Chapter 13
Applying Probabilistic Risk Assessment to Safety Risk Analysis in Aviation

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ABSTRACT

When making policy, procedural, or technological changes to a complex system that has safety implications, a key question decision makers must answer is: What are the risks to the users of the system that will result from making these changes to the system? This chapter illustrates a method to explore different facets of this question using mathematical modeling and probabilistic risk assessment techniques, with the objective of assessing the safety impact of changes to the National Airspace System that follow from the Federal Aviation Administration's next generation air traffic modernization program. The authors describe the development of an Integrated Safety Assessment Model as a structured approach to evaluating current and emerging risks in National Airspace System operations. This process addresses the previously stated risk question by combining fault tree and event sequence diagram modeling techniques, hazard identification and analysis methods, opinions from subject matter experts, and concepts from business intelligence.

INTRODUCTION

The Federal Aviation Administration's (FAA's) mission is to provide the safest, most efficient aviation system in the world (Federal Aviation administration [FAA], n.d.a). To achieve this goal, a proactive approach to safety is necessary so that vulnerabilities are identified and risks are mitigated before they result in accidents or incidents. This is particularly important when a change is introduced into the

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system. The FAA conducts specific risk-related analysis for any specific change to the United States National Airspace System (NAS); however, multiple changes occur within the system annually. Although the individual risk analysis results are often well understood, these results are seldom integrated with broader analysis for system-wide application. For instance, each proposed new component on an aircraft or a new procedure requires an individual risk assessment. These are seldom captured within a system-wide impact assessment model. As a result, overlapping analysis is often conducted, and incongruent baseline assumptions may be applied during the risk evaluation of a change. Beyond redundancy, the analyses conducted within the limited scope of each organization's area of responsibility fail to capture unintended effects outside of its own context – a problem that can result in unanticipated consequences for risk system-wide.

The most obvious major system change that has been undertaken by the FAA in the last five years is the Next Generation Air Transportation System (NextGen) program (FAA, 2014a). NextGen aims to improve the capacity and efficiency of the NAS while maintaining or enhancing safety. The plan, however, is an acquisition strategy only – and therefore additional safety analysis is required to capture the operational, training, and policy impacts of NextGen. The focus of this chapter is the development of an acquisition safety assessment capability: the Integrated Safety Assessment Model (ISAM).

The emerging complexity of aviation operations, impact of changes in roles and responsibilities, growth in air traffic, and diversity of aircraft fleets require the modernization of safety analysis methodology. To manage safety in consideration of NextGen, the FAA established the System Safety Management Transformation (SSMT) program. The SSMT program develops and implements the policies, processes, and analytical tools that allow the FAA to meet its NextGen schedule for demonstrating and monitoring safety compliance. Improvement in the description and tracking of an integrated NAS-wide risk baseline, together with a complementary risk forecast model that reliably represents the impact of NextGen system changes on that baseline, will provide the FAA with a required tool for NextGen implementation.

ISAM was developed under the SSMT program to capture the system-wide effects of implementation of the broad-reaching NextGen plan. ISAM supports risk-based decision making by providing managers, operators, and other internal and external stakeholders with local and national risk baselines and assessments of the impact of impending NextGen-related changes. Additionally, ISAM facilitates rapid scenario diagnosis and assessment, enabling managers to plan, train staff, and acquire resources to minimize safety risks and disruptions in the NAS. This chapter discusses the ISAM process as a probabilistic risk assessment methodology for planning and decision making.

BACKGROUND

Towards managing safety, the SSMT program has been involved in the design and development of an Integrated Safety Assessment Model (ISAM) for the analysis and assessment of risk in the NAS. Safety models are qualitative and/or quantitative representations of the system that assist in the identification and management of risk. The qualitative aspects of the model capture what must go wrong for a failure within the system to occur, and the quantitative aspects capture how probable or severe that failure is. The core of ISAM is an integrated pilot-controller safety model developed through adaptation of two European models, the Causal Model for Air Transport Safety (CATS) (Ale et al., 2009) and the EUROCONTROL Integrated Risk Picture (IRP) (Spouge & Perrin, 2006). The CATS safety model is a representation of world-wide historic accidents and incidents, and includes a Bayesian Belief Net (BBN) – based causal

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