the SafeCom system leading to reduced information transfer.	Moderate	Moderate	High	O2M1	Include all training mishaps regardless of location in the SafeCom system.	Low	Low	Low	Very Low	High	Best
Rappel Procedure	O3	There is a lack of clearly and thoroughly defined standard procedures, which could lead to a breakdown in communications leading to mishaps and individual interpretations.	Moderate	High	Extreme	O3M1	Develop clearly defined standard procedures.	Low	Low	Low	Moderate (O1M4)	Very High	Best
						O3M2	Develop a quality assurance process that implements inspections by HOS, check, spotter, peers and SME.	Low	Low	Low	High (O1M2)	Very High	Better
	O4	The use of non-standard verbiage, direction, and interaction between spotter and pilot during rappel operations could lead to miscommunication.	Moderate	High	Extreme	O4M1	Develop CRM training specific to pilot-spotter relationship.	Low	Low	Low	Low	Very High	Best
						O4M2	CRM training should be done in the field with the current pilots including relief pilots and crew.	Low	Low	Low	Very Low	Very High	Best
	O5	Diversion from intended mission with limited information.	High	Low	Moderate	O5M1	Obtain necessary information prior to accepting mission including frequencies, contacts, coordinates, additional aircraft involved and known hazards.	Low	Low	Low	Very Low	Moderate	Better
						O5M2	Ensure crew is "re-briefed" on new mission.	Low	Low	Low	Very Low	Moderate	Better
	O6	Exposure to off-site landing accidents.	High	Moderate	High	O6M1	Follow standard procedures (high-low recon, power checks, verify load calculations as valid, etc.)	Low	Moderate	Moderate	Very Low	Moderate	Better
						O6M2	Site selection needs to be mutually agreed upon by pilot and spotter.	Low	Moderate	Moderate	Very Low	Moderate	Better
	O7	Performing proficiency rappel in a community situation can create distraction; i.e. Air show syndrome, competition.	Moderate	High	Extreme	O7M1	Consider doing proficiency rappels at an off-site area where distractions are not present.	Low	Low	Low	Very Low	Very High	Best

Table 3- Operations System

			Pre-mitigation					Post-mitigation			Benefit~Cost		
Sub-System	ID	Hazards	Prob	Severity	Risk Rating	ID	Mitigation	Prob	Severity	Risk Rating	Cost	Benefit	B~C Rating
Rappel Site Selection	O8	Selection of an inadequate rappel site could result in an unsafe environment for rappellers and increased exposure to rotor strikes, entanglements, etc.	Low	High	High	O8M1	Develop a spotter-training Syllabus.	Low	Moderate	Moderate	Moderate (O1M4)	Moderate	Good
						O8M2	Develop a national standard Spotter Training Handbook.	Low	Moderate	Moderate	Moderate (O1M4)	Moderate	Good
						O8M3	Select site so that the spotter can maintain positive visual contact with rappellers to the ground.	Low	Low	Low	Very Low	High	Best
						O8M4	Follow rotor clearance standard in IHOG when descending below the canopy.	Low	Low	Low	Very Low	High	Best
						O8M5	Recommend staying 50 feet above obstacles.	Low	Low	Low	Very Low	High	Best
Management	O9	Current minimum qualifications standards for a spotter can lead to less than optimum future performance and does not meet the demands based on the current complexity of the mission.	Moderate	High	Extreme	O9M1	Develop minimum standards based on the current complexity of the mission.	Low	Moderate	Moderate	Very Low	High	Best
	O10	The rappel pilot's practical test standard may not adequately address standardization and quality assurance.	Moderate	Moderate	High	O10M1	Revise the rappel practical test standards to include standardization and quality assurance.	Low	Low	Low	Very Low	High	Best
	O11	There is a lack of feedback to maintaining standards, which leads to diverging missions, normalization of deviance and reduced management decisions.	High	High	Extreme	O11M1	Consider staffing a national rappel program manager.	Moderate	Low	Low	Moderate	Very High	Best
						O11M2	Consider developing a national quality assurance branch for rappel.	Low	Low	Low	High	Very High	Better
	O12	Medical conditions can impair the ability of rappel personnel to safely rappel or spot and can lead to accidents or incidents.	Low	High	High	O12M1	Develop medical screen criteria for rappel personnel.	Low	Low	Low	High (O11M2)	High	Better
	O13	The span of control of experienced to inexperienced rappellers may be higher than optimum allowing for compromised effectiveness of training and unacceptable risk.	High	High	Extreme	O13M1	Develop span of control of experienced to inexperienced rappellers.	Low	Low	Low	Very Low	Very High	Best

Table 3- Operations System

			Pre-mitigation					Post-mitigation			Benefit~Cost		
Sub-System	ID	Hazards	Prob	Severity	Risk Rating	ID	Mitigation	Prob	Severity	Risk Rating	Cost	Benefit	B~C Rating
External Cargo Letdown	O14	Rappellers on board helicopter during delivery of cargo, which translates, to longer exposure to rappellers during hover.	Moderate	Low	Low	O14M1	Follow risk management process to determine the decision on the number of personnel on-board.	Low	Low	Low	Very Low	Low	Good
	O15	External rappel cargo could be dragged into an object or hit somebody.	Low	Moderate	Moderate	O15M1	The spotter to implement CRM visually confirming external load is clear of obstacles and communicating this to pilot.	Low	Low	Low	Very Low	Moderate	Better
						O15M2	Follow risk management processes to minimize overflying people or objects.	Very Low	Low	Very Low	Very Low	High	Best
	O16	The letdown tape comes free from the cargo and could impact the aircraft.	Low	High	High	O16M1	Ensure equipment inspections are properly performed and documented.	Very Low	Moderate	Moderate	Very Low	Moderate	Better
						O16M2	Ensure procedures are followed in the rigging and deployment of the external cargo.	Very Low	Moderate	Moderate	Very Low	Moderate	Better
						O16M3	Develop emergency procedures and perform recurrent crew-wide emergency procedures training.	Very Low	Moderate	Moderate	Moderate (O1M4)	Moderate	Good
Internal Cargo Letdown	O17	The cargo restraining straps have no minimum written specifications compromising the security of cargo.	Low	Moderate	Moderate	O17M1	Establish minimum standard for cargo restraint straps and protective netting.	Low	Low	Low	Very Low	Moderate	Better
	O18	The letdown tape comes free from the cargo and could impact the aircraft.	Low	High	High	O18M1	Ensure equipment inspections are properly performed and documented.	Very Low	Moderate	Moderate	Very Low	Moderate	Better
						O18M2	Ensure procedures are followed in the rigging and deployment of the external cargo.	Very Low	Moderate	Moderate	Moderate (O1M4)	Moderate	Good
						O18M3	Develop emergency procedures and perform recurrent crew-wide emergency procedures training.	Very Low	Moderate	Moderate	Moderate (O1M4)	Moderate	Good
	O19	Exposure to rappellers during internal load operations due to denied living space.	Low	High	High	O19M1	Consider performing cargo operation separately.	Very Low	Low	Very Low	Very Low	Very High	Best
						O19M2	Ensure that method of securing cargo is adequate for the size and weight of the cargo in the event of an accident.	Low	Low	Low	Very Low	High	Best
						O19M3	Require agency-approved containers for hazardous materials.	Low	Low	Low	Very Low	High	Best
	O20	There is possible injury potential to spotter from moving cargo bags that exceed 125 pounds.	Low	Moderate	Moderate	O20M1	Do not load cargo bags with a weight greater than 125 pounds as per the rappel guide.	Low	Low	Low	Very Low	Moderate	Better

Table 3- Operations System

			Pre-mitigation					Post-mitigation			Benefit~Cost		
Sub-System	ID	Hazards	Prob	Severity	Risk Rating	ID	Mitigation	Prob	Severity	Risk Rating	Cost	Benefit	B~C Rating
Emergency Procedures	O21	The lack of adequate training and proficiency in emergency procedures leads to uncertain response during the emergency.	Low	High	High	O21M1	Define CRM and what the procedures will be.	Low	Moderate	Moderate	Moderate (O1M4)	Moderate	Good
						O21M2	Increase simulation training to include the pilot, spotter and rappeller.	Low	Moderate	Moderate	Very Low	Moderate	Better
	O22	Miscommunication during mission critical procedures results in inappropriate response; I.e. rope cutting, re-entry.	Low	High	High	O22M1	Increase CRM procedure training.	Low	Low	Low	Moderate (O1M4)	High	Better
						O22M2	Develop or refine challenge and response criteria between spotter and pilot.	Low	Low	Low	Very Low	High	Best
	O23	The belly bags can impede re-entry to the aircraft and emergency egress from the aircraft.	Extreme	High	Extreme	O23M1	Develop a lesser weight and size standard for belly bags.	Moderate	Low	Low	Very Low	Very High	Best
						O23M2	Consider development of an alternative to belly bags.	Low	Low	Low	Very Low	Very High	Best
						O23M3	Consider development of a quick release system for belly bags.	Low	Low	Low	Very Low	Very High	Best
	O24	The pilot and the spotter lose communications during the entire rappel operation.	Low	Moderate	Moderate	O24M1	Develop written standards and CRM procedures for lost communication at each phase of the rappel operation.	Low	Low	Low	Very Low	Moderate	Better
						O24M2	Implement written standards and CRM procedures for lost communication at each phase of the rappel operation.	Low	Low	Low	Very Low	Moderate	Better
Reconfigure Offsite	O25	One and possibly two additional landings resulting in exposure to an accident.	High	Moderate	High	O25M1	Follow standard procedures (high-low recon, power checks, verify load calculations as valid, etc.)	Low	Moderate	Moderate	Very Low	Moderate	Better
						O25M2	Site selection needs to be mutually agreed upon by pilot and spotter.	Low	Moderate	Moderate	Very Low	Moderate	Better
	O26	A sense of urgency and additional distractions may exist during reconfigure.	Moderate	Moderate	High	O26M1	Do additional proficiency training of reconfigure in or simulating an offsite environment with rotors turning.	Low	Low	Low	Very Low	High	Best
						O26M2	Ensure that inexperienced personnel are mixed with experienced personnel in the rappel load.	Low	Low	Low	Very Low	High	Best
	O27	Damage to doors may occur.	Moderate	Moderate	High	O27M1	Comply with contractor door storage requirements.	Low	Low	Low	Very Low	High	Best
						O27M2	Develop and follow training on proper removal and storage of equipment when flying with doors off.	Low	Low	Low	Very Low	High	Best

Table 3- Operations System

			Pre-mitigation				Mitigation	Post-mitigation			Benefit~Cost		
Sub-System	ID	Hazards	Prob	Severity	Risk Rating	ID		Prob	Severity	Risk Rating	Cost	Benefit	B~C Rating
Configure at Helibase	O28	During extended doors off flight, overexposure to environmental elements such as outside air temperatures can lead to compromised performance.	Low	Moderate	Moderate	O28M1	Consider use of sliding doors.	Low	Low	Low	Very Low	Moderate	Better
						O28M2	Personnel should wear appropriate apparel based on the potential exposure.	Low	Low	Low	Very Low	Moderate	Better
	O29	When rappel configured at the base, there is additional survivability exposure to personnel in doors off flight mode.	Very Low	High	High	O29M1	Consider use of sliding doors.	Very Low	Moderate	Moderate	Very Low	Moderate	Better
Large Fire Support	O30	There is a lack of operational planning for rappel operations during large fire support.	High	High	Extreme	O30M1	Develop a process to integrate rappellers in large fire support operations ensuring that there is a discrete radio frequency and a sterile airspace for the rappel operation to support midair collision avoidance.	Moderate	Moderate	High	Very Low	Moderate	Better

Considerations for Implementing Mitigation Measures

It is seldom possible to entirely eliminate risk, even when highly effective mitigation measures are used. After these mitigation measures 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. 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 (one month or less), short-term (one to six months), long-term period (6 months to one year) or extended period (greater than one year).

Effectiveness of the mitigation measure is addressed in the comparison of pre-mitigation and post-mitigation ratings. In Table 4, each mitigation measure is listed with residual risk, substitute risk and implementation considerations.

Table 4 – Analysis of Mitigation Measures

Mitigation Measure ID	Mitigation Measure	Residual Risk	Substitute Risk	Implementation Considerations
Aircraft System				
A1M1	Develop National Rappel Helicopter Screening and Evaluation Board.	None Anticipated	None Anticipated	The scope of the board could be broader than the Rappel mission.
A1M2	Develop a standard configuration by make and model.	None Anticipated	Change management from existing familiar systems.	Establish and implement standards.
A1M3	Technology transfer the standard configuration to the field.	None Anticipated	Change management from existing familiar systems.	Programmatic follow-up to ensure successful transition to new standards.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
A2M1	Develop National Rappel Helicopter Screening and Evaluation Board.	None Anticipated	None Anticipated	The scope of the board could be broader than the Rappel mission.
A3M1	Refine national rappel specifications template in the exhibit section of the contract. Utilize pilots, helicopter managers, helicopter operations specialists and rappel specialists when developing aircraft contract specifications and modifications.	None Anticipated	None Anticipated	Establish and implement standards. Do programmatic follow-up to ensure successful transition to new standards.
A3M2	Ensure rappel operation begins with the helicopter operating within the maximum continuous parameters. (Start in the green arc.)	None Anticipated	None Anticipated	Direction to be developed, implemented and incorporated into training and into contracts.
A3M3	Ensure strict compliance with flight manual and increased awareness training of aircraft performance for helicopter managers and proper mission planning (including downloading).	None Anticipated	None Anticipated	Direction and training to be developed and implemented.
A3M4	Apply additional downloading to maintain safe operating parameters.	None Anticipated	None Anticipated	Direction and training to be developed and implemented

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
A4M1	Develop a rappel mission statement so load parameters can be defined.	Hovering in the height/velocity curve as an essential component of the mission.	None Anticipated	Ensure compliance at all organizational levels.
A5M1	Consider only use of twin-engine helicopters with one engine out flyaway capability when within the height velocity curve.	Unknown as these aircraft have not been thoroughly screened for the rappel mission.	Unknown as these aircraft have not been thoroughly screened for the rappel mission.	Suitability of the aircraft for the rappel mission. Significantly higher program cost.
A5M2	Consider only use of twin-engine helicopters.	Engine failure in twin engine helicopters is extremely rare but more frequent than in single engine helicopters. This hazard is rated as high post mitigation.	Engine failure in twin engine helicopters is extremely rare but more frequent than in S/E helicopters.	Most currently used twin engine helicopters offer less performance than some currently used S/E helicopters. Somewhat higher program cost.
A5M3	Single engine operations maintain adequate rotor clearance for emergency landings in the rappel zone.	None Anticipated	Transfer risk to ground operations due to added distance from fire line.	Direction and training to be developed and implemented.
A6M1	Newly designed rappel anchors must be structurally field tested prior to use.	None Anticipated	None Anticipated	Ensure that processes are adequate and implemented.
A6M2	Ensure follow-up quality assurance.	None Anticipated	None Anticipated	Ensure that processes are adequate and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
A7M1	Ensure spotter tether attachment point is approved with proper and valid Sacs, tested annually, installed correctly, and inspected at manufacturer's recommendations.	None Anticipated	None Anticipated	Ensure that processes are adequate and implemented.
A8M1	Ensure thorough maintenance inspections, documented, verification of STC documentation and compliance, increased training for helicopter managers.	None Anticipated	None Anticipated	Ensure that processes and training are adequate and implemented
A9M1	Minimize doors off or open operation to essential missions only.	None Anticipated	Agency decision to fly non-essential missions.	Ensure that processes and training are adequate and implemented.
A10M1	Ensure security of external loads prior to mission.	None Anticipated	None Anticipated	Ensure that processes and training are adequate and implemented.
A11M1	Restrict rappel and cargo letdown operations only to helicopters that have a structural barrier that provides a defined barrier that cannot be compromised between the rappel operations and the pilot on command.	None Anticipated	None Anticipated	This mitigation applies to the AS 350 series of helicopters and will result in their non-use for rappelling until implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
A11M2	Ensure there is a physical barrier between the rappel operations area and the flight control operations area.	None Anticipated	None Anticipated	This mitigation applies to the AStar 350 series of helicopters and will result in their non use for rappelling until implemented.
A12M1	Ensure Maintenance Inspectors are conducting thorough reviews of aircraft maintenance logs.	None Anticipated	Consider QA inspections of vendors prior to contract award.	Ensure that direction, processes and training are developed and implemented.
Equipment System				
E1M1	Use education, supervision and expert quality assurance for following equipment use standards.	None Anticipated	None Anticipated	Ensure direction and processes are developed and implemented.
E1M2	When in doubt about equipment's usage, retire it.	None Anticipated	None Anticipated	Ensure direction and processes are developed and implemented.
E2M1	Use education, supervision and expert quality assurance for following equipment treatment standards.	None Anticipated	None Anticipated	Ensure that direction, processes and training are developed and implemented.
E3M1	Maintain comprehensive and current list of approved rappel equipment.	None Anticipated.	None Anticipated	Ensure that direction, processes and training are developed and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
E3M2	Maintain current equipment standards for rappel equipment.	None Anticipated	None Anticipated	None
E3M3	Only utilize approved rappelling equipment.	None Anticipated	None Anticipated	Ensure that direction, processes and training are developed and implemented.
E3M4	Design and implement a process for independent evaluation of equipment at individual rappel bases.	None Anticipated	None Anticipated	Ensure that direction, processes and training are developed and implemented.
E4M1	Use training and supervision to ensure that equipment inspection and documentation standards (IHRG) are followed.	None Anticipated	None Anticipated	Ensure that direction, processes and training are developed and implemented.
E4M2	Design and implement a process for independent evaluation of equipment at individual rappel bases.	None Anticipated	None Anticipated	Ensure that direction, processes and training are developed and implemented.
E4M3	Implement and utilize rappeller records (RAPREC) database.	None Anticipated	None Anticipated	Establish database and provide direction on its usage. Monitor for compliance in usage.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
E5M1	Develop and implement standard processes and procedures to include quality assurance.	None Anticipated	None Anticipated	Develop standard processes and direction on their usage.
E5M2	Perform proper training per the IHRG.	None Anticipated	Change management leading to field acceptance/support must be resolved.	Ensure that direction is established and implemented.
E5M3	Maintain currency and proficiency.	None Anticipated	There are a number of complex and intertwined issues to resolve to accomplish this mitigation.	Ensure that direction is established and implemented.
E5M4	Develop and implement a span of control criteria for training, operations and program management.	None Anticipated	This will involve significant change for several Regions which may take several years to fully implement.	Ensure that direction and processes are established and implemented.
E6M1	Develop and implement field-testing protocols.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.
E6M2	Ensure equipment sent to the field for testing has adequate instructions for testing and use.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.
E7M1	Identify and establish model specific configuration(s) and procedures.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
E8M1	Establish minimum standard for cargo restraint straps and protective netting.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.
E9M1	Consider development, testing and implementation of an auto locking brake (fail-safe) component on the descent control device.	None Anticipated	None Anticipated	None Anticipated
E10M1	Develop an agency quality assurance process targeted at manufacturer defects.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.
E10M2	Ensure compliance within the agency quality assurance process for newly acquired equipment.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.
Operations System				
O1M1	Develop standard procedures and instructional systems.	Some level of residual risk may remain until the new procedures become habitual to the instructors.	This will involve significant change for several Regions which may take several years to fully implement.	Ensure that direction and processes are established and implemented.
O1M2	Transfer and implement the standard procedures and delivery systems in training.	Some level of residual risk may remain until the new procedures become habitual to the instructors. .	This will involve significant change for several Regions, which may take several years to fully implement.	Ensure that direction and processes are established and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
O1M3	Utilize consolidated training as a method standardization and quality assurance regionally and nationally.	None Anticipated	Transition from current methods will involve significant change from current practices in several Regions.	Ensure that direction and processes are established and implemented. This mitigation will require significant business practice changes in most Regions.
O1M4	Develop and implement a train the trainer program and implement.	. Some level of residual risk may remain until the new procedures become habitual to the instructors	Transition from current methods will involve significant change from current practices in several Regions.	Ensure that direction and processes are established and implemented
O2M1	Include all training mishaps regardless of location in the SAFECOM system.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented
O3M1	Develop clearly defined standard procedures.	Some level of residual risk may remain until the new procedures become habitual to the instructors.	None Anticipated	Ensure that direction and processes are established and implemented.
O3M2	Develop a quality assurance process that implements inspections by HOS, check, spotter, peers and SME.	None anticipated	None Anticipated	Ensure that direction and processes are established and implemented.
O4M1	Develop CRM training specific to pilot-spotter relationship.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
O4M2	CRM training should be done in the field with the current pilots including relief pilots and crew.	None anticipated	QA and standardization of field training must be implemented.	Ensure that direction and processes are established and implemented.
O5M1	Obtain necessary information prior to accepting mission including frequencies, contacts, coordinates, additional aircraft involved and known hazards.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.
O5M2	Ensure crew is "re-briefed" on new mission.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented
O6M1	Follow standard procedures (high-low recons, power checks, verify load calculations as valid, etc.)	None anticipated	None Anticipated	None Anticipated
O6M2	Site selection needs to be mutually agreed upon by pilot and spotter.	None anticipated	None Anticipated	None Anticipated
O7M1	Consider doing proficiency rappels at an off-site area where distractions are not present.	Proficiency rappels are an inherent hazard that cannot be eliminated from the program.	Transition from current methods will involve significant change from current practices in several Regions.	Multiple issues need to be resolved to develop and communicate appropriate direction.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
O8M1	Develop a spotter-training Syllabus.	None Anticipated	None Anticipated	Ensure that the Syllabus is developed and implemented. Clarify if Regions can amend the Syllabus.
O8M2	Develop a national standard Spotter Training Handbook.	None Anticipated	None Anticipated	Ensure that the Handbook is developed and implemented. Clarify if Regions can amend the Handbook.
O8M3	Select site so that the spotter can maintain positive visual contact with rappellers to the ground.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.
O8M4	Follow rotor clearance standard in IHOG when descending below the canopy.	None Anticipated	Increased exposure to settling with power.	None Anticipated
O8M5	Recommend staying 50 feet above obstacles.	None Anticipated	None Anticipated	Ensure that direction and processes are established and implemented.
O9M1	Develop minimum standards based on the current complexity of the mission.	None anticipated.	None Anticipated	Standards to be developed and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
O10M1	Update the rappel practical test standards to include standardization and quality assurance.	None Anticipated	None Anticipated	Direction and processes to be developed and implemented.
O11M1	Consider staffing a national rappel program manager.	None anticipated	None Anticipated	None Anticipated
O11M2	Consider developing a national quality assurance branch for rappel.	None anticipated	None Anticipated	None Anticipated
O12M1	Develop medical screen criteria for rappel personnel.	None Anticipated	None Anticipated	None Anticipated
O13M1	Develop span of control of experienced to inexperienced rappellers.	None anticipated	Achieving a desired span of control may take several years in some locations.	Transition from current span of control will involve significant change from current practices in some Regions.
O14M1	Follow risk management process to determine the decision on the number of personnel on-board.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
O15M1	The spotter to implement CRM visually confirming external load is clear of obstacles and communicating this to pilot.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
O15M2	Follow risk management processes to minimize overflying people or objects.	None Anticipated	This may result in additional flight time.	Ensure that direction, processes and training are established and implemented.
O16M1	Ensure equipment inspections are properly performed and documented.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
O16M2	Ensure procedures are followed in the rigging and deployment of the external cargo.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
O16M3	Develop emergency procedures and perform recurrent crew-wide emergency procedures training.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
O17M1	Establish minimum standard for cargo restraint straps and protective netting.	None Anticipated	None Anticipated	Ensure procedures are developed and implemented.
O18M1	Ensure equipment inspections are properly performed and documented.	None Anticipated	None Anticipated	Ensure procedures are developed and implemented.
O18M2	Ensure procedures are followed in the rigging and deployment of the external cargo.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
O18M3	Develop emergency procedures and perform recurrent crew-wide emergency procedures training.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
019M1	Consider performing cargo operation separately.	None Anticipated	This may result in additional flight time.	None Anticipated
019M2	Ensure that method of securing cargo is adequate for the size and weight of the cargo in the event of an accident.	None Anticipated	None Anticipated	None Anticipated
019M3	Require agency-approved containers for hazardous materials.	None Anticipated	None Anticipated	None Anticipated
020M1	Do not load cargo bags with a weight greater than 125 pounds as per the rappel guide.	None Anticipated	None Anticipated	None Anticipated
021M1	Define CRM and what the procedures will be.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
021M2	Increase simulation training to include the pilot, spotter and rappeller.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
022M1	Increase CRM procedure training.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
022M2	Develop or refine challenge and response criteria between spotter and pilot.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
023M1	Develop a lesser weight and size standard for belly bags.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
023M2	Consider development of an alternative to belly bags.	Residual risk is uncertain pending a specific design.	Residual risk is uncertain pending a specific design	None Anticipated
023M3	Consider development of a quick release system for belly bags.	Residual risk is uncertain pending a specific design	Residual risk is uncertain pending a specific design	None Anticipated
024M1	Develop written standards and CRM procedures for lost communication at each phase of the rappel operation.	None Anticipated	Some level of substitute risk may remain until the new procedures become habitual to rappel personnel and pilots	Ensure that direction, processes and training are established and implemented.
024M2	Implement written standards and CRM procedures for lost communication at each phase of the rappel operation.	None Anticipated	Some level of substitute risk may remain until the new procedures become habitual to Rappel personnel and pilots.	Ensure that direction, processes and training are established and implemented.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
025M1	Follow standard procedures (high-low recons, power checks, verify load calculations as valid, etc.)	None Anticipated	None Anticipated	None Anticipated
025M2	Site selection needs to be mutually agreed upon by pilot and spotter.	None Anticipated	None Anticipated	None Anticipated
026M1	Do additional proficiency training of reconfigure in or simulating an offsite environment with rotors turning.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
026M2	Ensure that inexperienced personnel are mixed with experienced personnel in the rappel load.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
027M1	Comply with contractor door storage requirements.	None Anticipated	None Anticipated	None Anticipated
027M2	Develop and follow training on proper removal and storage of equipment when flying with doors off.	None Anticipated	None Anticipated	None Anticipated
028M1	Consider use of sliding doors.	None Anticipated	None Anticipated	This would require significant investment by the contractors and does not apply to medium helicopters.

Table 4 – Analysis of Mitigation Measures				
Mitigation Measure ID	**Mitigation Measure**	**Residual Risk**	**Substitute Risk**	**Implementation Considerations**
028M2	Personnel should wear appropriate apparel based on the potential exposure.	None Anticipated	None Anticipated	Ensure that direction, processes and training are established and implemented.
029M1	Consider use of sliding doors.	None Anticipated	None Anticipated	This would require significant investment by the contractors and does not apply to medium helicopters.
030M1	Develop a process to integrate rappellers in large fire support operations ensuring that there is a discrete radio frequency and a sterile airspace for the rappel operation to support midair collision avoidance.	None Anticipated	This may result in the number of LFS rappels.	Ensure that direction, processes and training are established and implemented.

Quality Assurance

U.S. Forest Service aviation continues forward incorporating the Safety Management System (SMS) into its missions. The agency is making strides in its transition as a learning culture by implementing risk management and quality assessment processes. Through actively and incrementally applying the risk assessment process mission by mission, senior management has been presented with a valuable opportunity to learn about the issues that could have the most profound effect upon the organization; the safety hazards of unknown risks, unreported risks and known risks that require proper assessment or mitigation measures. The recent involvement of the most experienced and knowledgeable agency employees applied the added benefit of quality assurance to the SMS process.

Quality assurance (QA), as a primary pillar of SMS, 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 FAA has described Quality Assurance as follows:

Quality assurance is designed to validate factual information to ensure that aviation operations perform as intended and accomplishes 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 SMS is to identify, document, monitor and control hazards in the operation (FAA Advisory Circular 120-9) (Appendix I).

The quality assurance team gathered information from various sources in an attempt to discover areas of strength or areas lacking adequate standards. These sources included management direction, appropriate resources and materials, efficient and effective use of the resource, how it measures against other organizations with similar missions, what information is provided by the reporting system and how well current policy and procedure is being adhered to.

This QA process was implemented through five elements:

- Analysis of rappel specific statistics from 2000 – 2008
- Analysis of rappel specific Safety Communication (SAFECOM) reports
- Conducting an online quality assurance survey specifically for the rappel community
- Site visits to four separate bases in three different regions
- Benchmarking other rappel programs outside of this agency

Analysis Elements of the Quality Assurance Process

Analysis of Rappel Statistics

In order to pull hard data together to begin analyzing numbers, the QA team was provided the data from the Annual Helicopter Questionnaire from 2000 to 2008. To break down the appropriate numbers and get to the specifics of the rappel operation, data exclusive to rappel had to be identified and then extracted from each year in order keep it separate from other helicopter mission information. Once this was complete, the numbers were processed and a spreadsheet was assembled showing 13 categories of information:

- Year
- Region
- Number of Training Rappels
- Number of Operational Rappels
- Percentage of Operational Rappels
- Number of Initial Attack Fires
- Number of Rappelled Fires
- Number of Large Fires Supported
- Percentage of Rappelled Fires
- Percentage of Rookies and Apprentices
- Number of Experienced Rappellers
- Number of Rappellers and Crewmembers
- Percentage of Experienced Rappellers

A summary of the results is found in Appendix D.

Findings from statistical data:

Below are four findings from an analysis of the statistical data.

- The crews conduct seven training rappels to one operational rappel.

- The crews staffed four initial attack fires via landing and deploying to each fire that was deployed to by rappelling.

- The crews supported an equal number of large fires as initial attack rappel fires.

- There are 0.80 first year rappellers per experienced rappeller.

Analysis of Rappel Specific SAFECOM Reports

The SAFECOM system is the reporting system for aviation hazards, conditions, observation, acts or situations that has the potential to cause an aviation related mishap. Studies focused on aviation indicate about one third of the occurrences that meet these criteria are reported. This is not specific to rappel, but all Forest Service aviation in general. This summary reviewed SAFECOM reports in the system to analyze those directly related to the rappel program. Once a list of rappel specific reports was developed, individual occurrences were reviewed and assigned two labels used in analyzing the data. The first label describes the purpose of the rappel from which the occurrence was generated. For instance, if an event happened during training, that SAFECOM would be labeled "training." Each SAFECOM was also categorized as to the main reason for the occurrence, such as an equipment failure or training issue. The category of "equipment" was further broken down by looking at individual pieces of equipment to see where the reported issues were.

SAFECOM - Overview Data

There were 179 SAFECOMs submitted that were associated with rappel operations from 1996 to 2009 (Table 5). The search parameters were such that data encompasses an interagency basis going back as far as the current electronic system has data on.

Table 5 – Rappel SAFECOMS

Year	Number
1996	1
1997	No Data
1998	13
1999	19
2000	14
2001	19
2002	14
2003	18
2004	12
2005	4
2006	12
2007	16
2008	16
2009	21

At a glance, this information in Table 5 appears to reveal that the agency has had more problems in recent years than in the past 10 years, but it needs to be acknowledged that there are more programs now. Employees have become more educated in safety management, which has significantly improved the safety culture resulting in better use of the available reporting system. In 2009, the reports dealing with rappel issues were at a record high.

SAFECOM - Purpose of the Rappel

Each SAFECOM narrative was reviewed to determine the purpose of the rappel that generated the report. The following definitions are used to define the reason that a rappel was performed.

- Certification – The event happened during an initial rappel, which is required during training to obtain the certification of rappellers.
- Inspection – The inspecting of equipment on the ground; not associated with another purpose.
- Operational - A rappel on an incident that is not conducted under controlled conditions.
- Pilot Evaluation - A rappel, under controlled circumstances, conducted for the purpose of evaluating a pilot as part of the carding process.
- Proficiency – A rappel conducted to maintain understanding of procedures and equipment.
- Not Applicable (N/A)- A report was filed in response to change in policy rather than specific event.

Table 6 shows the proportion of SAFECOM reports purpose for the rappel mission. Operational and proficiency rappels are the leading purpose behind rappels that generated SAFECOM reports. The average rappel program conducts more proficiency and training rappels (7 to 1) than any other. The number of SAFECOM reports occurring can be equated to quantity of rappels performed. Operational rappels are conducted in uncontrolled environments and are subject to more uncertainty. SAFECOM reports from certification rappels are a close third for occurrences. The purpose of a certification rappel is to train rappellers learning the process. It is easily understood why this category would generate a noticeable number of SAFECOM reports.

Table 6 – Rappel Purpose

Purpose	Percent
Operational	36%
Proficiency	34%
Certification	26%
Pilot Evaluation	3%
Not Applicable	1%
Inspection	< 1%

SAFECOM - Categories for the Event Reported

The SAFECOM reports were categorized to describe the reason for the reported event. The definitions and percent of SAFEROM reports by category are in Table 7.

Table 7

Category	Percent	Definition
Airspace	3%	Issue concerns intrusions, conflicts and congestion of airspace.
Communication	<1%	Issue concerned information exchange rather than training or equipment.
Equipment	22%	Issue was with actual hardware used in rappelling.
Human Factors	1%	Issue concerned fallibility of humans rather than training or equipment
Maintenance	28%	Issue concerned helicopter and not rappel operations.
Procedures	1%	Issue was centered in the procedure itself rather than execution of procedure
Policy Deviation	2%	Issue was caused by failure to follow policy.
Program Management	1%	Issue was with management of rappel program to include equipment handling and training.
Training	33%	Issue was with improper use of equipment or execution of procedures.
Weather	9%	Issue was with an environmental factor.

Many of the reports have underlying human factors (40%) associated with them. Several of the reports had more than one category influencing the occurrence or more than one occurrence listed. As part of this analysis, one main category for each report was determined.

The training category includes lack of training, incomplete training, or failure to follow training procedures. It is difficult to determine which applies to each individual report.

There was only one SAFECOM report submitted that dealt with the human factors aspect of the program. It reported a person conducting a buddy check and "seeing" what they wanted rather than what was actually there. This SAFECOM report relays a direct concern about rote inspections and the volume of inspections conducted.

Maintenance and airspace issues will be found in any aviation operation. They were not reviewed except to determine numbers of reports submitted when reviewing rappel mission related SAFECOM reports.

The category of equipment can be further analyzed by individual components. Table 8 shows the number of reports for events experienced with individual pieces of equipment as reported in the SAFECOM system.

Table 8 – Equipment Noted in SAFECOM Reports

Item	Number
Rope	18
J-Hook	5
PG Bag	4
Harness	3
Non-specific	2
Figure 8	2
Swivel	1
Ripper Knife	1
Genie	1
Carbineer	1

Summary

Many of the early SAFECOM reports highlighted issues that were mitigated through modifications to procedures or equipment. For instance, the reports of issues with the personal gear (PG) bag lead to changing the buckles from plastic to metal.

Using severity of the outcome as a filter, there is one troubling trend recorded in the SAFECOM system. There have been three instances of a rappeller getting to the doorsill of the helicopter without being attached to the Genie (descent device). This has happened once in each of the last three years.

Quality Assurance Survey

A quality assurance survey was developed. The quality assurance survey was a means for the quality assurance team to gather information from a large population of the rappel community. It provided a broad avenue to gain insight on the effectiveness of risk controls and evaluate policy compliance. Using this online tool, the team developed the survey based on the procedures in the Interagency Helicopter Rappel Guide (IHRG). The questions were built into eight categories:

- Administration and Management (ADM)
- Qualifications (QUA)
- Equipment (EQU)
- Documents and Records (DOC)
- Operations (OPR)
- Emergency Procedures (EMR)
- Cargo Letdown Operations (CLO)
- Safety Management System (SMS)

The survey questions are listed in Appendix E. A summary of the all responses is provided in Appendices F and G. The survey proved to be a valuable tool for quality assurance metrics of the rappel program as it relates to policy, procedures and directives from the IHRG. There were 97 responses to the survey, from which the significant groups are listed.

The response data most notable is listed below. The category is shown by abbreviation, followed by the survey question area and the survey question itself. There were a few areas that revealed some concern, but also many areas observed had very strong compliance. The notable results are follow.

Reporting Culture

Safety Management System (SMS 2)

The rappel unit implements a mishap/hazard reporting system (SAFECOM).

- 16% of respondents say the SAFECOM system is either not implemented or implemented but not documented.

Safety Management System (SMS 3)

The rappel unit has a process for identifying and investigating irregularities or other non-routine operational occurrences.

- 18% implemented this system but do not document it.
- 8% do not implement this kind of system.
- Between the two categories, as much as 26% of hazards may go unrecognized or lack follow-up.

Training

Qualifications (QUA 2)

The rappel unit has a process to ensure course materials used in the rappel training program are periodically evaluated to ensure compliance with the qualification and performance standards of the current IHRG.

- 15% of respondents said this is implemented but not documented.
- 5% of respondents said this is not implemented.

Qualifications (QUA 6)

The rappel unit ensures that training aids and equipment, to include mock-ups and other devices and/or course materials used in rappel training and evaluation, reasonably reflect the configuration of the helicopter model currently being used.

- 18% of respondents said training aids and mockups are implemented but not documented.
- 2.5% of respondents said this is not document and not implemented.

Cargo Letdown Operations (CLO 1)
The rappel unit ensures that personnel who perform helicopter cargo letdown operations maintain competence on the basis of continued training and proficiency in accordance with the IHRG, the helicopter contract and if applicable, continue to satisfy technical competency requirements to determine conformance with the IHRG on how competence is maintained for the following positions (Pilot-in-Command, Check Spotter, Spotter).

- The most noted response was 18.7% of respondents said for the pilot position, it is implemented but not documented.

Administration and Management (ADM 3)
The rappel unit ensures all specific positions have duties and responsibilities that are clearly defined and well communicated throughout the rappel organization, to include: (Check Spotter, Spotter, PIC, Rappeller)

- 11% of respondents said the pilot duties and responsibilities are not documented.

Emergency (EMR 2)
The spotter has a process to ensure cargo letdown emergency procedures are established to respond to a situation, serious in nature, developing suddenly or unexpectedly and demanding immediate action discussed and coordinated among the spotter, PIC and other involved personnel to include, as appropriate (cargo letdown procedures, helicopter or cargo on-line emergency, engine failure or major component failure).

- 30% of respondents said coordinated emergency procedures with the pilot and spotter is implemented but not documented.

Cargo Letdown (CLO 2
The spotter has a process to ensure issues that affect cargo letdown operational safety are coordinated among the PIC and other involved personnel.

- About 47% of respondents said it is implemented but not documented in all categories.

Safety Management Systems (SMS 1)
The rappel unit has a SMS that provides for collection of information and data associated with helicopter rappel operations, and includes systematic processes for identifying and assessing hazards and potentially hazardous conditions.

- 23% of respondents said this is implemented but not documented.

General
Qualifications (QUA 7)
Unit policy requires personnel to be physically and mentally fit for duty.

- 15% of respondents feel this policy is not implemented.

Documentation (DOC 1)
Control system for documents for policy and training and disposal of outdated documents.

- 17% responded that a document control system for policy and training is not implemented.
- 23% responded that a document control system for policy and training is not documented.

High Compliance Areas

Administration and Management (ADM1)

The rappel unit has a management system that ensures proper supervision and operational control functions of all rappel missions in accordance with the standards of the IHRG.

- 95% respondents said this is documented and implemented.

Qualifications (QUA 4)

The rappel unit ensures all rappel personnel receive comprehensive re-currency training at the specified frequency as directed in the IHRG.

- 98% respondents said this is documented and implemented.

Operations (OPR 1)

The rappel unit has a process to ensure issues that affect rappel operational safety are coordinated among the rappel spotter and personnel

- 95% - 100% of all categories showed compliance or implemented.
- 98% of the PIC having had completed a load calculation was documented and implemented.

Equipment (EQU 1)

The rappel unit has a process that ensures all rappel equipment utilized is approved and maintains detailed information on the equipment as specified in the IHRG.

- 94% respondents said this is documented and implemented.

Quality Assurance Site Visit Common Areas of Concern

Four site visits were conducted. The bases visited were John Day Rappel Base (Oregon), Price Valley Rappel Base (Idaho), Garden Valley Rappel Base (Idaho), Trinity Base (California). Areas of common concern are noted below.

- Higher standards for rappel pilot qualifications that either includes fire environment and rappel knowledge and skills.

- Consistent and higher pilot evaluation standards when agency inspector pilots conduct flight evaluations.

- Minimum standard of experienced rappel crewmember to rookies/apprentices (i.e. two experienced to one trainee).

- Standardized terminology nationally between spotters and rappellers as well as spotters and pilots.

- Rappel equipment is lacking a national quality control before equipment makes it to the base level. This missing link, requires bases to conduct the quality control from the manufacturer.

- Higher physical fitness level requirements for all rappel crewmembers. The current agency standard is too low for the mission of rappel.

- Administrative duties that have been passed down to the base level are impacting the ability of the manager/foreman/leadership of the base to actually oversee crew training and base operations.

- Consider providing training flight hours for pilot flight training at their specific bases to support local area orientation.

- Consider retiring the triangle blivet and replacing with rectangle blivet.

- At a minimum, a national level rappel program manager is most desirable, but they would like to see a regional level rappel position as an assistant to the HOS.

- Bolster the IHRG with more specific standards rather than vague standards that leave procedures open for local interpretation.

- Provide pilot training in fire environment operations and specific rappel mission operations for new rappel pilots and refresher for experienced rappel pilots who may have been away from the mission for a few seasons.

- Consider a standard for lost communications between the pilot and the spotter throughout all phases of the rappel mission.

Analysis of Benchmarking Other Rappel Programs

The Quality Assurance team gathered information from three other organizations that had similar rappel missions. By reviewing these other operations the team was able to evaluate how the rappel program differs in the implementation of the rappel mission. The team examined the operations manuals from the British Columbia Forest Service, Alberta Forestry Branch, and Starflight of Austin/Travis County, Texas. There are several areas revealed by these operation manuals that aren't evident in the Interagency Helicopter Rappel Guide as currently written.

Training

The U.S Forest Service rappel programs as they currently structured, conduct most of their training locally or at the helibase level. One Region conducts centralized training. The guidance for rappel training is addressed in Appendix D and E of the Interagency Helicopter Rappel Guide and generally covers all the same topics found in the operations manuals of the benchmark organizations. Some of these other organizations, specifically the Canadian programs, go into more detail and depth in requirements and procedures addressed during training.

Emergency Procedures

These are addressed in the IHRG, Chapter 6. This section provides descriptions of particular emergency situations. The agency's program may benefit by reviewing the other operations manuals to evaluate their emergency procedures section. Of the three other organizations reviewed, two specifically incorporated procedures to be followed in the event of an intercommunications systems failure.

Hazard Assessment and Risk Analysis (Job Hazard Analysis)

The Alberta Rappel Program has a Hazard Assessment and Risk Analysis of Rappel Personnel Deployment, which is similar to the Job Hazard Analysis used in the Project Aviation Safety Plan for the Forest Service Region 6 Rappel Academy. Differences between the two are noteworthy. The Alberta Hazard Assessment defines Hazard Frequency, Probability, Consequence resulting in a degree of risk. Risk is assigned in a category of low, medium or high. Once those are identified and rated, they have engineering controls added which may be required for mitigation and administrative controls that are required for mitigation. In addition, personal protective equipment that may be required. Also required is noting the status of the controls such as in place or pending and documenting the date the control was completed. The Alberta process not only assesses hazards, but it requires follow up and action until the mitigation measure is in place and the date is logged.

Conclusions and Recommendations

This section includes findings and recommendations relating to both the risk assessments and quality assurance elements of the helicopter rappelling program.

Finding 1 – SMS Policy Component: National Helicopter Program Management Structure

The national helicopter program management structure is not in alignment with the complexity of the current program.

Discussion

The helicopter program has evolved with mostly local and Regional guidance on many key program components. The helicopter rappelling program has evolved with very little national guidance on program development. National training and equipment guidance are considered with significant local variation, interpretation and adaptation.

Recommendation 1-1

Establish a National mission statement for the Helicopter program including Aviation Life Support Equipment.

Recommendation 1-2

Establish a National mission statement for the helicopter rappelling program.

Recommendation 1-3

Define and implement a National Helicopter and Helicopter Rappelling Program Management structure including Program Leadership and Quality Assurance Staff.

Recommendations1-4

Conduct a National Activity Review of the helicopter rappelling program.

Finding 2 - SMS Risk Management Component: Helicopter Rappelling Hazards And Mitigation Measures

U.S. Forest Service subject matter experts identified hazards and mitigation measures during the completion of the helicopter rappelling risk assessment.

Discussion

The hazards and mitigations were identified, evaluated and rated by experts including program leaders, managers, rappel spotters, pilots and safety specialists.

Recommendation 2-1

The Forest Service should identify elements of the rappel program that contain immitigable risk that are acceptable as a component of having a rappel program.

Recommendation 2-2

The Forest Service should prepare an action plan leading to implementation of the mitigation measures resulting in an acceptable level of program risk.

Finding 3 - SMS Quality Assurance Component: Implementation Of Policy Standards And Processes

The implementation of policy, standards and processes from the Interagency Helicopter Rappel Guide (IHRG) is high, but documentation standards are inconsistent.

Discussion

In order for a quality assurance process to be effective in its purpose within mission implementation, there must be consistent standards and processes throughout a program. Quality assurance within an organization is tasked to "monitor, measure, and evaluate the performance and effectiveness" of a program. This is not possible if the program to be measured varies in its implementation from one base to another.

Recommendation 3-1

Perform further review of program gaps is recommended for a proper conclusion as to what should and should not be required in documentation.

Recommendation 3-2

Clarify and define standards and procedures in the Interagency Helicopter Rappel Guide.

Recommendation 3-3

Rappel program reviews by the agency need to be standardized, documented, and complete.

Finding 4 - SMS Promotion Component: Agency Reporting Culture

The agency reporting culture does not provide comprehensive information on events that are needed to support management decisions.

Discussion

Many personnel perceive that the reporting system provides management a vehicle for punitive action. There is a stigma associated with the reporting system that continues to inhibit its use in the most beneficial way. The fully functional reporting system must attempt to assure complete confidentiality for the reporter. If the system provides any avenue for punitive action, management will lose the valuable opportunity to learn about the issues that could have the most profound effect upon the organization.

Recommendation 4-1

Augment the current system to ensure complete confidentiality.

Recommendation 4-2

Continuously market and campaign the importance of the reporting program to the field, to include vendors. Promote the use of the system by highlighting instances where reporting has been successful in preventing mishaps and negative consequences have not occurred.

Glossary

Assessment – The process of measuring or judging the value or level of something.

Federal Aviation Administration (FAA) – The US Government agency whose mission is to provide a safe and efficient aerospace system.

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.

IHRG - Interagency Helicopter Rappel Guide

Mishaps (Aviation) – A mishap is an unplanned, unintended event involving aircraft operations that results in damage to aircraft, injuries to personnel, or presents the potential for such. Mishaps include aircraft accidents, serious aircraft incidents, aircraft incidents, aviation hazards, and aircraft maintenance deficiencies.

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

Rappelling - Technique of landing specifically trained and certified firefighters from hovering helicopters; involves sliding down ropes with the aid of friction-producing devices.

RAPREC – Abbreviation for Rappel Records Database

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

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.

SAFECOM – An abbreviation for Aviation Safety Communiqué. The agency Form FS 5700-14,

SAFECOM - Aviation Safety Communiqué, which is used to report aviation mishaps or hazards. This form also is approved for interagency use as Form AMD-34.

SMS - Safety Management System, its 4 components are Policy, Risk Management, Quality Assurance, and Promotion.

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

Appendices

Appendix A - Project Team Members

Appendix B - Hazards and Mitigation Measures Developed by SMEs

Appendix C - 2009 Systems Safety Aviation Guide, Rappelling

Appendix D - Rappel Data from 2000 through 2008

Appendix E - Quality Assurance Survey Questions

Appendix F - Quality Assurance Survey Results

Appendix G - Analysis of Quality Assurance Survey Results

Appendix H - History of Rappelling on Fires

Appendix I - Civil Rotorcraft Risks

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

Appendix A

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Appendix B

Hazards and Mitigation Measures Developed by SMEs

Hazards and Mitigation Measures
Rappelling

A-Aircraft System

Performance, Capabilities, Limitations Subsystem

A1. There is a lack of standard aircraft configuration by make and model of helicopters to perform the rappel mission.

A1M1. Develop National Rappel Helicopter Screening and Evaluation Board.

A1M2. Develop a standard configuration by make and model.

A1M3. Tech transfer the standard configuration to the field.

A2. Lack of adequate screening of aircraft to perform the rappel mission prior to award.

A2M1. Develop National Rappel Helicopter Screening and Evaluation Board.

A3. The aircraft are performing near limits of capabilities due to mission, payload, and environment with constantly changing conditions.

A3M1. Refine national rappel specifications template in the exhibit section of the contract. Utilize pilots, helicopter managers, helicopter operations specialists and rappel specialists when developing aircraft contract specifications and modifications.

A3M2. Ensure rappel operation begins with the helicopter operating within the maximum continuous parameters. (Start in the green arc.)

A3M3. Ensure strict compliance with flight manual and increased awareness training of aircraft performance for helicopter managers and proper mission planning (including downloading).

A3M4. Apply additional downloading to maintain safe operating parameters.

A4. There is a lack of a definition of a standard load of rappellers and equipment.

A4M1. Develop a rappel mission statement so load parameters can be defined.

A5. There is an inherent hazard posed by helicopters hovering in the height velocity curve in the event of an engine loss or loss of control.

A5M1. Consider only use of twin-engine helicopters with one engine out flyaway capability when within the height velocity curve.

A5M2. Consider only use of twin-engine helicopters.

A5M3. Single engine operations maintain adequate rotor clearance for emergency landings in the rappel zone.

Aircraft Equipment

A6. There is a lack of follow-up quality assurance on new rappel anchors.

A6M1. Newly designed rappel anchors must be structurally field tested prior to use.

A6M2. Ensure follow-up quality assurance.

A7. The spotter tether attachment point is not uniformly defined, tested and designed in some aircraft.

A7M1. Ensure spotter tether attachment point is approved with proper and valid STCs, tested annually, installed correctly, and inspected at manufacturer's recommendations.

A8. Aircraft modifications improperly installed and documented could impede the airworthiness of the aircraft.

A8M1. Ensure thorough maintenance inspections, documented, verification of STC documentation and compliance, increased training for helicopter managers.

Configuration

A9. With the doors off or doors open during flight, crash survivability is reduced.

A9M1. Minimize doors off or open operation to essential missions only.

A10. Items in an external basket are not properly secured.

A10M1. Ensure security of external loads prior to mission.

A11. In some helicopters, no structural barrier exists between rappel operations and PIC resulting in exposure to the flight controls.

A11M1. Restrict rappel and cargo letdown operations only to helicopters that have a structural barrier that provides a defined barrier that cannot be compromised between the rappel operations and the PIC.

A11M2. Ensure there is a physical barrier between the rappel operations area and the flight control operations area.

Aircraft Health

A12. Undetected corrosion, stress crack, structural, limited, and/or unknown amount of aircraft health testing and monitoring being performed on current aircraft (fatigue, corrosion, airframe, etc.).

A12M1. Ensure Maintenance Inspectors are conducting thorough reviews of aircraft maintenance logs.

E-Rappel Equipment System

Human Factors

E1. Rappel equipment damaged or marginalized due to improper use.

E1M1. Use education, supervision and expert quality assurance for following equipment use standards.

E1M2. When in doubt about equipment's usage, retire it.

E2. Rappel equipment damaged or marginalized due to improper treatment.

E2M1Use education, supervision and expert quality assurance for following equipment treatment standards.

E3. The use of non-approved equipment can compromise safety and reliability.

E3M1. Maintain comprehensive and current list of approved rappel equipment.

E3M2. Maintain current equipment standards for rappel equipment.

E3M3. Only utilize approved rappelling equipment.

E3M4. Design and implement a process for independent evaluation of equipment at individual rappel bases.

E4. Equipment is not properly inspected or documented.

E4M1. Use training and supervision to ensure that equipment inspection and documentation standards (IHRG) are followed.

E4M2. Design and implement a process for independent evaluation of equipment at individual rappel bases.

E4M3. Implement and utilize rappeller records (RAPREC) database.

E5. Equipment is improperly rigged for a rappeller and spotter.

E5M1. Develop and implement standard processes and procedures to include quality assurance.

E5M2. Perform proper training per the IHRG.

E5M3. Maintain currency and proficiency.

E5M4. Develop and implement a span of control criteria for training, operations and program management.

E6. Improper use during the testing phase or improper use of newly approved equipment.

E6M1. Develop and implement field-testing protocols.

E6M2. Ensure equipment sent to the field for testing has adequate instructions for testing and use.

<u>Cargo Delivery</u>

E7. There is no national standard configuration, which results in potential confusion and mistakes as personnel move from base to base.

E7M1. Identify and establish model specific configuration(s) and procedures.

E8. Use of improper cargo restraint straps/cargo compartment netting (internal only) may fail due to over stressing.

E8M1. Establish minimum standard for cargo restraint straps and protective netting.

Rappel Equipment

E9 . The current descent control device does not have an auto locking brake (fail-safe) component in the event of an incapacitated rappeller.

E9M1. Consider development, testing and implementation of an auto locking brake (fail-safe) component on the descent control device.

Management

E10. There is uncertain equipment quality control and limited quality assurance from the manufacturer, which can lead to defective descent devices including ropes and decent devices.

E10M1. Develop an agency quality assurance process targeted at manufacturer defects.

E10M2. Ensure compliance within the agency quality assurance process for newly acquired equipment.

O-Operations System

Training

O1. Training in rappel procedures and instructional systems are non-standard and inconsistent throughout the agency leading to an increased likelihood of procedural errors.

O1M1. Develop standard procedures and instructional systems.

O1M2. Transfer and implement the standard procedures and delivery systems in training.

O1M3. Utilize consolidated training as a method standardization and quality assurance regionally and nationally.

O1M4. Develop and implement a train the trainer program and implement.

O2. Mishaps that occur during training on the ground are not being reported in the SafeCom system leading to reduced information transfer.

O2M1. Include all training mishaps regardless of location in the SafeCom system.

Rappel Procedure

O3. There is a lack of clearly and thoroughly defined standard procedures, which could lead to a breakdown in communications leading to mishaps and individual interpretations.

O3M1. Develop clearly defined standard procedures.

O3M2. Develop a quality assurance process that implements inspections by HOS, check, spotter, peers and SME.

O4. The use of non-standard verbiage, direction, and interaction between spotter and pilot during rappel operations could lead to miscommunication.

O4M1. Develop CRM training specific to pilot-spotter relationship.

O4M2. CRM training should be done in the field with the current pilots including relief pilots and crew.

O5. Diversion from intended mission with limited information.

O5M1. Obtain necessary information prior to accepting mission including frequencies, contacts, coordinates, additional aircraft involved and known hazards.

O5M2. Ensure crew is "re-briefed" on new mission.

O6. Exposure to off-site landing accidents.

O6M1. Follow standard procedures (high-low recon, power checks, verify load calculations as valid, etc.)

O6M2. Site selection needs to be mutually agreed upon by pilot and spotter.

O7. Performing proficiency rappel in a community situation can create distraction; i.e. Air show syndrome, competition.

O7M1. Consider doing proficiency rappels at an of- site area where distractions are not present.

Rappel Site Selection

O8. Selection of an inadequate rappel site could result in an unsafe environment for rappellers and increased exposure to rotor strikes, entanglements, etc.

O8M1. Develop a spotter-training Syllabus.

O8M2. Develop a national standard Spotter Training Handbook.

O8M3. Select site so that the spotter can maintain positive visual contact with rappellers to the ground.

O8M4. Follow rotor clearance standard in IHOG when descending below the canopy.

O8M5. Recommend staying 50 feet above obstacles.

Management

O9. Current minimum qualifications standards for a spotter can lead to less than optimum future performance and does not meet the demands based on the current complexity of the mission.

O9M1. Develop minimum standards based on the current complexity of the mission.

O10. The rappel pilot's practical test standard may not adequately address standardization and quality assurance.

O10M1. Update the rappel practical test standards to include standardization and quality assurance.

O11. There is a lack of feedback to maintaining standards, which leads to diverging missions, normalization of deviance and reduced management decisions.

O11M1. Consider staffing a national rappel program manager.

O11M2. Consider developing a national quality assurance branch for rappel.

O12. Medical conditions can impair the ability of rappel personnel to safely rappel or spot and can lead to accidents or incidents.

O12M1. Develop medical screen criteria for rappel personnel.

O13. The span of control of experienced to inexperienced rappellers may be higher than optimum allowing for compromised effectiveness of training and unacceptable risk.

O13M1. Develop span of control of experienced to inexperienced rappellers.

External Cargo Letdown

O14. Rappellers on board helicopter during delivery of cargo, which translates, to longer exposure to rappellers during hover.

O14M1. Follow risk management process to determine the decision on the number of personnel on-board.

O15. External rappel cargo could be dragged into an object or hit somebody.

O15M1. The spotter to implement CRM visually confirming external load is clear of obstacles and communicating this to pilot.

O15M2. Follow risk management processes to minimize overflying people or objects.

O16. The letdown tape comes free from the cargo and could impact the aircraft.

O16M1. Ensure equipment inspections are properly performed and documented.

O16M2. Ensure procedures are followed in the rigging and deployment of the external cargo.

O16M3. Develop emergency procedures and perform recurrent crew-wide emergency procedures training.

Internal Cargo Letdown

O17. The cargo restraining straps have no minimum written specifications compromising the security of cargo.

O17M1. Establish minimum standard for cargo restraint straps and protective netting.

O18. The letdown tape comes free from the cargo and could impact the aircraft.

O18M1. Ensure equipment inspections are properly performed and documented.

O18M2. Ensure procedures are followed in the rigging and deployment of the external cargo.

O18M3. Develop emergency procedures and perform recurrent crew-wide emergency procedures training.

O19. Exposure to rappellers during internal load operations due to denied living space.

O19M1. Consider performing cargo operation separately.

O19M2. Ensure that method of securing cargo is adequate for the size and weight of the cargo in the event of an accident.

O19M3. Require agency-approved containers for hazardous materials.

O20. There is possible injury potential to spotter from moving cargo bags that exceed 125 pounds.

O2OM1. Do not load cargo bags with a weight greater than 125 pounds as per the rappel guide.

<u>Emergency Procedures</u>

O21. The lack of adequate training and proficiency in emergency procedures leads to uncertain response during the emergency.

O21M1. Define CRM and what the procedures will be.

O21M2. Increase simulation training to include the pilot, spotter and rappeller.

O22. Miscommunication during mission critical procedures results in inappropriate response; i.e. rope cutting, re-entry.

O22M1. Increase CRM procedure training.

O22M2. Develop or refine challenge and response criteria between spotter and pilot.

O23. The belly bags can impede re-entry to the aircraft and emergency egress from the aircraft.

O23M1. Develop a lesser weight and size standard for belly bags.

O23M2. Consider development of an alternative to belly bags.

O23M3. Consider development of a quick release system for belly bags.

O24. The pilot and the spotter lose communications during the entire rappel operation.

O24M1. Develop written standards and CRM procedures for lost communication at each phase of the rappel operation.

O24M2. Implement written standards and CRM procedures for lost communication at each phase of the rappel operation.

Reconfigure Offsite

O25. One and possibly two additional landings resulting in exposure to an accident.

O25M1. Follow standard procedures (high-low recon, power checks, verify load calculations as valid, etc.)

O25M2. Site selection needs to be mutually agreed upon by pilot and spotter.

O26. A sense of urgency and additional distractions may exist during reconfigure.

O26M1. Do additional proficiency training of reconfigure in or simulating an offsite environment with rotors turning.

O26M2. Ensure that inexperienced personnel are mixed with experienced personnel in the rappel load.

O27. Damage to doors may occur.

O27M1. Comply with contractor door storage requirements.

O27M2. Develop and follow training on proper removal and storage of equipment when flying with doors off.

Configure at Helibase

O28. During extended doors off flight, overexposure to environmental elements such as outside air temperatures can lead to compromised performance.

O28M1. Consider use of sliding doors.

O28M2. Personnel should wear appropriate apparel based on the potential exposure.

O29. When rappel configured at the base, there is additional survivability exposure to personnel in doors off flight mode.

O29M1. Consider use of sliding doors.

Large Fire Support

O30. There is a lack of operational planning for rappel operations during large fire support.

O3OM1. Develop a process to integrate rappellers in large fire support operations ensuring that there is a discrete radio frequency and a sterile airspace for the rappel operation to support midair collision avoidance.

Appendix C

2009 Systems Safety Aviation Guide

Helicopter, Rappelling

2009 Aviation Risk Management Workbook
Rappelling

A-Aircraft System

Adequate Screening/Evaluation Subsystem

A1. Lack of Standardization

A1M1. Utilize joint training. Train the trainer to one standard.

A2. Aircraft perform near limits of capabilities due to mission, payload, and environment

A2M1. Create national rappel specifications template for Schedule B. Utilize SMEs - Helicopter managers/HOSs/rappel specialists when developing aircraft contract specifications/modifications

Performance, Capabilities, Limitations Subsystem

A3. Operating close to performance limitations of aircraft (weight/balance, DA, height/velocity curve, CG)

A3M1. Strict compliance with flight manual and increased awareness training of aircraft performance for helicopter managers and proper mission planning. Continue using high performace Type 2 Helicopters and Part 27 Type 3 Helicopters.

A4. Pilot visibility/vertical and horizontal reference.

A4M1. Develop National screening/evaluation process, identify minimum standards for visibility in rappel aircraft

A5. Pilot moving from right to left seat to fit mission in Bell medium helicopters.

A5M1. Ensure that Schedule B contract language is standardized Nationally for Type 2 Helicopters.

Equipment Subsystem

A6. Rappel anchor failure

A6M1. Ensure anchor is approved with proper and valid STCs, tested annually, installed correctly, and inspected at manufacturer's recommendations.

A7. Spotter anchor failure

A7M1. Ensure anchor is approved with proper and valid STCs, tested annually, installed correctly, and inspected at manufacturer's recommendations.

A8. Aircraft modifications improperly installed/false documentation

A8M1. Thorough maintenance inspections, verification of STC documentation and compliance, increased training for helicopter managers.

A9. ICS communications not available to all rappellers

A9M1. National rappel template for Schedule B.

Communications Subsystem

A10. Spotter cannot independently manipulate FM radios from back seat (pilot task saturation)

A10M1. Audio panel conveniently available for pilot and spotter to individually manipulate.

Configuration Subsystem

A11. Doors off flight; crash survivability

A11M1. Minimize doors off operation to essential missions only, create doors off checklist for IHOG and IHRG.

A12. Doors off flight; non-secured items

A12M1. Training on proper storage of equipment when flying with doors off. Create doors off checklist for IHOG and IHRG.

A 13. External basket security

A13M1. Assure security of external loads prior to mission.

Maintenance Subsystem

A 14. Lack of compliance with AD's, manufacturer's inspections

A14M1. Strict compliance with flight manual, increased awareness training of maintenance requirements and AD's for helicopter managers, spot inspections of aircraft. Recommend all rappel contract helicopters require a mechanic.

Aircraft Health Subsystem

A 15. Undetected corrosion, stress crack, structural. limited, and/or unknown amount of aircraft health testing and monitoring being performed on current aircraft (fatigue, corrosion, airframe, etc.).

A15M1. Ensure Maintenance Inspectors are conducting thorough reviews of aircraft maintenance logs

E-Equipment System

Common Factors Subsystem

E1. Misuse/mistreatment

E1M1. Education, supervision for following equipment use standards. When in doubt about equipment's usage, retire it.

E2. Use of non-standard equipment

E2M1. Maintain current equipment standards for rappel equipment, only utilize approved rappelling equipment, random peer inspections

E3. Improper inspections

E3M1. Education, supervision for following equipment inspection standards (IHRG)

E4. Improper rigging

E4M1. Proper training. Standardization. Maintain currency, proficiency, checks and balances. Place photos of correct model specific rigging on national rappel website and in IHRG.

E5. Inconsistent documentation

E5M1. Education, supervision for following equipment documentation standards, random inspections. Utilize rap records database.

E6. Not following established procedures/policy

E6M1. Peer monitoring, annual base reviews, accountability at all levels for compliance, follow-up of action items. Mandatory attendance of spotters to biennial rappel workshop or rappel academy.

Spotter Tether/Gunner Strap Subsystem

E7. Improper adjustment

E7M1. Initial set-up of gunner straps and spotter tethers for specific model aircraft, pre-mission check. Post photos of correct adjustments on national rappel website and IHRG.

Research and Development Subsystem

E8. Improper use of newly approved equipment or during testing phase.

E8M1. Education, training, documentation, thorough field testing in mutliple platforms and obtain feedback from field users. If one component of the system gets changed, the entire system needs to be re-evaluated.

Cargo Delivery Subsystem

E9. No standard configuration

E9M1. Identify and establish model specific configuration and procedures.

E10. Use of unapproved containers

E10M1. Supervisors, managers ensure only approved containers are properly utilized. All approved equipment is posted on the MTDC website.

E11. Improper cargo restraint straps/cargo compartment netting (internal only)

E11M1. Establish minimum standard for cargo restraint straps and protective netting.

O-Operations System

Training Subsystem

O1. Non-standard/inconsistent

O1M1. Utilize joint training. Train the trainer to one standard.

Supervision Subsystem

O2. Not properly qualified for firefighting mission

O2M1. Ensure Spotter and firefighters adhere to qualifications outlined in the IHRG.

O3. Escape routes and safety zones not identified

O3M1. Ensure Spotter and ALL firefighters have knowledge and location of safety zones, and escape routes prior to fast rope deployment.

<u>Rappel Procedure Subsystem</u>

O4. Non-standard procedures / policy deviation

O4M1. Frequent unscheduled inspections by HOS/check spotter/peers/SME, suspend operations until corrections are made. Violations will result in program suspension. Utilize joint training when practical. Check spotters from other bases and regions will conduct

O5. Non-standard verbiage, direction, and interaction between spotter and pilot during rappel operations

O5M1. Increase simulation training, mock-ups, and proficiency (especially with relief pilots). Ensure proper briefing for new/relief personnel. Develop Challenge and Response criteria between spotter and pilot. Develop CRM training specific to pilot-spotter relationship to be included in the IHOG or 310-1.

O6. Deviation from intended mission with limited information

O6M1. Obtain necessary information prior to accepting mission, obtain frequencies, contacts, coordinates, additional aircraft, known hazards, de-conflict airspace, follow all FTA procedures. Ensure crew is "re-briefed" on new mission.

O7. Exposure to off site landing

O7M1. Follow standard procedures (high-low recon, power checks, verify load calculations as valid, etc.) Follow risk management process. Site selection needs to be mutually agreed upon by pilot and spotter. Respond to the incident configured to rappel when appropriate.

<u>Rappel Site Selection Subsystem</u>

O8. Poor site selection

O8M1. Spotter training, develop national standard Spotter Training Handbook, CRM, depth of fire experience, minimal red card qualification of single resource boss with ICT4 being preferred.

External Cargo Letdown Subsystem

O9. Rappellers on board helicopter during delivery of cargo, which translates, to longer exposure to personnel during high power settings in hover

O9M1. Follow standard procedures (high-low recon, power checks, verify load calculations as valid, etc.) Follow risk management process. Site selection needs to be mutually agreed upon by pilot and spotter. Respond to the incident configured to rappel when appropriate.

O10. Overflying highways, major population area, personnel

O10M1. Establish and brief on proper flight paths, update maps, see and avoid, find other means for mission.

Internal Cargo Letdown Subsystem

O 11. Security of Cargo without appropriate or approved hardware

O11M1. Establish minimum standard for cargo restraint straps and protective netting.

O12. Exposure to rappellers during internal load operations due to additional weight on board the aircraft and denied living space

O12M1. Consider performing cargo operation separately. Ensure that method of securing cargo is adequate for the size and weight of the cargo in the event of an accident. When possible secure the cargo outside of the passenger compartment. Limit internal cargo weight. Require DOT approved containers for hazardous materials.

Emergency Procedures Subsystem

O13. Lack of adequate training / Proficiency

O13M1. Increase simulation training, utilize tower/elevated platform to increase rappeller / spotter emergency procedure proficiency, develop training which includes pilot, spotter and rappeller. Improve / update spotter/rappeller training syllabus.

O14. Non standard verbiage for mission critical / non-critical situations (Emergency vs. Non-Emergency "in hover" during rappel ops)

O14M1. Increase simulation training, fund and utilize current simulators at McClellan, develop challenge/response criteria between spotter and pilot.

Appendix D

Rappel Data from 2000 through 2008

The following is the pertinent information of the rappel data from 2000 through 2008:

- Training Rappels
  - Average number of training rappels was 6979.
  - High in 2003 was 7813
  - Low in 2007 was 6228

- Operational Rappels
  - Average number of operational rappels was 980.
  - High in 2006 was 1305
  - Low in 2002 was 747

- Number of Initial Attack Fires
  - Average number of initial attack fires was 1245.
  - High in 2000 was 1713
  - Low in 2008 was 877

- Number of Rappelled Fires
  - Average number of rappelled fires was 328.
  - High in 2003 was 510
  - Low in 2008 was 241

- Numbers of Large Fires Supported
  - The average number of Large Fire Support was 318.
  - High in 2000 was 497
  - Low in 2004 was 211

- Percent of fires rappelled
  - Average percentage of fires rappelled was 17.25%
  - High was in 2003 at 24.50%
  - Low was in 2000 at 11%

- Number of First Year and Apprentice Rappellers (data only covers from 2000 through 2005)
  - Average number of Rookies and Apprentices was 245.
  - High was in 2002 at 411
  - Low was in 2000 and 2001 with 175

- Number of experienced Rappellers
  - Average number of experienced rappellers was 303
  - High was in 2005 with 413
  - Low was in 2000 with 209

Appendix E

Quality Assurance Survey

Interagency Helicopter Rappel Quality Assurance Survey Questions

ID	Statement
ADM 1	The rappel unit has a management system that ensures proper supervision and operational control functions of all rappel missions in accordance with the standards of the Interagency Helicopter Rappel Guide (IHRG).
ADM 2	The rappel unit has a process that ensures agency policy to include amendments and revisions (IHOG) are current and maintained in accordance with agency requirements (USFS, DOI, manuals and directives).
ADM 3	The rappel unit ensures all specified positions have duties and responsibilities that are clearly defined and well communicated throughout the rappel organization, to include: (refer to results)
QUA 1	The program manager shall ensure that personnel who perform operationally critical functions maintain competence on the basis of continued education and training in accordance with the IHRG, the helicopter contract and continually satisfies technical competency requirements, if applicable.
QUA 2	The rappel unit has a process to ensure course materials used in the rappel training program are periodically evaluated to ensure compliance with the qualification and performance standards of the current IHRG.
QUA 3	The rappel unit has a process to ensure that individuals who are designated to evaluate the competency of rappel personnel are qualified and current to conduct such evaluations.
QUA 4	The rappel unit ensures all rappel personnel receive comprehensive re-currency training at the specified frequency as directed in the IHRG.
QUA 5	All rappel proficiency operations are conducted within a 14-day cycle.
QUA 6	The rappel unit ensures that training aids and equipment, to include mockups and other devices and/or course materials used in rappel training and evaluation, reasonably reflect the configuration of the helicopter model currently being used.
QUA 7	The rappel unit has a policy that requires personnel who perform operationally critical functions to be physically fit and mentally prepared/ready for the duty day.

Interagency Helicopter Rappel Quality Assurance Survey Questions

ID	Statement
EQU 1	The rappel unit has a process that ensures all rappel equipment utilized is approved and maintains detailed information on the equipment as specified in the IHRG.
EQU 2	The rappel unit ensures that the rappel platform training simulator (even if the simulator is based at a separate location) is constructed and maintained in accordance with agency and Occupational Safety and Health Administration (OSHA) standards.
EQU 3	The rappel unit has a process to ensure that rappel equipment removed from service (retired) is destroyed to the point it can no longer be utilized for its intended purpose.
EQU 4	The rappel unit ensures that the formal process for approval and technical support for new or improved rappel equipment is in accordance with the IHRG and approved by the RWG.
DOC 1	The rappel unit has a management and control system in accordance with the IHRG for documentation and/or data used directly in the conduct and/or support of rappel operations to include: (refer to results)
DOC 2	The rappel unit has processes to ensure the content of documentation used directly in the conduct or support of rappel operations (logs, local policies, etc.) is clear and legible, in a usable format and is accepted or approved by RWG, if applicable.
DOC 3	The rappel unit has a document and records management and control system in accordance with the IHRG that includes training, qualifications, and proficiency for all rappel personnel and any other operational rappel requirements to ensure: (refer to results)
OPR 1	The rappel unit has a process to ensure issues that affect rappel operational safety are coordinated among the rappel spotter and personnel to include, as appropriate: (refer to results)
EMR 1	The rappel unit has a process to ensure rappel emergency procedures are established to respond to a situation, serious in nature, developing suddenly or unexpectedly and demanding immediate action, are discussed and coordinated among the rappel spotter and personnel to include, as appropriate: (refer to results)
EMR 2	The spotter has a process to ensure cargo letdown emergency procedures are established to respond to a situation, serious in nature, developing suddenly or unexpectedly and demanding immediate action discussed and coordinated among the spotter, PIC and other involved personnel to include, as appropriate: (refer to results)

Interagency Helicopter Rappel Quality Assurance Survey Questions

ID	Statement
CLO 1	The rappel unit ensures that personnel who perform helicopter cargo letdown operations maintain competence on the basis of continued training and proficiency in accordance with the IHRG, the helicopter contract and, if applicable, continue to satisfy technical competency requirements. Determine conformance with the IHRG on how competence is maintained for the following position: (refer to results)
CLO 2	The spotter has a process to ensure issues that affect cargo letdown operational safety are coordinated among the PIC and other involved personnel to include, as appropriate: (refer to results)
SMS 1	The rappel unit has a Safety Management System (SMS) that provides for collection of information and data associated with helicopter rappel operations, and includes systematic processes for identify and assessing hazards and potentially hazardous conditions.
SMS 2	The rappel unit implements a mishap/hazard reporting system (SAFECOM) that: i) encourages and facilitates feedback from personnel to identify deficiencies, exposes hazards and raises safety concerns; ii) includes analysis and management action to address operational deficiencies, hazards and concerns identified through the reporting system.
SMS 3	The rappel unit has a process for identifying and investigating irregularities or other non-routine operational occurrences that might be precursors to a rappel or aircraft accident or incident.

Appendix F

Quality Assurance Survey Results

Rappel Program Quality Assurance Survey Results

ADM 1 Administration	The rappel unit has a management system that ensures proper supervision and operational control functions of all rappel missions in accordance with the standards of the Interagency Helicopter Rappel Guide (IHRG).				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
2.1%	2.1%	1.0%	94.8%	0	97

ADM 2 Administration	The rappel unit has a process that ensures agency policy to include amendments and revisions (IHOG) are current and maintained in accordance with agency requirements (USFS, DOI, manuals and directives).				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
2.1%	10.6%	4.3%	81.9%	1.1%	94

ADM 3 Administration	The rappel unit ensures all specified positions have duties and responsibilities that are clearly defined and well communicated throughout the rappel organization, to include: (refer to results)					
Category	Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
ADM 3						
-Check Spotter	1.1%	3.3%	1.1%	74.4%	20.0%	90
-Spotter	0.0%	4.4%	2.2%	93.4%	0.0%	91
-PIC	5.5%	11.0%	2.2%	76.9%	4.4%	91
Rappeller	0.0%	5.4%	3.2%	89.2%	2.2%	93

QUA 1 Quality Assurance	The program manager shall ensure that personnel who perform operationally critical functions maintain competence on the basis of continued education and training in accordance with the IHRG, the helicopter contract and continually satisfies technical competency requirements, if applicable.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
1.2%	4.8%	1.2%	92.9%	0	84

QUA 2 Quality Assurance	The rappel unit has a process to ensure course materials used in the rappel training program are periodically evaluated to ensure compliance with the qualification and performance standards of the current IHRG.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
4.8%	16.7%	0.0%	75.0%	3.6%	84

QUA 3 Quality Assurance	The rappel unit has a process to ensure that individuals who are designated to evaluate the competency of rappel personnel are qualified and current to conduct such evaluations.				
Not Documented Not Implemente d	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
1.2%	9.8%	1.2%	89.0%	0	82

QUA 4 Quality Assurance	The rappel unit ensures all rappel personnel receive comprehensive re-currency training at the specified frequency as directed in the IHRG.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
0.0%	2.4%	0.0%	97.6%	0	83

QUA 5 Quality Assurance	All rappel proficiency operations are conducted within a 14-day cycle.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
1.2%	2.4%	4.9%	90.2%	1.2%	82

QUA 6 Quality Assurance	The rappel unit ensures that training aids and equipment, to include mockups and other devices and/or course materials used in rappel training and evaluation, reasonably reflect the configuration of the helicopter model currently being used.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
0.0%	17.9%	2.4%	79.8%	0	84

QUA 7 Quality Assurance	The rappel unit has a policy that requires personnel who perform operationally critical functions to be physically fit and mentally prepared/ready for the duty day.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
4.8%	15.7%	9.6%	69.9%	0	83

EQU 1 Equipment	The rappel unit has a process that ensures all rappel equipment utilized is approved and maintains detailed information on the equipment as specified in the IHRG.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
0.0%	4.8%	1.2%	94.0%	0	84

EQU 2 Equipment	The rappel unit ensures that the rappel platform-training simulator (even if the simulator is based at a separate location) is constructed and maintained in accordance with agency and Occupational Safety and Health Administration (OSHA) standards.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
2.4%	8.5%	1.2%	80.5%	7.3%	82

EQU 3 Equipment	The rappel unit has a process to ensure that rappel equipment removed from service (retired) is destroyed to the point it can no longer be utilized for its intended purpose.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
1.2%	7.2%	1.2%	89.2%	1.2%	83

EQU 4 Equipment	The rappel unit ensures that the formal process for approval and technical support for new or improved rappel equipment is in accordance with the IHRG and approved by the RWG.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
3.6%	2.4%	2.4%	84.3%	7.2%	83

DOC 1 Documentation	The rappel unit has a management and control system in accordance with the IHRG for documentation and/or data used directly in the conduct and/or support of rappel operations to include: (refer to results)					
Category	Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
DOC 1 A means to ID the version of ops documents	6.3% (5)	10.0% (8)	2.5% (2)	76.3% (61)	5.0%	80
Review and revision process to maintain currency of information contained in documents	9.2% (7)	15.8% (12)	0.0%	75.0% (57)	0.0%	76
Retention of documents that permits easy reference and accessibility	5.2% (4)	11.7% (9)	1.3% (1)	81.8% (63)	0.0%	77
ID and disposal of obsolete documents	17.1% (13)	23.7% (18)	3.9% (3)	50.0% (38)	5.3% (4)	76

DOC 2 Documentation	The rappel unit has processes to ensure the content of documentation used directly in the conduct or support of rappel operations (logs, local policies, etc.) is clear and legible, in a usable format and is accepted or approved by RWG, if applicable.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
2.5%	8.8%	2.5%	87.5%	1.3%	80

DOC 3 Documentation	The rappel unit has a document and records management and control system in accordance with the IHRG that includes training, qualifications, and proficiency for all rappel personnel and any other operational rappel requirements to ensure: (refer to results)					
Category	Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
DOC 3						
1. Identification	0.0%	1.3% (1)	0.0%	97.4% (76)	1.3% (1)	78
2. Legibility	0.0%	7.7% (6)	0.0%	92.3% (72)	0.0%	78
3. Maintenance	0.0%	5.1% (4)	0.0%	94.9% (74)	0.0%	78
4. Retrieval	2.6% (2)	5.1% (4)	0.0%	85.9% (67)	6.4% (5)	78
5. Protection & security	9.0% (7)	10.3% (8)	1.3% (1)	69.2% (54)	10.3% (8)	78

OPR 1 Operations	The rappel unit has a process to ensure issues that affect rappel operational safety are coordinated among the rappel spotter and personnel to include, as appropriate: (refer to results)					
Category	Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
OPS 1 • Flight risk analysis	1.2% (1)	45.1% (37)	1.2% (1)	51.2% (42)	1.2% (1)	82
• Pre-flight spotter check	1.3% (1)	51.3% (41)	0.0%	47.5% (38)	0.0%	80
• PIC completed helicopter weight & balance for rappel ops	1.3% (1)	12.7% (10)	2.5% (2)	82.3% (65)	1.3% (1)	79
• PIC completed load calculation	0.0%	1.3% (1)	0.0%	97.5% (78)	1.3% (1)	80
• Pre-flight rappel equipment check	0.0%	38.8% (31)	0.0%	61.3% (49)	0.0%	80
• Pre-flight rappeller buddy check	0.0%	52.5% (42)	0.0%	47.5% (38)	0.0%	80
• Spotter/PIC and approach evaluations	0.0%	55.0% (44)	0.0%	45.0% (36)	0.0%	80
• Rappel procedures: spotter	0.0%	40.0% (32)	0.0%	60.0% (48)	0.0%	80
• Rappel procedures: rappeller	0.0%	40.0% (32)	0.0%	60.0% (48)	0.0%	80
• Cargo delivery: Spotter	0.0%	36.3% (29)	0.0%	63.8% (51)	0.0%	80
• Post-rappel: spotter	0.0%	48.1% (37)	0.0%	51.9% (40)	0.0%	77
• Post-rappel briefing: spotter	1.3% (1)	52.5% (42)	1.3% (1)	43.8% (35)	1.3% (1)	80

EMR 1 Emergency Procedures	The rappel unit has a process to ensure rappel emergency procedures are established to respond to a situation, serious in nature, developing suddenly or unexpectedly and demanding immediate action, are discussed and coordinated among the rappel spotter and personnel to include, as appropriate: (refer to results)					
Category	Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
EMR 1 • Rappel procedures & signals	0.0%	16.5% (13)	0.0%	83.5% (66)	0.0%	79
• Helicopter emergency	0.0%	24.1% (19)	1.3% (1)	74.7% (59)	0.0%	79
• Engine failure or major component failure	1.3%	26.6% (21)	0.0%	72.2% (57)	0.0%	79
• Rappeller in distress	0.0%	19.0% (15)	0.0%	78.5% (62)	2.5% (2)	79

EMR 2 Emergency Procedures	The spotter has a process to ensure cargo letdown emergency procedures are established to respond to a situation, serious in nature, developing suddenly or unexpectedly and demanding immediate action discussed and coordinated among the spotter, PIC and other involved personnel to include, as appropriate: (refer to results)					
Category	Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
Cargo Letdown procedures	0. (0)	30.4% (24)	0.0% (0)	68.4% (54)	1.3% (1)	79
Helicopter or Cargo on-line emergency	1.3% (1)	29.1% (23)	1.3% (0)	65.8% (52)	2.5% (2)	79
Engine failure or major component failure	1.3% (1)	29.1% (23)	0,0% (0)	67.1% (53)	2.5% (2)	79

CLO 1 Cargo Let-Down	The rappel unit ensures that personnel who perform helicopter cargo letdown operations maintain competence on the basis of continued training and proficiency in accordance with the IHRG, the helicopter contract and, if applicable, continue to satisfy technical competency requirements. Determine conformance with the IHRG on how competence is maintained for the following position: (refer to results)					
Category	Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
CLO 1						
• PIC	1.3% (1)	18.7% (14)	0.0%	78.7% (59)	1.3%	75
• Check Spotter	1.3% (1)	8.0% (6)	0.0%	74.7% (56)	16.0% (12)	75
• Spotter	0.0%	9.2% (7)	0.0%	90.8% (69)	0.0%	76

CLO 2 Cargo Let-Down	The spotter has a process to ensure issues that affect cargo letdown operational safety are coordinated among the PIC and other involved personnel to include, as appropriate: (refer to results)					
Category	Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
CLO 2						
• Flight risk analysis	0.0%	40.8% (31)	0.0%	57.9% (44)	1.3% (1)	76
• Pre-flight spotter check	0.0%	47.4% (36)	1.3% (1)	50.0% (38)	1.3% (1)	76
• PIC completed helicopter weight & balance for cargo letdown ops	1.4% (1)	17.6% (13)	1.4% (1)	78.4% (58)	1.4% (1)	74
• Pre-flight equip. check	0.0%	45.3% (34)	1.3% (1)	53.3% (40)	0.0%	75
• Spotter/PIC in-flight: approach evaluation	0.0%	50.7% (38)	1.3% (1)	48.0% (36)	0.0%	75
• Cargo letdown procedures: spotter	0.0%	36.0% (27)	0.0%	62.7% (47)	1.3% (1)	75

SMS 1 Safety Management Systems	The rappel unit has a Safety Management System (SMS) that provides for collection of information and data associated with helicopter rappel operations, and includes systematic processes for identify and assessing hazards and potentially hazardous conditions.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
4.0% (3)	22.7% (17)	1.3% (1)	70.7% (53)	1.3% (1)	75

SMS 2 Safety Management Systems	The rappel unit implements a mishap/hazard reporting system (SAFECOM) that: i) encourages and facilitates feedback from personnel to identify deficiencies, exposes hazards and raises safety concerns; ii) includes analysis and management action to address operational deficiencies, hazards and concerns identified through the reporting system.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
3.8% (3)	9.0% (7)	3.8% (3)	82.1% (64)	1.3% (1)	78

SMS 3 Safety Management Systems	The rappel unit has a process for identifying and investigating irregularities or other non-routine operational occurrences that might be precursors to a rappel or aircraft accident or incident.				
Not Documented Not Implemented	Implemented Not Documented	Documented Not Implemented	Documented and Implemented	N/A	Response Number
7.9% (6)	18.4% (14)	0.0%	72.4% (55)	2.6% (2)	76

Appendix G

Analysis of Quality Assurance Survey Results

Interagency Helicopter Rappel Quality Assurance Survey

ADM - The rappel unit has a management system that ensures proper supervision and operational control functions of all rappel missions are in accordance with the standards of the Interagency Helicopter Rappel Guide (IHRG).

	Response Percent	Response Count
1. Not Documented not Implemented	2.1%	2
2. Implemented not Documented	2.1%	2
3. Documented not Implemented	1.0%	1
4. Documented and implemented	**94.8%**	**92**
5. N/A	0.0%	0
	Comments	8
	answered question	97
	skipped question	5

Comments		
1	We always conduct rappel missions in accordance with the IHRG. Also, we train rappellers using the model specific prodedures in the IHRG and document each individuals training. Rappel missions are documented by rappellers on a rappeller report at the completion of the mission. The rappeller report is then brought back to the base and entered into RapRec.	Oct 29, 2009 2:54 PM
2	Base ops plan and Spotter training dictate procedures according to IHRG and excecution thereof.	Oct 29, 2009 7:26 PM
3	The rappel unit utilizes and refers to the Interagency Rappel Guide if there are any questions while at the home unit or boosting any other base. Each rappel operation also has a cooresponding rappel report showing the spotter, rappellers, and equipment utilized.	Oct 29, 2009 9:06 PM
4	We have, what seems like several hundred, binders that go with us wherever we might be assigned. What is more we follow the intent of those binders to the letter.	Oct 30, 2009 6:57 PM
5	Both DOI and FS regional/national officials have come to our base for inspection. We have followed procedures and policies and provide good leadership in our rappel program. Few if any inadequacies have been found. None of which would have suggested ay lack of supervision or control.	Nov 2, 2009 5:00 PM
6	the unit has an approved operating plan that complies with IHRG. Unit has a comprehensive records system that can generate reports for individuals, unit, and equipment.	Nov 5, 2009 5:55 PM
7	In working with other rappel crews from different regions the mindset of utilizing rappelling vastly differs. I feel the use of rappeling as a last resort in lieu of finding a suitable landing area isn't the same mindset throughout the regions. This is shown through the initial attack procedures of varying rappel crews who choose to depart their helibase configured to rappel, regardless of the possibilty of having a suitable helispot close to the fire.	Nov 5, 2009 10:15 PM
8	The rappel units in R-5 to the best of my knowledge have the proper supervision and operational control of all missions. Although each unit may have the proper supervision and control of each mission, a standard MUST be defined for documenting these missions. There are suggested forms in the IHRG for documentation, but i have seen many iterations of these forms.	Nov 15, 2009 8:23 PM

Interagency Helicopter Rappel Quality Assurance Survey

ADM - The rappel unit ensures all specified positions have duties and responsibilities that are clearly defined and well communicated throughout the rappel organization, to include:

Select One

	Not Documented not Implemented	Implemented not Documented	Documented not Implemented	Documented and Implemented	N/A	Response Count
Check spotter	1.1% (1)	3.3% (3)	1.1% (1)	74.4% (67)	20.0% (18)	90
Spotter	0.0% (0)	4.4% (4)	2.2% (2)	93.4% (85)	0.0% (0)	91
Pilot-in-command (PIC)	5.5% (5)	11.0% (10)	2.2% (2)	76.9% (70)	4.4% (4)	91
Rappeller	0.0% (0)	5.4% (5)	3.2% (3)	89.2% (83)	2.2% (2)	93
					Comments	10
					answered question	96
					skipped question	6

Comments		
1	Rappeller duties are outlined and discussed at the beginning of every fire year. All spotter and rappeller requirements in the IHRG are met and currency is maintained and documented using a rappeller report. All training is documented on the forms provided by the IHRG.	Oct 29, 2009 2:54 PM
2	Rappel guide procedures that are subject to interpretation are interpreted by the R-6 academy spotter group and the results of such interpretation are implemented immediately during academy.	Oct 29, 2009 7:26 PM
3	IHRG is used and guidelines and policies are followed.	Oct 29, 2009 8:26 PM
4	A briefing is accompanied by a handout of the organizational structure of the rappel unit at the beginning of the season. If any persons from an outside organization arrive for duty, a manditory briefing of the base operations is to be provided before participating in any rappel or fire operations.	Oct 29, 2009 9:06 PM
5	This is borderline insulting, we live these duties and responsibilities. and they are WELL documented.	Oct 30, 2009 6:57 PM
6	The problem that an individual from the outside with some knowledge of teaching personnel technical tasks or skills may notice: We should have the ability to hire/select individuals who have an aptitude for learning the skills and a measurable physical fitness level to evaluate. Supervisors should be hiring their crew, not anyone else.	Nov 2, 2009 5:00 PM
7	Not sure what you are asking for with the Pilot. They are carded of course but I belive that is the extent of documention. not sure of Check spotter documentation?	Nov 2, 2009 9:41 PM
8	I have noticed some discrepancy in how different PIC interpret their responsibilities, ie. some tell the spotter everything they are doing, others don't.	Nov 4, 2009 3:51 PM
9	There is a range of interpretation among PICs regarding what is required/expected communiation	Nov 4, 2009 5:17 PM
10	all contained in the unit rappel plan	Nov 5, 2009 5:55 PM

Interagency Helicopter Rappel Quality Assurance Survey

QUA - The program manager shall ensure that personnel who perform operationally critical functions maintain competence on the basis of continued education and training in accordance with the IHRG, the helicopter contract and continually satisfies technical competency requirements, if applicable.

	Response Percent	Response Count
1. Not Documented not Implemented	1.2%	1
2. Implemented not Documented	4.8%	4
3. Documented not Implemented	1.2%	1
4. Documented and Implemented	**92.9%**	**78**
5. N/A	0.0%	0
	Comments	10
	answered question	84
	skipped question	18

Comments		
1	All qualified managers attend required refresher training and maintain the helicopter contract by printing ammendments and adding them directly to the contract.	Oct 29, 2009 3:17 PM
2	Assured by base ops. plan and RAPPEL WORKING GROUP.	Oct 29, 2009 7:49 PM
3	R-6 rappel units participate in a regional rappel academy each year. At the academy, all qualifications to be a successful, carded rappeller are met. Additional base training and proficiency rappels are completed to ensure all personnel are fit for duty.	Oct 29, 2009 9:14 PM
4	I can only speak for my unit.	Oct 30, 2009 3:41 AM
5	We do weekly training at our base, which I believe helps a lot. But, I think once a week is not enough when the season is slow and you are not getting out a lot. I would suggest doing more practical training during the week, especially if you have time and the season has been slow.	Oct 30, 2009 6:59 PM
6	Proficiency rapps every week. Well documented in rappel reports.	Oct 30, 2009 7:04 PM
7	The managers of our program possess the maturity and professionalism required for program oversight and implementation.	Nov 2, 2009 5:11 PM
8	monitored through records system	Nov 5, 2009 6:07 PM
9	thats what the rappel workshops are for	Nov 15, 2009 8:33 PM
10	Only one party of our permanent overhead ensures continuing education & training. I am not sure this is documented other than the daily diary (if the ship turns rotors) & our time book.	Nov 19, 2009 8:16 PM

Interagency Helicopter Rappel Quality Assurance Survey

QUA - The rappel unit has a process to ensure course materials used in the rappel training program are periodically evaluated to ensure compliance with the qualification and performance standards of the current IHRG.

	Response Percent	Response Count
1. Not Documented not Implemented	4.8%	4
2. Implemented not Documented	16.7%	14
3. Documented not Implemented	0.0%	0
4. Documented and Implemented	**75.0%**	**63**
5. N/A	3.6%	3
	Comments	8
	answered question	84
	skipped question	18

Comments		
1	The IHRG is used as a guide for training. As far as the training syllabus is considered, we vary from the IHRG in some areas, but all information and procedures are covered and covered more extensivley than what is currently outlined tin the IHRG training syllabus.	Oct 29, 2009 3:17 PM
2	Rappel guide and Rappel Working Group.	Oct 29, 2009 7:49 PM
3	See above.	Oct 30, 2009 3:41 AM
4	Whith much scrutiny.	Nov 2, 2009 5:11 PM
5	As a seasonal, I wouldn't know the answer to this question	Nov 2, 2009 9:21 PM
6	we use the IHRG when training and follow the syllybus.	Nov 2, 2009 9:48 PM
7	updates are provided trough email system and then implemented. Not sure how to document this though. Some times difficult for DOI personnel to access USFS document libraries to maintain most up to date info.	Nov 5, 2009 6:07 PM
8	I have no part in rappel training instruction.	Nov 19, 2009 8:16 PM

Interagency Helicopter Rappel Quality Assurance Survey

QUA - The rappel unit has a process to ensure course materials used in the rappel training program are periodically evaluated to ensure compliance with the qualification and performance standards of the current IHRG.

	Response Percent	Response Count
1. Not Documented not Implemented	4.8%	4
2. Implemented not Documented	16.7%	14
3. Documented not Implemented	0.0%	0
4. Documented and Implemented	**75.0%**	**63**
5. N/A	3.6%	3
	Comments	8
	answered question	**84**
	skipped question	**18**

Comments		
1	The IHRG is used as a guide for training. As far as the training syllabus is considered, we vary from the IHRG in some areas, but all information and procedures are covered and covered more extensivley than what is currently outlined tin the IHRG training syllabus.	Oct 29, 2009 3:17 PM
2	Rappel guide and Rappel Working Group.	Oct 29, 2009 7:49 PM
3	See above.	Oct 30, 2009 3:41 AM
4	Whith much scrutiny.	Nov 2, 2009 5:11 PM
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8	I have no part in rappel training instruction.	Nov 19, 2009 8:16 PM

Interagency Helicopter Rappel Quality Assurance Survey

QUA - The rappel unit ensures all rappel personnel receive comprehensive recurrency training at the specified frequency as directed in the IHRG.

	Response Percent	Response Count
1. Not Documented not Implemented	0.0%	0
2. Implemented not Documented	2.4%	2
3. Documented not Implemented	0.0%	0
4. Documented and Implemented	**97.6%**	**81**
5. N/A	0.0%	0
	Comments	8
	answered question	83
	skipped question	19

Comments		
1	Training division of base tracks, and the rappel academy provides the venue.	Oct 29, 2009 7:49 PM
2	R-6 Rappel academy and proficiencies satisfy these requirements	Oct 29, 2009 9:14 PM
3	Rappellers are required to complete the specified sequence of tower work and mock ups each year before rappel operations take place.	Oct 29, 2009 11:45 PM
4	See above	Oct 30, 2009 3:41 AM
5	Budgets are sometimes a concern if we recognize a need for a higher frequency of recurrency training.	Nov 2, 2009 5:11 PM
6	Some IMT IC's are getting a little hesitant in allowing proficiencies happen on the incidents they are managing. Needs to be addressed by the Geat Basin Coordination Group or on a national level. We need support from above so we can stay proficient while working away from our home bases.	Nov 2, 2009 9:41 PM
7	tracked in records system	Nov 5, 2009 6:07 PM
8	It would help if spotters remain involved at the home unit when critical changes are made to meet WO direction. For bases with only one spotter, it is imperative to have the spotter remain attached to the module and put team assignments as a lower priority.	Nov 15, 2009 8:33 PM

Interagency Helicopter Rappel Quality Assurance Survey

QUA - All rappel proficiency operations are conducted within a 14-day cycle.

	Response Percent	Response Count
1. Not Documented not Implemented	1.2%	1
2. Implemented not Documented	2.4%	2
3. Documented not Implemented	4.9%	4
4. Documented and Implemented	**90.2%**	**74**
5. N/A	1.2%	1
	Comments	20
	answered question	82
	skipped question	20

Comments		
1	Sometimes rappellers may be on assignment which makes proficiencies unavailable to them. In which the crew follows the IHRG with mockups or tower work to bring the crewmember back into currency. This does not happen often but does occur.	Oct 29, 2009 3:02 PM
2	within reason, often times an assignment or other priorities get in the way ot the 14 day cycle, made up with mock-ups when needed.	Oct 29, 2009 6:57 PM
3	At least every 7 days there is opportunnity to conduct proficiency flights.	Oct 29, 2009 7:49 PM
4	Indicitated by the rappel records and rappel reports	Oct 29, 2009 9:14 PM
5	Opportunity is given weekly during a crew training day for proficiencies.	Oct 29, 2009 11:45 PM
6	I can only speak for my unit and we attempt to do it on a 7 day period.	Oct 30, 2009 3:41 AM
7	When not completed in a 14 day period due to fire activity or other unforseen reasons, mock-ups are performed before live rappel.	Oct 30, 2009 3:12 PM
8	Some individual proficiencies go beyond 14 days if the person is away from base on assignment	Oct 30, 2009 6:56 PM
9	We do rappel proficiencies on a weekly basis.	Oct 30, 2009 6:59 PM
10	you mean a forrtnight.	Oct 30, 2009 7:04 PM
11	Due to fire assignments, some individuals exceed the 14-day cycle. However, the are made recurrent within policy prior to the 21 day limit.	Nov 2, 2009 5:11 PM
12	If the rappelers go past 14 days we do mock-ups and then a helicopter proficiency rappel before any live rappels.	Nov 2, 2009 9:41 PM
13	sometimes the 14 day period laspes but we do mock ups when past two weeks then proficencies.	Nov 2, 2009 9:48 PM
14	Except when re-currency can't be met due to assignments away from the base or module.	Nov 4, 2009 12:24 AM
15	Sometimes certain individuals fall outside the 14 day cycle, if they were on an assignment or were sick the day the crew conducted proficiencies. This is documented.	Nov 4, 2009 4:02 PM
16	Not all the time due to other activities such as single resource assignments or being on the fire line. But that is mitigated by doing mock ups if you go past 14 days and if performed satisfactory, doing a live rappel within 28 days.	Nov 4, 2009 4:17 PM
17	Not always possible to get everyone done every 14 days - people can be on assignments away from the crew, sick on the day of proficiency, etc.	Nov 4, 2009 5:24 PM
18	Sometimes, due to high activity in the fire season, some personnel may miss their 14-day cycle. There is an approved method for the rappel unit to regain their currency and it is always utilized.	Nov 4, 2009 9:14 PM
19	tracked in records system. posted on daily operational board to ensure dates are not missed	Nov 5, 2009 6:07 PM
20	refer to previos comment. There are cases where our entire module has gone 20-30 days without a proficiency rappel b/c of single resource assignments.	Nov 15, 2009 8:33 PM

Interagency Helicopter Rappel Quality Assurance Survey

QUA - The rappel unit ensures that training aids and equipment, to include mock-ups and other devices and/or course materials used in rappel training and evaluation, reasonably reflect the configuration of the helicopter model currently being used.

	Response Percent	Response Count
1. Not Documented not Implemented	0.0%	0
2. Implemented not Documented	17.9%	15
3. Documented not Implemented	2.4%	2
4. Documented and Implemented	**79.8%**	**67**
5. N/A	0.0%	0
	Comments	7
	answered question	84
	skipped question	18

Comments		
1	Tower configuration is documented in training records. All mock-ups are completed using the appropriate aircraft.	Oct 29, 2009 3:17 PM
2	Tower is adjustable to excactly mirror the aircraft dimensions. Aircraft are always available for mock-up if not on assignment.	Oct 29, 2009 7:49 PM
3	Tower Work and class work in Academy mirror operational work out of the bell mediums and the 407's.	Oct 29, 2009 11:45 PM
4	See above	Oct 30, 2009 3:41 AM
5	Currently it does but the contract will be new this coming season and the tower configuration might not be reflective of the platform immediately.	Nov 2, 2009 8:24 PM
6	although simulators for training are hard to ensure they meet all makes and models of aircraft. use of retired equipment to display deviations from the standard are essential.	Nov 5, 2009 6:07 PM
7	It would be nice to make a S-61 simulator, but understandibly so, that is not monetarily possible. Awesome platform, proven through time, but we (R-5) have allowed R-6 to dictate our policy and procedures. Rappeling in R-5 is used as a different tool.	Nov 15, 2009 8:33 PM

Interagency Helicopter Rappel Quality Assurance Survey

QUA - The rappel unit has a policy that requires personnel who perform operationally critical functions to be physically fit and mentally prepared/ready for the duty day.

	Response Percent	Response Count
1. Not Documented not Implemented	4.8%	4
2. Implemented not Documented	15.7%	13
3. Documented not Implemented	9.6%	8
4. Documented and Implemented	69.9%	58
5. N/A	0.0%	0
	Comments	13
	answered question	83
	skipped question	19

Comments		
1	PT tests are conducted and documented at the beginning of the season.	Oct 29, 2009 3:17 PM
2	All national standards are exceded. Pre-day managment group meetings are venues to modify days assignments.	Oct 29, 2009 7:49 PM
3	fitness standards, both physical and mental, are not policed very well. The minimums are too easy for a type I rappel crew, yet people cannot pass them and are not disciplined.	Oct 29, 2009 8:48 PM
4	The rappel unit not only requires the minimum standards of an ardurous wildland firefighter, but additional requirements before personnel can fight fire or participate in rappel operations: 11 minute 1.5 mile, 7 pullups, 25 pushups, 30 situps in a minute.	Oct 29, 2009 9:14 PM
5	Minimum Physical Training Standards for Rappel Assignment Availability	Oct 29, 2009 11:45 PM
6	See above.	Oct 30, 2009 3:41 AM
7	I believe we should have a higher standard than the pack test for rappel crews. Some crews seem to implement higher standards similar to the smokejumper standards, however I do not think policy supports this. Our crew lists the smokejumper standards as crew goals for each individual, but we do not limit them from rappelling if they don't meet the standard. I strongly believe that we should have a national standard above what the pack test measures.	Nov 2, 2009 5:11 PM
8	Not Documented and Implemented	Nov 2, 2009 8:37 PM
9	Only reccomended not required, except for the basic pack test.	Nov 4, 2009 12:24 AM
10	The agency has policies for fitness and fit for duty standards. However, these are difficult to implement. The pack test is the only required fitness test, and being able to pass the pack test does not mean that someone is fit to pack out in steep terrain after a rappel. The unit has a PT program, and it is up to the discretion of the overhead if a person is physically fit enough to perform critical functions, but no formal policy exists. It is difficult to determine if people are mentally prepared for the day. Due to lack of qualified spotters, the overhead in my unit work 13 or 14 days in a row on a regular basis while at the home unit. Mental fatigue becomes obvious, but nothing is done about it.	Nov 4, 2009 4:02 PM
11	The agency has policies for fitness and fit for duty standards. However, this is hard to implement in the field. The pack test is the only required fitness standard, and passing the pack test does not mean that someone can pack out in steep terrain. The crew has a daily PT program to evaluate and maintain physical fitness, but there is nothing we can do legally if someone is not physically fit. It is also hard to evaluate whether someone is mentally prepared - that is very subjective. On my unit, the overhead often work 13 or 14 days in a row for the whole season, even when at home.	Nov 4, 2009 5:24 PM
12	all personnel evaluated by base manager. Physical fittness standards and participation are documented	Nov 5, 2009 6:07 PM
13	This touches on physical fitness standards, in my opinion. We have standards - but they are not enforced - they should be. How do you evaluate mental preparedness? It's easy to send a seasonal home if they're unfit for duty - but try sending a base manager or assistant home - how do we do that? It hasn't been an issue yet, but I think we should plan for it - or give PSEs some options and some back up for when they have to make those decisions. I digress...	Nov 19, 2009 8:16 PM

Interagency Helicopter Rappel Quality Assurance Survey

EQU - The rappel unit has a process that ensures all rappel equipment utilized is approved and maintains detailed information on the equipment as specified in the IHRG.

	Response Percent	Response Count
1. Not Documented not Implemented	0.0%	0
2. Implemented not Documented	4.8%	4
3. Documented not Implemented	1.2%	1
4. Documented and Implemented	**94.0%**	**79**
5. N/A	0.0%	0
	Comments	12
	answered question	84
	skipped question	18

Comments		
1	All equipment useage and inspection is tracked and documented in the Rappel Equipment Inspection Log.	Oct 29, 2009 3:43 PM
2	the unit does the very best we can, though there is no one spot to learn all that is necessary about equipment changes, we have a web page that worthless.	Oct 29, 2009 7:05 PM
3	Hard copy documentation and electronic back-up through RapRec.	Oct 29, 2009 7:56 PM
4	Would like to see a set of standardized forms/electronic forms are used to document usage. Currently we are still using hardcopy forms as well as electronic documentation. Would like to strictly use electronic methods as the program is efficient and covers most equipment. Would like to see these electronic forms incorporated into guide. If standardization is to occur then it would need to include a standardization of these forms/methods.	Oct 29, 2009 8:36 PM
5	Ropes, Sky Genies, Letdown Lines, Harnesses are all numbered and require an inspection and logging after each use. Information can be found in equipment logs or rappel reports.	Oct 29, 2009 9:17 PM
6	Per my unit.	Oct 30, 2009 3:41 AM
7	Both hard copy and electronically kept.	Nov 2, 2009 8:27 PM
8	There is some discrepancy between what is required in the IHRG and what is required in the rappel records database. We have been keeping records according to the IHRG, but we have had a hard time with the rappel records database because it requires information we have not been keeping. For example, we document how many rappellers went down rope #10, side A per load, but we have not been documenting exactly WHO went down rope #10, side A on that load.	Nov 4, 2009 4:07 PM
9	We maintain records as specified in the IHRG, but the rappel records database requires more specific documentation. This has made it hard to implement the rappel records database. For example, we document that rope #10, side A had two rappels, but we had not been documenting that those two rappels were by Rappeller A and Rappeller B.	Nov 4, 2009 5:28 PM
10	inspected by approved personnel documented on paper then entered into computer based records system	Nov 5, 2009 6:10 PM
11	Usage is tracked, but there is limited information on the technical specifications of the equipment that is readily available.	Nov 10, 2009 9:37 PM
12	All rappel equipment is inspected and documented after each rappel. It would be nice to have a procedure for documenting and evaluating caribeener usage.	Nov 15, 2009 8:40 PM

Interagency Helicopter Rappel Quality Assurance Survey

EQU - The rappel unit ensures that the rappel platform training simulator (even if the simulator is based at a separate location) is constructed and maintained in accordance with agency and Occupational Safety and Health Administration (OSHA) standards.

	Response Percent	Response Count
1. Not Documented not Implemented	2.4%	2
2. Implemented not Documented	8.5%	7
3. Documented not Implemented	1.2%	1
4. Documented and Implemented	**80.5%**	**66**
5. N/A	7.3%	6
	Comments	10
	answered question	82
	skipped question	20

Comments		
1	Periodic inspection throughout the year with OSHA, Engineering, Rappel Academy Group, etc.	Oct 29, 2009 7:56 PM
2	Currently we have to travel a significant distance to use an outdated tower that is marginal at best and does not meet the needs of the two rappel programs on our forest. With a new helicopter platform and possible larger crew it may be important to evaluate if current rappel towers in R-3 meet the needs of the program.	Oct 29, 2009 8:36 PM
3	unknown	Oct 30, 2009 3:14 PM
4	I am assuming that this is documented and implemented. We use a tower that is not at our home unit, and we do not do the maintenance ourselves.	Nov 4, 2009 4:07 PM
5	Unsure about the tower but the anchors, gunner straps, seat belts and other equipment, yes	Nov 4, 2009 4:20 PM
6	The tower is not on our unit, and someone else (?) maintains it.	Nov 4, 2009 5:28 PM
7	We check the tower ever season but as Forestry Techs we should not be asked to inspect such a piece of equipment without proper training. This process should be done by a qualified person that knows structural engineering and such.	Nov 5, 2009 5:23 AM
8	base takes the word of the host base where the simulator is housed. Manager has asked to see this documentation	Nov 5, 2009 6:10 PM
9	We travel to another rappel base for low and high tower training. Unkown wether or not the simulator is being maintained with OSHA standards.	Nov 15, 2009 8:40 PM
10	I would assume they do, since the tower is not at our base, but I have to concrete knowledge of their OSHA documentation.	Nov 19, 2009 8:18 PM

Interagency Helicopter Rappel Quality Assurance Survey

EQU - The rappel unit has a process to ensure that rappel equipment removed from service (retired) is destroyed to the point it can no longer be utilized for its intended purpose.

	Response Percent	Response Count
1. Not Documented not Implemented	1.2%	1
2. Implemented not Documented	7.2%	6
3. Documented not Implemented	1.2%	1
4. Documented and Implemented	**89.2%**	**74**
5. N/A	1.2%	1
answered question		83
skipped question		19

Interagency Helicopter Rappel Quality Assurance Survey

ADM - The rappel unit has a process that ensures agency policy to include amendments and revisions (IHOG)are current and maintained in accordance with agency requirements (USFS, DOI, manuals and directives).

	Response Percent	Response Count
1. Non Documented not Implemented	2.1%	2
2. Implemented not Documented	10.6%	10
3. Documented not Implemented	4.3%	4
4. Documented and Implemented	**81.9%**	**77**
5. N/A	1.1%	1
	Comments	8
	answered question	94
	skipped question	8

Comments		
1	Anytime a change is made to the IHOG we make sure everyone on the crew gets the new information. The same is done with any contract ammendments and changes to the IHRG. Relevant safety alerts are discussed with the crew and posted for future reference.	Oct 29, 2009 2:54 PM
2	Again spelled out in the base ops. plan.	Oct 29, 2009 7:26 PM
3	The rappel unit utilizes and refers to the IHOG for all helicopter operations. Manifests and Load Calculations are completed for each day and each mission.	Oct 29, 2009 9:06 PM
4	Annual Spotter workshop instead of every once in awhile workshops would do a better job of passing on information.	Oct 29, 2009 10:27 PM
5	we spend about two weeks at the beginning of each season ensuring that all of our guiding manuals have the correct and up to date amendments and revisions.	Oct 30, 2009 6:57 PM
6	Outsiders might think we need more restrictive policy if their goal is to eliminate human error. More control measures are not the answer. Removing the ability for one to manage one's own equipment will lead tomore error.	Nov 2, 2009 5:00 PM
7	Changes to policy are briefed and updated in on site manuals.	Nov 5, 2009 5:55 PM
8	All updates are implemeted into both IHOG's and all copies of the Rappel Guide.	Nov 5, 2009 10:15 PM

Interagency Helicopter Rappel Quality Assurance Survey

EQU - The rappel unit ensures that the formal process for approval and technical support for new or improved rappel equipment is in accordance with the IHRG and approved by the RWG.

	Response Percent	Response Count
1. Not Documented not Implemented	3.6%	3
2. Implemented not Documented	2.4%	2
3. Documented not Implemented	2.4%	2
4. Documented and Implemented	**84.3%**	**70**
5. N/A	7.2%	6
	Comments	9
	answered question	83
	skipped question	19

Comments		
1	All letters of approval from the RWG for new rappel equipment are included in the base and spotter copies of the IHRG.	Oct 29, 2009 3:43 PM
2	the RWG does not create a feeling of confidence, they make changes and retract, they test commercially available equipment, then go to their garage to change it. They tell you about a web page that has nothing.	Oct 29, 2009 7:05 PM
3	I have no idea what it is you are asking? As far anew and improved equipment and the rwg, I have no faith in the rwg due to the fact of the knee-jerk reaction to a fatality. Also the group requires me to implment a specfic procedure and then retracts that procedure.	Oct 29, 2009 7:46 PM
4	Equipment committee and Working group representitives at base ensure compliance.	Oct 29, 2009 7:56 PM
5	The ability to have approval and technical support for new or improved rappel equipment is stymied by the approval process. Several good ideas (Rappel simulator, new cargo let down bag) have come out of region 5, and have not been properly evaluated. Instead our technical bulletins and quick procedure fixes seem to be dictated to us by Tim Lynch.	Nov 1, 2009 9:19 PM
6	I do not belive approval is by RWG, but by Unit Fire Managemnt Officer	Nov 2, 2009 8:30 PM
7	As a seasonal, I don't deal directly with the aquisition/approval of new equipment. However, when changes/improvements to current equipment were made, the process above was followed	Nov 2, 2009 9:21 PM
8	requests for new equipment are run through IREPC and evaluations from the RWG are documented and returned to appropriate authorities	Nov 5, 2009 6:10 PM
9	Why is a non-rappeler at MTDC issuing safety alerts relating to equipment for which he probably has never operationally used. Its seems as though the equipment commitees should be making these decisions and following up accordingly.	Nov 15, 2009 8:40 PM

Interagency Helicopter Rappel Quality Assurance Survey

DOC - The rappel unit has a management and control system in accordance with the IHRG for documentation and/or data used to directly in the conduct and/or support of rappel operations to include:

Select One

	Not Documented not Implemented	Implemented not Documented	Documented not Implemented	Documented and Implemented	N/A	Response Count
A means of identifying the version of operational documents	6.3% (5)	10.0% (8)	2.5% (2)	76.3% (61)	5.0% (4)	80
A review & revision process to maintain currency of information contained in documents	9.2% (7)	15.8% (12)	0.0% (0)	75.0% (57)	0.0% (0)	76
Retention of documents that permits easy reference and accessibility	5.2% (4)	11.7% (9)	1.3% (1)	81.8% (63)	0.0% (0)	77
Identification and disposal of obsolete documents	17.1% (13)	23.7% (18)	3.9% (3)	50.0% (38)	5.3% (4)	76
					Comments	11
					answered question	80
					skipped question	22

Comments		
1	What?	Oct 29, 2009 7:16 PM
2	Hard copy and RapRec in place and maintained.	Oct 29, 2009 8:02 PM
3	I think the program does a fair to good job at documentation and associated tasks.	Oct 29, 2009 8:52 PM
4	Raprec is now obsolete due to microsoft 2007 update. This hasn't been addressed by working group and we currently have no access to past documentation.	Oct 30, 2009 6:22 PM
5	We hold on to all past rappel documents. It may be time to discard some of these. Maybe scan some of these into computer.	Oct 30, 2009 7:01 PM
6	Review of document currency is not done on a routine schedule. Usually found when doing Forest level reviews.	Nov 2, 2009 8:33 PM
7	not sure what question 2 is asking, also don't know the timeframe of when a document becomes obsolete. I.e. how long does a base have to keep documentation?	Nov 2, 2009 9:54 PM
8	dont know how to answer this question, it is writen poorly.	Nov 4, 2009 4:37 PM
9	The rappel records database does not allow for easy reference and accessibility.	Nov 4, 2009 5:32 PM
10	Question poorly written.	Nov 4, 2009 9:22 PM
11	These questions are upsurd and reflect the fact that the author has no concept of what is involved in rappelling. The poor grammar and sentence structure is such that they cannot be accurately answered, nor could any relevant information be gleaned from them. Can we as an agency please have our written material edited by qualified individuals prior to release? This document is an embarrassment to anyone with a reasonable amount of intelligence or education.	Nov 19, 2009 10:14 PM

Interagency Helicopter Rappel Quality Assurance Survey

DOC - The rappel unit has processes to ensure the content of documentation used directly in the conduct or support of rappel operations (logs, local policies, etc.) is clear and legible, in a usable format and is accepted or approved by RWG, if applicable.

	Response Percent	Response Count
1. Not Documented not Implemented	2.5%	2
2. Implemented not Documented	8.8%	7
3. Documented not Implemented	2.5%	2
4. Documented and Implemented	**87.5%**	**70**
5. N/A	1.3%	1
	Comments	8
	answered question	**80**
	skipped question	**22**

Comments		
1	All forms used for rappel operations come from Appendix C in the IHRG.	Oct 29, 2009 3:52 PM
2	Hard copy and RapRec in place and maintained.	Oct 29, 2009 8:02 PM
3	Yes, we have the process in place but for me it is outdated and forms could be all converted to an electronic format. With that being said I think it that consideration should be given to creating a mandatory and standardized format of documenting all raapel operations and equipment usage. If all programs are to be standardized then I would think it would be critical that all bases use the exact same format of documentation procedures and forms.	Oct 29, 2009 8:52 PM
4	Manifests, Rappel Reports, and Load Calcs are all used.	Oct 29, 2009 9:19 PM
5	Just using the basic IHRG forms.	Oct 30, 2009 6:22 PM
6	The electronic forms and paper copies that we have been using meet these standards. I do not think that the rappel records database is an acceptable usable format.	Nov 4, 2009 5:32 PM
7	We do not see this kind of documentation	Nov 5, 2009 5:27 AM
8	All policy documents are housed at the rappel base and carried in support trucks for operations away from the base.	Nov 5, 2009 6:14 PM

Interagency Helicopter Rappel Quality Assurance Survey

DOC - The rappel unit has a document and records management and control system in accordance with the IHRG that includes training, qualifications, and proficiency for all rappel personnel and any other operational rappel requirements to ensure:

Select one

	Not Documented not Implemented	Implemented not Documented	Documented not Implemented	Documented and Implemented	N/A	Response Count
1. Identification	0.0% (0)	1.3% (1)	0.0% (0)	97.4% (76)	1.3% (1)	78
2. Legibility	0.0% (0)	7.7% (6)	0.0% (0)	92.3% (72)	0.0% (0)	78
3. Maintenance	0.0% (0)	5.1% (4)	0.0% (0)	94.9% (74)	0.0% (0)	78
4. Retrieval	2.6% (2)	5.1% (4)	0.0% (0)	85.9% (67)	6.4% (5)	78
5. Protection & Security	9.0% (7)	10.3% (8)	1.3% (1)	69.2% (54)	10.3% (8)	78
					Comments	9
					answered question	78
					skipped question	24

Comments		
1	All training, qualifications, and proficiency information is documented using hard copy forms. Proficiencies and operational rappells are also recorded using RapRec.	Oct 29, 2009 3:52 PM
2	Training division tracks, records verify.	Oct 29, 2009 8:02 PM
3	Unit does a fair to good job but I believe it could be better and much more efficent as it appears to be outdated. I think a standardized format such as the rappel database should be used as it is a much more efficent method and "cleaner" method of doing business.	Oct 29, 2009 8:52 PM
4	IQCS, Personal Records, Rappel Logs, Online Rappel logs are all updated nd used.	Oct 29, 2009 9:19 PM
5	Again no Raprec, can't retrieve records. No security or protection. Just paper hard copies in a binder.	Oct 30, 2009 6:22 PM
6	Local managers need a higher level of understanding for the demands on time and budget of training, equipment maintenance, and documentation.	Nov 2, 2009 5:15 PM
7	using computer records system developed by R6. Records are kept on local unit server with back-up on external hard drive	Nov 5, 2009 6:14 PM
8	the files are lock by the normal base doors no spical locks on files	Nov 10, 2009 5:05 PM
9	The current system we have in place (RapRec) is working, but is becoming obsolete and clumsy. It needs a review.	Nov 10, 2009 9:41 PM

Interagency Helicopter Rappel Quality Assurance Survey

OPR - The rappel unit has a process to ensure issues that effect rappel operational safety are coordinated among the rappel spotter and personnel to include, as appropriate:

Select one

	Not Documented not Implemented	Implemented not Documented	Documented not Implemented	Documented and Implemented	N/A	Response Count
Flight risk analysis	1.2% (1)	45.1% (37)	1.2% (1)	**51.2% (42)**	1.2% (1)	82
Pre-flight spotter check	1.3% (1)	**51.3% (41)**	0.0% (0)	47.5% (38)	0.0% (0)	80
PIC completed helicopter weight & balance for rappel ops	1.3% (1)	12.7% (10)	2.5% (2)	**82.3% (65)**	1.3% (1)	79
PIC completed load calculation	0.0% (0)	1.3% (1)	0.0% (0)	**97.5% (78)**	1.3% (1)	80
Pre-flight rappel equipment check	0.0% (0)	38.8% (31)	0.0% (0)	**61.3% (49)**	0.0% (0)	80
Pre-flight rappeller buddy check	0.0% (0)	**52.5% (42)**	0.0% (0)	47.5% (38)	0.0% (0)	80
Spotter/pilot in-flight and approach evaluations	0.0% (0)	**55.0% (44)**	0.0% (0)	45.0% (36)	0.0% (0)	80
Rappel procedures/spotter	0.0% (0)	40.0% (32)	0.0% (0)	**60.0% (48)**	0.0% (0)	80
Rappel procedures/rappeller	0.0% (0)	40.0% (32)	0.0% (0)	**60.0% (48)**	0.0% (0)	80
Cargo delivery/spotter	0.0% (0)	36.3% (29)	0.0% (0)	**63.8% (51)**	0.0% (0)	80
Post-rappel/spotter	0.0% (0)	48.1% (37)	0.0% (0)	**51.9% (40)**	0.0% (0)	77
Post-rappel briefing/spotter	1.3% (1)	**52.5% (42)**	1.3% (1)	43.8% (35)	1.3% (1)	80
					Comments	10
					answered question	82

1	All of these processes are completed every time but many are not documented.	Oct 29, 2009 9:01 PM
2	RAG group can't seem to address weight and balance for model-specific aircraft. They just say its the pilots responsibility but can't give the pilot or spotter any direction.	Oct 30, 2009 6:24 PM
3	To place into context my responses of implemented not documented I must say the following: That response may suggest a need for documenting each one of those procedures, however that is not true. We train extensively for each step of our procedure and to add a requirement for checking off a list that each step has been done would be distracting. Our procedure is complete with redundancy and is beyond adequate. It is not failure proof because humans are doing it and to attempt to become more restrictive adds only to confuse.	Nov 2, 2009 5:29 PM
4	This field of questions concerns me. I am concerned that we will have to document all this stuff prior to each mission which will greatly hinder our ability to do our job effeciently.	Nov 2, 2009 7:12 PM
5	post rappel spotter debriefing is occasssionally documented.	Nov 2, 2009 8:34 PM
6	As Forest Fire staff Officer I know the Rappeller shave processes in place, but I have not seen specific documentation, checklists, processes writen down.	Nov 2, 2009 8:36 PM
7	The items not documented are in the IHRG but we do not document when a buddy check has been done. etc.	Nov 2, 2009 9:59 PM
8	All of these items are done but not really documented besides the the load calcs and manifesting.	Nov 5, 2009 5:29 AM
9	If an issue where to arise in a rappel operation it should be documented. I answered these questions as if there were no issues during a procedure.	Nov 7, 2009 5:38 PM
10	I know weight and balance was a big issue for the short S-61 platform; tested through extreme scenarios, the long body rarely can be put out of CG. If rappel units utilizing a type one aircraft are forced to complete a weight and balance calc for each takeoff and landing, why arn't we (USFS) requiring this for all makes and models?	Nov 15, 2009 8:45 PM

Interagency Helicopter Rappel Quality Assurance Survey

EMR - The rappel unit has a process to ensure rappel emergency procedures are established to respond to a situation, serious in nature, developing suddenly or unexpectedly and demanding immediate action, are discussed and coordinated among the rappel spotter and personnel to include, as appropriate:

Select one

	Not Documented not Implemented	Implemented not Documented	Documented not Implemented	Documented and Implemented	N/A	Response Count
Rappel procedures and signals	0.0% (0)	16.5% (13)	0.0% (0)	83.5% (66)	0.0% (0)	79
Helicopter emergency	0.0% (0)	24.1% (19)	1.3% (1)	74.7% (59)	0.0% (0)	79
Engine failure or major component failure	1.3% (1)	26.6% (21)	0.0% (0)	72.2% (57)	0.0% (0)	79
Rappeller in distress	0.0% (0)	19.0% (15)	0.0% (0)	78.5% (62)	2.5% (2)	79
					Comments	9
					answered question	79
					skipped question	23

Comments		
1	Crash rescue protocols are established at the helibase. Also, protocols for an aircraft emergency are discussed and known by all base personnel (e.g. flight following, search and rescue activation). The IHRG outlines procedures for emergencies during rappel operations.	Oct 29, 2009 4:03 PM
2	Academy/spotter/rappeller training.	Oct 29, 2009 8:11 PM
3	ETOs, Bad rope, Bad rappel site are all signals between rappeller and spotter. Crash landing and crash rescue are drilled.	Oct 29, 2009 9:23 PM
4	We live these every day.	Oct 30, 2009 7:16 PM
5	In an emergency, every situation is different. We train our rappellers the emergency procedures established in the IHRG. As spotters, we discuss with our pilots different scenarios that could take place and how we might react to each one.	Nov 2, 2009 7:19 PM
6	these not documented are discussed as a group.	Nov 2, 2009 10:01 PM
7	This is comunicated to use heavily throughout the season and during our training but have not seen this written in a manual or documented	Nov 5, 2009 5:32 AM
8	most documentaion comes from the little direction in the IHRG. All other scenarios are discussed at a local level with all involved but not documented.	Nov 5, 2009 6:18 PM
9	The forms we have do not include a column or row to clearly show where rookie rappelers are performing (w/o prodedural error) ETO procedures.	Nov 15, 2009 8:47 PM

Interagency Helicopter Rappel Quality Assurance Survey

EMR - The spotter has a process to ensure cargo letdown emergency procedures are established to respond to a situation, serious in nature, developing suddenly or unexpectedly and demanding immediate action discussed and coordinated among the spotter, PIC and other involved personnel to include, as appropriate:

Select one

	Not Documented not Implemented	Implemented not Documented	Documented not Implemented	Documented and Implemented	N/A	Response Count
Cargo letdown procedures	0.0% (0)	30.4% (24)	0.0% (0)	68.4% (54)	1.3% (1)	79
Helicopter or cargo on-line emergency	1.3% (1)	29.1% (23)	1.3% (1)	65.8% (52)	2.5% (2)	79
Engine failure or major component failure	1.3% (1)	29.1% (23)	0.0% (0)	67.1% (53)	2.5% (2)	79
					Comments	5
					answered question	79
					skipped question	23

Comments		
1	All of the procedures are outlined in the IHRG.	Oct 29, 2009 4:03 PM
2	Covered in training of all concerned.	Oct 29, 2009 8:11 PM
3	Same response as above.	Nov 2, 2009 7:19 PM
4	This information is in the spotter manuals but as rappellers we do not really know this stuff except the things we need to know if we are still onboard.	Nov 5, 2009 5:32 AM
5	same as above	Nov 5, 2009 6:18 PM

Interagency Helicopter Rappel Quality Assurance Survey

CLO - The rappel unit ensures that personnel who perform helicopter cargo letdown operations maintain competence on the basis of continued training and proficiency in accordance with the IHRG, the helicopter contract and, if applicable, continue to satisfy technical competency requirements. determine conformance with the IHRG on how competence is maintained for the following positions:

Select One

	Not Documented not Implemented	Implemented not Documented	Documented not Implemented	Documented and Implemented	N/A	Response Count
Pilot-in-Command	1.3% (1)	18.7% (14)	0.0% (0)	78.7% (59)	1.3% (1)	75
Check Spotter	1.3% (1)	8.0% (6)	0.0% (0)	74.7% (56)	16.0% (12)	75
Spotter	0.0% (0)	9.2% (7)	0.0% (0)	90.8% (69)	0.0% (0)	76
					Comments	8
					answered question	76
					skipped question	26

Comments		
1	All proficiencies are documented on rappeller reports and transferred to the rappel unit log.	Oct 29, 2009 4:06 PM
2	Compliance with IHRG,IHOG, etc. assured by managment/training division/ops division.	Oct 29, 2009 8:57 PM
3	unknown	Oct 30, 2009 3:23 PM
4	Nationally we do not have a proficiency requirement for pilots	Nov 2, 2009 3:34 PM
5	An outsider may suggest we should do more cargo let down and I would agree.	Nov 2, 2009 5:33 PM
6	We do not keep records (other than copies of pilot cards) for how often PICs are participating in cargo or rappel operations	Nov 4, 2009 5:37 PM
7	unknown if this is documented, not a spotter	Nov 5, 2009 5:33 AM
8	documented annually either through AMD or RAM	Nov 5, 2009 6:20 PM

Interagency Helicopter Rappel Quality Assurance Survey

CLO - The spotter has a process to ensure issues that affect cargo letdown operational safety are coordinated among the PIC and other involved personnel to include, as appropriate:

Select One

	Not Documented not Implemented	Implemented not Documented	Documented not Implemented	Documented and Implemented	N/A	Response Count
Flight risk analysis	0.0% (0)	40.8% (31)	0.0% (0)	57.9% (44)	1.3% (1)	76
Pre-flight spotter check	0.0% (0)	47.4% (36)	1.3% (1)	50.0% (38)	1.3% (1)	76
PIC completed helicopter weight and balance for cargo letdown operations	1.4% (1)	17.6% (13)	1.4% (1)	78.4% (58)	1.4% (1)	74
Pre-flight equipment check	0.0% (0)	45.3% (34)	1.3% (1)	53.3% (40)	0.0% (0)	75
Spotter/pilot in-flight/approach evaluation	0.0% (0)	50.7% (38)	1.3% (1)	48.0% (36)	0.0% (0)	75
Cargo letdown procedures/spotter	0.0% (0)	36.0% (27)	0.0% (0)	62.7% (47)	1.3% (1)	75
					Comments	4
					answered question	76
					skipped question	26

Comments		
1	The IHRG procedures are used for all cargo letdown prodcedures.	Oct 29, 2009 4:06 PM
2	Through IHRG, spotter training, academy training, and proficiency evolutions, all personnel are trained to this standard.	Oct 29, 2009 8:57 PM
3	items left blank are unknown	Oct 30, 2009 3:23 PM
4	The context of these responses should be the same as where I placed the comments of the rappel ops.	Nov 2, 2009 5:33 PM

Interagency Helicopter Rappel Quality Assurance Survey

SMS - The rappel unit has a Safety Management System (SMS)that provides for collection of information and data associated with helicopter rappel operations, and includes systematic processes for identifying and assessing hazards and potentially hazardous conditions.

	Response Percent	Response Count
1. Not Documented not Implemented	4.0%	3
2. Implemented not Documented	22.7%	17
3. Documented not Implemented	1.3%	1
4. Documented and Implemented	**70.7%**	**53**
5. N/A	1.3%	1
	Comments	3
	answered question	75
	skipped question	27

Comments		
1	The crew conducts briefings before each rappel mission to identify any possible hazards or safety concerns.	Oct 29, 2009 4:10 PM
2	Spotter training, spotter mentoring, spotter/spotter, spotter/pilot etc. de-brief procedures, AAR, working group representation.	Oct 29, 2009 9:19 PM
3	AARs, SafeComs, and informal communication between the crew are all forms of sharing information.	Oct 29, 2009 9:26 PM

Interagency Helicopter Rappel Quality Assurance Survey

SMS - The rappel unit implements a mishap/hazard reporting system (SAFECOM) that: i) encourages and facilitates feedback from personnel to identify deficiencies, exposes hazards and raises safety concerns; ii) includes analysis and management action to address operational deficiencies, hazards and concerns identified through the reporting system.

	Response Percent	Response Count
1. Not Documented not Implemented	3.8%	3
2. Implemented not Documented	9.0%	7
3. Documented not Implemented	3.8%	3
4. Documented and Implemented	**82.1%**	**64**
5. N/A	1.3%	1
	Comments	5
	answered question	78
	skipped question	24

Comments		
1	Safecoms are filed when necessary. Safecoms from other places are also reviewed during safety briefings that occur each morning.	Oct 29, 2009 4:10 PM
2	Safecom, Safenet, Working group, spotter group, etc.	Oct 29, 2009 9:19 PM
3	An area that needs improvement.	Nov 2, 2009 8:42 PM
4	This systems needs to be inforced more even when they are minor events	Nov 5, 2009 5:35 AM
5	Although we are 'encouraged' to identify safety concerns or document SAFECOM's when there is a mistake, this is not always the case. We work in an environment in which making a mistake during a rappel operation is greatly looked down upon, for good reason. Yet this pressure does not encourage individuals to speak up when there has been a mistake made especially when they are at fault. It is a vicious cycle. We are hammered on to not make mistakes, yet to let ego go when a mistake has been made is harder to do in this type of work environment.	Nov 7, 2009 5:49 PM

Interagency Helicopter Rappel Quality Assurance Survey

SMS - The rappel unit has a process for identifying and investigating irregularities or other non-routine operational occurrences that might be precursors to a rappel or aircraft accident or incident.

	Response Percent	Response Count
1. Not Documented not Implemented	7.9%	6
2. Implemented not Documented	18.4%	14
3. Documented not Implemented	0.0%	0
4. Documented and Implemented	**72.4%**	**55**
5. N/A	2.6%	2
	Comments	5
	answered question	76
	skipped question	26

Comments		
1	Safecoms	Oct 29, 2009 4:10 PM
2	We follow IHRG guidelines and policies.	Oct 29, 2009 9:05 PM
3	Working groups, spotter groups, etc.	Oct 29, 2009 9:19 PM
4	It depends where you go some places are very good with info sharing but other places don't spread the word. So it's Implemented but not always passed on for others to learn from lacking documentation	Nov 2, 2009 10:11 PM
5	any actions that are outside of established standards are reviewed documented and evaluated for changes and coorective actions	Nov 5, 2009 6:21 PM

Appendix H

History of Rappelling on Fires

A Brief History of Helicopter Rappelling on Wildfires

Much of the information noted for events prior to 1995 is from a History of Helirappelling, 1964-1995, by Scott Whitmire.

Following the Korean War, the helicopter had really started to come into its own as a viable and useful flying machine. Though it had been around since the 1930's, and was beginning to get some notoriety as an air-rescue platform in the 1940's, the Korean War provided the budget and environment needed for the helicopter to develop and prosper. As the military had realized the value and diversity of this aircraft, other civilian and government agencies in Canada and the United States determined that it would add a new element to their land management organizations' already well established aerial firefighting programs.

The US Forest Service had utilized this new aircraft on wildfires as early as 1946 and by 1949 the helicopter played a critical role in one of the most devastating fires experienced in wildland firefighting. The Mann Gulch incident sent a devastating blow across the nation and the agency recognized the needed asset of the helicopter. It employed the aircraft to provide observation duties and the solemn transport of thirteen young fatalities out of that remote Montana burn over.

In an attempt to further use helicopters for firefighter transport, the agency stepped up the employment of the helicopter and creative and determined crews began to develop a means of exiting helicopters by having the aircraft hover just above the ground while crewmembers jumped. Quickly discovering the perils of this mode of exit, they soon developed a well padded "helijumping suit" designed to cushion the landing as the fearless men launched themselves from a height of 10-15 feet into the brush. Though it was a small improvement, the entire ordeal proved cumbersome and was often riddled with injuries.

By the late 1950's and early 1960's the military had taken on the challenge of rappelling from the helicopter.

In the meantime, the Bureau of Land Management was beginning to dabble in this delivery system as the need for rappel capability from helicopters became apparent. It was put to the test on a 20,000 acre Alaskan fire that required clearing of several helispots in a heavily wooded area. With a few smokejumpers donning their jump pants, running the ropes through the D rings on their pants and tying off to the skids, they slid down the ropes and cleared the area for a week. It was a success, and by the following winter pursuit of a rappel program was in full swing and equipment was a priority. That spring, after several hundred practice rappels, a demonstration rappel was scheduled for the media. Cameras were abundant as the rappellers readied themselves for this very public introduction to a new form of firefighter delivery. One young rookie smokejumper who had been heavily involved in the training, began his descent from the helicopter with a Sky Slide, part way down the rope the device failed plummeting the young man the remaining 60 feet to the ground. Seriously injured and fortunate for the close location of a military hospital, the young firefighter endured significant rehabilitation and eventually recovered – the Sky Slide was never used again (Whitmire, S., (August 1995) History of Helirappelling, p.4.) To this day, the Sky Genie descent device has

been the only piece of equipment used for rappel in the US Forest Service and has never had a failure.

In the late 1960's and early 1970's Professor Bob Henderson of the University of British Columbia a principal in the company International Forest Fire Fighting Systems, LDT, (IFFS) offered full service helicopter rappelling to the province of British Columbia. Utilizing Bell 206A helicopters with 2 firefighter rappellers and 1 rappel spotter aboard per mission they were able to safely and efficiently place firefighters on fires. By 1975 BC had completed over 50,000 rappels with only one significant injury.

USFS Region 6 Fire Director K.O. (Ken) Wilson and Assistant Director Frank Lewis were both intrigued by the concept and saw an opportunity to utilize Helicopter Rappellers in some of the east-to-west running drainages on the west side of the cascade mountains. These drainages had both a high incidence of lightning fires and an unfortunate record of smokejumper injuries. The injuries often occurred as smokejumpers landed in snag patches from old fires and incurred serious leg, knee, hip and back injuries as they "burned out of the snags."

The Redmond Air Center, led by Air Center Manager Jim Allen, with Smokejumper Operations Foreman Tom Bowen and the project leader took on the task of designing the procedures and equipment.

Behind the scenes Regional Aviation Officer Wally Tower and Regional Helicopter Pilot Larry Johnson assessed the aircraft needs for the project and initially determined that the Bell 201A1 would be the preferred platform to use. The 205A1 and the Bell 212 were both used during the evaluation period of the program (1972-1975). Another key contributor was Region 6 Fire Equipment Specialist Bill Wood who guided the development of the equipment used in Helicopter Rappelling.

As the developers honed the equipment for the program they also recognized that training, an appropriate rappel platform and efficiency would need to be justified if the program would ever become a viable resource for wildland firefighter transport.

With the Sky Genie as the descent device of choice, the rope was just as critical. During the early tests, the Sky Genie was 3/8 inch and the rappellers were handed a ½ inch rope for their test rappels. Obviously this required a lot of feeding of the rope and a very slow descent. As is the purpose of testing, they soon abandoned the 3/8 Sky Genie for a ½ inch Sky Genie as standard equipment.

Harnesses, helmets, gloves, clothing and eye protection all went through various stages of trials, setbacks and improvements. Much of the equipment was adopted from the smokejumper community and then augmented to meet the unique needs of the rappel mission. The harness experienced a minimum of five variations and has now settled on the HR-2 rappel harness. The helmet was again borrowed from the smokejumper world complete with face mask. It evolved to a standard agency approved flight helmet with intercom capabilities and a visor that meets the eye protection requirements.

The anchor plates were a real concern when developing the rappel system. Several different bracket systems were applied with satisfactory success, but two of the systems created enough apprehension in the structure that the technology laboratories soon came into play. With so many different helicopter platforms used in rappel operations, one standard anchor plate was not possible. As the anchor plates were developed and tested, they were required to go through a rigorous approval process through the Federal Aviation Administration (FAA). This process ensures a safe experimentation protocol, which at the end of the process provides a Supplemental Type Certificate (STC) for approved use of the device. Today, all contractors must have an STC for their anchor device and it must be inspected as per the instructions on the certificate.

Cargo delivery was a final piece to the rappel system puzzle that proved difficult for the pioneers of the program. Anyone with a good idea or even a not so good idea would get a crack at attempting a successful cargo letdown. This ranged from a free fall (resulting in equipment fatality) to a 12-foot cargo chute to finally the suggestion of a figure 8 descent device. The often 100 pound bag of equipment was cumbersome, especially in the lighter Type 3 helicopters where space was minimal. This created a second means of cargo deployment, the external cargo letdown. The external cargo system took much of the strain off the spotter and opened up another option for rappel configuration.

The aircraft was obviously a critical part of the equation. The Canadians had only certified a small single engine turbine aircraft for their program, the Bell 206 Jet Ranger. However, the US opinion was that the medium platform was a more reliable aircraft and a better risk for the program. The Bell 205A-1 was assigned the job and in July 1973 the first fire rappel took place on the Deschutes National Forest. That season saw 140 rappels into 27 different fires on five different forests (Whitmire, S., (August 1995) History of Helirappelling, p.5). Rappel had proven itself and was well on its way – or so it thought.

In 1975, the Chief of the Forest Service directed Region 6 to produce a document assessing the results of the evaluation years and to recommend a course of action regarding helicopter rappelling. Region 6, with the assistance of the National Office and the Bureau of Land Management completed the report and recommended that Helicopter Rappelling be approved as a system and that it be limited to twin engine helicopters. The Chief concurred and approved the Region 6 recommendation. However, there was little agreement on the wisdom of rappelling by the other western Regions. Region 5 went so far as to ban the practices. However, rumor has it that every now and then the Cave Junction Rappellers rappelled in California with their resource status reported to the Regional Office as Cave Junction Smokejumpers.

From 1977-1982 the helicopter rappel program continued, although with a reduced number of aircraft each year after 1978, only in Region 6 and only with twin engine helicopters.

By 1983, the rappel program had been shut down. With a requirement established to only use dual engine aircraft, the program became too cost prohibitive for the value to the agency.

By 1987, with a lot of work, reliability testing on L-III and Allison engines and determination by a

handful of individuals, a single engine rappel program re-emerged with an eye on lean, safe and efficient operations. This time Region 3 took the lead. The program quickly spread through Regions 3, 4, 5 and 6 and the value that the helicopter brought to firefighting was quickly embraced by incident commanders. Not only did the aircraft bring firefighters to the fire and place them in strategic locations, but it quickly transformed into a multi-use support tool; flying buckets of water in support of fire lines and personnel, slinging gear and equipment to remote locations in a short amount of time and even providing medivac capabilities if necessary. By 1995 there were 32 rappel bases nationwide and again the program was strong.

Training back in the day was what they could make of it. Obviously they needed ground training before they could step off a skid on a live rappel, so towers and simulators began popping up at these bases. As their experience with simulators grew and the value was evident, all bases were eventually required to have a tower of at least 20 feet in height, for initial and refresher training. Region 6 found immense value in establishing standardized training thorough the region. They were very active in the booster program, which allows the exchange of rappellers from one base to another base who may need extra personnel with an increase in activity at their location. Region 6 settled on an annual rappel academy that requires all seasoned and rookie rappellers to attend the week long academy in John Day, Oregon. The success of this academy has been lauded by regional and national aviation managers for its professionalism, safety, expertise, experience and value for the Region 6 rappel program.

By the mid 1990's however, the federal budget was in a crisis and federal programs were taking big hits. The rappel program kept its place through the lean times of the federal squeeze and as the 21st Century flourished, so did the rappel program. Bases were being added in new locations such as Region 1 and Region 2 and today there are 50 bases with nearly 750 rappellers throughout the country.

From 1995 through 2009, the rappel community had become well established with its history of hard fought battles and determination to build a successful program. This determined culture of the rappel personnel continued as they worked to improve their operations. In the late 90's a national group was established which brought together management representatives and rappel specialists with a responsibility to ensure the exchange of ideas and techniques throughout the entire program. This group was called the Rappel Working Group. Its specific mission is to promote the safety and well being of all involved in rappel. They have a charter within the Interagency Helicopter Rappel Guide, which spells out in detail how the group is selected, how meetings are to be conducted, what their mission is and how the general business of the rappel community is to be run in a more standardized manner.

This group has significantly impacted the entire program. One area that was tackled was the anchor system in the aircraft. The many of the anchor systems were floor anchors while others were overhead anchors. The group chose to approve the overhead system as the primary anchor system for several reasons. First, to get the rappel equipment up off the floor so it wasn't being stepped on or tripped over, and the second was to standardize the exit procedures from the helicopter. All aircraft with the exception of the Bell 206-L4 now operate only with the overhead anchor system.

In the early 2000's, Region 6 saw a need among their bases to continue toward a standardized program, at least region wide. By 2002 they had launched an annual rappel academy in John Day, Oregon, that would bring together all the bases within the region and train all rookies, recertify all seasoned rappellers and standardize all the operations between bases. Some crews outside Region 6 have attended the academy, but it remains a unique training project to Region 6.

In 2009 a tragic accident occurred during a proficiency rappel at an active helibase. A young firefighter fell to his death, the result of an incorrect hook-up between the harness and the Sky Genie. He became the first fatality in the 37 years since the program began. Following this accident the rappel program began to examine itself very thoroughly and a major effort was set in motion to standardize the program nationally.

Over the years the vision of the pioneers of the program mostly turned out to be accurate. Rappellers were able to land safely near fires in a wide variety of weather conditions and implement effective initial attack and the overall accident or injury occurrences for rappellers have been minimal through the years.

The adventurous and determined individuals who helped test, develop and grow the program in those early years of the 70's and 80's moved into positions of management and authority. Their presence has continued to impact the program, bringing a valuable level of professionalism and knowledge to this ever improving and evolving system of firefighter delivery. Professional training has taken center stage in most regions; passion for safety was paramount from the beginning and has continued to be the focal point of the program, and finally a determination for efficient utilization of the asset is instilled to every young crewmember on every base. Those hard fought battles in the early days instilled pride in ownership and success of a now nationally respected and valuable program.

Appendix I

Civil Rotorcraft Risks

CIVIL ROTORCRAFT RISKS

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Presented at the2002 China International Helicopter Forum,
Chengdu, Sichuan, People's Republic of China,
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CIVIL ROTORCRAFT RISKS

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INTRODUCTION

Safety has always been a factor in the growth or lack-of-growth of the helicopter industry. The perception of the lack of safety has caused fleet groundings and the prohibition of helicopter operations. There are many facets of safety, but the bottom line is that occupant safety is achieved by the management of risk. If you can reduce the risk, safety has improved.

CIVIL HELICOPTER HISTORY

The civil helicopter history started with the first civil certificated helicopter in 1946, the Bell Model 47, registry of NC1H (Fig.1.). The civil helicopter industry, like the military helicopter industry, has since grown and spread throughout the world. The Model 47 series included about 4,600 civil and military models until all Model 47 production was stopped in 1974. The safety history of the Bell Model 47 series, which was the most popular helicopter in those early days, is typical of the early aviation. The 47 accident rate was very high at the start of civil helicopter aviation, as the operators were finding new ways to use the helicopter. The designers were fixing those problems due to the aircraft as they became evident from accident investigations. The annual accident rate decreased over time with the maturing of the 47 fleet, but it stabilized to a fairly constant rate (Fig. 2). The large fluctuations in annual accident rates in the later years are due to inaccuracies of the FAA's estimates of Model 47 flight hours. Basically, the Model 47 accident rate has been the fairly constant for the last 40 years.

WHAT IS AN ACCIDENT?

When an unusual occurrence happens in or around an operating aircraft, the severity of the damage or possible injuries can vary widely. Thus there is a threshold beyond which the government must be notified of a serious occurrence. Events severe enough to be called accidents are required to be reported to the government and some type of investigation is warranted. Events less than this threshold level, such as maintenance or very minor events, are generally not reported to government. Therefore the location of this dividing line between required reportable and non-reportable events becomes quite important and must be defined. Each government has an agency tasked to investigate such serious occurrences with the goal of reducing that type of problem in the future for the flying public. In the United States of America (USA), that government agency is the National Transportation Safety Board (NTSB). Each of the Military Services has a similar segment of the service that is tasked to do accident investigations. Countries that are signatories of the International Civil Aviation Organization (ICAO) have agreed to standardization of accident investigation (as much

Fig. 1. NC1H, the first civil certificated helicopter.

Prepared for the 2002 China International Helicopter Forum, Chengdu, Sichuan, China, 27–28 August 2002.
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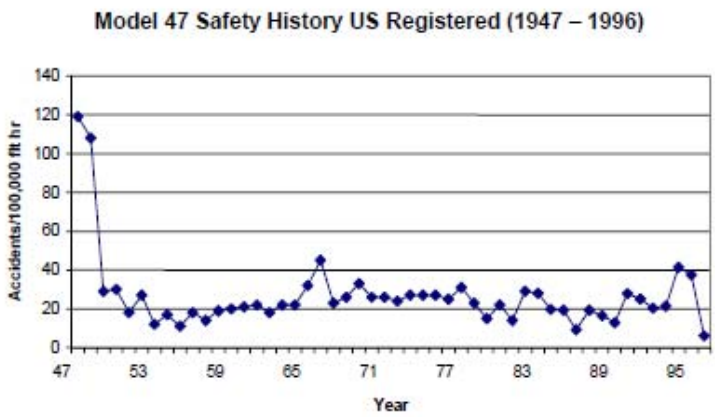


Fig. 2. Model 47 annual accident rates for 50 years.

as possible) based on ICAO Annex 13. Each country then bases its definition of a reportable event on the definition in Annex 13. NTSB's definition is defined in 14 CFR Part 830.2, which states:

> "Aircraft accident" means an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.

Substantial damage requires further definition, as the range of damage may be quite wide. Therefore 14CFR Part 830.2 continues and states:

> "Substantial damage" means damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component. Engine failure or damage limited to an engine if only one engine fails or is damaged, bent fairings or cowling, dented skin, small puncture holes in the skin fabric, ground damage to rotor or propeller blades, and damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wingtips are not considered "substantial damage" for the purpose of this part.

Examples of this wide range of what is considered an accident with substantial damage range from a minimal accident of a wrinkled tail boom requiring maintenance with no injuries during a poor landing (Fig. 3.) to a very serious accident where the aircraft is destroyed by fire and all occupants were fatally injured (Fig. 4). As a side note, the aircraft data plate from this foreign accident shown in Fig. 4, was sold for $1.00, and another aircraft was counterfeited using that plate and a military surplus UH–1 fuselage. That counterfeited aircraft later crashed in the USA due to a military surplus part failure.

Accident rate comparisons should always use a common definition of what constitutes an accident. Otherwise, one data set will be including only extremely severe events whereas the other data set will be considering minimal damage events as well as severe fatal events. With civil aviation around the world, the definition of an accident is quite commonly based on the ICAO Annex 13, and does not change over the years. The U.S. Military Services under Department of Defense (DOD) use a different classification system. Both the civil NTSB and the U.S. Military Services include a serious or fatal injury as part of the accident definition threshold, but differ in the aircraft damage. The DOD definition for aircraft damage is based on the cost to repair. This level of aircraft damage cost for a Class A mishap has changed over the years from:

- $100,000 or more, then changed to
- $200,000 or more, then changed to
- $500,000 or more, then changed to
- $1,000,000 or more (present level)

Fig. 3. Wrinkled tail boom accident.

Fig. 4. Aircraft destroyed by fire with fatal injuries.

Thus one should not attempt safety comparisons between civil helicopter safety and military helicopter safety, due to the lack of a common event being measured. Safety comparisons should stay within common guidelines of events and types of exposure to be meaningful.

PERIOD OF EXPOSURE TIME

Measuring risk can only be done by knowing the amount of exposure to risk. Some people express risk in terms of accidents per departure or takeoff, which is quite misleading. You are at risk at all phases of flight, not just during the departure/takeoff. In flying, you are exposed from the time you leave the ground until you return to the ground; that period is referred to as the flight time, measured in hours. Thus the flight hours of an aircraft type must be known in order to develop the different types of risks relative to that aircraft type. The only official U.S. Government source of flight hours is the FAA General Aviation Avionics and Activities Survey (now called General Aviation and Air Taxi

Activity Survey), which is conducted on an annual basis. The FAA sends out a questionnaire to a sampling of operators of U.S. Registered aircraft base on models and the state of the owners. The FAA then develops annual flight hours based on the questionnaire responses. Unfortunately, the FAA has stopped providing flight hours by model series, beginning in 1997. Thus the latest year for developing meaningful risk measurements is 1996.

The helicopter accidents used to determine frequency of occurrence must be applicable to the flight hours available for that model. The amount of flight hour exposure was determined for this study by helicopter model for the last 10-year period of 1987 through 1996 from the FAA data. Helicopter models deleted to improve accuracy were those models with less than 50,000 flight hours for the 10-year period, homebuilt/kit helicopters, and those with non-U.S. registry numbers. Also, if a model had an accident in a year in which there were no FAA flight hours estimated, that accident was deleted. This resulted in the elimination of 181 accidents. The remaining 1534 accidents and their respective flight hours were separated into five groups for analysis.

The "Military Surplus UH–1" group was separated out. This is a rapidly growing segment due to the U.S. Department of Defense (DOD) services (Army, Navy, Marine Corp, and Air Force) release of military aircraft as surplus aircraft into the civil fleet. These single turbine-powered helicopters were designed and produced by Bell to military requirements and not to civil certification requirements. These aircraft include UH-1A/B/C/D/E/F/H/K/L/M/P/V military models. The military services have modified their aircraft design over the years before their release into the civil world. Some of the UH–1s are being used well beyond what they were designed to do, which has caused a growing number of accidents. The military surplus UH–1 aircraft are in many severe uses, such as repeated heavy lift and logging. The FAA flight hour estimate is a mixture of these military surplus UH–1s and the Bell civil certificated 204B and 205A1. The 204B and 205A1 flight hours in some years were separate; in other years, the flight hours were combined into the military surplus UH–1. The 1996 U.S. registry showed that 93.2% of this group of 616 aircraft (UH–1, 204B, 205A1) were actually military UH–1 aircraft. Therefore this single turbine-powered helicopter group is predominately military surplus UH–1s and is treated as such. Since more UH–1 aircraft are scheduled to be surplussed in the future, they will continue to be major growing segment of civil aviation.

The "206" series is a group of its own, since it flew 40.9 % of all helicopter flying during this 10-year study period. The single-turbine-powered 206 helicopter continues to be the most prevalent helicopter in the USA and the world.

The "Other Single Turbine" group consists of the remaining single turbine-powered helicopter models with FAA flight hours, which are the 369/500/600, AS350, and SA316/319 models.

The "Single Piston"-powered group consisted of the following series: R22, 47/H13, 269/300/TH55, F28/280, and UH12/H23. The term "piston" is commonly used to describe a reciprocating engine that has pistons. Those accidents of aircraft where the original piston-engine certificated configuration was modified to a single turbine configuration were also deleted.

The "Twin Turbine" group consisted of the following series: BO105, BK117, 412, 212, AS355, 222/230, A109, S76, S61, and S58T. The flights hours of exposure and the number of accidents for these five groups are Table 1.

The helicopter models within this study of Table 1 accounted for 9,841 U.S. registered helicopters as of the end of 1996. The percentage of each group's fleet is Fig. 5.

RISK TO THE AIRCRAFT

When the amount of damage or injury exceeds the definition of an accident discussed earlier, that event is an accident and must be reported to the government authorities. The frequency of those reported accidents also determines the financial risk of operating fleet of those aircraft. The proper metric is the common accident rate calculated as the number of accidents of a time period divided by the flight hours flown during that time period. This rate determines the likelihood of having a reportable accident for all causes, but that

Table 1. Helicopter groups with 10-year accidents and exposure

Helicopter Group	Accidents (1987 – 1996)	Flight Hours (1987 – 1996)	Percentage of Flight Hours
Single piston (reciprocating engine)	864	4,974,421	23.3
206 Single Turbine	306	8,739,554	40.9
Other Single Turbine	226	3,734,015	17.5
H–1 Military Surplus Single Turbine	55	496,204	2.3
Twin Turbines	83	3,406,927	16.0
Totals	1,534	21,351,121	100.0

is not the same as the likelihood of the occupant being injured or killed. Different types of aircraft have different accident rates. Further, the types of operations (missions) being flown by these aircraft are likewise very different. Some types of operations are extremely safe and others are extremely hazardous. So the same helicopter model can have significantly different accident rates, depending on how it is being used. As a starting point, the risk to the aircraft of a government reportable accident is shown in Fig. 6. The five helicopter groups of this study are noted in red color. "R/W" indicated rotary-wing aircraft (helicopter), whereas "F/W" indicates fixed-wing (airplane). Fixed-wing airplane segments of U.S. Aviation are noted in blue color. Scheduled 121 Air Carriers and Scheduled 135 Air Carrier (Commuter) operations are the typical airlines used by the flying public. The Non-Scheduled 135s group is made up of commercial operations called Air Taxi, which are predominately fixed-wing airplanes.

The "HSAC Gulf of Mexico" is a select group of helicopters (single-turbine and twin-turbine) that operate offshore in the Gulf of Mexico to and from oil/gas rigs. Note that the HSAC aircraft risk of a reportable accident is significantly lower than the other three turbine helicopter fleets of this study that include all types of operations, even though their over-water operations can be quite hazardous. HSAC (Helicopter Safety Advisory Conference) is a group of oil companies and helicopter operators who have banded together as an organization to improve safety for all that operate in the Gulf of Mexico. Their accident rate is about the same as General Aviation turbojet airplanes and the Commuter Airlines.

Accident rates are risk of a reportable accident occurring, which is not the same as the risk of injury to an aircraft occupant.

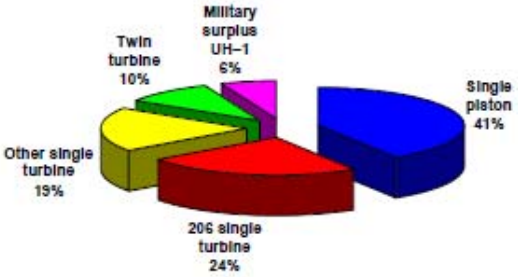


Fig. 5. US Registered Helicopter Fleet in 1996.

RISK OF ACCIDENT DUE TO INITIATING CAUSE

The overall accident rate just shown in Fig. 6 is the total of all of the accident causes that required the reporting of an accident to the government agency (NTSB). Accident causes are separated into two major categories. One category consists of those accident causes that were due to the aircraft (called airworthiness causes, as they directly relate to the certification of airworthiness). The other category consists of the non-airworthiness causes of pilot error, weather, maintenance error, other persons, and unknowns. The accident rates from all causes and airworthiness-only causes are shown in Fig. 7. The Twin Turbine helicopters had the lowest accident rate (risk to the aircraft) for all causes and the Single Piston helicopters had the highest accident rate. Considering only the accidents that are due to the aircraft (e.g., airworthiness failures), the lowest accident rate is shared by the Twin Turbine and the 206 (a single turbine) at a rate of 0.7/100,000 hours. The highest accident rate due to the aircraft airworthiness failures was the Military Surplus UH–1s at 5.4/100,000 flight hours. This is an indicator of the severe use (and sometimes abuse) of using an aircraft to do missions for which it was not designed.

Again all of these aircraft are used in many different types of operations (Table 2).

ARE YOU SAFER WITH A TWIN ENGINE OR A SINGLE ENGINE?

This question has been around for years and the myth has unfortunately continued into the turbine helicopter fleets. The two-engine safety myth is based upon early 1900s aviation, when airplanes were equipped with extremely unreliable reciprocating engines that failed quite often. This historic multi-engine airplane thinking has mistakenly been applied to helicopters. In commercial airline operations, we started with two-engined airplanes, then went to three-engined airplanes, and then went to four-engined airplanes. The commercial airlines then switched from reciprocating engines to the new and reliable turbine engines. In the last decade or so, commercial airlines have gone from four-turbine engines, to three-turbine engines, and to the present two-turbine engine aircraft. The reliability of the present-day turbine engine in airplanes and helicopters is extremely high. Even on the latest large transport airplanes (Boeing 767, etc.) used by the airlines, ETOPS regulations allows the two-turbine engine airplane in commercial service, after an engine failure or is shutdown, to fly up to 3 hours on the remaining engine (now it is a single engine aircraft) before it is required to land. Even with the major engine reliability improvements is aviation over the years, some people still mistakenly believe the myths of Table 3.

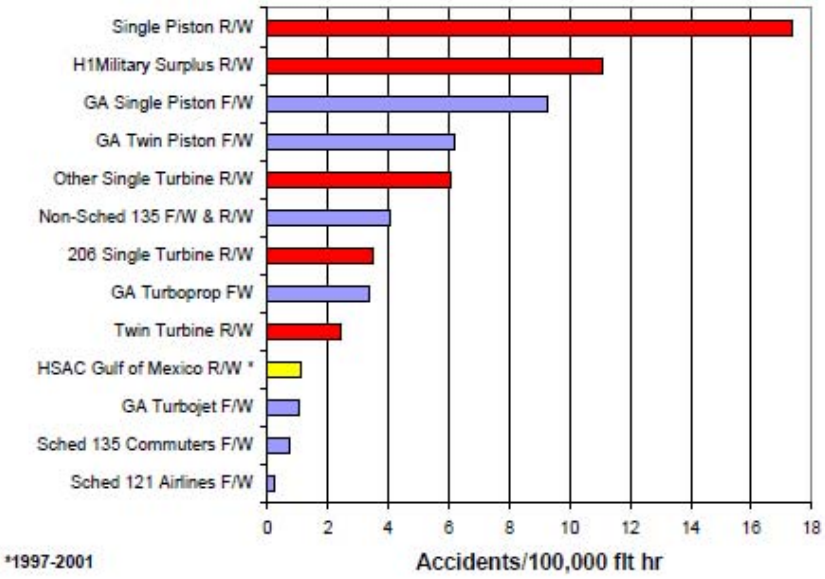


Fig. 6. Risk of Reportable Accident of US Registered Aircraft (1987-1996).

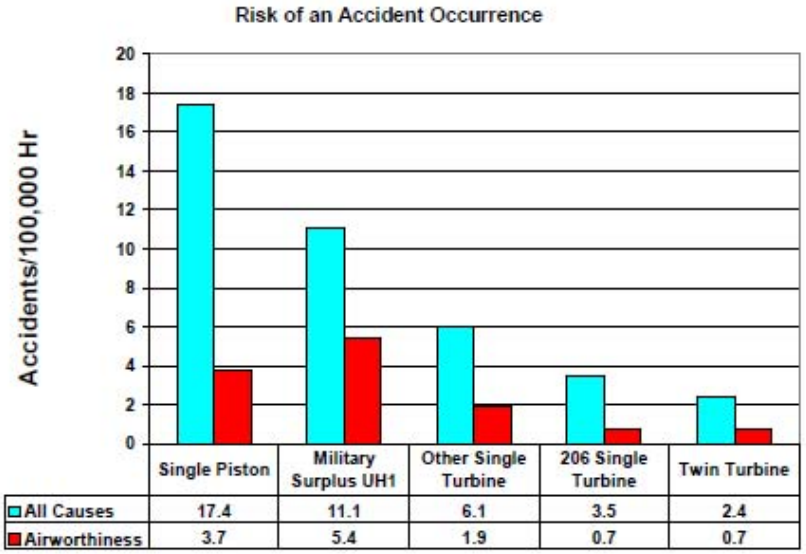


Fig. 7. Risk of a reportable accident.

Table 2. Helicopter civil types of operations.

FAR	TYPE OF CIVIL OPERATIONS
137	Aerial Application
133	External Loads (Logging)
133	External Loads (Others)
135	Air Taxi (Air Medical Service)
135	Air Taxi (Commercial Air Tour)
135	Air Taxi (Commercial Passenger – Other)
135	Air Taxi (Cargo)
91	Aerial Observation/Patrol
91	Air Medical Service
91	Business
91	Commercial Air Tour
91	Corporate/Executive
91	Electronic News Gathering
91	Instructional (Part 61/145)/Training
91	Maintenance/Test Flight
91	Personal/Private
91	Positioning/Ferry
91	Sightseeing
91	Utility Patrol & Construction
91	Other Aerial Work
N/A	Public Use/Government Use (FARs not applicable)

All of the beliefs in Table 3 are FALSE. They are only myths that are not supported by actual facts.

The single-turbine 206 and twin turbines from Fig. 7 had the same airworthiness accident rate of 0.7/100,000 flight hours. Airworthiness includes failures of all components of the aircraft such as the engine(s), airframe structure, rotors, drive systems, hydraulics, electrical, controls, etc. Comparing just the engine failure portion to the rest of the aircraft failure causes shows a different distribution of where the airworthiness failures are being initiated (Fig. 8). On the 206, 80% of the airworthiness accidents were due to the engine, and the Twin Turbines had 12% of their airworthiness accidents still caused by engine failure. So the second engine in a twin did not eliminate all accidents due to power loss and thus dispels one of the myths. The non-engine airworthiness (the rest of the aircraft) causes accounted for 20% for the 206s and 88% for the Twin Turbine's airworthiness accidents. It is obvious that the "remainder-of-the-aircraft-stays-the-same" belief is not true, and is only a myth.

There are many factors at work. One should not count number of engines, as that is misleading from a safety point of view.

Sometimes a single turbine is best choice for safety; sometime a twin turbine is the best choice for safety. Most of the time, it doesn't matter for safety reasons, and the choice should be based on payload and economic issues. The specific type of operation being planned, where it is to be done, and how you will do that operation are far more important than an engine count. The above is only related to the chance of a reportable accident occurring and does not consider the myths related to the actual risk of an occupant being hurt, which will be discussed later.

Table 3. Twin-Engine Safety Myths

1. You are automatically safer with two engines than with one engine, since you have one engine left when the other one fails such that you can always fly away.
2. That the effects of the remainder of the aircraft failing is the same with one or two engines installed.
3. That the increase of pilot errors from the additional pilot workload, decisions, and mistakes in normal and emergency procedures is the same with one or two engines installed.
4. That safety regulation should be based on One Engine Inoperative (OEI) performance and the failures of the rest of the aircraft can be ignored
5. That the injury risk resulting from an engine failure is eliminated by having a second engine.
6. That the injury risk is the same in all types of helicopters.
7. That the injury risk is the same regardless of what caused the accident.
8. Regardless of being in a helicopter or in an airplane, if you lose all engine power, you will likely die.

WHAT CAUSES HELICOPTER ACCIDENTS?

The causes of the accidents of the five separate helicopter groups are Fig. 9. The Engine Airworthiness (Eng AW) and Non-Engine Airworthiness (Non-Eng AW) were those accidents where the failure was confirmed (i.e. fatigue, broken, etc.). There was another group in which the pilot "claimed" that he had a power loss and that was the reason he crashed. However, during the accident investigation, the engine subsequently ran fine and no failures in the engine or related systems such as fuel, could be determined. The dilemma for the investigator then becomes what/who to believe. The hard facts (nothing found wrong with the engine or related systems) or the pilot's statement? This is a difficult situation that will not likely improve in the future until there is some type of recording device onboard, such as a Flight Data Recorder (FDR) or Cockpit Audio Visual Recorder (CAVR). Until the investigator can prove one way or the other, this group of accident causes (Suspected Eng AW) will continue.

During this 10-year study, the Suspected Engine AW accidents were considered as actual Engine AW accidents, with the exception of Fig. 9. This Fig. 9 is in descending order of all Airworthiness failures (Engine, Suspected Engine, and Non-Engine AW). Pilot Error is the most common cause of helicopter accidents. The segment labeled "Maint-Other" is accidents due to gross maintenance errors and other persons (other than the pilot or mechanic) that caused the accident. This could include interfering with flight controls or a non-pilot attempting to fly. The remainder was Unknown causes. Although most accidents have several causes, the initiating cause was used in this study.

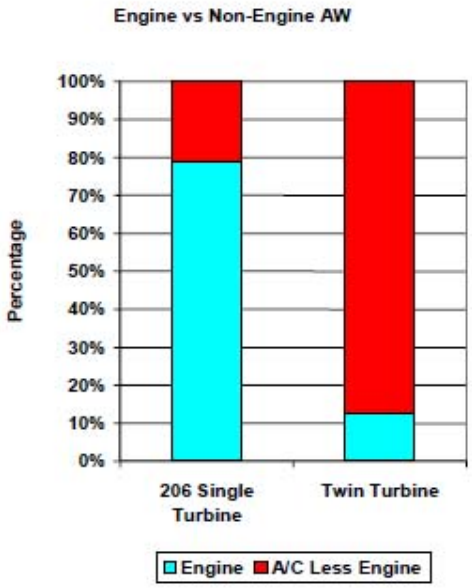


Fig. 8. Airworthiness failure causes of accidents.

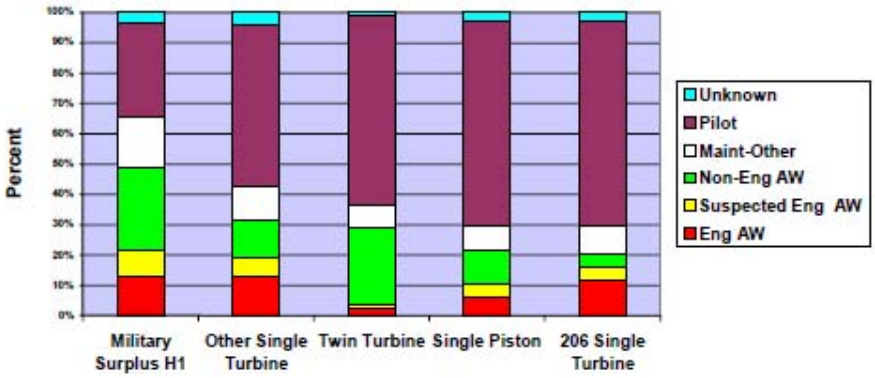


Fig. 9. Accident causes.

SURVIVAL IN HELICOPTER ACCIDENTS

Is the risk of an occupant injury determined by the aircraft accident rate? No. Most of the occupants in accidents are not seriously hurt. Survival depends on many factors, such as

- Aircraft attitude at impact,
- The amount of impact load and direction,
- The type of restraint worn,
- Occupant impact load tolerance,
- Impact surface,
- Aircraft,
- Type of seat,
- Post-crash fire protection,
- Emergency egress

Fig. 10 shows the percentage of occupants that received a fatal injury or survived in Airworthiness caused accidents and the remaining accidents (Non-AW causes) for each of the five groups. Fig. 10 is ordered by descending percentage of fatalities. About 5% of the occupants received fatal injuries in accidents from airworthiness failures (includes engines and non-engine airworthiness failures). Overall, 90% of the occupants survived in helicopter accidents. It is interesting to note that the Twin Turbine had the highest percentage of fatalities for all airworthiness failure of the five study groups. Again, it is apparent that the number of engines is not the controlling factor in occupant survival and the remaining myths are dispelled. Although these values are percentages, they are consistent with the injury rates that are discussed in a later section.

SAFETY IS THE LACK OF INJURY RISK

Webster's Dictionary defines "safety" as "the condition of freedom from harm, loss, or injury." There is no absolute safety in aviation. If you minimize the risk to the occupants, you have improved their safety. Safety is the management of risk. The key is to remember that safety is primarily an outcome related to the occupant, whereas an accident is an event primarily related to reporting aircraft damage.

Some people incorrectly use fatal accident rates as a measure of safety. A fatal accident in any accident in which at least one person receives a fatal injury. The fatal accident rate then is the number of fatal accidents divided by the hours of exposure. As an example, consider a Model A aircraft had an accident in which one of the two occupants received a fatal injury and that fleet had flown 100,000 hours. The Model A fatal accident rate is 1/100,000 hr. Model B also flew 100,000 hours, and one aircraft crashed and 235 occupants of the 300 occupants onboard received fatal injuries. The Model B fatal accident rate was 1/100,000 hr, which was the same fatal accident rate of Model A. Therefore Model A and B have the same safety? No, there is a vastly different societal loss. Fatal accident rates are misleading and should not be used.

RISK OF FATAL INJURY

Safety is measured by an individual's risk of being seriously injured. Risk of fatal injury (RFI) is the method to calculate that individual's risk as the likelihood of an accident

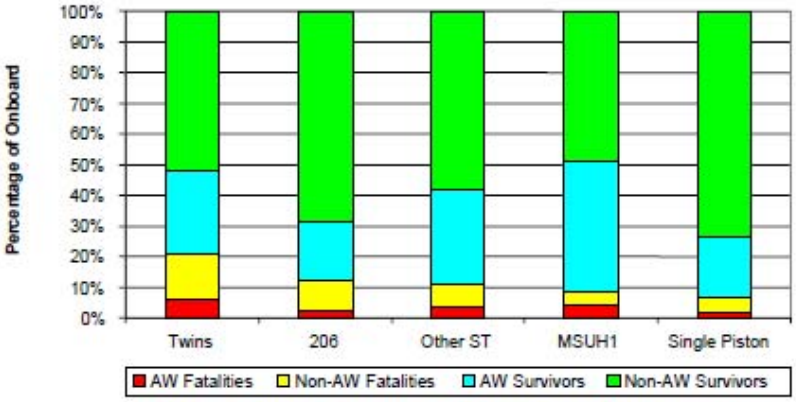


Fig. 10. Survival percentage in helicopter accidents.

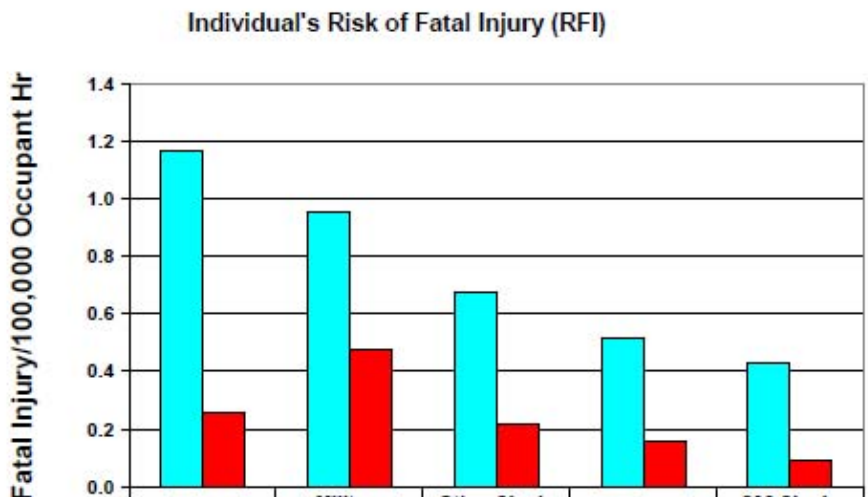
occurring, times the likelihood of receiving a fatal injury. Thus RFI can be expressed as follows:

$$\text{RFI} = \frac{\text{Number of accidents}}{\text{Flight hours flown}} \times \frac{\text{Number of people with fatal injuries}}{\text{Total number of people on board in accidents}}$$

RFI is your individual risk of receiving a fatal injury per 100,000 occupant hours to which you are personally exposed (flying) in that aircraft. The RFI for the five groups was determined for all accidents (all causes) and for just those caused by airworthiness failures (Fig. 11).

First, consider what your individual risk is, due to the aircraft itself. The lowest individual's RFI was 0.09/100,000 occupant hours for all airworthiness-caused accidents (including suspected airworthiness causes) was the single engine 206. This occupant risk in a 206 was a 43.8% lower risk than for an occupant in the Twin Turbine group. This indicates that the number of engines on a helicopter is certainly not the predictor of an individual's risk of a fatal injury—and more myths are dispelled. Likewise, the 206 occupant RFI for airworthiness-caused accidents was 59.1%, 65.4%, and 80.9% lower than the Other Single Turbine group, Single Piston group, and Military Surplus UH–1 group, respectively. This points out that the individual aircraft design and how the aircraft is used, and the type of operation being conducted, are extremely important. The detrimental effect of the Military Surplus UH–1 being used in operations for which it was not designed is quite evident. The laws of physics always apply, regardless of civil aviation regulations and aviation myths.

The reality is that you will not die from just airworthiness failures. Your true risk in flying must include accidents due to all causes. The lowest individual's RFI for all causes was 0.43/100,000 occupant hours in the single-engine 206; that was a 17.3 % lower risk than for an occupant in the Twin Turbine group. Again, this points out that the number of engines installed is not the determinator of your safety. The 206 occupant RFI for all causes was 35.8%, 54.7% and 64.2% lower than the Other Single Turbine group, the Military Surplus UH–1 group, and the Single Piston group, respectively. Again, there are many facets of safety that affect your likelihood of a fatal injury to include the design of the aircraft, its design simplicity and forgiveness in an emergency, crash survival features such as the use of a shoulder harness, the type of operation being conducted, abusive use, maintenance, and pilot skills and judgment. Once again, the actual facts regarding occupant risk prove that the "twins are always safer" beliefs are all myths.



	Single Piston	Military Surplus H1	Other Single Turbine	Twin Turbine	206 Single Turbine
All Causes	1.17	0.95	0.67	0.52	0.43
Airworthiness	0.26	0.47	0.22	0.16	0.09

Fig. 11. Individual's risk of fatal injury.

LIFE SPAN IN FLIGHT

An individual RFI is an extremely small number and comparisons of such small numbers are difficult for the flying public to comprehend. A more understandable interpretation of the RFI would be the answer to "On the average, how many hours can I fly before I would die in a helicopter accident?" The Flight Life Span is the inverse of RFI or 1/RFI, which answers that question. Another way to express this is, using the average hours of occupant flight exposure that are expected to occur between fatal injuries. Since each of us is only allocated one fatal injury, it becomes our life span average in the flight environment. Your Flight Life Span when flying in the five study groups for accidents due to Airworthiness and All Causes is Fig. 12.

If one could only die from just an Airworthiness failure, the individual's Flight Life Spans would range from 384,475 to 1,071,300 occupant hours. The Flight Life Spans for All Causes (what each of us are truly concerned about) ranges from 85,684 to 232, 265 occupant hours. That is a long, long time.

As a general comparison, how does your Flight Life Span compare to when you are flying in the highly standardized and consistent environment of the Part 121 Air Carriers (Scheduled and Unscheduled) and the Commuter Air Carriers (Part 135)? That comparison, plus the inclusion of Unscheduled Air Taxi (consisting of mostly airplanes) under Part 135, is shown in Fig. 13. This shows that your individual risk in turbine-powered helicopters falls between the typical Unscheduled Air Taxi operation under Part 135 and the Air Carriers. The excellent history of the Large Transport Airplanes operating under Part 121 gives us, the helicopter industry, a safety direction for the future. Unfortunately, that airline safety level is an unrealistic and non-achievable goal, even as a safety target, for helicopters due to unique missions that are the only reasons that helicopters even exist. Regulators should not expect helicopters to match airline safety. The helicopter can do unique tasks that no airplane can. These helicopter tasks are always riskier that the highly structured (and expensive) tasks of going from Airport A to Airport B in controlled airspace and returning. We in the helicopter industry must use a multi-faceted and continuing approach to reduce risk of an accident occurring as well as to reduce the risk of an injury when the accident does occur. There is no single solution. Safety is the continuous process of improvement by the management of risks.

Since no one individual flies 24 hours a day, every day of the year, a conservative estimate of your flight career longevity in helicopters can be made. Assume you fly 8 hours a day on each day of the year. The number of years of your Flight Life Span is shown in Fig. 14.

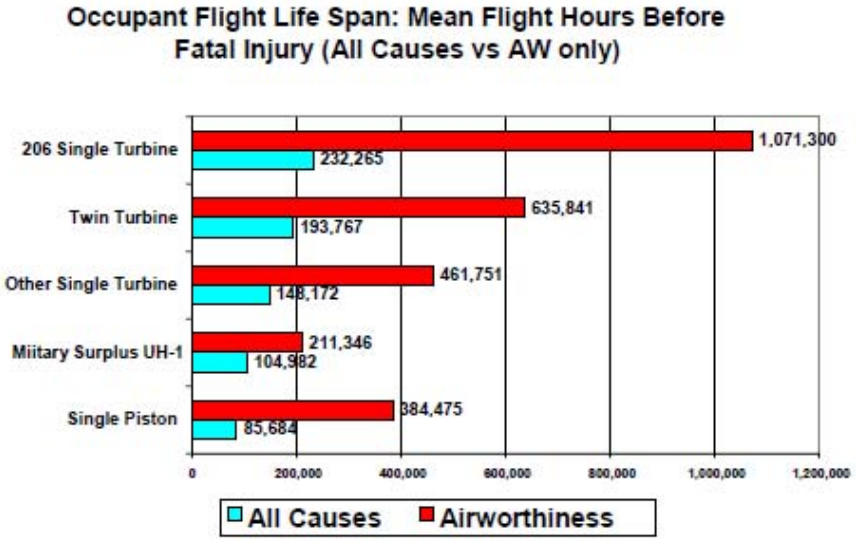


Fig. 12. Occupant flight life span.

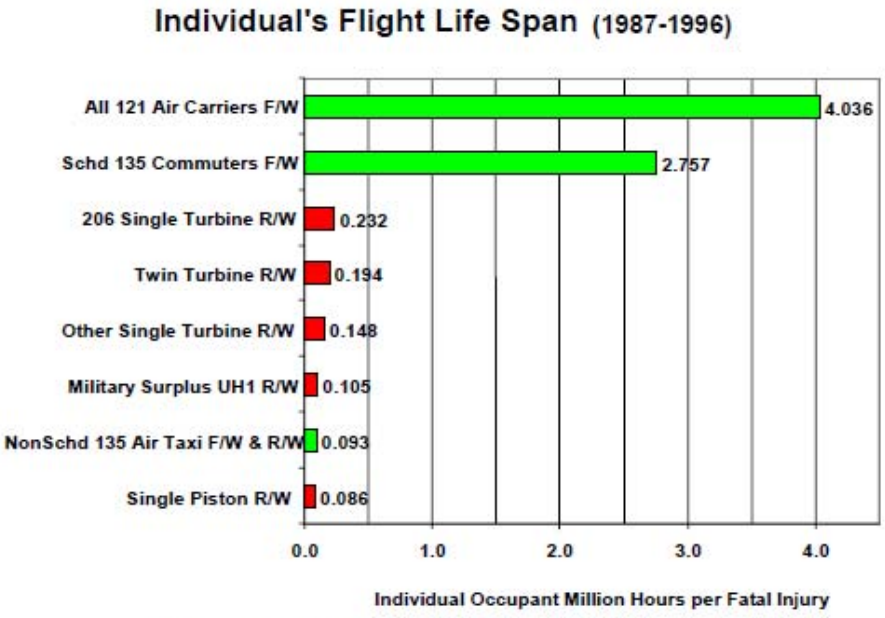


Fig. 13. Individual flight life span in helicopters and airplanes.

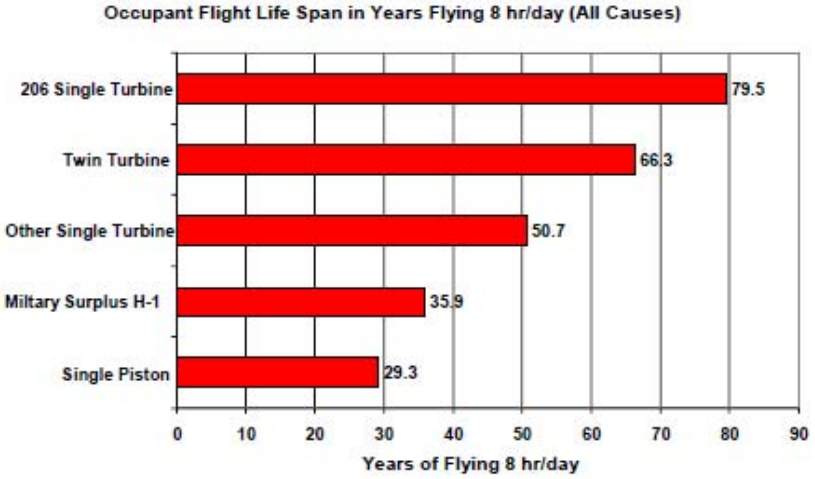


Fig. 14. Occupant flight life span in years.

Thus a helicopter occupant could expect a Flight Life Span period of 29.3 to 79.5 years of flying 8 hours/day (e.g. 2,292 hours/year). In reality, there are very few people who are in the air 2,292 hours each year, so this is quite conservative. This does show that an individual is safe when flying in all helicopters.

SUMMARY

A study of 1,534 U.S. registered helicopters in five groups for the last 10-year period of 1987 through 1996 found that

- For all helicopter accident causes, your individual Risk of Fatal Injury ranged from once in 85,684 to 232,265 occupant hours of exposure, based on today's fleets and different types of operations.
- For only airworthiness causes, your individual Risk of Fatal Injury ranged from once in 384,485 to 1,071,300 hours of occupant exposure.
- Accident rates are more related to airframe damage, and are poor indicators of occupant safety. Individual Risk of Fatal Injury is a better indicator of occupant safety.

Further, the myths related to "twin-engines are always safer than one engine" was dispelled by actual helicopter safety history. An occupant in the single-engine 206 has a risk of a fatal injury due to all airworthiness failures (engine and the rest of the aircraft) that was 43.8% lower than an occupant in a Twin Turbine helicopter. Likewise, an occupant in the single-engine 206 has a risk of a fatal injury due to all causes that was 17.3% lower than an occupant in a Twin Turbine helicopter. Overall, it was shown that there are many more factors to be considered rather than the counting of engines. In some cases, a single turbine helicopter is safer; in some cases, a twin turbine helicopter is safer. However, in the majority of cases, the number of engines does not make any difference, and other issues such as payload, type operation, pilot issues, and economic factors should determine what type of helicopter should be used.

All helicopters are safe with some more than others, but we must improve much further for wider public acceptance. The key to moving to a new safety plateau level will require recording devices to document what is actually occurring in the cockpit during the accident sequence. Only then with understanding those actions and sequences, can we correct those elusive human errors.

Appendix J

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

Advisory Circular

Subject: Introduction to Safety Management Systems for Air Operators

Date: 6/22/06

AC No: 120-92

Initiated by: AFS-800

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.

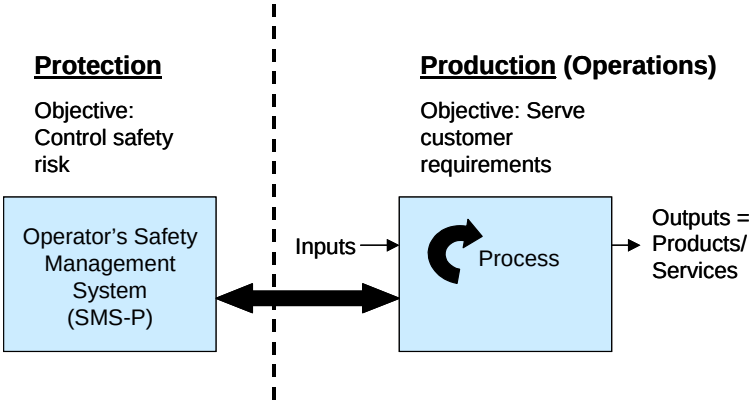
a. System Goals: Production and Protection. The global aviation system is really a "system of systems." Figure 1 depicts the relationship between the systems that are related to safety. The Figure depicts the relationships between the technical and management functions in the company that are related 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

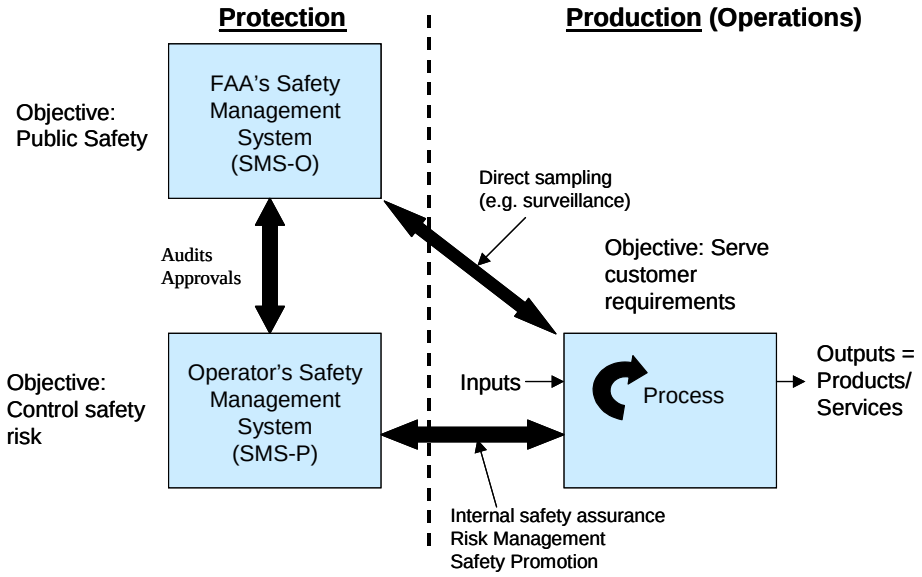
States Code, subtitle VII, chapter 447, section 44702 states, in part, that "When issuing a certificate under this chapter, the Administrator shall consider the duty of an air carrier to provide service with the highest possible degree of safety in the public interest and differences between air transportation 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.

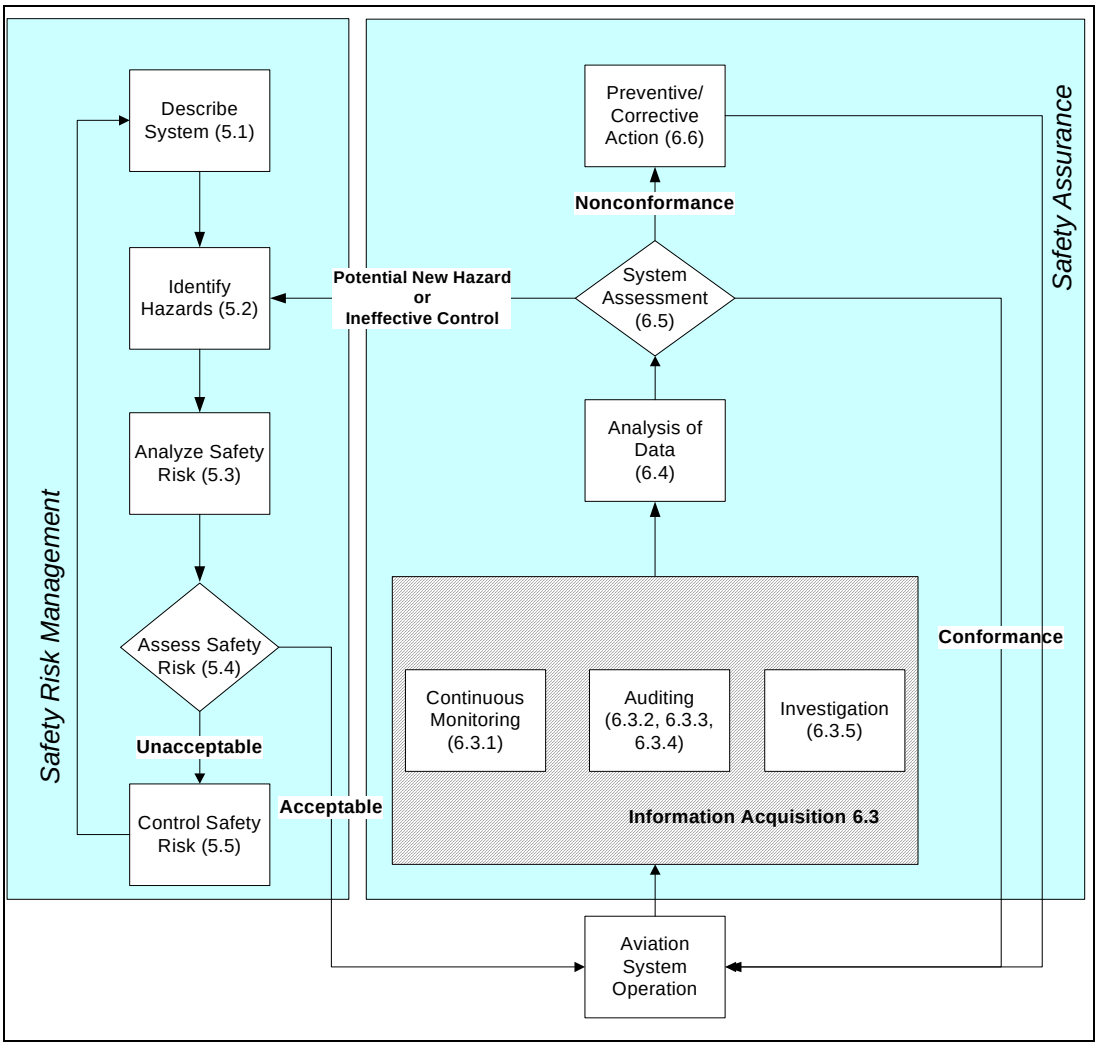
(b) Safety risk management. A formal system of hazard identification and safety risk management in Appendix 1, par. 5 is essential in controlling risk to acceptable levels. The safety risk management component of the SMS is based upon the system safety process model that is used in the system safety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

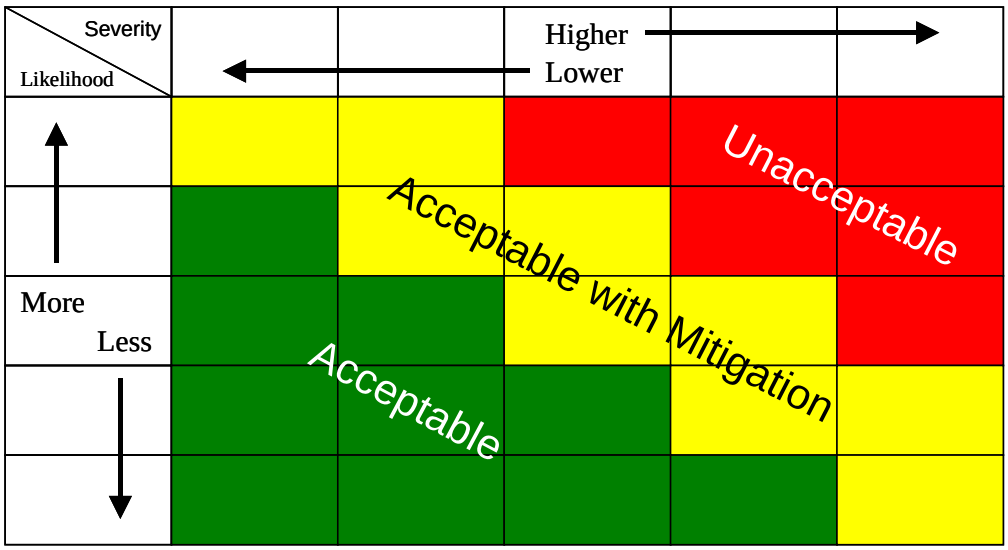
(a) Unacceptable (Red). Where combinations of severity and likelihood cause risk to fall into the red area, the risk would be assessed as unacceptable and further work would be required to design an intervention to eliminate that associated hazard or to control the factors that lead to higher risk likelihood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

[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 be assessed for its safety risk acceptability using the safety risk objectives described in Section 5D.

B) The organization shall define levels of management that can make safety risk acceptance decisions.

5.5. Control Safety Risk

A) Safety control/mitigation 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 comprehensive system description as described in Section 5.1.

6.3. Information Acquisition

The organization shall collect the data necessary to demonstrate the effectiveness 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 evaluations 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 management official 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 performing evaluations of operational departments must 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 Investigation

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 Employee Reporting and Feedback System.

A) The organization shall establish and maintain a confidential employee safety reporting and feedback system as in Section 7.1.5).

B) Employees shall be encouraged to use the safety reporting and feedback system without reprisal as in Section 4.2 B) 5).

C) Data from the safety reporting and feedback system shall be monitored to identify emerging hazards.

D) Data collected in the safety reporting and 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 demonstrate the effectiveness of:

1) risk controls in the organization's operational processes, and

2) the SMS.

B) Through data analysis, the organization shall evaluate where improvements 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 existing safety risk control(s)/ SMS requirement(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 information shall be used to promote continuous improvement 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