Implementing a Process for Marketing Optional Safety Equipment

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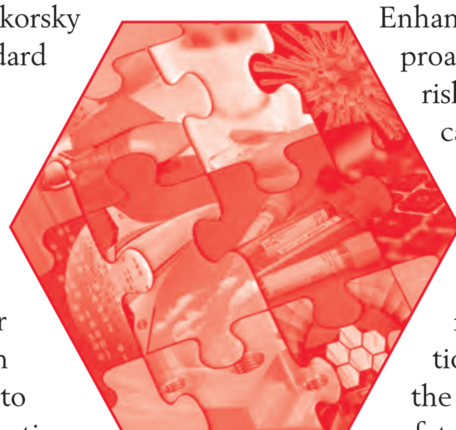
A technical paper at the 31st International System Safety Conference (ISSC) in 2013 discussed work that was being done at Sikorsky Aircraft Corporation to develop a standard process for marketing safety-enhancing features and equipment that are above and beyond airworthiness certification and regulatory requirements. Sikorsky has taken the stance that it's worth the cost and weight associated with including certain items in our bid offerings because of their impact on safety. Although customers can choose to remove these items during contract negotiations, those decisions will initiate a dialogue to ensure that customers fully understand the consequences of doing so. Sikorsky's Product Equipment List (PEL) process was implemented in August, 2014. This paper discusses changes that were incorporated during the PEL launch.



Introduction

Sikorsky Aircraft has a long history of developing and maintaining safe products, originating with its founder, Igor I. Sikorsky, who designed and flew the first successful helicopter in 1939. Sikorsky's vision was that the helicopter should be, first and foremost, a lifesaving machine. While basic flight theory has not changed, technological advancements and incorporation of complex avionic systems have expanded rotorcraft capabilities and performance tremendously. Additionally, the company is embracing globalization, with product design and development increasingly shared among suppliers and partners. At the same time, changes within U.S. Department of Defense and civil certification safety standards, along with customer and other stakeholder expectations, have continually raised the bar with regard to what is considered to be "safe."

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 policy cited in Reference 1 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 No. 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 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, re-design, retrofit, and

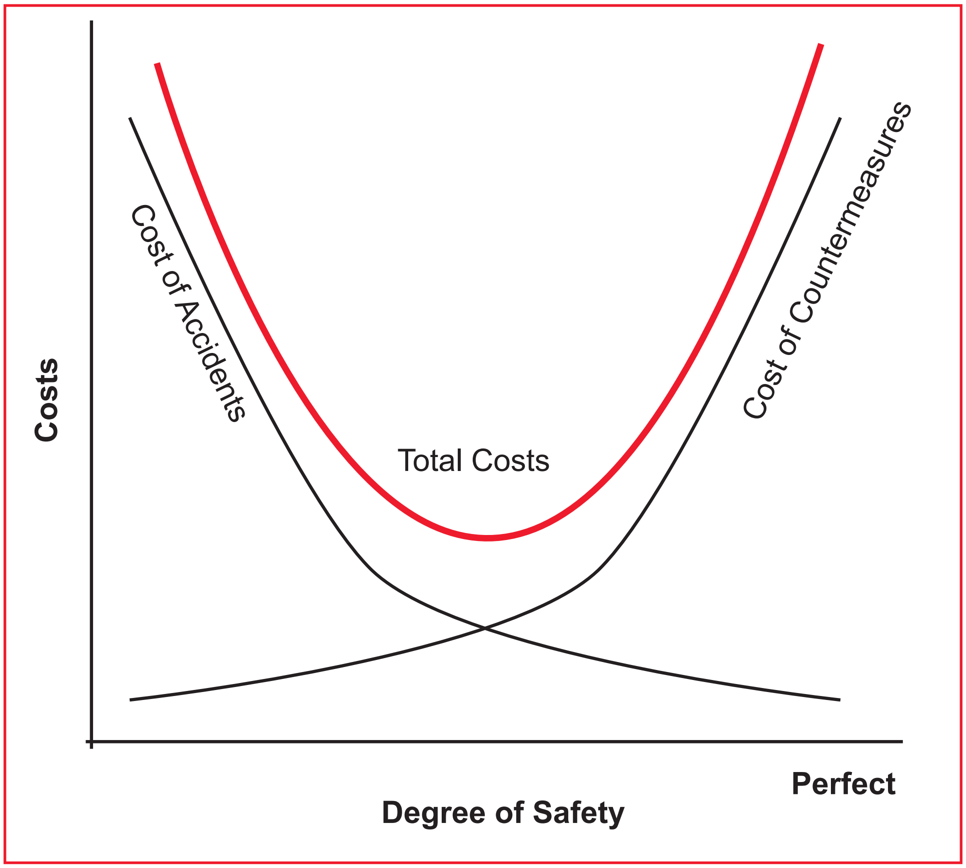


Figure 1 — Cost of Safety.

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 the 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, includ-

1.	Eliminate Hazards Through Design Selection	If unable to eliminate an identified hazard, reduce the associated risk to an acceptable level through design selection.
2.	Reduce Risk Through Design Alteration	If unable to eliminate the hazard through design selection, consider design changes that reduce the severity and/or the probability of the mishap potential caused by the hazard(s)
3.	Incorporate Engineered Feature or Devices	If unable to eliminate the hazard through design selection, reduce the risk to an acceptable level using protective safety features or devices.
4.	Provide Warning Devices	If safety devices do not adequately lower the risk of the hazard, include a detection and warning system to alert personnel to the particular hazard.
5.	Incorporate Signage, Procedures, Training and PPE	Where it is impracticable to eliminate hazard through design selection or to reduce the associated risk to an acceptable level with safety and warning devices, incorporate special procedures and training. Procedures may include the use of personal protective equipment. **Note:** For catastrophic or critical hazards, avoid using warning, caution or other written advisory as the ***only*** risk reduction method.

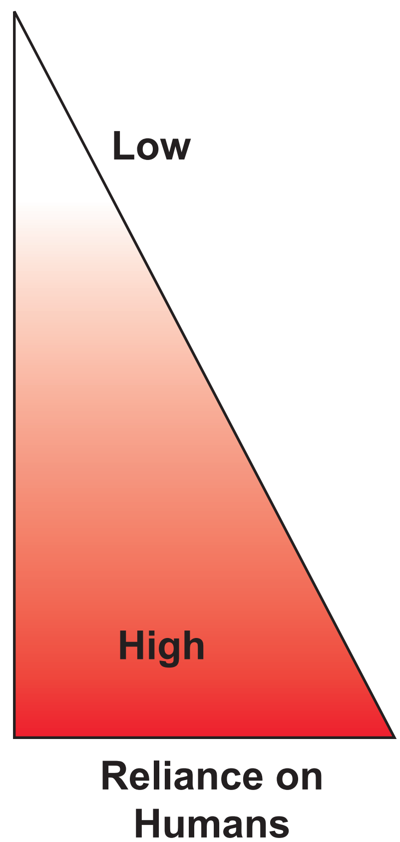


Figure 2 — System Safety Design Order of Precedence.

Category	Exception Management
Mandatory	Sikorsky cannot deliver aircraft without this equipment because of certification/regulatory requirements
Opt-Out	Safety benefit/risk discussion with customers who remove this equipment from bid offerings
Opt-In	Customers choose to have this equipment installed based on intended use
Future	Safety equipment that is not currently available for installation on customer aircraft

Figure 3 — Product Equipment List (PEL) Definitions.

ing the incorporation of hazard warning and safety devices [Ref. 3]. Paragraph 4.3.4 of MIL-STD-882E 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.

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 design 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-882E, and the functional hazard assessment, preliminary system safety assessment and system safety assessment as described in the civil aircraft equivalent, SAE ARP-4761 [Ref. 4]. 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 U.S. Department of Defense (DOD) and Federal Aviation Administration (FAA). These types of programs tend to drive the development of new safety technologies because they have the experience and 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

PEL Ranking Matrix		Safety Equipment Implementation		
		Easy (3)	Moderate (2)	Hard (1)
Safety Impact	High (3)	**9**	**6**	**3**
	Medium (2)	**6**	**4**	**2**
	Low (1)	**3**	**2**	**1**

Equipment Classification Factors	
Impact	Implementation
Fleet History	Cost
Mission Rank	Weight
Exposure	Complexity
Effectiveness	Maturity

Classification	Exception Management
Opt-Out (4-9)	Safety Intervention
Opt-In (1-3)	Customers Choose

Figure 4 — PEL Classification Tool.

types of systems/equipment become excellent candidates for NORSEE consideration for marketing and sales discussions with other potential customers.

PEL Process

A Product Equipment List (PEL) process was developed to provide consistency regarding the 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.

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An ad-hoc PEL 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 and development, marketing and sales, litigation management, and customer support. PEL 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 PEL 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 PEL lists based on fleet experience, customer acceptance of opt-out and opt-in safety equipment recommendations and technological readiness of new candidate PEL 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. 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.

A PEL classification tool was developed to assist in determining Opt-Out versus Opt-In safety equipment categories for the various rotorcraft product lines and customer configurations (Figure 4).

The tool is similar to hazard risk assessment matrices described in References 2 and 3. It is essentially a table with three rows denoting the safety impact associated with incorporation of the safety equipment being classified, as well as 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 to three, and each of the cells where the rows intersect columns are labeled with the resulting PEL classification, which is the simple product of the two. The tool facilitates combining PEL classification inputs from multiple individuals, where the end result is the arithmetic average.

PEL values between four and nine correspond to an Opt-Out PEL 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 PEL committee to explain to that customer the safety-enhancing benefits they would forfeit by removing the item, so that an informed decision can be made. If that customer still wanted the item removed, he or she must acknowledge that they understand and accept the safety risk and bear any costs associated with removing it from their rotorcraft. PEL values of three or lower correspond to Opt-In, and installation of this recommended safety equipment would be at the customer's discretion.

As mentioned previously, 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 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 illuminates emergency exits and deploys a floating rescue transponder might be classified as Opt-In for desert operations, but Opt-Out for over-water 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.

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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 safety equipment in product marketing and sales materials, and some considerations on how this can be done were discussed. These include making use of a cross-functional team approach and applying a methodology that takes into account both the impact on safety and various equipment installation factors.

Acknowledgement

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Clifford 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 38 years of experience in the 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 has 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 in helping to form the Northeast Chapter in 2011.

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