Safety is not an Option

Clifford Parizo; Manager - System Safety; Sikorsky Aircraft Corporation, Stratford, CT USA
R. Brandon Daugherty; System Safety Engineer; Sikorsky Aircraft Corporation, Huntsville, AL USA

Keywords: ASEL, NORSEE, opt-in, opt-out, option, rotorcraft

Abstract

This paper presents a method for evaluating and classifying rotorcraft safety enhancing equipment in terms of impact on safety and various equipment installation factors. Guidance from certifying agency policy and system safety standard practice were considered, resulting in a classification tool that can be used to determine if equipment should be marketed and sold as either mandatory or optional. The methodology that was developed may have applications for other products and industries.

Introduction

The U.S. Department of Transportation Federal Aviation Administration (FAA) encourages the use of optional, non-required equipment that can improve safety for increased numbers of rotorcraft under most operational conditions, ref. 1. The FAA expects that safety benefits will be greater than the potential risk introduced by the installation of NOn-Required Safety Enhancing Equipment (NORSEE). This approach involves considering not only the risk side of the safety equation, as is typically done, but also the safety benefits. The reference 1 policy states that a possible increased safety risk from failed or malfunctioning non-required equipment to an individual rotorcraft operating in unusual conditions should not necessarily overshadow the rest of the fleet benefiting from the safety enhancement resulting from the introduction of such equipment in most operational conditions. The policy provides detailed guidance for development and certification of NORSEE equipment, and focuses on safety assessment of potential hazards associated with the loss of function of the equipment. However, the policy is generic in nature and does not attempt to provide any guidance on the identification or classification of specific types of NORSEE.

Optional Safety?

At first glance, the terms "option" and "safety" would appear to be incompatible. At one time or another we've all seen or heard slogans such as "safety is job #1", "safety first", "beware of good enough", and "there is no compromise when it comes to safety". So how can any safety enhancing equipment features ever be considered optional? This matter has been considered previously by expert system safety practitioners, ref. 2.

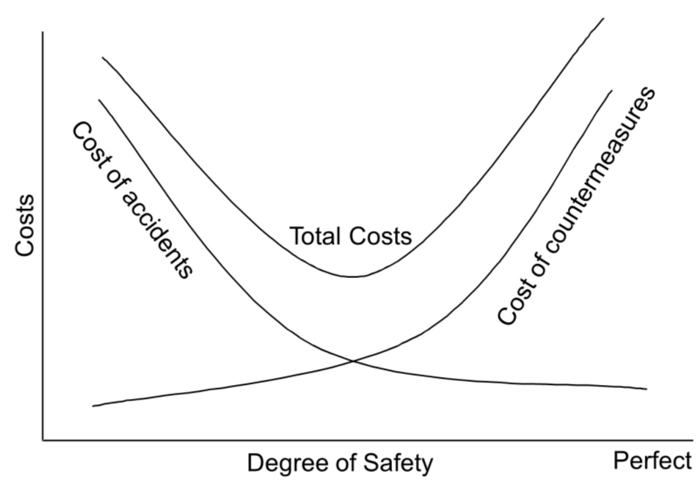

Figure 1 — Cost of Safety

Figure 1 notionally depicts costs associated with accidents that are attributed to the absence of safety, along with those costs that are associated with countermeasures that would be required to mitigate or eliminate those accidents. The costs of accidents could be associated with injuries and fatalities, damage to equipment and property, loss of productivity, damage to reputations, reduced future sales, higher insurance premiums, and litigation. Countermeasure costs could include those associated with additional safety training, product operating restrictions, redesign, retrofit, and additional maintenance and inspections. They could also include the costs associated with developing, installing, operating, and maintaining NORSEE equipment. Figure 1 also shows total costs which are the sum of the accident and countermeasure costs. Consider first the state of zero safety. Nothing is spent on countermeasures but accidents are costly resulting in a high but finite total cost. At the opposite end of the safety spectrum we see decreasing safety returns from ever increasing cost of countermeasures, with total costs becoming prohibitively expensive in order to achieve a state of perfect safety. The desired state of safety must therefore lie somewhere between these two extremes, probably somewhere to the right of the degree of safety associated with the lowest total costs.

MIL-STD-882E provides guidance for mitigating identified safety risks by alternative means, including the incorporation of hazard warning and safety devices, ref. 3. Paragraph 4.3.4 of the MIL-STD states that when a safety hazard cannot be eliminated through design, the associated risk should be reduced to the lowest acceptable level within the constraints of cost, schedule, and performance by applying the system safety design order of precedence. Figure 2 shows that incorporation of warning and safety devices falls in between hazard elimination and relying on personnel for achieving safety.

Figure 2 — System Safety Order of Precedence

The rotorcraft design and development team is therefore presented with a number of options and alternatives for achieving program safety requirements. Safety-affecting design decisions typically involve a combination of individual stakeholder preference, experience, and judgment. Fortunately, the system safety team has a number of tools at their disposal that can be used to assess and influence system architectures and developing designs in terms of hardware, software, human interfaces, incorporation of safety lessons learned from other programs, and compliance with the aforementioned system safety order of precedence. These safety analyses include the preliminary hazard analysis, system and sub-system hazard analyses, hazard tracking, and safety assessments as described in the MIL-STD, and the functional hazard assessment, preliminary system safety assessment, and system safety assessment as described in the reference 4 civil aircraft equivalent, SAE ARP-4761. The process works especially well when the system safety program is properly planned, engaged early, appropriately staffed, and tied to a systems engineering process. Rotorcraft development programs that satisfy these requirements are typically sponsored, managed, regulated, and/or funded by sophisticated customers or certifying agencies such as the US DOD and FAA. These types of programs tend to drive the development of new safety technologies because they have the experience, vision, and possess the resources to do so. Examples include Global Position System-based rotorcraft terrain avoidance systems (TAWS and EGPWS), advanced air traffic collision alert and avoidance systems (TCAS), expanded capability engine inlet air particle filtration, and overwater rotorcraft emergency ditching survivability equipment. Once developed and fleet proven, these types of systems/equipment become excellent candidates for NORSEE consideration for marketing and sales discussions with other potential customers.

ASEL Process

An Aviation Safety Equipment List (ASEL) process was developed to provide consistency regarding inclusion of mandatory versus optional safety equipment in new rotorcraft customer proposal offerings. Four equipment classification categories of decreasing safety impact were defined, as illustrated in Figure 3.

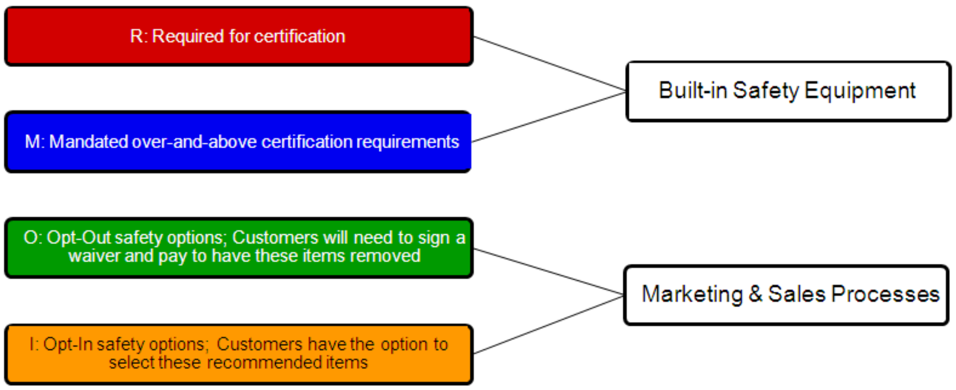

Figure 3 — Aviation Safety Equipment Definitions

An ad-hoc ASEL committee was tasked with developing lists of safety equipment classifications for each rotorcraft product line and their various mission configurations. The committee was comprised of individuals that have extensive experience in areas of rotorcraft system safety, accident investigation, pilot operations, engineering design & development, marketing & sales, litigation management, and customer support. ASEL classifications were based on the impact that the particular equipment has in preventing and/or mitigating the effects of rotorcraft accidents and incidents, as well as the complexity of the equipment, invasiveness to installation, customer acceptance, reliability, weight, and lifecycle costs. Information sources included accident reports and recommendations from industry and operator safety groups. Differences in operator missions, operating environment, and other factors may result in different ASEL classifications for the same piece of safety equipment on similar rotorcraft. Documenting classification rationale is therefore essential. The process calls for the committee to meet on a recurring basis to update the ASEL lists based on fleet experience, customer acceptance of opt-out and opt-in safety equipment recommendations, and technological readiness of new candidate ASEL equipment.

There are several benefits associated with establishing safety equipment lists. First and foremost it reduces the possibility that an important piece of safety equipment will be left out of a new product proposal and subsequent production contract. It provides key safety information so customers can make informed decisions, and a forum for discussing that information with customers when the need arises. This helps fulfill the obligation to treat all customers fairly and openly with regard to safety. And that could eventually develop into a market discriminator and recognition as an industry leader in terms of the lifecycle safety of our products, and the people who operate and fly in them.

An ASEL classification tool was developed to assist in determining safety equipment categories for the various rotorcraft product lines and customer configurations. Refer to Figure 4.

ASEL Ranking Matrix		Safety Equipment Implementation		
		Easy (3)	Moderate (2)	Hard (1)
Safety Impact	Hi (3)	9	6	3
	Med (2)	6	4	2
	Low (1)	3	2	1

ASEL Classification Factors	
Impact	Implementation
Fleet History	Cost
Mission Risk	Weight
Exposure	Complexity
Effectiveness	Maturity

Classification	ASEL Definition	Exception Management
Mandated (5-9)	No aircraft deliveries without this equipment	Waiver Process
Opt-Out (3-4)	Customers sign / pay to have these items removed	Safety Intervention
Opt-In (1-2)	Recommended but optional safety equipment	N/A – Customer Choice

Figure 4 — ASEL Classification Tool

The tool is similar to hazard risk assessment matrices described in references 2 and 3. It is essentially a table with three rows denoting safety impact associated with incorporation of the safety equipment being classified, and three columns for equipment implementation. Safety impact ranges qualitatively from low to high depending on factors such as effectiveness of the equipment in preventing or mitigating the results of an accident or incident. Similarly, equipment implementation ranges qualitatively from easy to hard depending on cost, weight, complexity, maturity and other factors associated with installation of the subject equipment. Impact and implementation ranks are each numbered from one (1) to three (3) and each of the cells where the rows intersect columns are labeled with the resulting ASEL classification, which is the simple product of the two. The tool facilitates combining ASEL classification inputs from multiple individuals, where the end result is the arithmetic average.

ASEL values between five (5) and nine (9) correspond to a Mandated ASEL classification due the combination of relatively high safety impact and ease of installation. In general, equipment falling into this category are treated as if they were required for certification by regulatory authorities or customers, and unless a waiver is accepted, rotorcraft will not be delivered without it. TAWS and EGPWS are examples of Mandated safety equipment. Their benefit in preventing controlled flight into terrain accidents is widely recognized, and current trends call for it to be integrated into avionic systems to the point where it cannot be easily removed.

ASEL values between three (3) and four (4) correspond to an Opt-out ASEL classification. This would require that the equipment be included in all proposed standard configurations. Should a customer wish to have this equipment removed it would trigger a discussion with a representative from the ASEL committee to explain to that customer why they should not do so. And if that customer still wanted it removed, they must acknowledge that they understand and accept the safety risk and bear any costs associated with removing it from their rotorcraft. ASEL values two (2) or lower correspond to Opt-in, and installation of this recommended safety equipment would be at the customer's discretion.

As mentioned above, it's possible that a particular piece of safety equipment could be classified differently for different product offerings. For example, an enhanced engine inlet air particle filtration system might be classified as Opt-out or possibly Mandated when installed on a rotorcraft derivative intended for operation primarily in a sand/desert environment. However that same device might be classified as Opt-in for a customer who intends to operate off of aircraft carriers most of the time. Similarly, survivability equipment that illuminate emergency exits and deploy a floating rescue transponder might be classified as Opt-in for desert operations, but Mandated for overwater operations.

The classification tool is new and still somewhat of a work in progress. There are opportunities to clarify impact and implementation criteria, and the classification value ranges are subject to change. There is also an opportunity to adapt the tool to help determine priorities for safety equipment currently in development and pursuit of new safety technologies.

Summary

The concept of optional safety equipment as described in current regulatory policy is supported by traditional system safety principles. There are advantages in identifying mandatory (built-in) and optional safety equipment in product marketing and sales materials, and some considerations on how this can be done were discussed. These include making use of cross-functional team approach and applying a methodology that takes into account both the impact on safety and various equipment installation factors.

Acknowledgement

The authors would like to thank Kevin Ohrenberger and Paul Inguanti from the Sikorsky Aircraft Corp. research & engineering department and Brian Mularski from the aviation & product safety group for help in identifying the need for and developing and administering Sikorsky's ASEL process. They would also like to acknowledge senior Sikorsky leaders and their representatives on the ASEL committee for their vision, guidance, and contributions in implementing the ASEL process.

References

1. PS-ASW-27, 29-10, Policy Statement Concerning Non-Required Safety Enhancing Equipment (NORSEE) in Rotorcraft, Federal Aviation Administration, 29 May 2013.

2. System Safety Engineering and Management, 2nd Edition, Harold Roland and Brian Moriarty, ©1990 John Wiley & Sons.

3. MIL-STD-882E, Standard Practice – System Safety, US Department of Defense, 11 May 2012.

4. SAE ARP-4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment, Society of Automotive Engineers, Dec 1996.

Biography

Primary Author: Clifford Parizo, BS, MS, Manager – System Safety, Sikorsky Aircraft Corp, 6900 Main Street, Stratford, CT USA, telephone – (203) 386-6103, facsimile – (869) 998-6807, e-mail – cparizo@sikorsky.com.

Mr. Parizo holds a Bachelor of Science degree in Mechanical Engineering from Worcester Polytechnic Institute and a Master of Science degree in Management from Rensselaer Polytechnic Institute. He has a total of thirty-five years of experience in areas of test engineering, product safety, and system safety for rotorcraft design and development programs. He has attended and supported ISSC conferences since 2003, and been a member of the ISSS since July 2008. He received the Northeast Chapter President's Award for his efforts in revitalizing the New England Chapter and helping to form the Northeast Chapter in 2011.

Co-author: R. Brandon Daugherty, BS, MS, System Safety Engineer, Sikorsky Aircraft Corp, 5025 Bradford Drive, Huntsville, AL USA, telephone – (256) 327-7536, facsimile – (256) 327-7504, e-mail – robert.daugherty@sikorsky.com.

Mr. Daugherty holds a Bachelor of Science degree and a Master of Science degree in Industrial and Systems Engineering along with a Graduate Certificate in Occupational Safety and Ergonomics from Auburn University, Auburn, AL, USA. He has served as a System Safety Engineer supporting a variety of US Army and US Air Force Programs out of the Huntsville, AL, Facility since 2010. He also serves as the Environment, Health and Safety representative for the Huntsville Facility. He attended and supported the ISSC in 2012, and been a member of the ISSS since 2009. He is currently serving as Treasurer for the Tennessee Valley Chapter.