Sharing is caring: a discussion for combining risk information

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Abstract. As the aviation system continues to grow, the need to develop models that allow for an understanding of the complex interactions that occur within the industry. This paper will present some preliminary finding of the PROactive Safety PERformance for Operations (PROSPERO), an FP7 project, regarding the development of the conceptual and practical implication of such a model. Additionally, work concerning the development of a new understanding of risk, which will be necessary to fully understand the complexities of highly interconnected systems, will be discussed, which will be continued in future papers.

Keywords. Risk, Safety, Safety Management, Future System State.

1. Introduction

Aviation is today an ultra-safe system. EU has set a goal to reduce accident rate by 80%. This requires aviation to go from the current plateau to a new hyper-safe level. At the same time the air traffic is anticipated to double in 20 years' time. This not only put the capacity of the system to a test but new technology is being introduced to cope with this and is increasing stakeholder's dependency and the overall system complexity in an already complex transportation system. To breach the safety stagnation in the future system the old thinking that took us this far need to be complemented by new innovative approaches. This paper will act as a catalyst and allow beliefs that have become widely accepted to be questioned for this new challenge. The first of these concepts that will need to be questioned, is what exactly is safety risk? which leads directly to how this understanding will change the way in which organizations are designed to manage safety (PROSPERO, HCI paper 2014). The next corner stone requiring scrutiny is the idea that accidents are linear and belief they can be forecast to any degree with current models.

This is particularly relevant since a purely reductionist philosophy regarding such complicated systems no longer appears able to cope with the complexity that is becoming standard in such systems **(Anderson, 1999; Moliterno & Mahony, 2011; Salvato & Rerup, 2011; Mathieu & Chen, 2011; Mathieu & Chen, 2011)**. Any type of progress must start by critically examining and questioning the status quo. Regardless of how secure each component seems it must be inspected, tested, and passed before it can be placed back into the system as a trusted component again.

By 2014 all air transport system (ATS) stakeholders will be regulated to have a Safety Management System, SMS (ICAO, 2012). This has been thoroughly studied and analyzed and new advanced concepts for SMS in an airline have been developed (Ulfvengren and Corrigan, 2014). Some challenges are still under debate among safety researchers and yet practitioners are asked to be able to prove safety performance in a year or two. The main challenges are for example how to measure safety and developing safety performance indicators. The truth is that aviation lack fundamental models to model safety and safety risk. Aviation also lacks models that can support a functional analysis of the complex interdependent processes involved in both a single airline but also in the system of systems. For safety critical industry the organizational design and management it is essential that the process being controlled is understood and for safety reasons the risk in this process also needs to be understood.

2. Purpose

The purpose of this paper is three fold. First it is to discuss several research pursuits that have already begun to be examined and will continue in on-going research projects. Second, is to introduce a methodology that will work towards grasping the highly integrated, complex, and growing aviation system **(Airbus, 2013; Boeing, 2013)**. Finally, the paper will discuss additional research that is argued to be needed to further develop the concepts above, and understand the holistic nature of safety risk in complex social technical systems (Ulfvengren et al, 2013, Baranzin et al, 2013). The combination of these three topics will provide an overview of continuing research that has been done in multilevel organizational analysis, using aviation as a prime example. Therefore the question must be asked, what is required of stakeholders' organizational design and management, as safety management systems become regulator requirements?

3. Methods

Prior to the development of an in-depth methodology to study a problem, an understanding of some of the problems that are currently being encountered by members of the industry must first be examined to ensure that the "solution" addresses issues that are encountered in the real world. This will be required to develop an understanding of industry needs as well as develop a system that will be able to cope with these requirements. Thus one of the major goals in the PROactive Safety Performance for Operations (PROSPERO) FP7 project, to this point has been to create an understanding of some of the major challenges that will be encountered. To date there has been one aspect that has proven to be particularly difficult and actually relates to three aspects of the same problem. These consist of a unified understanding of the terms being used, the creation of a unified understanding of what components are required in a holistic approach, and gaining access to highly protected data (Ulfvengren et. al, 2013).

Through workshops, each hurtle has been systematically approached and overcome with a very intricate structure having been developed during the course of workshop meetings. As an understanding that is very broad and deep requiring a explanation of several different research stems a complete report of the PROSPERO project is outside the scope of this paper, however as it will relate to some research in risk the relevant parts will be highlighted below.

3.1 Process Approach in Human Factors

The entire idea of process control is to identify undesired outcomes (through the measurement of the output) produced by a procedure and subsequently improve the process input until the desired outcome is achieved. The first step in gaining control over an organization is to know and understand the basic process for production (Juran, 1988; Deming, 1986). In aviation the product is delivered through a complex socio-technical system. If safety is to be maintained, or even improved, relevant mechanisms influencing these processes need to be identified by a model. Improvements may be accomplished only by changing the processes' functionality. Traditional human factors and safety research does not provide any method to complete a functional process analysis of socio-technical systems in order to identify relevant indicators for safety and to improve safety performance resulting in actual change in operations. A functional process model is essential for analyzing and identifying influencing mechanisms of the operations where risk needs to be controlled. With such a model it is possible to link in-depth investigation and analysis of particular events with the extensive analysis of data from normal operations. This will deliver a composite assessment of risk.

In a series of EU-projects, a method and tool called SCOPE has been developed (Leva et al. 2011, Bunderath et al., 2008; Morrison, 2009). On a conceptual level it has been used for adding core functionalities in Safety Management Systems in both airline and airports. Some of the functionalities include system description, hazard and indicator identification, support for process analysis to identify needs for improvements, as well as to simulate and anticipate effects of system changes. In PROSPERO SCOPEs value for analyzing integrate and systemic risk will be validated.

3.2 System Risk

Despite the interdependencies between all the components of the Air Transport System there is no integrated system risk concept. Within an airline, the definition of risk varies within different sections of the organization, each of which has different baselines and priorities. For example, deferred defects may be an acute immediate risk for a maintenance organization, but not be high on the list of priorities for flight operations. Therefore it is important to establish a common framework of safety performance because it is these mutual interdependencies that ultimately determine system risk. However, a significant challenge in achieving this is the lack of one institutional owner of a system risk concept.

PROSPERO will facilitate the development of an integrated risk framework that establishes sufficient commonality between safety performance indicators to support an appropriately integrated analysis of risk. PROSPERO will integrate Human Factors in a systemic analysis of risk, based on the innovative SCOPE methodology (Leva et a 2011), which analyzes how human and social information as well as other factors combine to influence system performance. It will develop an integrated concept of risk that equally reflects human behavior in the mission of the crew, maintenance personnel, ATC, and ground operations. The PROSPERO methodology will provide for a proactive anticipation of complex system risks that have the potential to result in abnormal situations and crises.

3.3 Operational Management of Risk

Risk analysis and assessment should be part of a risk management process that concludes with an evaluation of risk reduction following the implementation of measures to control and eliminate the risk. Where this is not possible it should at least mitigate the risk (through design, process change, planning, etc.) so that active and explicit management of operational risks occur in real time by crew during operations. Hence the quality of the management of risk is dependent on the quality of the initial assessment of the risk itself. Unfortunately current operationally focused risk management methodologies (for example, Threat and Error Management TEM) are not integrated with an effective risk assessment methodology. The Intelligent Flight Plan developed in the HILAS Project (from an Iberia use of TEM) is a smart concept for improving operational management of risk, incorporating an operational risk assessment in the normal flight preparation process rather than having it as an extra task with more effort involved (Cahill, 2009). This can be further developed by incorporating a comprehensive, authoritative and up-to-date account of operational risk.

3.4 Statistical Methodology

The information that is collected in the above categories (as well as several others that have not been mentioned for the sake of brevity), will be used to construct a statistical model that focuses not only on a single level or even organization but will attempt to take all the data and create a leveraged model. This model will need to have several components, to fully understand the dynamic conditions that are experienced within a work environment, a non-linear structural equation model nested within a hierarchical model. The power of such a nested model that does not make the assumption of linearity, allowing for connects and correlations that may not be linearly related to be explored creating a method to help develop the path that risk takes within an industry. The beginnings of such thinking is still relatively new with a renewed interest being discussed within a 2011 issue of The Journal of Management (Mathieu & Chen, 2011; Salvato & Rerup, 2011; Moliterno & Mahony, 2011). A further explanation of such model will be the central topic of a future paper.

4. Results and Discussion

Though there has been a significant degree intellectual ground work laid forth this complicated subject is still in need of future study. However, as can be seen in the above section serious inroads have been made regarding the first research question proposed (Ulfvengren et. al, 2013). The second research question has started to be addressed though to date it has not been as thoroughly explored. The question of risk is a critical one since it will likely dictate how resources are distributed in this complex system, and thus will be responsible for the success or failure of any process.

Stogsdill & Ulfvengren (2014 submitted) discusses risk not in a conventional probability multiplied by severity context, but rather as the relationship between four key elements that are critical in defining not only the "risk" of a situation but also some aspects of the surrounding context. The relationship is as follows: the ratio of the rate of change over the ability to change, divided by the ratio of energy within the system over the time that the energy is disseminated.

This relationship of changes in states and the energy held within a system gives an individual attempting to understand risk not only what may be considered the severity of a potential event, but also how much the change will effect the operation as a whole. If the rate of change within a situation is very high but the corresponding ability to change is only mediocre, then it will be difficult or impossible for the organization to keep up with the change resulting in an increased likelihood of an event occurring. If this type of understanding can be applied to each leveraged aspect in a system, then it may be possible to create a holistic risk picture that can then be tracked as time progresses demonstrating how risks propagate and aggregate in the system.

4.1 Moving Forward

The need to be able to integrate an understanding of how risk propagates through a system will be key in the development of the PROSPERO concept (Ulfvengren et al, 2013).

With this in mind it is critical that the methodology described above along with data that has been (and will continue to be) collected can be integrated with the statistical modeling approach that is described above. Though a model will never be a perfect representation of the world, the goal will be to create a system that is sufficiently robust to understand the behaviors of the more intricate "real world" situations, while still being able to determine where to devote the limited resources available to any given company to best reduce risk and increase safety.

This forward-looking movement will take two forms. The first will be empirical, while the second being theoretical. The empirical aspect will be dependent on the building of trust and the social networks that are a prerequisite, prior to the data being used and disseminated to the areas in the system that will allow for the most effective resource distribution. Such data will be input into models that will be used to determine relationships, and correlations. This information when combined with functional process modeling should allow for a model with the most highly leveraged components to become apparent. The second aspect that must be considered is that of the theoretical, as stated previously this paper is not the place for a full discussion of the topic, however, the realization that a the work described thus far will span many conventional boundaries requiring a framework of theories to be established and utilized to help determine what aspects are most changeable within the model creating a more effective tool for the industry.

5. Conclusion

The first phase of the research involved the overall concept and highlighted the system requirements as depicted in figure 1 above. The research and development needs of PROSPERO have thus far involved a complex combination of methodologies, information systems and software, organizational processes, and social and business relations between stakeholders. Each of these requires a specific research focus, but not in isolation - rather, as a multi-layered systems integration project. The next phase of the research is to detail the functional specification of the actual PROSPERO system. This will also involve understanding how the identified industry needs should be expressed as a set of requirements against which PROSPERO can clearly demonstrate the feasibility (in terms of technical criteria, rules and procedures, organizational capabilities, etc.) of a data-driven framework with common methodologies. All of this is required to understand risk in air transport as a system and to use the knowledge available from multiple sources to mitigate risk in everyday operations while radically reducing risk through future system design.

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