

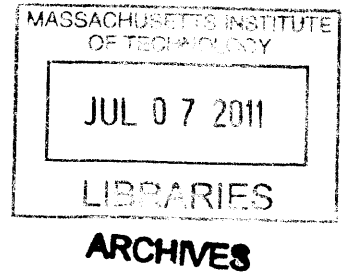
**A Program Risk Assessment Method for Aviation Technology
Transitions**

By

Jonathan Marcus Gibbs

Bachelor of Science in Aeronautics and Astronautics

Massachusetts Institute of Technology 2006



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In partial fulfillment of the requirements of degree of

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A Program Risk Assessment Method for Aviation Technology Transitions

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Massachusetts Institute of Technology

Abstract

This work presents a method for assessing the potential impacts of program risks on aviation technology transitions. It first establishes a framework that provides a methodology to complete the assessment of those risks. Next, the framework is applied to a technology transition to data link and reduced separation procedures in the North Atlantic airspace for commercial and business aircraft. This transition is facilitated by the International Civil Aviation Organization (ICAO) and supported by the Air Navigation Service Providers (ANSPs) and other state authorities within the North Atlantic airspace. The assessment identified the most influential risks for each stakeholder impact category, mitigation difficulty, and highlighted the ways each risk influenced other risks. In total, 24 risks were identified. The assessment found that the risks were highly connected and influenced several stakeholder impact categories simultaneously. Out of the five risks with the highest aggregate stakeholder impact, only one also had a high likelihood of occurrence.

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1 Background

1.1 Risk Assessment Purpose

The purpose of this risk assessment is to aid the North Atlantic Systems Planning Group (NATSPG) and the International Civil Aviation Organization (ICAO) in the implementation of the Data Link Mandate and 25NM Lateral Reduced Separation procedures by identifying and analyzing the impacts of program risks to safety, operational efficiency, and the costs and benefits of Air Navigation Service Providers (ANSPs) and Operators.

1.2 Mandate Background

In early 1995, the ANSPs providing service for the Pacific Ocean implemented a satellite based air traffic control capability called Controller Pilot Data Link Communications (CPDLC) to improve operational efficiency in over water operations without radar coverage. The participating aircraft required upgraded communications, surveillance and navigational equipment. The upgraded aircraft equipment became known as the Future Air Navigation System or FANS 1/A. The participating aircraft were allocated preferred flight routes over the pacific and received more efficient climb profiles because the new equipment allowed them to safely reduce their separation with respect to other CPDLC equipped aircraft (NAT SPG 45 Summary, 2009).

In the 1990's Eurocontrol implemented a CPDLC capability in domestic airspace using an equipment standard called the Aeronautical Telecommunication Network (ATN), a different standard than FANS 1/A. The Aeronautical Telecommunication Standard differs from FANS 1/A in 3 key ways: first, the communication task is accomplished using ground based systems instead of satellites; second, there is no surveillance standard and the third, the data between pilots and controllers is exchanged in a different format and presented to the pilots in a different format. The Europeans created an implementation rule mandating the use of ATN in European Airspace by 2011

In 2004, ICAO commissioned a study to understand the feasibility of incorporating CPDLC into the North Atlantic airspace to improve safety and operational efficiency. The findings showed that FANS 1/A would be compatible for use in the North Atlantic Airspace and that ATN, because of a lack of oceanic coverage and incompatible message sets, would not be

compatible (NAT SPG 45). These studies also found that FANS 1/A ground stations were incapable of providing service to ATN aircraft.

Efforts to enable ATN ground stations in European domestic airspace to support FANS 1/A aircraft began in 2007. These efforts culminated with a mandate for datalink equipage and a phased roll out of reduced separation procedures at the NAT SPG (Systems Planning Group) meeting 45. The upgrades were broken into two mandates. The first is an equipment mandate designed to increase the percentage of aircraft equipped with the upgraded avionics equipment in the North Atlantic. It requires operators to upgrade avionics equipment to CPDLC by steadily limiting the airspace in the North Atlantic in which unequipped aircraft can fly. The second is a procedural mandate. It is designed to enable reduced separation procedures in the airspace mandated for the new equipment to increase operational efficiency (NAT SPG 45 Summary, 2009).

2 Previous Literature

This section will review methods of risk assessment in previous literature coming from finance, economics and transportation. This review aims to reveal the important procedural steps, sources of uncertainty or complexity that warrant analysis in a risk assessment and, a basic methodology for completing the assessment.

2.1 Finance

The financial risk assessment considered comes from Froot & Stein (1997). It aims to provide a framework for understanding the risk involved in trading assets. The main sources of uncertainty were the future market conditions and the main source of complexity was the heterogeneity of stakeholders.

The market conditions influence the risk to the return on investment because they determine the future value of the invested asset. In the case of finance, maximizing the future value of the asset is the objective. This risk is quantified as an expected future value of the asset, and, the probability that the actual future differs from the expected value by a given margin.

Heterogeneity of stakeholders is a source of complexity in the financial system and must be understood. The behavior of the stakeholders influences the market conditions and therefore contributes to the uncertainty surrounding the objective, maximizing the future value of the asset. When the stakeholders have different individual objectives, or, play different parts in the system, they can be classified as heterogeneous. The stakeholder behavior can be influenced by their knowledge of the system, their perceived best interest, their knowledge of other stakeholders and a variety of other

factors. The stakeholders may also have conflicting interests causing them to act in ways that penalize each other. Understanding how the stakeholders will likely behave and even perhaps influencing their behavior can be an effective tool for mitigating risk (Froot & Stein 1997).

The behavior of the stakeholders in the financial system can present many scenarios with varying values of the final asset. The stakeholders in the financial system described by Froot & Stein (1997) are the bank itself, the competing banks, the government, and the general public. The banks compete to invest and buy assets in an effort to maximize profits for their stakeholders. At times, an asset can be bought by one bank from another bank. The bank buying the asset wishes to purchase the asset lowest price possible while the bank selling the asset wishes to sell it at the highest price possible. The actual price of the asset is determined by the both stakeholders' willingness to negotiate, their perceived value of the asset, and the amount of money paid for similar assets in the system. If the buyer is unwilling pay what the seller wants for the price, then the assets value goes down from an expected value because of the behavior of the buying stakeholder. Alternatively, the selling stakeholder can find another buyer for the asset in an effort to increase the value above the expected value. In both scenarios, the heterogeneity of the stakeholder interests and behaviors influenced the final value of the asset and thus and must be considered as part of the risk to future value of the investment.

2.2 Work force

An economic risk assessment for the work force is described by Calmfors (1994). As with the financial assessment, market conditions are a cause of uncertainty. Competing market forces are a cause of complexity that result in an equilibrium between the demand for jobs and the price paid for labor. It may be convenient to view the prevailing (or future) market condition as an equilibrium between (future) uncertain forces. The difference with the financial system is in that case, the objective is to influence the equilibrium instead of maximizing the value of an asset that is determined by the equilibrium.

The work force assessment begins by mapping the behavior of the equilibrium against forces by quantifying the relationship between the forces and equilibrium. This step is intended to understand the nature of the uncertainty in the system.

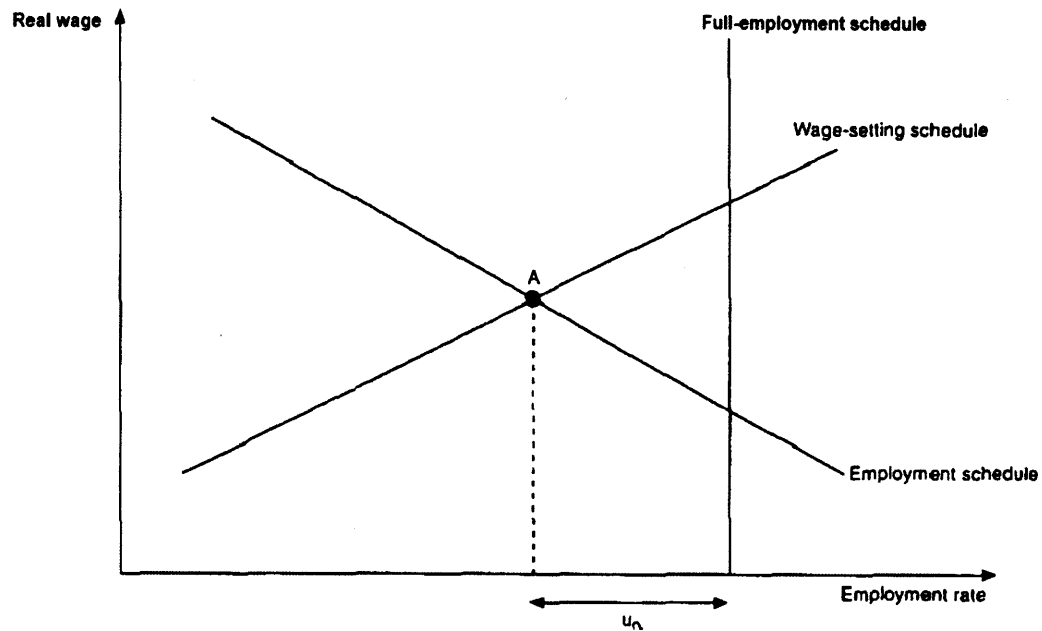


Figure 1: Wage vs. Employment Rate for different scheduling strategies

Figure 1 shows the relationship between the forces acting on the equilibrium (Demand for Wages labeled “Wage-setting schedule”, and, Demand for Employment labeled “Employment schedule”). The equilibrium point is point A, which corresponds to the values of the stakeholder value-variables: Wages labeled Real Wage on the Y Axis, and Employment rate on the X axis and is determined by the strength of the competing forces. A second equilibrium point is labeled “Full-employment schedule”. It corresponds to the point where all workers are employed.

The next step is to find the level of equilibrium that will best satisfy the heterogeneous stakeholders. The stakeholders are the workers who wish to both have a job and maximize their wage, and, the employers also wish to have workers but minimize their wage. The workers can be viewed as a group of heterogeneous stakeholders because they have varying behaviors. Some workers are willing to work for less money than others and, they all have a different objective in maximizing their own individual income (not the income of other workers). The government must then find an equilibrium that satisfies the worker stakeholders by increasing the number of jobs and satisfies the employers by not increasing the price of jobs too much.

The study then goes on to identify the “crucial design features” for employment policies that can help achieve the desired equilibrium. These crucial design features include compensation levels, the extent of job

program targeting, the resources allocated for job placement and training programs, and coordination of unemployment insurance. Specific nuances and effects in each of these features are identified in a way that will aid the policy maker in crafting a policy that will achieve the desired equilibrium

2.3 Transportation:

Corrigan et al. (1999) presents a quantitative risk assessment for “transitioning from a ground-based navigation system to a satellite-based system using signals provided by the Department of Defense’s Global Positioning System”. This risk assessment most resembles in terms of application and technology to the data link case study in this thesis which is a program risk assessment. The technical objective of the GPS design study is and risk assessment is quantitative: it is to find the parameters of the system design needed to meet a set of quantitative of performance standards for navigation. The risk assessment is intended to gain insight into the risks that would prevent the system from meeting these performance standards. The performance standards set requirements for accuracy, integrity, continuity, and availability or, a required navigation performance standard (RNP). This standard is the main technical performance specification that comes from the program’s stakeholders. The risk identification process showed that “unintentional interference” and “propagation effects from the ionosphere” were identified that could impact the ability of the GPS system to meet the performance standard. The impact to the performance standards and the impact of the possible mitigation strategies were determined with mathematical models. A hazard risk index was developed to probability or likelihood of occurrence, and, the impact of the occurrence. After the risks and mitigation strategies were evaluated, recommendations were made as to the best GPS configuration and mitigation strategies. The findings for each risk were also described in detail so that the stakeholders could understand the assumptions made in the assessment and nuances that were the driving factors in the impact and likelihood of each of the risks.

2.4 Summary

The common steps in the risk analysis methods are designed to reduce the uncertainty and complexity in the system of interest. The first step is a stakeholder analysis; it is needed to gain insight in to stakeholder behavior. The financial risk assessment included analytical models of stakeholders (households, and banks) behavior and the unemployment policy assessment included an analytical model of firm behavior and worker behavior. It is important to note that each assessment recognized the heterogeneity in the stakeholders and assigned different models when the behavior differed and when different roles in the system were played. The second step was to understand the relationships between the forces in the system and the

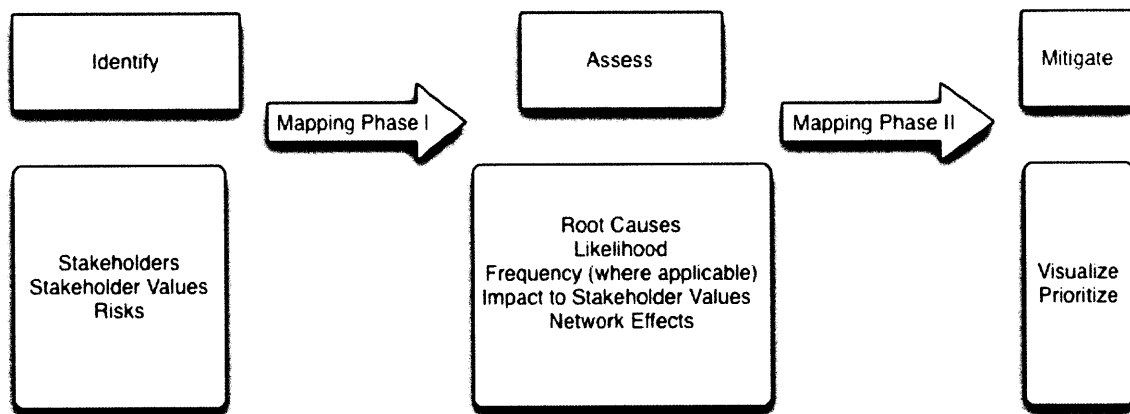
equilibrium. The equilibrium point can be thought of as a state vector or a set of values of variables that are important to stakeholders. In the unemployment assessment, the equilibrium point was the number of employed workers, and, the wages the employed workers received. These variables are influenced by a number of forces including the demand for labor and the wage that workers are willing to accept. The relationship between the forces and the equilibrium point was quantified analytically and graphically as shown in Figure 1. The last step is to identify what causes uncertainty in the forces on the equilibrium and try and come up with a remedy to either minimize or contain the uncertainty within acceptable bounds, or introduce a new and perhaps overwhelming force to move the equilibrium point to a more desirable location for the stake holders. The GPS risk assessment used analytical models to determine the affects of uncertainties on the performance metrics (or the equilibrium point). An example of an overwhelming force could be a tax credit for employers who raised their wages. The result of the tax cut would be increased wages and employment for the workers and a lower cost of business for the employers. Another overwhelming force that could be introduced is a mandate, that could disallow wages below a certain threshold. After the stakeholder behavior is understood, the relationship between the forces in the system and the equilibrium point is understood, then mitigation strategies such as introducing forces or reducing the uncertainty in the forces can be tested.

3 Framework

The framework described in this thesis divides the risk assessment into three distinct phases: Identification, Assessment, and Mitigation and is depicted in Figure 2. This framework is adapted from Campos (2008). The purpose of the identification phase is to identify the major stakeholders, the value categories of the stakeholders, and an initial set of risks that could impact the value to the stakeholders. This step fulfills the need to understand what the stakeholder values are and the behavior of the stakeholders. A mapping step is required to transition from the identification phase to the assessment phase. The mapping step is intended to match information needed to assess the identified risks to the sources of information available for the assessment. The assessment phase is used to determine the impact, likelihood, and frequency of each risk, and the intensity of the network effects of each risk. Network effects are effects stemming from interactions between risks. They include the dependency and influence a risk has on other risks. The root causes for each risk are also determined in the assessment phase along with their corresponding network effects. These steps are meant to identify the forces on the equilibrium point, and understand their sources of uncertainty. Another mapping step, visually

mapping the network effects and the impact and likelihood simultaneously to each risk is required to transition from the assessment phase to the mitigation phase. The mitigation phase is intended to communicate the integrated picture of network effects, impact, and likelihood of the entire set of risks to the risk assessor so that a mitigation strategy can be formulated. The complete assessment should include the integrated visualization, a set of summaries about the caveats of each risk, and a statistical analysis of the responses so the assessor can gauge the confidence of individual pieces of the assessment and easily prioritize the order in which the risks should be mitigated.

Figure 2: Framework Diagram



3.1 Identification

The identification step consists of the stakeholder identification, stakeholder value identification, and risk identification. This step may also seek insight into stakeholder behavior but the full analysis is completed in the assessment phase.

3.1.1 Stakeholder Category Identification

Stakeholder category identification should be conducted by first interviewing the parties in charge of the policy to find out who the policy will affect, and then by conducting a comprehensive investigation to determine the ways in which stakeholders extract and contribute value to and from the system and to other stakeholders. Sources of heterogeneity between the stakeholder behavior and system roles should be identified at this stage and modeled as separate entities.

3.1.2 Stakeholder Value

Determining the stakeholder values should be accomplished by conducting a comprehensive investigation of the stakeholder behavior, economic and non-economic values in the system, and through reviewing literature and notes written about the system by stakeholders and others. Stakeholder values in technology systems are usually of economic, technical and safety in nature. Where possible, it is important to distinguish the between same value type for different stakeholders categories. For example, if costs were identified as a stakeholder value, the costs for stakeholder 1 and stakeholder 2 could be independent and should be treated as such.

A comprehensive method for Stakeholder analysis is described in the class notes by deWeck (2010) which are adapted from the NASA Systems Engineering Handbook. The actual characteristics that need to be known about the stakeholders should be determined in the context of the risk assessment.

3.1.3 Risk

Risk identification should be accomplished by analyzing meeting notes, technical papers, and interviews with experts and stakeholders. The risk identification process should also culminate with verification by an expert and should be allowed to continue throughout the assessment phase in case any new risks are identified.

3.2 Mapping Phase I

The mapping phase is a transition phase meant to prepare the data gathered and generated in the identification phase for further data gathering and investigation. Each risk should be mapped to a set of data gathering instruments which can include interviewing and experts, written sources of information, or analytical models. The mapping should then be verified by a third party or even the interviewees in the data gather instrument to insure that the data can be gathered from the intended sources.

3.3 Assessment Phase

The assessment phase is intended to assess the, background, root causes, the likelihood, impact and frequency (where applicable) of each risk along with the various network effects or coupling effects that exist between risks. This phase is similar to the risk analysis described in the GPS risk assessment. The assessment phase should also attempt to assign a root cause and outcome to each risk. The data gathering for the assessment phase should be conducted by the investigator and should produce a set of comparable data using either analytical methods or ordinal data from stakeholders as comparisons.

3.3.1 Impact

The impact assessment is meant to quantify in some way, the potential impact of each risk to each value category and compare these results to the impact results of other risks. The impact of each risk to each value category must be assessed independently despite the fact that some people may not identify the same risk impact as being part of the same category. At this point in the process, little is known about the network effects between impact categories and other risks but these effects, such as impacts to an aggregate set of categories can be examined in the next step. When there is little data available about the intended impacts of each scenario and the potential impacts of the risks, ordinal data should be used to describe the impact of each risk.

3.3.2 Network Effects

Risks can have dependencies on other risks, influence other risks, or act in a compound with other risks to form a more impactful set of consequences, a more likely outcome or a more frequent outcome. Questions of dependency and influence can be assessed in survey and perhaps using the same data gathering instruments used for assessing impact.

3.3.3 Root Causes & Outcomes

Root causes and possible outcomes should also be captured by the data gathering instruments. The root causes need to be analyzed to find possible network effects and shared causes between risks. If possible, root causes and backgrounds can be linked dynamically with other risks by combining the data found and the network effects.

3.4 Mapping Phase 2

The second mapping phase involves creating a graphic representation of the data collected in the assessment phase. The data collected in the assessment phase has several dimensions: root causes, likelihood, impact to each impact category, influence on other risk and dependencies on other risks. Much of this data can be visualized using a combination of shapes, colors, network diagrams and aggregating schemes.

3.5 Mitigation Phase

The mitigation phase is intended to present the data that is gathered in the assessment phase in a way that is helpful in forming mitigation strategies. The mitigation phase should consist of a statistical analysis in order to rank risks with a weighting scheme which could include combinations of impact, dependencies, or any of the dimensions reported in the assessment phase. The mitigation phase should also contain an analysis of the root causes and the background information gathered during the assessment phase. These recommendations are based on the premise that a mitigation strategy is

likely to involve prioritizing risks and that the categories assessed are the most relevant to creating an effective priority list. Further studies should be conducted to determine the usefulness of basing mitigation strategies on different types of prioritized lists and in comparison to other mitigation strategies.

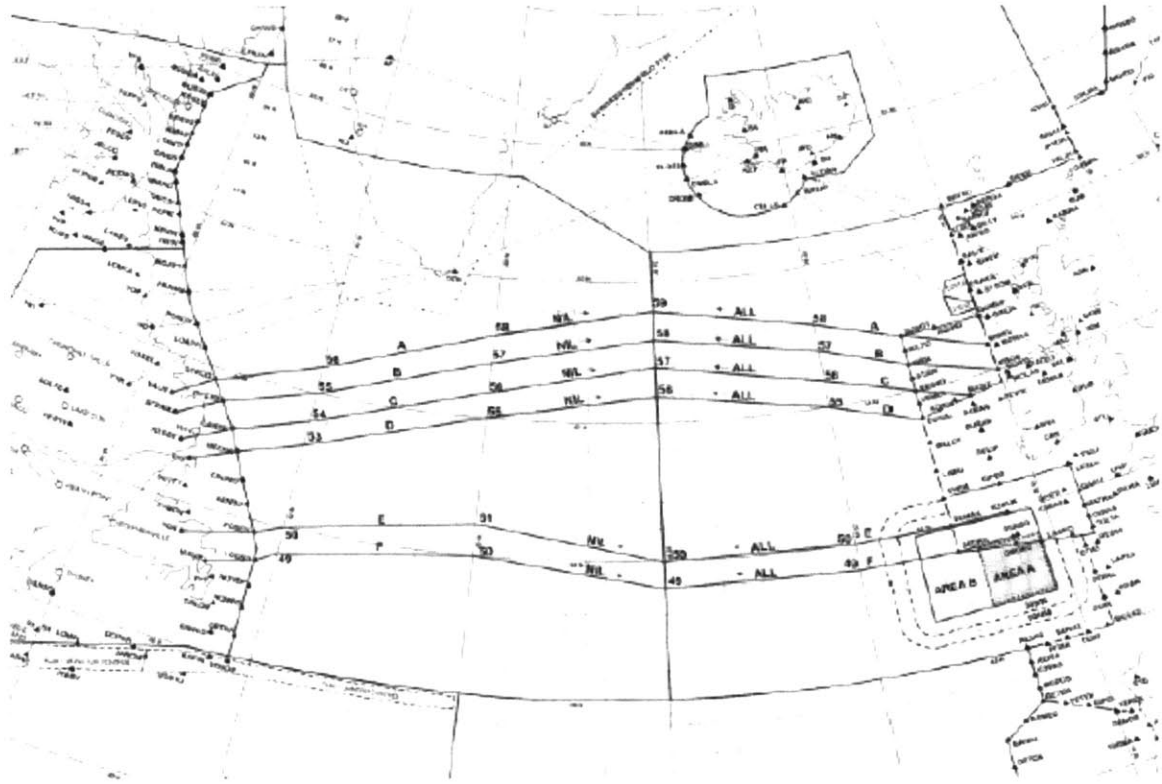
4 Conceptual Model of Oceanic Flight Operations

Computer pilot data link (CPDLC) emerged as a technology to deliver enhanced communications during over water operations that are out of the range of typical radar services. The data link equipment allows text messages containing instructions and position reports to be exchanged between pilots and controllers through satellite and ground stations. These communications would otherwise be completed verbally and then transmitted through high frequency radio and radio relay operators in places without radar coverage. CPDLC communication has several advantages over High Frequency radio (HF) including quicker message exchanges, a larger number of allowable messages that can be exchanged over a given period of time, and a lower probability for human error. These advantages make reduced separation and more efficient operations possible (NAT Concept, April 1999).

4.1 Traffic Flows:

The concept of operations in the North Atlantic involves a track system called the Organized Track System (OTS) and the ability for aircraft to request routes inside and outside of the track system. A depiction of a set of westbound tracks in OTS is shown in Figure 3. The track system occupies a section of airspace that contains optimal routes for flights between the upper east coast of North America and the Upper West Coast of Europe. There are two sets of tracks one for eastbound flight and one for westbound flights. Within each set of tracks for aircraft, there are individual tracks that are separated laterally by 60 miles. In addition to the track separation, each aircraft must maintain 10 minutes of separation from other aircraft flying on the same track (ICAO, April 1999). Each aircraft enters or leaves a track at the oceanic entry point (OEP). The OEP is in an area with radar coverage and represents the border between oceanic operations and domestic operations. The positions of the tracks in OTS are updated twice per day depending on the wind directions. There are also high and low points of traffic activity along the tracks due to the travel patterns that passengers prefer the most.

Figure 3: West Bound Tracks (OTS) Nat SPG 2005

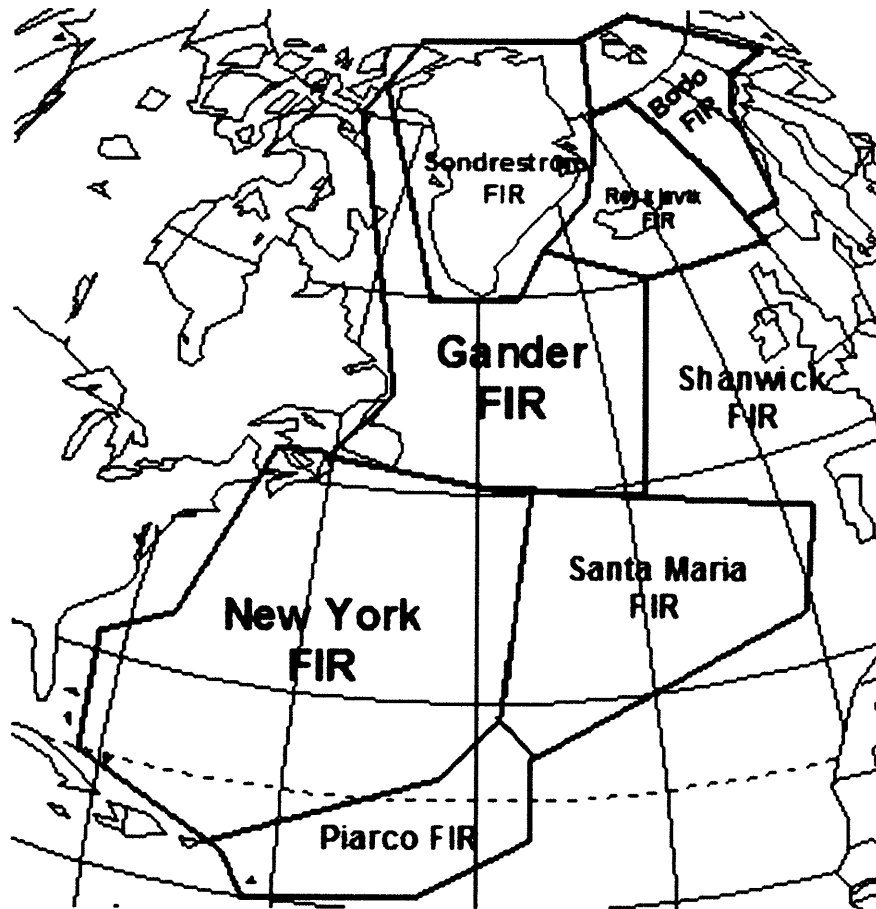


In cases where the optimal route does not lie within the OTS airspace, an operator can request a route outside the tracking system known as a “random route”. Aircraft using random routes must make more position reports and observe the same separation distances. The entire oceanic airspace is referred to as Minimum Navigation Performance Specification airspace or (MNPS) and is vertically bounded by a lower altitude of 28000 feet and an upper altitude of 41000 feet (NAT Concept, April 1999).

4.2 Oceanic Control Areas

There are several oceanic control areas or flight information regions (FIRs) that cover the entire North Atlantic Airspace. When an operator is flying in a designated FIR, that operator will interact with the corresponding Air Navigation Service Provider (ANSP) and will also pay a communications fee for the messages exchanged with the provider. A map of providers and FIR’s is shown in Figure 4.

Figure 4: North Atlantic Flight Information Regions (Adapted from FAA June 1999)



4.3 Inefficiencies

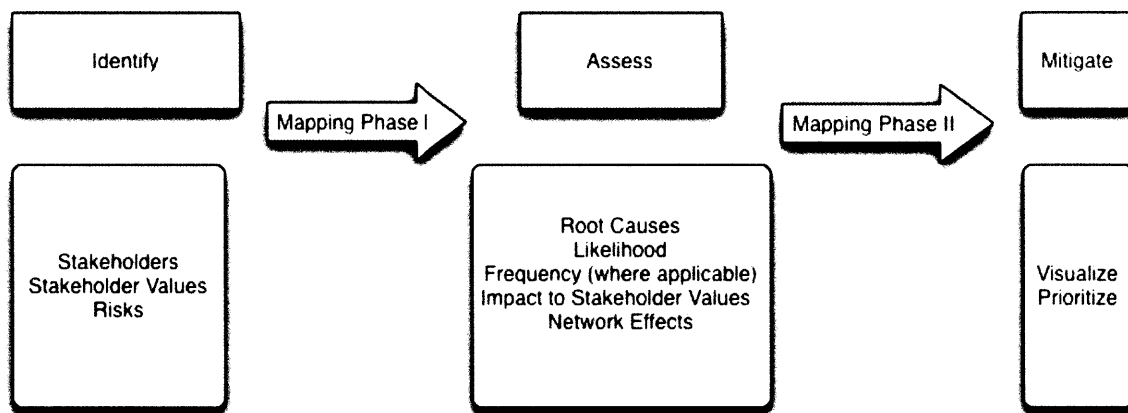
There are several inefficiencies present within the OTS. First, because of the large aircraft separation distances required and the long lag time in using HF radio communications, flights must often operate at suboptimal flight levels for long periods of time before receiving clearance to operate at more fuel efficient flight levels. Second, also because of the large separation distances, there is a limit to number of aircraft that fly using the optimal tracks for coast to coast routes. Aircraft that wish to fly these tracks may encounter delays to wait for a space to become available or, suffer a fuel burn penalty for leaving on time and operating on a less optimal track. It is difficult to know which track an aircraft will be assigned so airlines must carry extra fuel which also results in an additional fuel burn penalty when flying an optimal route due to the extra weight of the extra fuel. Reducing the separation distances is thought to have the potential of mitigating against these inefficiencies by saving the operator fuel and increasing the number of aircraft that can fly safely in the North Atlantic a given time. The data link

mandate and 25NM lateral reduced separation procedures are policies that encourage operators to adopt data link equipment which would then allow for the reduction in separation distances.

5 Framework Application

The framework application section will describe how the framework described in section 3 was applied to this problem. For reference, the framework diagram is reproduced in Figure 5.

Figure 5: Framework Diagram



5.1 Identification

The identification step consists of the stakeholder identification, stakeholder value identification, and risk identification. As mentioned in the framework section, these steps must occur concurrently, require stakeholder input, and determine the format of the data set that will be collected.

5.1.1 Stakeholder Category Identification

The stakeholder categories were determined by examining three types of sources: past ICAO surveys, past ICAO meeting papers, and past ICAO papers. After several iterations of the creating categories, a consensus was built with FAA input.

5.1.2 Stakeholder Value Identification

The stakeholder value categories were identified by consulting stakeholders and reviewing the stated benefits of the data link mandate and reduced separation procedures. The categories consisted of safety benefits and economic benefits aligned to the stakeholders.

5.1.3 Risk Identification

Lastly, the risks were identified, by reviewing previous ICAO meeting notes, survey and technical papers. The stakeholders were given an opportunity during the interviews to add and modify the list of risks during the assessment phase. The risks were also separated by which risks influenced reduced separation initiatives only and those that influence both the data link mandate and reduced separation initiatives.

5.2 Mapping Phase

The mapping phase is a transition phase meant to prepare the data gathered and generated in the Risk Identification Phase for further data gathering and investigation. During this phase, a survey was created as the main data collection instrument. The survey was given to stakeholders from each stakeholder category for gathering ordinal data on the root causes, impact to stakeholder value metrics, dependencies and mitigation difficulties for each risk. Stakeholders were allowed to pick the questions they wished to answer and were asked to indicate qualitative levels for some categories such as “Very High, High, Medium, Low, Very Low, or None” to generate the ordinal data and the ability to compare responses to those of other stakeholders.

5.3 Assessment Phase

The assessment phase is intended to assess the collected data from the survey instrument and analyze in a way that is meaningful the users of the risk assessment. The assessment phase consisted of a data reduction step to aggregate the responses of all of the stakeholders who took the survey in a way that can be represented and graphically and analyzed to uncover key insights.

5.3.1 Impact

The impact of each risk was assessed with ordinal data and reduced into an aggregated average for each stakeholder value category. Based on these averages, an aggregated impact category was created by summing the risk impacts to each category. This strategy allows the user of the assessment to have visibility into which risks have the largest overall impacts in addition to the knowledge of how each risks impacts each stakeholder value category.

5.3.2 Network Effects

The network effects encompass the ways in which risks influence each other. The respondents were asked to identify risk dependencies for each risk and sometimes identified how risks influence other risks. These dependencies

and influences were mapped graphically and converted into a matrix to reveal loops and co-dependencies that formed between risks.

5.4 Mapping Phase 2

Several graphical depictions of the impacts and network affects were completed for the second mapping phase. These depictions were then used to discern the key insights of this risk assessment which will be used by others in the mitigation phase to form a mitigation strategy.

5.4 Mitigation Phase: It was determined that the mitigation phase was outside the scope of this assessment and is left to the ICAO leaders who will use the data gathered to decide on a mitigation strategy.

6.0 Results

The results of the risk analysis are presented in this chapter in four parts: stakeholder categories, risk identification, a graphical depiction of the risk impacts, dependencies and influences and, a discussion with key insights about each stakeholder category and the important relationships depicted in the graphical section.

6.1 Stakeholder Categories

The stakeholder impact categories are categories or dimensions in which the impact of each risk was measured. These categories are considered important to one or more stakeholders of the data link mandate plan.

6.1.1 Safety

The safety category captures any perceived risk to the safety of operations in the North Atlantic. Impacts to overall safety can occur as changes to the probability of a collision, the ability or time needed to detect or correct a hazardous situation, the availability and reliability of equipment, and the likelihood of human errors.

6.1.2 Operational Efficiency

Operational Efficiency encompasses any perceived change in efficiency in operations of the ANSPs and aircraft operators. These operations include but are not limited to, delivering climb and cruise clearance, filing flight plans and making flight plan changes, handling congestion and the potential for congestion along the tracks and oceanic entry points, the handling of delays and equipment failures, and the potential throughput of the aircraft in the North Atlantic System.

6.1.3 ANSP Costs

The ANSP costs category encompasses the perceived changes in costs to Air Navigation Service Providers. These costs include but are not limited to staffing costs, equipment costs, and training costs.

6.1.4 ANSP Revenues

The ANSP Revenues category encompasses the perceived changes in revenues to Air Navigation Service Providers. These revenues include but are not limited revenue changes due to changes in traffic volume, message volume, and messaging fees.

6.1.5 Operator Costs

The Operator Costs category encompasses the perceived changes in costs aircraft operators. These costs include but aren't limited to fuel burn costs, ANSP costs, costs due to aircraft delays, and costs associated with aircraft downtime for equipment installation, training and equipment upgrades.

6.1.6 Operator Revenues

The Operator Revenues category encompasses the perceived changes in revenues to operator revenues. These revenues include but are not limited to revenue changes due to flight cancelations and restrictions on aircraft that were previously in service in the North Atlantic.

6.2 Risk Identification

The Risk Identification Process initially resulted in the identification of 23 risks with a 24th risk, added by one of the respondents. For the purposes of the survey, the risks were identified by an alphabetical letter (A-Z) and a short descriptive phrase of the risk and or possible result of occurrence. For the purposes of this analysis each risk is first grouped by category, then the identifying letter and descriptive phrase. A detailed analysis of each individual risk is included as a separate appendix at the end of this thesis. The risk categories are: Policies and Procedures, Coordination and Timing, Technology, Equipage, Safety, and Business Concerns. These categories are adapted from Campos, (2008 pg. 82).

6.2.1 Policies and Procedures

The Policy and Procedures category encompasses risks that can compromise the development of policies and procedures to ensure a safe, efficient, and seamless implementation of NAT SPG data link initiatives and the successful accommodation of those aircraft that are unable to equip.

G: Failure to develop measures to accommodate unequipped aircraft

H: Restricted access to airspace for unequipped aircraft

J: Operators choosing to operate in areas where other types of surveillance are provided (e.g. radar, ADS-B)

M: Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT

6.2.2 Coordination and Timing

The coordination and timing category encompasses risks that could hinder the effective coordination and timely completion of planning tasks for data link mandate and 25NM Lateral Separation.

D: Late completion of data link mandate plan. Not enough time for commercial and business operators to plan and comply with mandate (e.g. determination of entire flight level spectrum and OTS tracks where mandate is to be applied, etc.).

E: Failure to achieve effective coordination with other ANSPs (harmonization of technical systems and operating methods)

F: National Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe

S: Late completion of 25NM lateral separation planning tasks.

C: ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation (e.g. ensuring that deviations from norm are captured quickly, etc.)

6.2.3 Technology

The technology risks category encompasses risks to the timely development and approval of technical standards or technical designs for data link equipment.

L: Failure to establish a plan or go forward with mitigation to meet RCP240.

This also includes failure of ground infrastructure to support RCP240

N: Impact of ICAO Annex 6 data link communications airborne recording standard (See Appendix B)

R: No ICAO communication, navigation, and surveillance standards available to support implementation of 25NM lateral separation (for example, RNP 4 meets navigation criteria for 30 NM)

P: Uncertainty in approval of Iridium-based equipage to meet requirements for data link mandate and 25 NM reduced lateral separation

6.2.4 Equipage

The equipage risk category encompasses risks that could reduce the availability and sustainability of data link equipment (or equipage) as well as data link adoption by operators

A: Equipage for business operators not available or certified in time to meet mandate
B: Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand
I: Mixed equipage environment during transition
O: End of service life of I3 satellite services expected about 2016. New equipage may be required to use classic aero services via I4 satellites.
Q: Failure to achieve percentage of equipped flights needed to move forward with phases of 25NM lateral separation
W: Late delivery of new aircraft orders that are replacing older, unequipped or unequippable aircraft

6.2.5 Safety

The safety category encompasses risks that could hinder the ICAO, the operator's and, the ANSP's ability to maintain or improve safety levels in the NAT through the implementation of data link mandate and 25NM lateral separation.

T: Failure to meet safety case for 25 NM lateral separation (Feasibility analysis may find that better performance is needed. Actual performance may not meet feasibility analysis expectations
U: Failure to control vertical risk when 25 NM lateral separation is implemented
Y: HF network may be unable to support communications demand in event of total data link failure or reversion to normal separation.
K: Increased traffic in MNPS routes other than OTS routes

6.2.6 Business Concerns

The Business Concerns category encompasses risks that can hinder the economic ability of the operators and ANSPs to comply with the data link mandate and 25NM lateral separation.

V: High costs preventing operators from retrofitting to meet requirements for data link mandate and 25 NM lateral separation
X: Cost benefit analysis may show that costs outweigh the benefits of implementing the data link mandate and/or 25 NM lateral separation

6.3 Stakeholder Values and Graphical Depictions of Impact and Likelihood

The following sub sections include a graphical depiction the impact, likelihood, dependency, corrective action difficulty and category information for each risk. The impact section will describe the potential risk impacts to individual stakeholder categories and aggregated categories. The dependency section will describe patterns in the risk dependencies along with several examples of high impact risks that form the patterns. These graphical depictions are meant to give insight into the relationships between risks (dependencies and influences) and their relative impacts. The root causes and outcomes are not depicted directly in these graphs but are discussed in detail in the individual risk dependencies. The risk dependencies are shown with a directional arrow. If an arrow is pointing from risk A to risk B, then risk B is dependant upon risk A.

6.3.1 Impact Likelihood Summary

The following graphs depict the perceived possible impacts of each risk on stakeholder categories, likelihood of occurrence for each risk, and dependencies of each risk upon other risks. In addition to the stakeholder categories, two additional aggregate categories are constructed from the results of the individual stakeholder categories. The Aggregate Impact category is a representation of the overall risk impacts. Each risk's impact is computed as cumulative sum of the impacts from each risk category which are converted to integers from ordinal data. The risks are then ranked into quintiles with the highest 20% of overall impacts receiving the red color signifying the "first fifth". The Aggregated Impact to benefits section is computed in the same way but only the operational efficiency, ANSP Costs, ANSP Revenues, Operator Costs, and Operator Revenues will be considered.

6.3.2 Aggregate Impacts:

The graphical depiction of the likelihood and aggregated impact of all the risks for the Mandate and Reduced Separation is shown in Figure 6, for the mandate only in Figure 7, and to economic benefits in Figure 8. The highest aggregated impact risks shown in Table 1 come from the coordination and timing category (Risks C and F), the technology category (Risk R), the technology category (Risk R) and the safety category (Risks T and Y). The coordination and timing risks (C, and F) both impact the rulemaking process. The rulemaking process is required a safety certification process that is conducted by local state authorities in order to verify the new standards or

procedures meet the individual safety requirements of each state. The timely implementation of new procedures can be compromised by these risks because the rulemaking process must be completed before the implementation of any new procedures in the North Atlantic. The technology risk R impacts the technical performance standards that must be met by the data link equipment. These standards are needed by the equipment manufacturers and must be set before the safety and verification processes can take place. Impacts to standards definition can create significant delays in implementation because later processes such as safety certification tests and equipment procurement need the definitions before moving forward. The safety risks T and Y, can impact all processes that lead to implementation because once a safety risk occurs, it must be addressed before 25NM lateral implementation and the solution must again be verified through flight tests. It is highly recommended by multiple respondents that risk Y (HF network may be unable to support communications demand in event of total data link failure or reversion to normal separation) be assessed as part of the safety case so that an occurrence of an data link failure after implementation of 25NM lateral procedures will not impact the achieved level of safety. All of these risks can compromise the ability of ANSPs and Operators to gain economic benefits because they delay implementation of 25NM lateral which is expected to yield fuel burn, operational efficiency and capacity improvements.

| Risk | Category | Description |
|------|-------------------------|---|
| C | Coordination and Timing | ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation (e.g. ensuring that deviations from norm are captured quickly, etc.) |
| F | Coordination and Timing | National Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe |
| R | Technology | No ICAO communication, navigation, and surveillance standards available to support implementation of 25NM lateral separation (for example, RNP 4 meets navigation criteria for 30 NM) |
| T | Safety | Failure to meet safety case for 25 NM lateral separation (Feasibility analysis may find that better performance is needed. Actual performance may not meet feasibility analysis expectations) |
| Y | Safety | HF network may be unable to support communications demand in event of total data link failure or reversion to normal separation. |

Table 1: Highest Impact Risks (Aggregated Impact)

Figure 6: Aggregate Impact (Mandate and Reduced Separation)

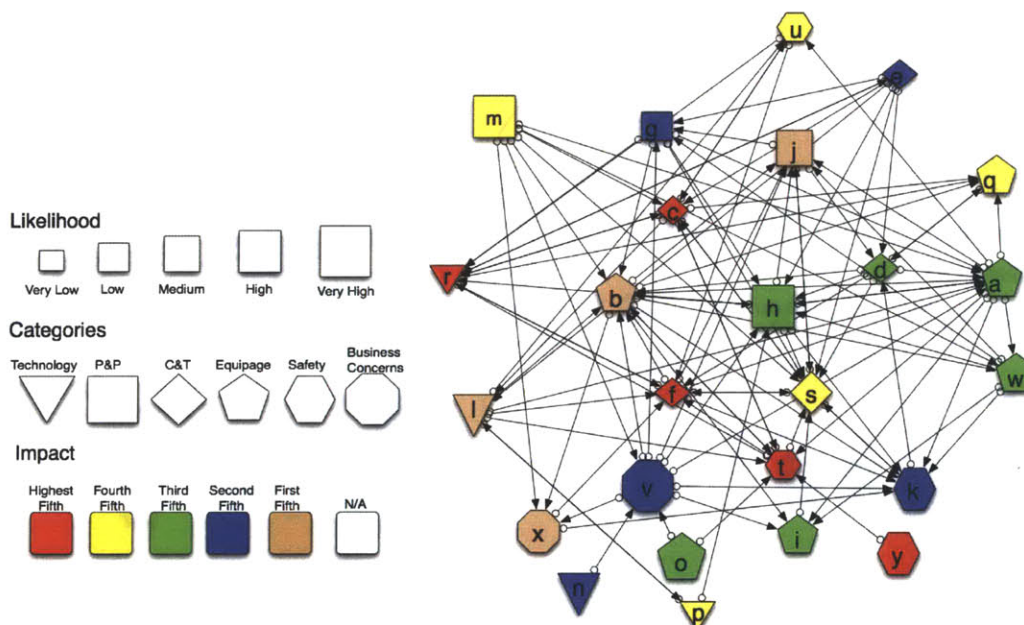


Table 1 lists the highest-ranking risks for the Aggregated Impact category and Aggregated Impact to benefits category. The impact of these risks is summarized in beginning of this section.

The aggregated impacts for risks affecting the mandate only are shown in Figure 7. Risks M (Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT) and P(Uncertainty in approval of Iridium-based equipage to meet requirements for data link mandate and 25 NM reduced lateral separation) are part of the highest ranking risks when only the risks affecting the mandate are considered. Risk M can result in large equipment costs if operators need to equip with both ATN and FANS 1/A, significant numbers of data link equipped aircraft (FANS 1/A or ATN) that come into service after 2015 could be restricted from serving destinations between Europe and North America none of the current equipage policies (Europe and North Atlantic), and restrictions (Europe and North Atlantic) don't change. Risk P is an equipage risk that could also result in significant numbers of data link equipped aircraft (using Iridium) becoming out of compliance with the mandate if the Iridium satellite system does not meet the necessary performance requirements. The primary goal of the mandate is to increase safety by increasing the number of data link mandate compliant aircraft.

Figure 7: Aggregate Impact, Mandate Only

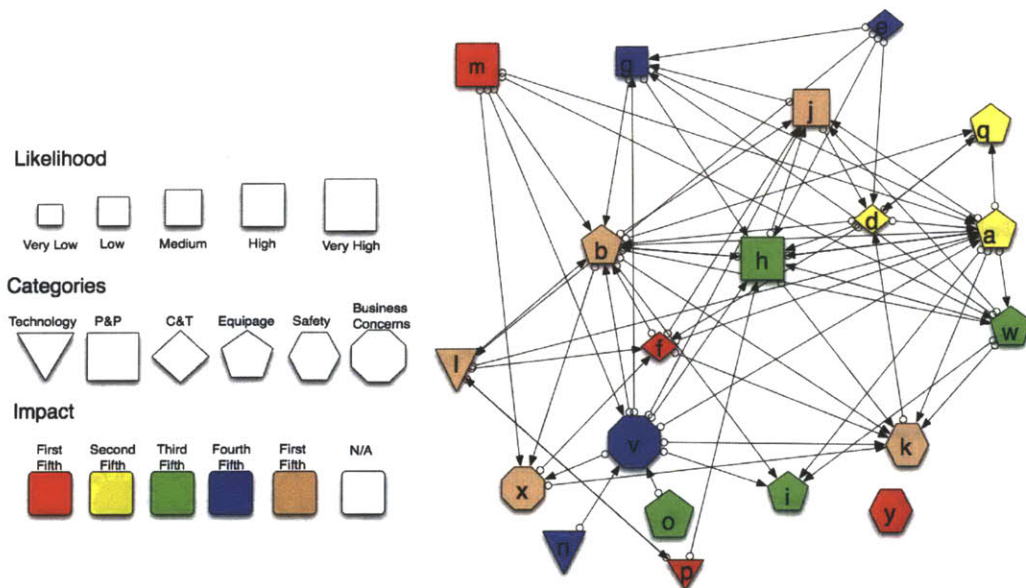
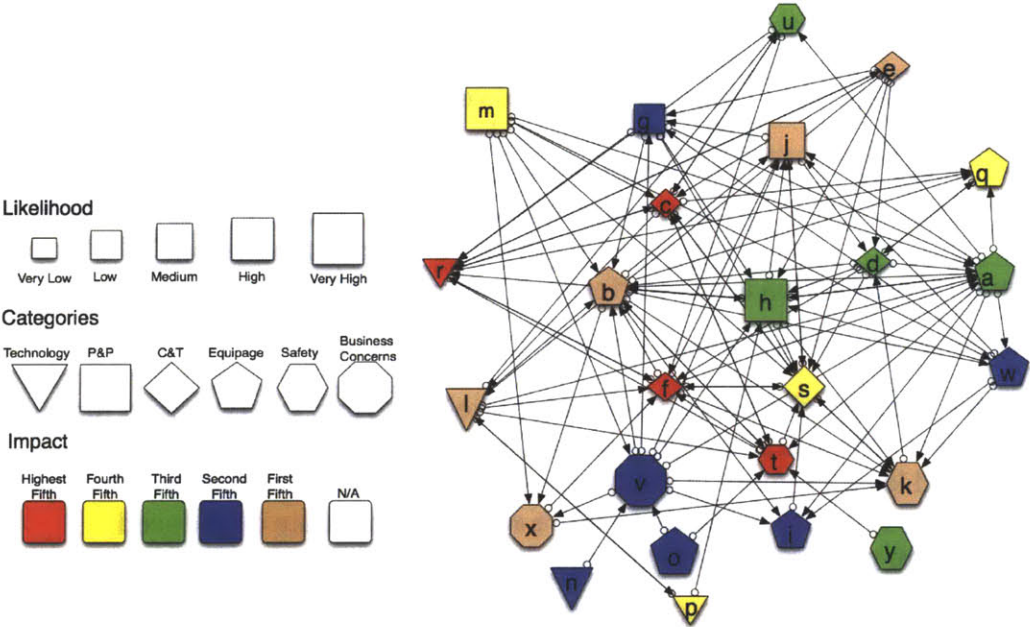


Figure 8 is a graphical depiction of the likelihood and aggregated impact to economic benefits for all of the risks. The aggregated impact economic benefits category considers each risks impact operational efficiency, ANSP costs and revenues, and Operator costs and revenues according to the

respondents. This is an important category because it highlights the potential risks with the highest economic impact and captures the different types of economic impacts in one category. These risks are summarized in the beginning of this section shares the same highest impact risks as the aggregated impact category.

Figure 8: Aggregate Impact to Economic Benefits, Mandate & Reduced Separation



6.3.3 Safety Impact

The graphical depiction of the likelihood and Safety impact of each risk is shown in Figure 9. The program risks can impact the level of safety by causing a reduction in the number of equipped aircraft, hindering the ability of operators and ANSPs to respond to operational failures, and, by increasing the level of operational risks. The highlighted risks that impact these areas are shown in Table 2. Risk Y is a safety risk that can impact the ability of ANSPs and Operators to respond to a data link failure when there are high traffic loads. Risk U describes the operational risk of a reduced vertical safety margin when 25NM lateral procedures are implemented however, this risk was given a low likelihood by the respondents. The respondents did suggest that both risks Y and U be examined as part of the safety case. The technology risk O can impact aircraft that are data link equipped and use the Iridium satellite services. If risk O occurs, those aircraft would be out of compliance with the mandate and the number of equipped aircraft could drop significantly. Lastly, the technology risk L can impact the communications requirement for 25NM lateral separation. If the RCP240 is not met by either the current data link equipment or the current ground

infrastructure the 25NM lateral initiatives could either be delayed or

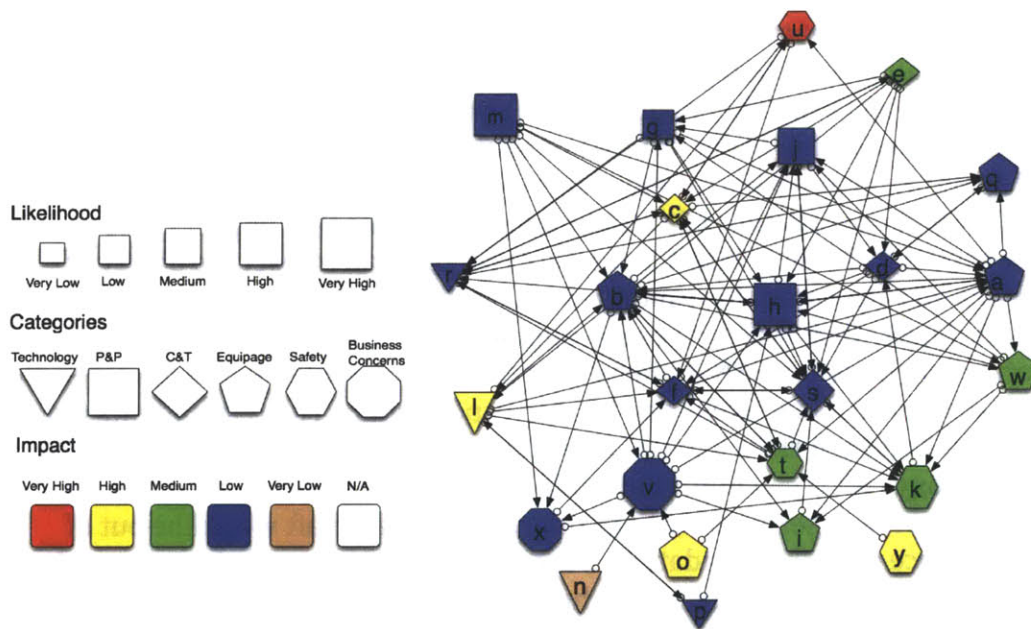
| Risk | Category | Description |
|------|------------|---|
| L | Technology | Failure to establish a plan or go forward with mitigation to meet RCP240. This also includes failure of ground infrastructure to support RCP240 |
| O | Equipage | End of service life of I3 satellite services expected about 2016. New equipage may be required to use classic aero services via I4 satellites. |
| U | Safety | Failure to control vertical risk when 25 NM lateral separation is implemented |
| Y | Safety | HF network may be unable to support communications demand in event of total data link failure or reversion to normal separation. |

implemented with a lower performing communications standard.

Table 2: Highlighted Risks (Impact to Safety)

Figure 9 is a graphical depiction of the likelihood and safety impact for all of the risks. The safety category considers a risks' potential impact to the achieved level of safety in the North Atlantic and impacts that would require some sort of safety mitigation before either the mandate or reduced separation procedures are implemented.

Figure 9: Impact to Safety: Mandate & Reduced Separation



6.3.4 Operational Efficiency Impact

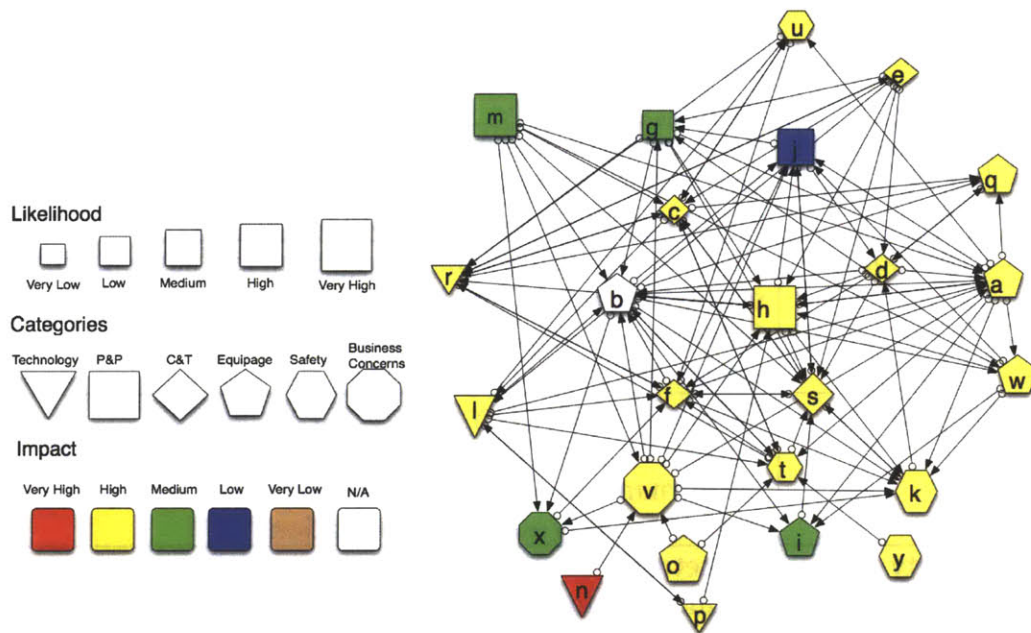
The graphical depiction of the likelihood and operational efficiency impact of each risk is shown in Figure 10. Operational efficiency can be impacted by risks that can reduce the number of equipped aircraft, by impending restrictions that could result in congestion, delays to the implementation of 25NM lateral, and operational risks that can cause certain areas of the North Atlantic to temporarily revert back to larger levels of separation. Some of the risks that impact these areas are highlighted in this summary and are listed in Table 3. Risks N and V can impact the levels of equipage in the North Atlantic. Risk N, if enforced, would render all aircraft without a data link recording capability out of compliance with the mandate. This would add also to the economic barriers, which are encompassed in Risk V, that could keep the levels of equipage down in the North Atlantic. The level of equipage is an important determining factor in the achieved operational efficiency because unequipped aircraft are subject to restrictions. These restrictions are encompassed in Risk H and, some of the effects of these restrictions, such as increased traffic in MNPS airspace (Risk K) outside of the OTS, can result in traffic patterns that reduce operational efficiency. Risk Y is a safety risk that can cause aircraft to revert back to larger separation distances in the event of a data link failure. If risk Y occurs during peak travel times, operators who have scheduled takeoffs may encounter delays or have to accept less optimal flight levels. Additionally, operators that have flights in the air may be forced to hold or slow down in order to increase the separation distances. The ANSPs may need to reduce their aircraft throughput rates and will need to safely separate the aircraft with a reduced communications capability.

Table 3: Highlighted Risks (Impact to Operational Efficiency)

| Risk | Category | Description |
|------|-------------------------|--|
| H | Policies and Procedures | Restricted access to airspace for unequipped aircraft |
| K | Safety | Increased traffic in MNPS routes other than OTS routes |
| N | Technology | Impact of ICAO Annex 6 data link communications airborne recording standard (See Appendix B) |
| V | Business Concerns | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25 NM lateral separation |
| Y | Safety | HF network may be unable to support communications demand in event of total data link failure or reversion to normal separation. |

Figure 10 is a graphical depiction of the likelihood and operational efficiency impact for all of the risks. The operational efficiency category considers a risks' potential impact to the achieved operational efficiency of the ANSPs and aircraft operators. Operational Efficiency can encompass metrics such as aircraft throughput, impacts to total flying time such as delays and congestion, optimal route placement, and impacts fuel efficiency.

Figure 10: Impact to Operational Efficiency: Mandate and Reduced Separation



6.3.5 ANSP Cost Impact

The graphical depiction of the likelihood and ANSP Cost impact of each risk is shown in Figure 11. ANSP costs are impacted by the need for additional or unanticipated equipment investments and additional or unanticipated staffing investments. Some of the risks that impact these areas are highlighted in this summary and are listed in Table 4. Risks C, F, R, and T, and Y can all cause a need for additional or unanticipated equipment investments. Risk C can result in upgrades to automation software that is needed to handle conflict resolution for the lower separation levels of 25NM lateral procedures. Risk F can result in additional hardware, software, or staffing requirements if the rulemaking process finds that the current capabilities of the ANSP are not sufficient. Risk R can result in additional hardware and software investments if the final standards set by ICAO aren't meant with the ANSP's current capabilities. Risk T, like risk F can result in hardware, software, and staffing investments if the safety case finds that additional ANSP capabilities are needed. In theory the safety case should be evaluated and satisfied before the rulemaking process takes place. Risk Y, can result in additional equipment investments such as Satcom phones, or additional staffing requirements to mitigate against a data link failure in high traffic loads.

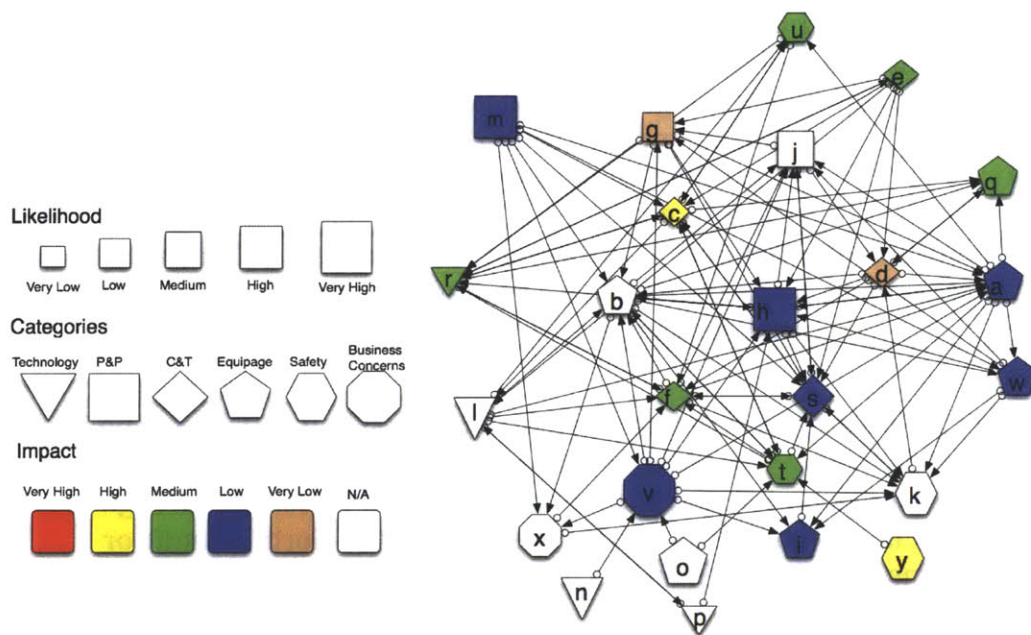
| Risk | Category | Description |
|------|----------|-------------|
|------|----------|-------------|

| | | |
|---|-------------------------|---|
| C | Coordination and Timing | ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation (e.g. ensuring that deviations from norm are captured quickly, etc.) |
| F | Coordination and Timing | National Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe |
| R | Technology | No ICAO communication, navigation, and surveillance standards available to support implementation of 25NM lateral separation (for example, RNP 4 meets navigation criteria for 30 NM) |
| T | Safety | Failure to meet safety case for 25 NM lateral separation (Feasibility analysis may find that better performance is needed. Actual performance may not meet feasibility analysis expectations) |
| Y | Safety | HF network may be unable to support communications demand in event of total data link failure or reversion to normal separation. |

Table 4: Highlighted Risks (ANSP Cost Impact)

Figure 11 is a graphical depiction of the likelihood and ANSP Cost impact for all of the risks. The ANSP Cost category considers a risks' potential impact to any further or unanticipated costs that could be incurred by the ANSP as a result of complying with the mandate and implementing 25NM lateral procedures.

Figure 11: Impact to ANSP Costs: Mandate and Reduced Separation



6.3.6 ANSP Revenue Impact

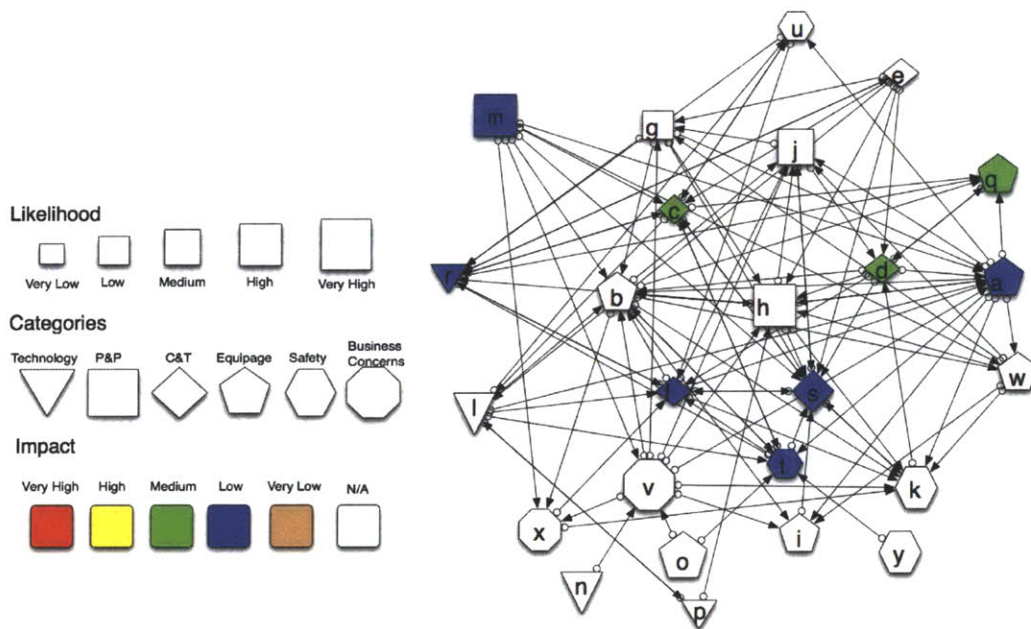
The graphical depiction of the likelihood and ANSP Revenue impact of each risk is shown in Figure 12. ANSP Revenues can be impacted by risks that decrease the total number of aircraft flying in the North Atlantic, (equipped or unequipped), risks that can cause the cancelation of flights, and risks that result in fewer communication messages between ANSPs and operators. Some of the risks that impact these areas are listed in Table 5 and are described in this summary. Risk D can delay the implementation of 25NM lateral separation if the ANSPs automation systems are not ready in time. An occurrence Risk Q can also delay the implementation of 25NM lateral separation procedures if the rulemaking process is delayed. The 25NM lateral separation procedures will increase the capacity and any delay to the implementation of these procedures can limit the capacity of the North Atlantic airspace and thus impact the revenues of ANSPs.

Table 5: Highlighted Risks (ANSP Revenue Impact)

| Risk | Category | Description |
|------|-------------------------|---|
| D | Coordination and Timing | ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation (e.g. ensuring that deviations from norm are captured quickly, etc.) |
| Q | Coordination and Timing | National Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe |

Figure 12 is a graphical depiction of the likelihood and ANSP revenue impact for all of the risks. The ANSP Revenue category considers a risks' potential impact to the potential revenues received by ANSPs possibly through a reduction in the number of aircraft operating in the North Atlantic or regulations affecting ANSP message pricing.

Figure 12: ANSP Revenue Impact: Mandate and Reduced Separation



6.3.7 Operator Cost Impact

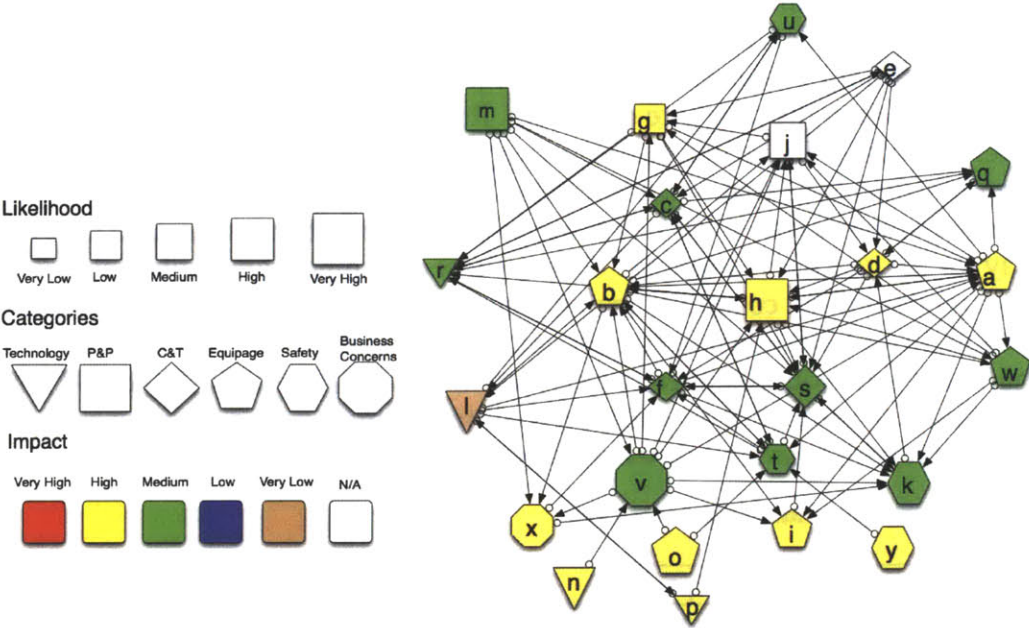
The graphical depiction of the likelihood and Operator Cost impact of each risk is shown in Figure 13. Operator costs can be impacted by risks that impact the ability for an operator to comply with the mandate, the restrictions that come from not complying with the mandate, the economic burdens from operational failures, and the economic burdens of added equipment costs. Some of the risks that impact these areas are listed in Table 6. Risks A and B can make it more difficult for operators to comply with the mandate. Risk A can result in business operators not having a way to comply with the mandate because the equipment may not yet exist or be certified before the mandate deadline. Risk B can impact the ability of an operator equip due to delays in the supply chain. All of the high costs or economic burdens that make it difficult for operators to equip are encompassed in risk V. If risk V occurs, some operators will not be able to pay for the costs of equipping. These costs can come from equipment costs, aircraft downtime costs, and training costs. Risks N and O both represent unanticipated increases to equipment costs. Risk N could force operators to purchase new equipment to record data link transactions. Risk O could force operators to remove their existing satellite communications hardware and replace it with heavier, more expensive hardware.

Table 6: Highlighted Risks (Operator Cost)

| Risk | Category | Description |
|------|-------------------------|--|
| A | Equipage | Equipage for business operators not available or certified in time to meet mandate |
| B | Equipage | Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand |
| H | Policies and Procedures | Restricted access to airspace for unequipped aircraft |
| G | Policies and Procedures | Failure to develop measures to accommodate unequipped aircraft |
| O | Equipage | End of service life of I3 satellite services expected about 2016. New equipage may be required to use classic aero services via I4 satellites. |
| N | Technology | Impact of ICAO Annex 6 data link communications airborne recording standard (See Appendix B) |
| V | Business Concerns | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25 NM lateral separation |

Figure 13 is a graphical depiction of the likelihood and Operator Cost impact for all of the risks. The Operator Cost category considers a risks' potential impact to operator costs including fuel costs, aircraft downtime costs, equipment costs, and communications message costs.

Figure 13: Operator Cost Impact: Mandate and Reduced Separation



6.3.8 Operator Revenue Impact

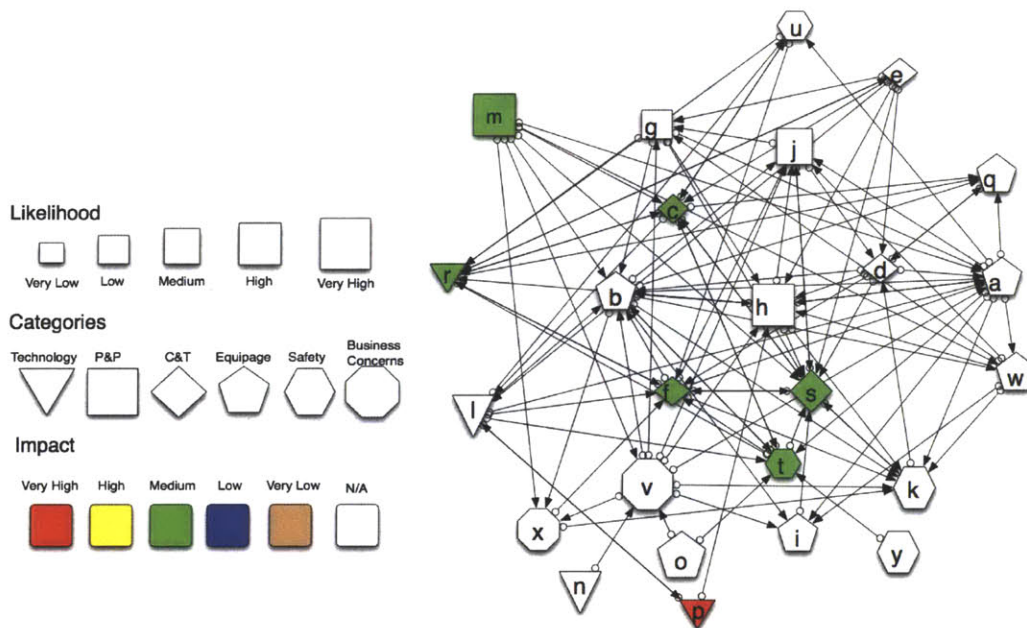
The graphical depiction of the likelihood and Operator Revenue impact of each risk is shown in Figure 14. Operator Revenues can be impacted by risks add barriers to operators that wish to increase or maintain the level of air service across the North Atlantic. Possible barriers include restrictions which could prevent new aircraft from complying with the both North Atlantic and European data link mandates (Risk M), which then prevent these aircraft from connecting cities in North America and Europe and equipment requirements that increase weight and prohibitively decrease the range (Risk P).

Table 7: Highlighted Risks (Operator Revenue)

| Risk | Category | Description |
|------|-------------------------|---|
| M | Policies and Procedures | Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT |
| P | Technology | Uncertainty in approval of Iridium-based equipage to meet requirements for data link mandate and 25 NM reduced lateral separation |

Figure 14 is a graphical depiction of the likelihood and Operator revenue impact for all of the risks. The Operator Revenue category considers a risks' potential impact to the revenues of operators possibly through a reduction in the number of aircraft operating in the North Atlantic or equipment requirements that add weight to an aircraft, subsequently making North Atlantic routes unserviceable.

Figure 14: Operator Revenue Impact: Mandate and Reduced Separation

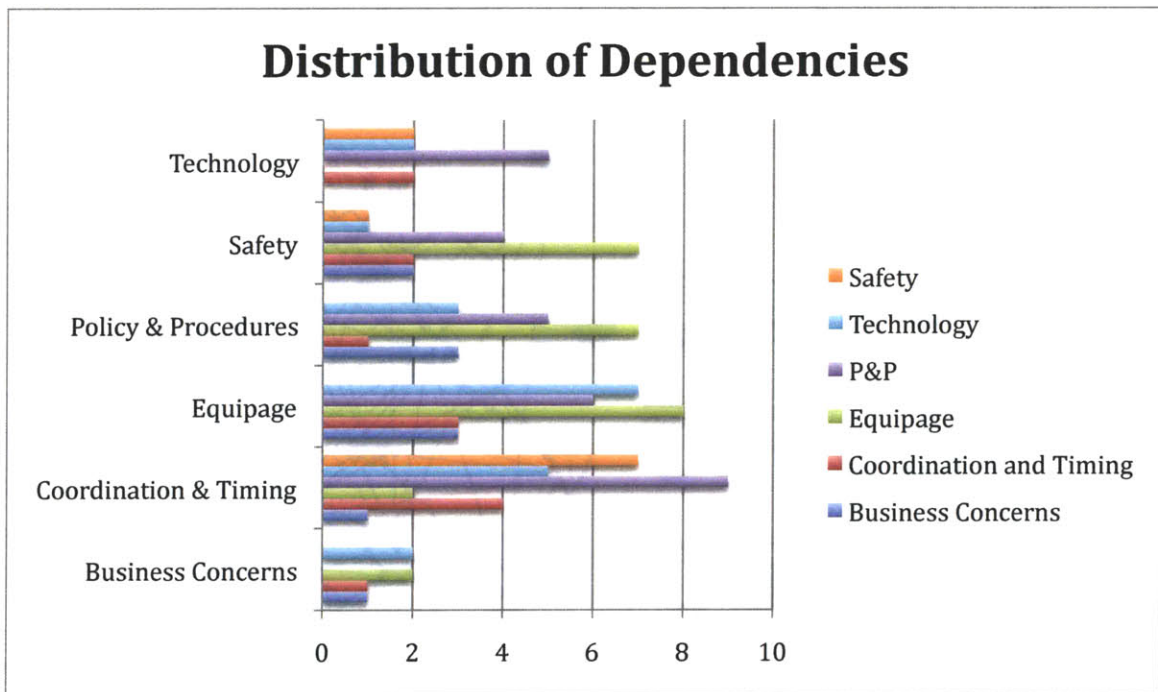


6.4 Graphical Dependency Pattern Depictions

The distribution of dependencies and influences can provide insight into how the risks influence each other. Figure 15 shows the distribution of

dependencies by risk category and Figure 16 shows the opposite, distribution of influences by risk category. The technology category and the coordination and timing category both have the largest number of dependencies on risks from the policy and procedure category. The policy and procedure risks can influence the level of technology and amount of equipment needed to comply with the mandate. The policy and procedure risks can influence the coordination and timing risks because changes and policies can cause delays in rulemaking and other planning tasks. The risks in the safety category, the equipage category, policy and procedure category and business concerns category are most influenced by risks in the equipage category. Equipage risks can influence the equipage levels and thus the ability to meet the safety case which is dependent on the equipage level. The level of equipage also will influence polices for unequipped aircraft and the subsequent traffic patterns that result. Lastly, the cost and availability of equipage is an important driver in the cost benefit analysis for operators.

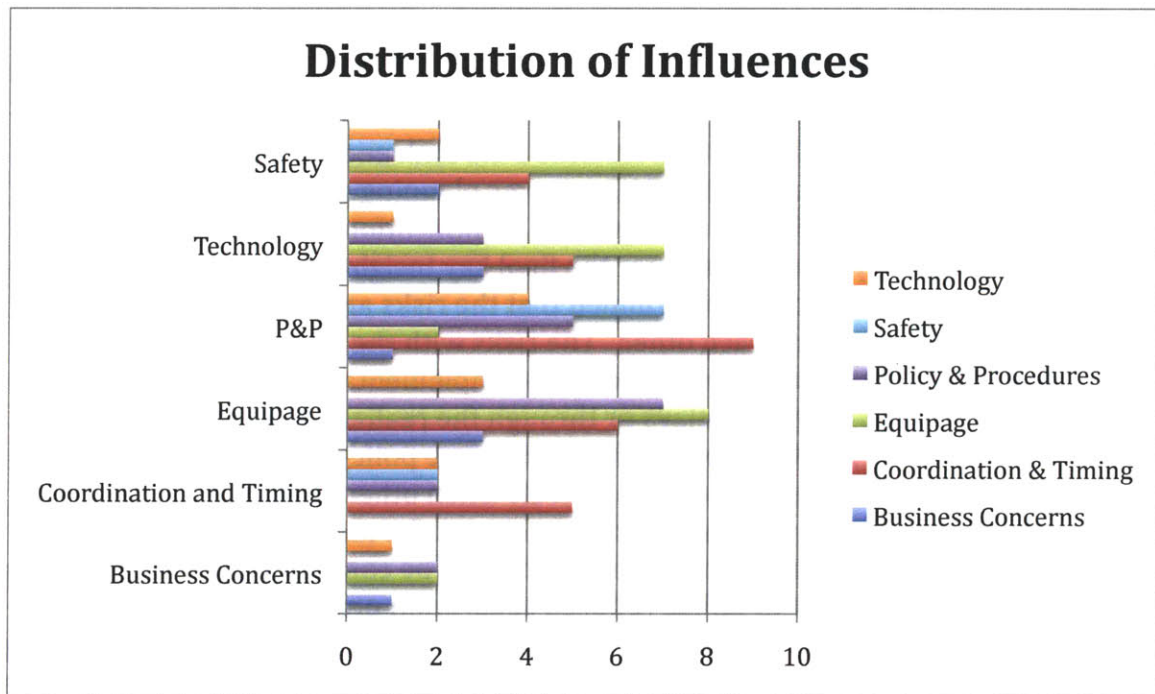
Figure 15: Distribution of Dependencies



The distribution of influences is shown in Figure 16. This graph is essentially an inverse or a complement of Figure 15 and highlights the strong interaction between the risks. Figure 15 and Figure 16 show that the larger number of

interactions is between the coordination and timing category and the policy and procedure category.

Figure 16: Distribution of Influences



6.5 Results Summary

The results of this study uncovered valuable insights in to how each risks impacts the stakeholder value categories and how the risks influence each other. The highest ranking risks for the aggregate impact came from the coordination and timing, safety, and technology categories. These risks were ranked highly because they all had the potential to delay the implementation of 25NM lateral procedures or prevent operators from equipping, both of which are needed to recoup the investments that are required to comply with the mandate. The risks are highly connected and the risks and equipage and policy and procedure categories had the highest number of influences across all of the risks. The policy and procedure risks can determine the penalties for not equipping and the costs for equipping depending on what and how the restrictions are implemented. The equipage risks can add to the difficulties of equipping by introducing economic and supply chain barriers which can then cascade into lower equipage levels, and thus a lower level of achieved safety and usage of 25NM lateral procedures. Because the risks are highly connected to each other the mitigation strategies

must address risks simultaneously in order to make sure both the dependencies and influences are addressed.

7 Thesis Summary

This thesis has described a program risk assessment framework and its application to the ICAO North Atlantic Data Link and Reduced Separation Initiatives in support of the ICAO systems planning group. The framework was administered in two main phases, identification and assessment, and two mapping phases to produce the final key insights that will be used in the risk mitigation. It was determined that the risks are highly interconnected and dependent upon each other. The risks with the highest overall impacts were risks that could possibly delay the implementation of the initiatives either through program delays or through the realization of safety barriers. The risks that most influence other risks were policy risks that impact restrictions for unequipped and aircraft when other critical processes could be completed, and equipage risks that impact the amount and cost of the equipment that must be procured in order to be compliant with the mandate and thus the ability to utilize reduced separation procedures. The users of this assessment must determine an appropriate mitigation strategy for going forward. Because the risks are highly interconnected, a successful mitigation strategy must address multiple risks simultaneously and verify that as many of the stakeholders values as possible are not adversely impacted by the resulting solution.

Appendix

Risk Appendices

A.0 Description

Risk A is described as “Equipage for businesses operators not available or certified in time to meet mandate.” “Equipage” refers to the FANS 1/A CPDLC and ADS-C aircraft equipment needed to comply with the data link mandate.

A.1 Background

The data link mandate requires aircraft operating in North Atlantic Minimum Navigation Performance Separation (MNPS) airspace to have ADS-C, and CPDLC equipment certified against the standards in RTCA DO-258A/EUROCAE ED-100A or ED-100 (NAT EFG 19, NAT SPG Conclusion 45/11).

Most aircraft fall into one of three categories: unequipped, partially equipped, or fully equipped. Risk A affects aircraft from the first two categories. Unequipped aircraft may not have equipment available due to the system architecture of the aircraft, lack of the demand necessary to develop the equipment, or, because proposed equipment has not been certified. For partially equipped aircraft, there may not be a solution compatible with the equipment already on the aircraft, or, there could be future upgrades that will not be ready in time for the mandate.

Business operators are at a particular disadvantage for equipping. Many business aircraft manufacturers do not have ADS-C and CPDLC equipment available or in development. Some business aircraft operate within the vertical limits of the proposals for data link mandate (expected to be lower than FL390) and reduced lateral separation (FL350 to FL400 inclusive). Business aircraft operating at these altitudes will likely be subject to the altitude restrictions in the mandate and reduced separation procedures without an available equipment solution to comply.

Several manufacturers have indicated to survey respondents they do not have plans to develop equipment. Additionally, equipment costs are expected to exceed the economic benefits of reduced separation.

A.2 Root Causes

Risk A has several root causes. These root causes are associated with the business case, system architecture, and regulations.

A.2.1 Business Case

Equipment may not be available because the business case will not show a positive net present value for either the avionics manufacturer or the aircraft manufacturer to continue development. According to the respondents, the main reason the business case fails is that there is not enough demand from operators that could use the equipment to justify the expense of development and certification. Another consideration is the development of equipment for retrofit and forward fit aircraft. A retrofit for out of production aircraft may have a more difficult business case because the manufacturer can not count on new orders for future aircraft and the existing operators may not elect to upgrade an older aircraft.

A.2.2 Systems Architecture

Avionics systems architecture issues can prevent manufacturers from developing a solution for equipage. Some business aircraft do not have the glass cockpit displays that are necessary for displaying the messages that come from CPDLC and ADS-C for the pilots. Other aircraft may already be equipped with ATN CPDLC equipment which cannot be integrated with the FANS 1/A equipment and message sets needed for the mandate (ICAO SPG 45 2.2.26).

A.2.3 Regulations

Regulations that do not provide enough lead time for manufacturers to complete development and certification of the equipment can also be a root cause. The first target dates of the NAT SPG initiatives are only 2-3 years away in 2012 and 2013.

A.3 Impact on Stakeholder Value Metrics

Table 8: Risk A Impact Levels (Mandate and Reduced Separation)

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | High | Low | Low | High | None |

As seen in Table 8, Risk A has high impact levels in operational efficiency and operator costs. Risk A can affect equipage levels. Raising the data link

equipped level is a main goal of the mandate in support of meeting the NAT Target Level of Safety (NAT SPG 46 3.1.15). The operational efficiency and operator cost impact is due to the anticipated restrictions of unequipped aircraft from optimal flight levels and flight paths. Flying non-optimal paths and altitudes raises the fuel costs for operators and decreases their operational efficiency. Respondents did not indicate an operator revenue impact due to Risk A.

The low safety impact comes from a potential increase in the concentration of aircraft operating near a single oceanic entry point due to restrictions imposed by the regulations. Handling increased amounts of unequipped traffic at these points will require increased controller workload for conflict resolution and emergency descents.

ANSP costs can increase from the extra staffing needed to accommodate unequipped aircraft.

ANSP revenues could be impacted at a low level depending on changes to the traffic volumes of equipped and unequipped aircraft operating in each ANSP region.

A.4 Direct Risk Dependencies, Influences & Outcomes

This section will introduce the risk dependencies, influences and outcomes from Risk A. Figure 17 shows the categorization, likelihood, and impact of Risk A with regard to the mandate only.

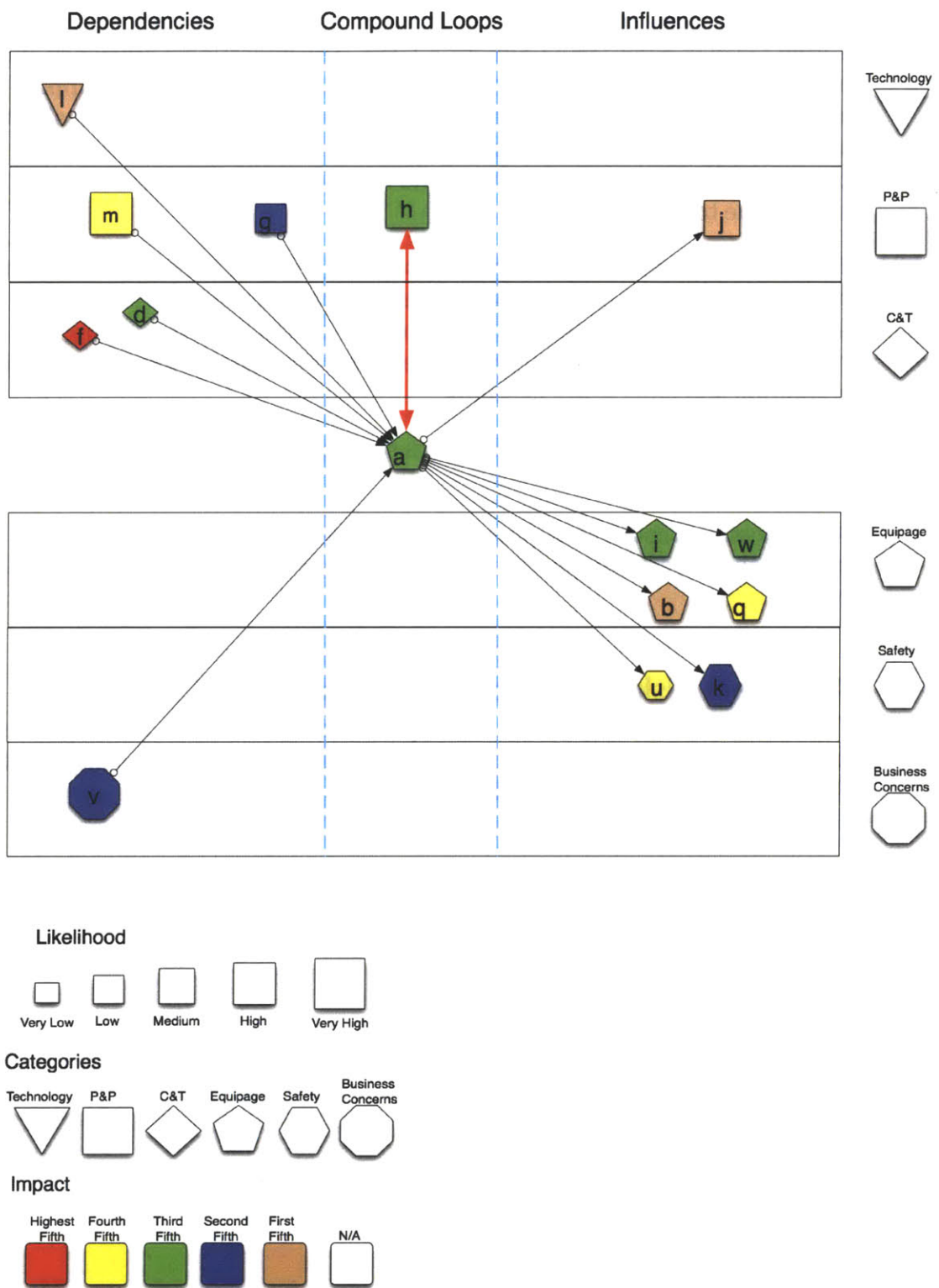


Figure 17: Risk A Aggregated Impact and Dependencies, Mandate Only

Risk A is an equipage risk with direct dependencies on risks related to technology, policy, certification, and business concerns. It has a high likelihood and is a direct influence to risks related to equipage, safety and business concerns. Figure 18 includes risks related to 25 NM lateral separation initiatives, and adds the additional safety-related Risk T (Failure to meet the safety case for 25 NM Lateral Separation).

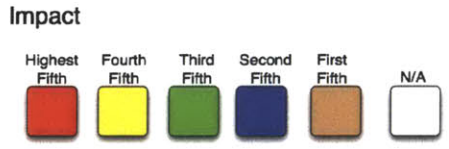
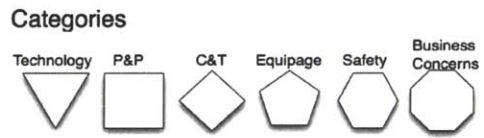
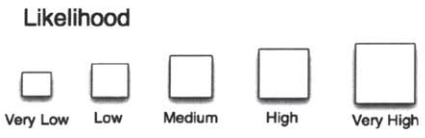
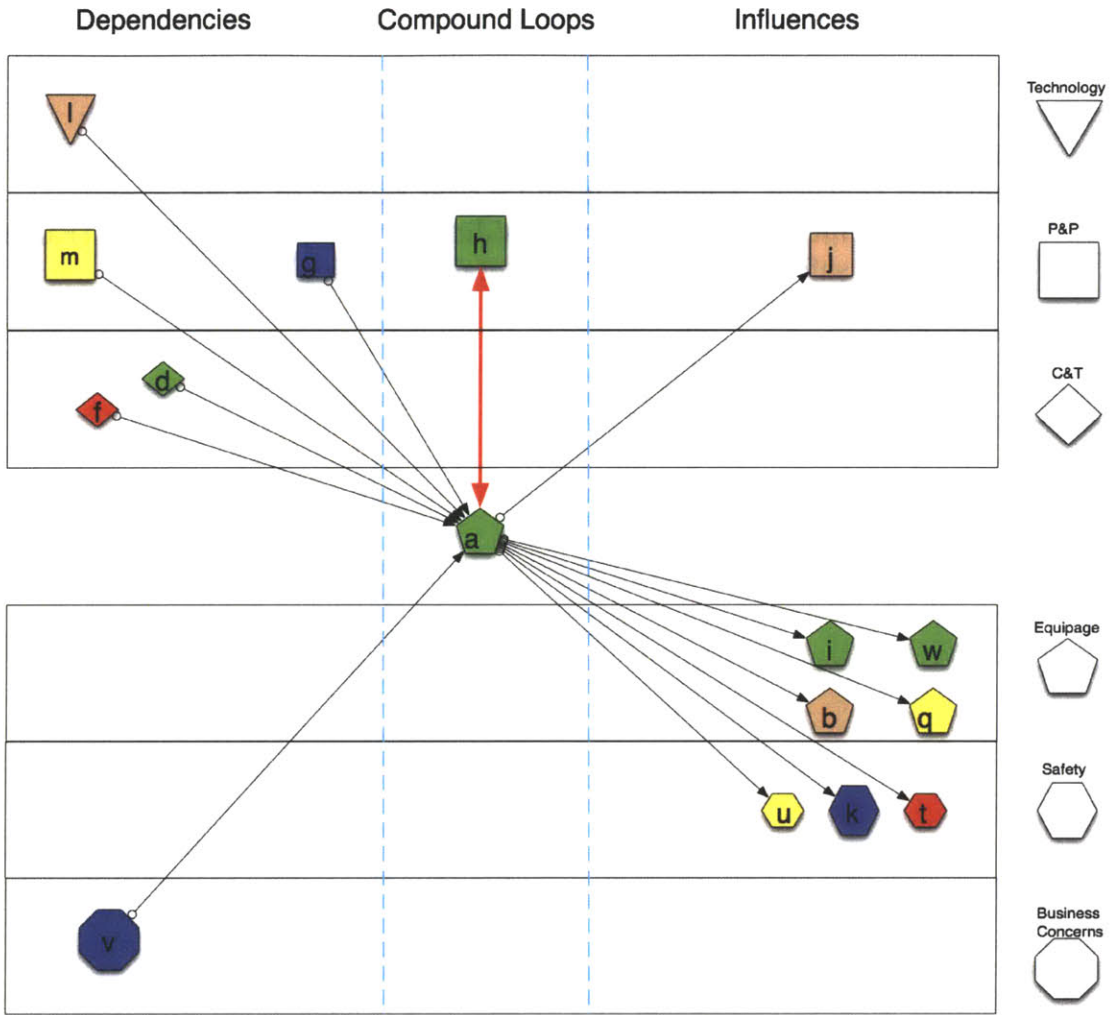


Figure 18: Risk A Aggregated Impact, Reduced Separation Only

A4.1 Direct Dependencies

Risk A, as shown in Figure 17 and Figure 18, has a medium aggregate impact (3rd quintile) and has many dependencies and influences.

A4.1.1 Technology

Risk A's dependence on technology risks comes from the role that technology risks play in setting the specifications and requirements for data link equipment. Specifically, it is a technology risk and refers to the possible delays surrounding a communication performance standard called RCP240. Communications standards specify the time that can be taken for data link messages to be exchanged between ANSPs and aircraft. These specifications influence the equipment design on board the aircraft and the system architecture that is needed to send and receive the messages.

A4.1.2 Policies and Procedures

Risk A's dependences on policy and procedural risks also come from the roles that those risks play in setting the specifications and requirements for the data link equipment and the likelihood of business case closing. Risk M refers to the different equipment specifications between the North Atlantic and Europe. These specifications are not compatible with each other although there is an exception in Europe to allow FANS 1/A aircraft to operate if they have airworthiness certificates issued before 2015. Risk M creates uncertainty in the system architectures that will be needed onboard the aircraft that will be compliant with the mandate because it makes it unclear whether or not operators will need both types of equipment.

The measures to accommodate unequipped aircraft (Risk G), and the procedures that operators use with unequipped aircraft (Risk H) will determine the flight levels and allowable flight paths that unequipped aircraft will be allowed to follow. These paths and flight levels will determine the economic impact of not equipping for each flight and will be factored into the operators' business case.

A4.1.3 Coordination and Training

Risk A is dependent on the coordination and training risks because they play a role in knowing the level of demand for the data link equipment and in setting the requirements. Late completion of the data link plan (Risk D) will force operators to wait longer until the plan is complete in order to weigh the

costs and benefits of equipping. The rulemaking that will support 25 NM lateral separation (Risk F) is needed for the operators and manufacturers to know the requirements for the equipment that must be developed, and, for individual operators to know the specific requirements for the parts of the world in which they operate.

A4.1.4 Business Case

High costs (Risk V) can also prevent equipment from becoming available. If the costs are too high, operators may elect not to purchase the equipment which could lead to significantly decreased demand. If demand decreases, the equipment development could be delayed or prevented altogether.

Table 9: Risk A Direct Dependencies

| | |
|--------|---|
| Risk D | Late Completion of data link mandate plan. Not enough time for commercial and business operators to plan to comply with the mandate. |
| Risk F | Rulemaking to support data link mandate and 25 NM lateral separation not completed within timeframe. |
| Risk G | Failure to develop measures to accommodate unequipped aircraft. |
| Risk L | Failure to establish a plan or go forward with mitigation to meet RCP 240. This also includes failure of ground infrastructure to meet RCP 240. |
| Risk M | Lack of harmonization in technologies: ATN mandate in Europe vs. FANS 1/A mandate in the North Atlantic. |
| Risk V | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25 NM lateral separation. |

A.4.2 Direct Risk Influences & Associated Outcomes

The risks that are directly influenced by Risk A are listed in Table 10 and seen in Figure 17 and Figure 18.

A4.2.1 Equipage

The unavailability of equipment due to Risk A will influence the equipage levels. The outcomes of low equipage levels can be a mixed equipage environment (Risk I) and, a failure to achieve the percentage of equipped aircraft (Risk Q), and the delivery of new aircraft that are equipped (Risk B, and Risk W).

A4.2.2 Safety

Risks Q, T, and U are safety risks. The level of safety in the North Atlantic increases with the number of aircraft that are equipped. If the equipment is not available, the risks to reaching the appropriate safety levels increase. Risk A influences the level of equipage and these risks because they are dependent on the level of equipage.

A4.2.3 Policies and Procedures

Risk J relates the procedures that operators will use when they operate unequipped aircraft. Risk A can influence the likelihood occurrence of Risk J because operators will be more likely to have an unequipped aircraft if there is no equipment available.

Table 10: Risks that are directly influenced by Risk A

| | |
|--------|---|
| Risk C | ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation. |
| Risk H | No ICAO standards to support implementation of 25 NM lateral separation |
| Risk I | Late completion of 25 NM lateral separation planning tasks |
| Risk J | Operators choosing to operate in areas where other types of surveillance are provided |
| Risk K | Increased traffic in MNPS routes other than OTS routes |
| Risk Q | Failure to achieve percentage of equipped flights needed to move forward with phases of 25 NM lateral separation |
| Risk T | Failure to meet safety case for 25 NM lateral separation |
| Risk U | Failure to control vertical risk when 25 NM lateral separation is implemented |
| Risk W | Late delivery of new aircraft orders that are replacing older, unequipped aircraft. |

A.4.3 Compound Loops

There is a compound loop between Risk A (Equipage for businesses operators not available or certified in time to meet mandate), and Risk H (No ICAO standards to support implementation of 25 NM lateral separation) indicated by the red double arrow in Figure 17 and Figure 18. A compound loop occurs when two or more risks influence each other. The business case affecting Risk A is influenced by the level of restriction resulting from Risk H. Coordination will be required between the regulators who determine the occurrence of Risk H, and the operators and manufacturers, who determine

the occurrence of Risk A to converge upon an anticipated level of equipage and restrictions. These regulations also have timelines for implementation that determine when the operators must equip to be compliant with the mandate and reduced separation.

A.5 Mitigation

Table 66 shows the reported mitigation difficulty for Risk A. Detection difficulty is low because aircraft must indicate their equipment levels when filing flight plans and when checking the aircraft's method of correspondence with air traffic controllers. Corrective action will be difficult because of the financial barriers posed by the business case, and the technical barriers posed by system architectures. Coordination will be of medium difficulty. Regulators must coordinate with both operators and aircraft manufacturers to determine what aircraft will have equipment available and when it will be certified. Some respondents gave Risk A a high likelihood because they believed that several types of common business jets will not have equipment available.

Respondents felt that little can be done to mitigate against system architecture and business case root causes. Changing the system architecture of an aircraft can cost millions of dollars on top of the millions of dollars it can already cost to acquire and certify the proper equipment and would significantly weaken the business case.

Business aircraft manufacturers in particular face different obstacles than commercial aircraft manufacturers. Business aircraft manufacturers do not know what after market avionics equipment has been installed in each airframe currently in service, which could complicate the solution they develop to comply with the mandate. Commercial aircraft manufacturers more tightly control the types of avionics that are installed on their aircraft after delivery.

Respondents felt one way to mitigate against the obstacles faced by business aircraft manufacturers is to communicate clearly and quickly the restrictions that will be put on business operators for not equipping through regulation and coordination with trade groups representing the operators and manufacturers, and to facilitate an assessment of installed aftermarket equipment against the requirements to aid in the development. Additionally, communication between the regulators and business operators

can help to determine appropriate regulation timelines and appropriate measures to accommodate aircraft that can not equip.

Table 11: Risk A Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | Medium | High |

B.0 Description

Risk B is described as “Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand”. Risk B is categorized as an equipage risk because it affects the level of data link equipage and the data link adoption rate.

B.1 Background

Retrofit equipment must go through several processes before being certified and installed on an aircraft. Delays can be encountered in any of these policies and are encompassed by Risk B. The data link equipment must first go through a research and development processes during which the requirements are made and the preliminary design is completed. Next, the preliminary design must receive market confirmation, or, confirmation that there will be sufficient demand for the package from operators. In some cases, the market confirmation can take place during or prior to the research and development phase. The next process is the fabrication and testing process. This process includes both the fabrication of the prototype and testing onboard an actual aircraft. The last process for the manufacturer is the certification process. Operators, depending on their country of origin, may need to obtain a supplemental type certificate certifying the new equipment. Lastly, the equipment must be manufactured, delivered to the operator, and installed on the aircraft.

Delays in receiving equipment can happen for a variety of reasons. Delays in receiving equipment can have a number of outcomes that affect the assumptions and the system performance of the mandate implementation.

B.2 Root Causes

Delays in receiving datalink equipment can happen for a variety of reasons in any of the processes. These delays may add pressure to regulators to develop measures for unequipped aircraft.

B.2.1 Business Case

Respondents indicated that uncertainty with the business case can cause delays in receiving the equipment. The manufacturers need to know with some certainty how many customers will purchase the retrofit package in order to justify devoting the appropriate resources to development and certification.

B.2.2 Coordination and Regulations

Lead time for manufacturers to complete development and certification of the equipment can also be a root cause. The first target dates of the NAT SPG initiatives are only 2-3 years away in 2012 and 2013.

B.2 Impact on Stakeholder Value Metrics

The impact on the stakeholder value metrics according the respondents is given in Table 12: Risk B Impact Levels (Mandate and Reduced Separation)

Table 12: Risk B Impact Levels (Mandate and Reduced Separation)

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | None | None | None | High | None |

Risk B has a low safety impact because it reduces the number of aircraft that are equipped with data link.

The operator costs are high because of the economic penalties and suffered by not having an equipped aircraft. The operator must fly with an unequipped aircraft longer than anticipated which could result in fuel burn penalties depending the current regulations. Delays can also cause more aircraft downtime if a subsequent maintenance visit must be scheduled.

The respondents did not indicate an impact level for operational efficiency, ANSP Costs and Operator Revenues.

B.3 Direct Risk Dependencies, Influences & Outcomes

The dependencies and outcomes for Risk B are shown in Figure 17 and Figure 18 for the Mandate only and Reduced Separation. Both figures show several dependencies and influences for Risk B. As with Risk A, many of the dependencies come from the technology, policy and procedure, and coordination and training categories.

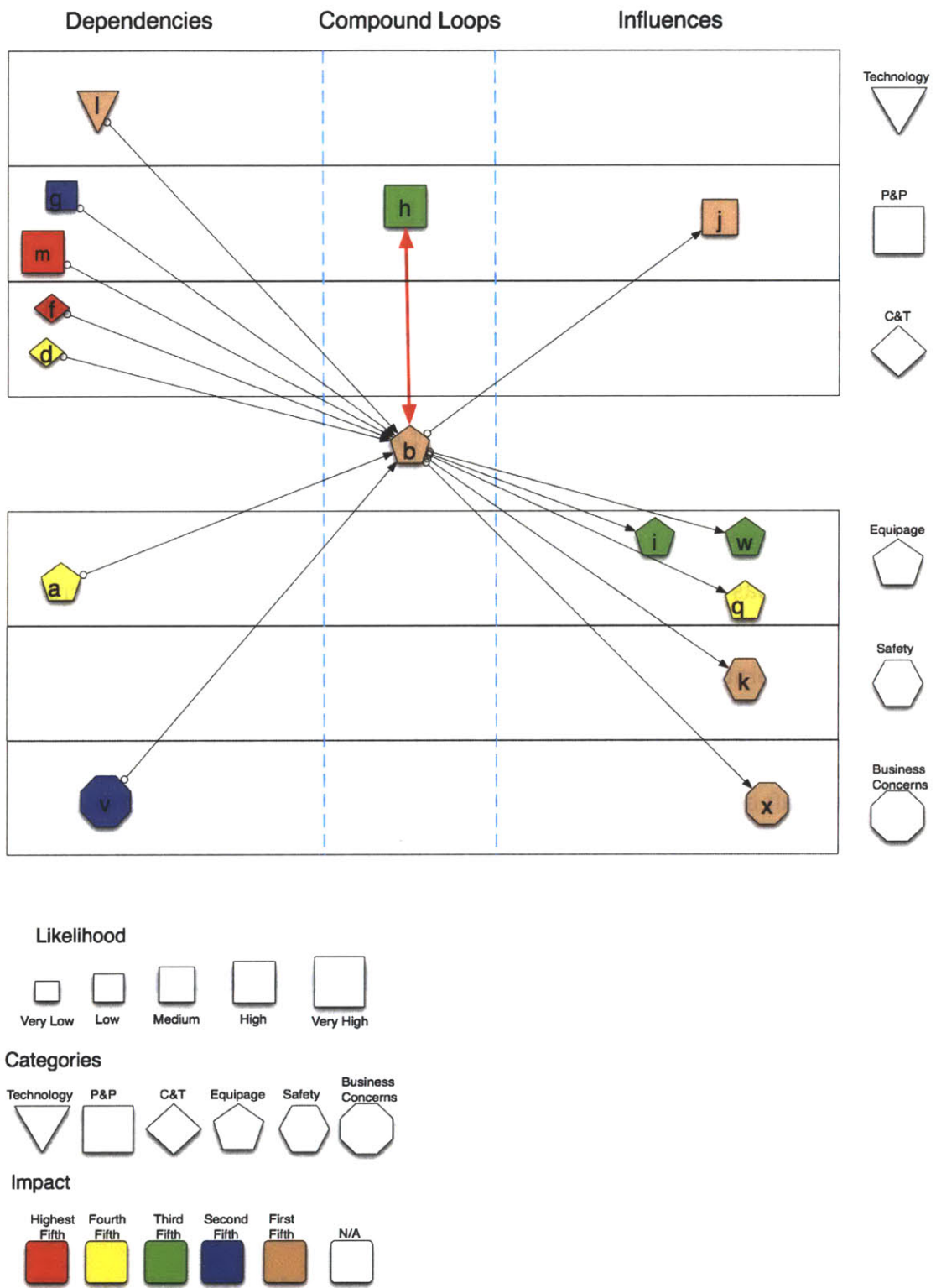


Figure 19: Risk B Aggregated Impact and Dependencies, Mandate Only

The reduced separation graph shown in Figure 18 adds Risk T, failure to meet the safety case for 25 NM Lateral Reduced Separation, as a safety risk that is influenced by Risk B. Some of the risks that are included in the mandate also have a lower aggregated impact relative to other risks because

more risks have been considered.

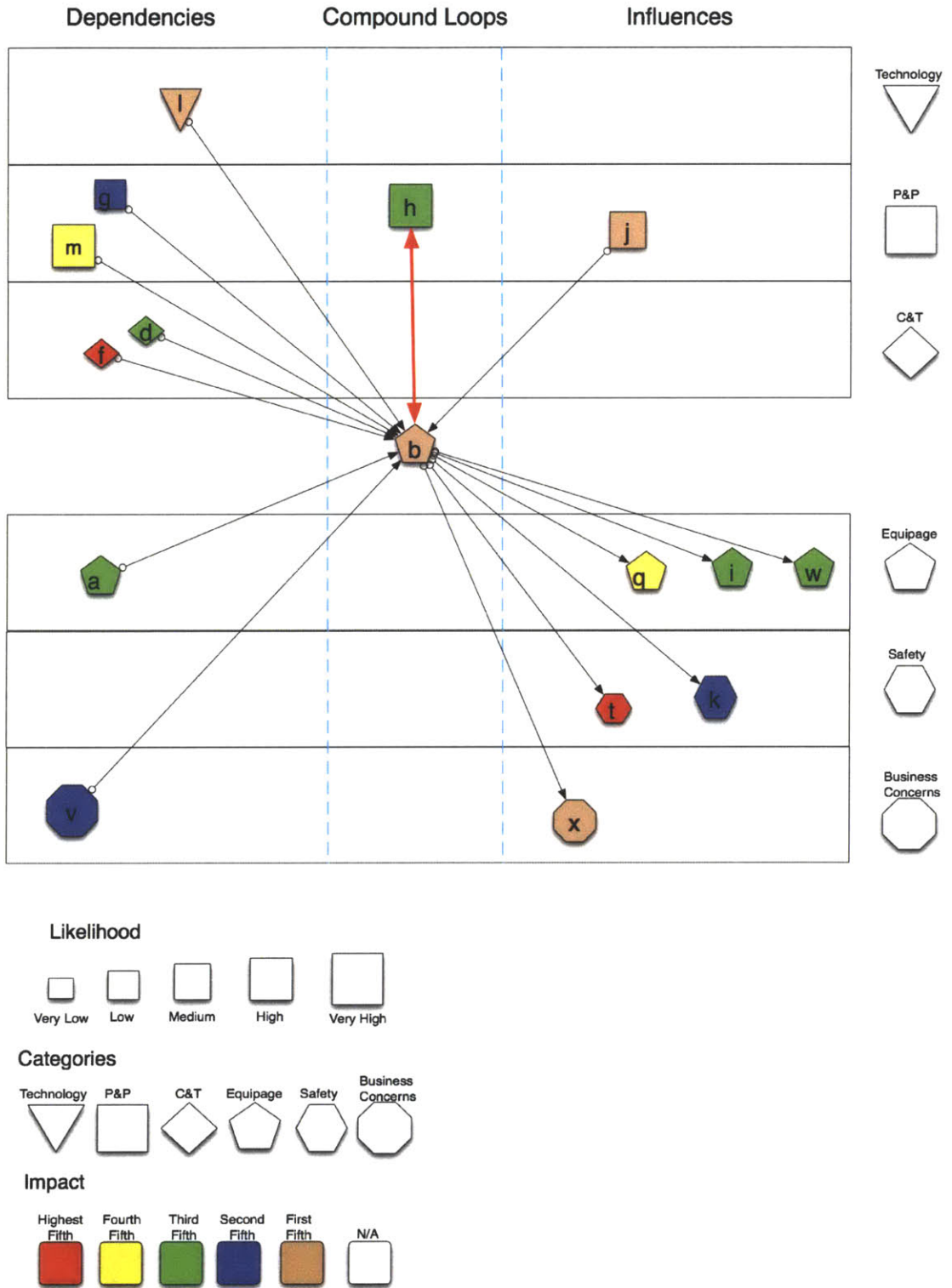


Figure 20: Risk B Aggregated Impact, Mandate & Reduced Separation

B3.1 Direct Dependencies

Risk B has several direct dependencies. These dependencies come from the technology, policy and procedures, coordination and training, other equipage risks.

The technology Risk L, Failure to establish a plan to meet RCP240 affects the system requirements that are needed for the data link equipment. If these equipment requirements are not set, then delays in research and development process for the equipment can arise.

The policy and procedure risks (Risk G, Risk M) determine the economic penalties that unequipped aircraft endure. These penalties in turn will drive the business case for both operators and aircraft manufacturers who need to develop new equipment. If Risk G, Failure to develop measures to accommodate unequipped aircraft, occurs, uncertainty in the economic penalties could force operator and manufactures to wait longer before deciding whether or not to equip. Risk M affects operators in Europe. It creates ambiguity as to which data link standard an operator should equip with when operating in both the North Atlantic and Europe.

The equipage Risk A, is a determining factor in the delivery process for data link equipment to business operators specifically. If Risk A, lack of data link equipment availability for business operators occurs, then there will inherently be delays in acquiring the equipment.

The business case risks can pose delays because of uncertainties in revenues or costs coming from the decision to equip or not to equip with CPDLC. Risk V specifically refers to the costs exceeding a threshold above which operators cannot afford to equip. Delays can arise in equipping as ways for cost cutting are researched.

Table 13: Risk B Direct Dependencies

| | |
|--------|---|
| Risk A | Equipage for business operators not available or certified in time to meet mandate. |
| Risk D | Late Completion of data link mandate plan. Not enough time for commercial and business operators to plan to comply with the mandate. |
| Risk F | Rulemaking to support data link mandate and 25 NM lateral separation not completed within timeframe. |
| Risk G | Failure to develop measures to accommodate unequipped aircraft. |
| Risk L | Failure to establish a plan or go forward with mitigation to meet RCP 240. This also includes failure of ground infrastructure to meet RCP 240. |

| | |
|--------|--|
| Risk M | Lack of harmonization in technologies: ATN mandate in Europe vs. FANS 1/A mandate in the North Atlantic. |
| Risk V | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25 NM lateral separation. |

B.3.2 Direct Risk Influences & Associated Outcomes

The occurrence of Risk B introduces delays for operators wishing to equip with datalink in the North Atlantic. These delays and the subsequent lower equipage levels at a given time influence the likelihood and severity of other policy, equipage, safety and business risks.

The policy and procedural risks are influenced by the occurrence of Risk B because more unequipped aircraft will result in an increase operators that must use procedures for unequipped aircraft. Risk J specifically describes an increase in operations over routes where datalink is not needed.

The equipage risks are all influenced by the level of equipage that can be reduced by the occurrence of Risk B. If Risk B occurs, these equipage risks are more likely to occur. Risk Q is an outcome of not achieving the appropriate level of equipped flights. Risk W, late delivery of equipped aircraft, is also a direct outcome of delayed delivery of data link equipment. Risk I, mixed equipage during transition, is also an outcome of a reduced number of equipped aircraft.

The safety risks T and K are influenced by the level of equipage in the North Atlantic. If the level of equipage is lower due to Risk B occurring, then both Risk T and Risk K are more likely to occur. More operators may be forced to operate outside the OTS (Risk K), during the later phases of reduced separation and the mandate if they are not equipped. Also, the safety case may be harder to meet (Risk T) if there are fewer equipped aircraft.

The delays in receiving equipment can influence the business case for equipping because the service life of the aircraft will go down as delays accumulate. If the breakeven service life for equipping passes during the delays then operators may instead choose not to equip or retire the aircraft. Risk X reflects changes in the cost benefit analysis that could be prohibitive to equipping.

Table 14: Risks that are directly influenced by Risk A

| | |
|--------|--|
| Risk H | No ICAO standards to support implementation of 25 NM lateral separation |
| Risk I | Mixed equipage environment during transition |
| Risk J | Operators choosing to operate in areas where other types of surveillance are provided |
| Risk K | Increased traffic in MNPS routes other than OTS routes |
| Risk Q | Failure to achieve percentage of equipped flights needed to move forward with phases of 25 NM lateral separation |
| Risk T | Failure to meet safety case for 25 NM lateral separation |
| Risk W | Late Delivery of new aircraft orders that are replacing older, unequipped aircraft. |
| Risk X | Cost benefit analysis may show the costs outweigh benefits |

B.3.3 Compound Loops

Risk B has one compound loop with Risk H: No ICAO standards to support the implementation of 25NM lateral separation. The standards rely on an estimate of the number of aircraft that will equip. The delays that can reduce this number and impact the standard also rely on the standard to specify the economic penalties for not equipping.

B.4 Mitigation

The mitigation difficulty results for Risk B are shown in Table 15. Coordination and Likelihood received “high” responses while Detection and Corrective action received low and medium responses respectively.

Table 15: Risk B Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | Medium | High | High |

Respondents gave Risk B a low difficulty in detection level because they felt manufacturers would be forth coming about delay in delivering the equipment. They also felt that the process of obtaining a supplemental type certificate would be transparent, and therefore allow for easy detection of delays.

The corrective action difficulty for Risk B is medium. Possible corrective actions include changing the dates of the regulation, developing measures to

accommodate unequipped aircraft, and resolving the differences in regulations and procedures across the world.

The coordination level for Risk B is High. All three of the suggested corrective actions will require coordination between ANSP's, manufacturers, and operators.

The likelihood for Risk B is high. Some respondents indicated that they expect to receive their equipped aircraft late, and, they believe that waiting for future, complementary upgrades to their flight management systems will be more cost effective than making a temporary upgrade to comply with the mandate and then making a subsequent upgrade to add the rest of the complementary features.

The main complementary feature is an increase in memory which is essential to future operational efficiency. New RNAV approaches and new waypoint half-degree formats add to the memory requirements of current flight management computers. When these requirements can't be met, operators must load east bound data for east bound flights, then load westbound data for westbound flights. The loading can take up to 50 minutes and is sometimes unsuccessful, requiring the process to start over again. Waiting the memory upgrade *and* the datalink simultaneously is a way to avoid the possible loading time issue when just the datalink upgrade is installed.

C.0 Description

Risk C is described as “ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of reduced separation initiatives”. Some ANSPs need to install upgraded software and hardware to support reduced separation procedures. The upgraded software and hardware is needed to process conflict resolution under the newly defined reduced separation procedures and to send and receive CPDLC signals to and from aircraft. Local rulemaking in some regions is needed to satisfy the safety concerns local authorities. Rulemaking typically involves completing safety analysis and adding some local specifics to the operating procedures. If either the hardware and software is not ready in time, or, the local rulemaking is not completed in time, the reduced separation initiatives could be delayed. Risk C is a coordination and timing a risk that only affects reduced separation initiatives.

C.1 Background

The automation systems are necessary for ANSPs to process conflicts and position reports with the increased volume of traffic and the reduced separation procedures. The automation systems must also be able to interact with systems from other ANSPs to coordinate traffic handoffs so some coordination will be required. Some ANSPs such as the Shanwick, Ireland, and Gander can delay initiatives in the entire North Atlantic because they lie in critical parts of the region that are often used by the organized track system.

C.2 Root Causes

Respondents did not feel there were significant technical barriers to implementing reduced separation procedures in ANSPs. They felt instead that lack of planning, lack of financial resources, and the business case would be the key root causes preventing ANSPs from updating their equipment. Lastly, some respondents felt that the 25 nautical mile lateral separation standard needed to be further defined before an ANSP planning process could begin.

C.2.1 Planning & Standards Definition

Planning was the most common root cause cited by the respondents. The implementation, testing and certification process can be long and will require significant resources in planning to complete. Some respondents indicated that the planning process is dependent on further definition and testing of the 25NM lateral standard to update the conflict resolution software. One

respondent estimated that the process could take between 12 and twenty 28 months depending on the ability to get new software implemented (between 3 and 12 months), the time needed complete test cases for 25 NM lateral separation (3 months) and the time needed to complete definition of the 25NM lateral separation (2-4 months).

Most respondents felt that only a software change was necessary but one respondent (Norway) did need to upgrade some of the hardware.

C.2.2 Resources

Some ANSPs may not have the necessary resources to complete the planning and implementation process for 25NM lateral separation. The level of resources can vary between ANSPs based on whether or not both hardware and software are required, and the requirements for local rule making,

C.2.3 Business Case

The Business case can also be a root cause for delayed implementation. There will be costs associated with upgrading the equipment and maintaining HF as a back up. Some ANSPs may elect to add revenue by changing the charging scheme. Some airlines have asked for a uniform charging scheme and it is unclear what if any rules will be made regarding the fees that will be charged to operators (both equipped and unequipped).

C.3 Impact on Stakeholder Value Metrics

The impact of risk C on the stakeholder value metrics according the respondents is given in Table 8.

Table 16: Risk C Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| High | High | High | Medium | Medium | Medium |

Risk C has a high safety and operational efficiency impact but it is conditional on the behavior of adjacent ANSPs. If Risk C occurs and an ANSP can't support reduced separation, the implementation of 25 NM lateral reduced separation in an adjacent ANSP can pose high safety risk. If the adjacent ANSP reverts to the previous 60NM separation, then there is no safety impact. Additionally, the North Atlantic may not be able to realize its peak operational efficiency if the reduced separation initiatives are delayed.

The ANSP Costs impact can be high if the planning required to implement reduced separation is incomplete depending on what costs were not anticipated.

The costs can include software upgrade costs, possible hardware costs, training costs, and possibly the cost of maintaining a backup system. There could be additional costs if local rulemaking is required. These costs can include safety analysis, testing, and the costs of making possible revisions to the standard.

ANSP revenue impact and the operator cost impact will be medium. The revenue impact will depend on the charging scheme that ANSPs adopt when reduced separation initiatives begin. If revenue is charged on a per message basis then revenue will be equal to: $rev = \text{messages per plane} * \text{Number of planes}$. Changes in the charging scheme can affect the number of planes if operators choose other routes to reduce messaging costs. The operator cost impact will also equal $\text{messages per plane} * \text{number of planes}$. The number of messages per plane is expected to increase when reduced separation initiatives are implemented because more position reports will be needed to maintain the level of safety.

Operator Cost impact can be medium if the occurrence of Risk C influences traffic levels. One of the goals of the reduced lateral separation initiatives is to increase the capacity of the airspace. If the initiatives are delayed then the operators may lose revenue from not being able to increase their capacity.

C.4 Direct Risk Dependencies, Influences & Outcomes

The dependencies and outcomes for Risk C are shown in Figure 17. Risk C affects the reduced separation initiatives only although it is impacted and influenced by risks that impact the mandate. Risk C forms several compound loops with risks from the reduced separation initiatives. It also has two dependences and two influences.

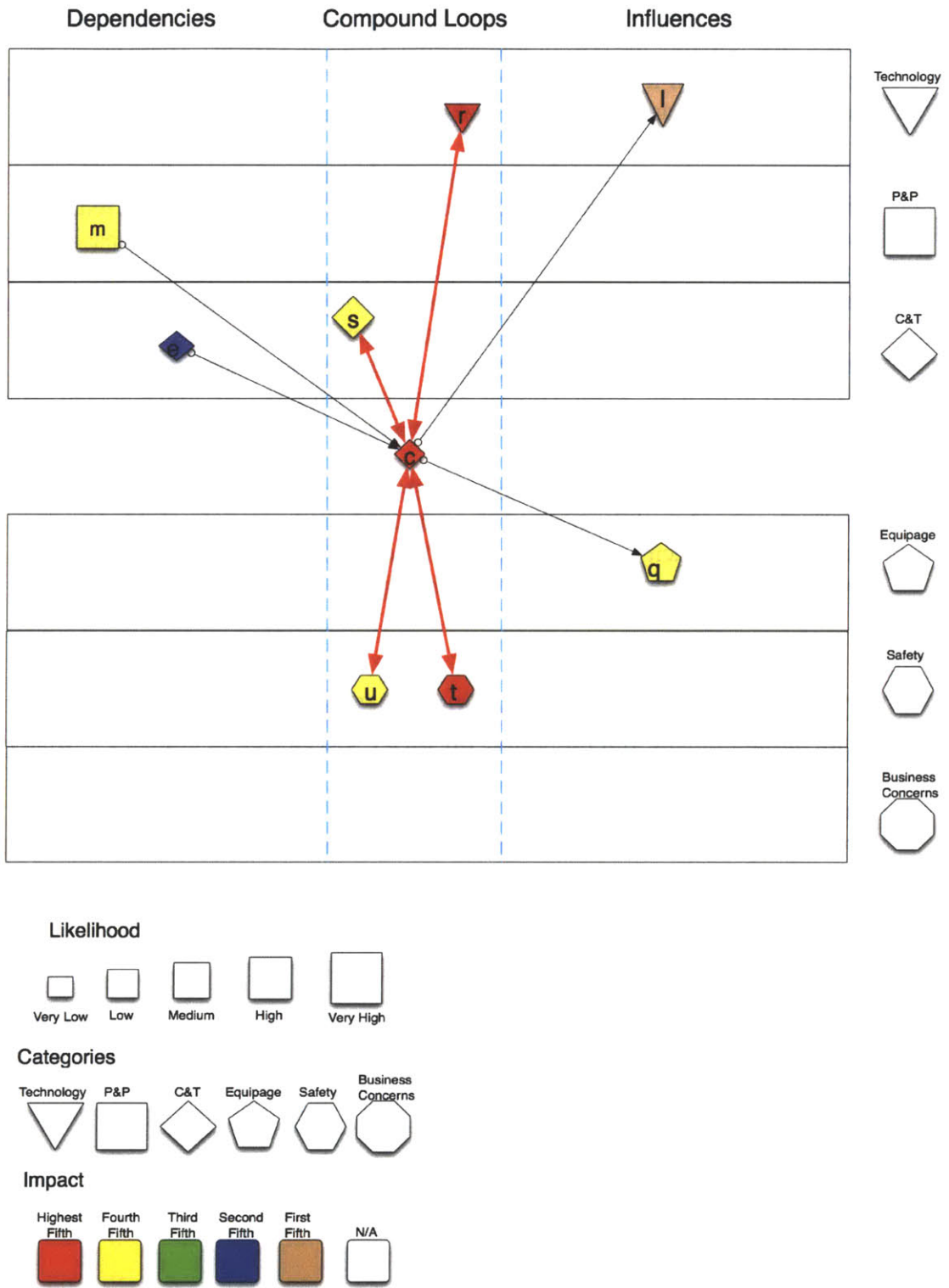


Figure 21: Risk C Aggregated Impact and Dependencies, Mandate and Reduced Separation

C4.1 Direct Dependencies

Risk C has two direct dependencies as shown in Table 9 and Figure 17, one from the coordination and timing category and one from the policy and procedure category.

The ANSP automation systems supporting reduced separation must be able to communicate with the automation systems from adjacent ANSPs in order to handle handoffs and conflict resolution at ANSP boundaries. Risk E represents a failure to get the automation systems across the North Atlantic coordinated which will in turn will delay the readiness of the ANSPs and the reduced separation initiatives.

The communication protocol and procedures must be agreed upon before the new automation systems and reduced separation procedures can become operational. The automation systems need to send and receive messages from aircraft with the protocol and the pilots must acknowledge and act upon the messages sent from ANSPs and other aircraft. Currently there are conflicting protocols and standards for CPDLC between the North Atlantic (FANS 1/A) and Europe (ATN). If the differences cannot be resolved in time then the ANSP implementation can be delayed.

Table 17: Risk C Direct Dependencies

| | |
|--------|---|
| Risk E | Failure to achieve effective coordination with other ANSPs (harmonization of technical methods and operating methods) |
| Risk M | Lack of harmonization in technologies: ATN mandate in Europe vs. FANS 1/A mandate in the North Atlantic. |

C.4.2 Direct Risk Influences & Associated Outcomes

The outcome of Risk C has two direct influences in the technology and equipage categories as seen in Figure 17 and referenced in Table 10. In the technology category, the ground infrastructure must perform well enough to meet the standards of RCP240. RCP240 is a communication standard that determines the maximum amount of time that messages can be exchanged between ANSPs and aircraft. Risk L represents a failure of the ground infrastructure to meet this standard and its outcome is influenced by the software and hardware readiness of the ANSPs. The hardware changes that ANSPs need to plan for to mitigate against risk C should include the hardware compliance to the 25 NM lateral communication standard (currently anticipated to be RCP240).

Risk Q represents a failure to achieve the percentage of equipped flights needed to move forward with phases of 25NM lateral separation. Delays in ANSP readiness can influence an operators decision to equip if it is unclear

when a given region will support reduced separation and if there will be corresponding economic penalties.

Table 18: Risks that are directly influenced by Risk C

| | |
|--------|--|
| Risk L | Failure to establish a plan to go forward with mitigation to meet RCP240. This also includes failure of ground infrastructure to support RCP240. |
| Risk Q | Failure to achieve percentage of equipped flights needed to move forward with phases of 25NM lateral separation |

C.4.3 Compound Loops

Risk C has compound loops in the technology, coordination and timing, and safety categories. These loops are listed in Table 19 and shown in Figure 17. These loops reflect the interdependence between these categories and the level of coordination required to get the technology working, meet the safety standards, and agree on the communication standards with in the time frame of the initiatives.

Risk R represents a failure to agree on the communication standards. ANSPs may need to implement new software and hardware depending on standards. Conversely, without knowledge of these standards, ANSPs cannot procure compliant equipment. One of these standards is RCP240 which is part of risk L.

Risk S represents late completion of 25NM lateral separation tasks. Some of these tasks involve standards that are ANSPs need to upgrade their software in hardware. ANSP readiness including testing is also encompassed in these tasks. If ANSPs are delayed in getting software and hardware for reduced separation up and working than Risk S is more likely to occur.

Risk T represents a failure to meet the safety case for 25NM lateral separation. The safety case has many requirements including communication requirements that are influenced by the hardware of the ANSPs to meet them. Risk T can also affect Risk C if changes to the standards are needed to meet the safety case.

Risk U represents a failure to control the vertical risk when 25NM lateral separation is implemented. The vertical risk involves aircraft flying on the same lateral track or direction that come too close in altitude. This risk should be evaluated during testing so it can influence the readiness of ANSPs by forcing software or hardware changes. It can also be influence by the performance ANSPs in operation if there is a failure or the equipment does not perform as expected.

Table 19: Risk C Compound Loops

| | |
|--------|--|
| Risk R | No ICAO communication navigation and surveillance standards available to support implementation of 25NM lateral separation |
| Risk S | Late completion of 25NM lateral separation tasks |
| Risk T | Failure to meet safety case for 25NM lateral separation. |
| Risk U | Failure to control vertical risk when 25NM lateral separation is implemented. |

C.5 Mitigation

Table 15 shows the mitigation difficulty results for Risk C. Respondents gave Risk C a low detection difficulty because operators won't be able to file for or use reduced separation procedures if the ANSP equipment is not ready. ICAO and the ANSPs will communicate any changes to the operating procedures if necessary to the pilots.

Corrective action is rated is high because it will require changing the initiatives, adding new hardware or software and possible retraining ANSP employees. One respondent commented that coordinating in ICAO meetings would be the best way to mitigate against the root causes from planning. A readiness survey completed by each ANSP would work well in ensuring that reduced separation can be implemented in the anticipated timelines.

The coordination required to mitigate against Risk C is medium. In addition to coordinating through ICAO meetings, ANSPs much coordinate their software with each other to ensure handoffs and conflict resolution work seamlessly.

Respondents felt that the likelihood of Risk C was low. Some of the ANSPs participated in the survey. All indicated they had plans to equip in time for the reduced initiatives or that they were already equipped. Most of the respondents indicated that only software upgrades were needed but one ANSP indicated that a hardware update was needed as well.

Table 20: Risk C Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | Medium | Low |

D.0 Description

Risk D is a coordination and timing risk described as “Late Completion of data link mandate plan. Not enough time for commercial and business operators to plan to comply with mandate (e.g. determination of entire flight level spectrum and OTS tracks where mandate is to be applied). Risk D as stated is both a risk and an outcome. The risk is completing the data link mandate plan late and the outcome is that operators may not have enough time to equip. The data link plan currently has stated timelines but incomplete details on how to equip and the penalties for not equipping. Operators who are waiting for more details may not have enough time to equip if the mandate takes too long to complete.

D.1 Background

The data link mandate plan in Table 21 shows timelines for phased introductions of restricted airspace that only FANS 1/A equipped aircraft can operate in. However the definitions of which tracks will be affected and the flight and the flight levels are significant to the economic impact of not equipping. The flight levels especially need to be known before operators can make a decision. There is also a significant amount of time required to equip. The manufactures must develop and certify equipment and the operators must procure the equipment and schedule aircraft downtime for installation. The total length of the process can vary and if the data link plan details aren't ready in time, it may not be feasible for an operator to equip before the restrictions are implemented.

Table 21: Data Link Mandate Plan

| Year | Airspace Where Applicable | Flight Levels Where Applicable | Remarks |
|-------------|----------------------------------|---------------------------------------|---|
| 7 Feb 2013 | *To-be-determined OTS tracks | *To-be-determined FL's | Aircraft to be equipped <u>in order to operate</u> at specified FL's, however, NAT SPG to explore measures to accommodate non-equipped aircraft |
| 5 Feb 2015 | *MNPS Airspace | *To-be-determined FL's | Remark above applies |

***Operational Restrictions.** Operators/aircraft not appropriately equipped and, as required,

authorized could be restricted from operation on specified tracks or airspace at specified flight levels.

Additional Note:

European Air Navigation Planning Group (EANPG) proposed exemption to data link requirement in designated European airspace: aircraft with an individual certificate of airworthiness first issued before 1 January 2014 and fitted with data link equipment certified against requirements specified in RTCA DO-258A/EUROCAE ED-100A (or ED-100) are exempted for the life of that particular airframe.

D.2 Root Causes

The respondents identified two root causes for late completion of the datalink mandate plan: lack of coordination between the regulators and all the stakeholders, and, lack of progressive review after the mandate details are set. The details of these root causes are discussed in the following section.

D.2.1 Poor Coordination

Poor coordination was cited as the main root cause for the occurrence of Risk D. Respondents felt that a high level of coordination between regulators, operators, and manufacturers would be the best way to pick dates that work for as many people as possible. Respondents also pointed out that they would like to see the enforcement dates harmonized with European CPDLC initiatives and harmonized procedures worldwide.

D2.2 Lack of Progressive Review

Lack of progressive review of the data link mandate was also cited as a root cause. A progressive review is necessary to both incorporate all the analysis that is been done in support of the planning tasks, and, to make sure all the stakeholders are aware of what is expected of them and the complete details of how to comply with the rules. The planning process is iterative so it is important that everyone agrees and is aware of the final plan when it is put in place.

D.3 Impact on Stakeholder Values

The impact on stakeholder value metrics for Risk D is given in Table 21.

Table 22: Risk D Impact on Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | High | Very Low | Low | Medium | None |

The low safety impact is due to a fewer than desired number of aircraft operating in the NAT with CPDLC. This is due to the anticipated outcome of operators not having enough time to equip.

The operational efficiency impact is high due to the implications of the likely outcomes. Operators that do not have enough time to comply will have to follow the procedures put in place for unequipped aircraft. An unanticipated high number of these aircraft could put a significant strain on the operational efficiency of the North Atlantic, especially if they are all forced to the same oceanic entry points and flight paths. Operators may also have a need to schedule extra downtime for the aircraft in order to equip them with CPDLC which also hurts the efficiency of their operation.

The impact to ANSP Costs is indicated as very low. These costs are likely from unanticipated staffing or software changes that come from changes to the data link mandate plan.

The impact on ANSP revenues is indicated as low. The low impact is due to traffic fluctuations (either positive or negative) due to the late completion of the plan. The ANSP brings in revenue by charging for messages exchanged between the aircraft and the ANSP. If there are fewer aircraft or fewer messages due to fewer aircraft having CPDLC, the overall revenue could change. Alternatively, HF messages for unequipped aircraft could be priced higher than data link messages from CPDLC equipped aircraft so ANSP revenue could also increase to slightly higher than expected levels.

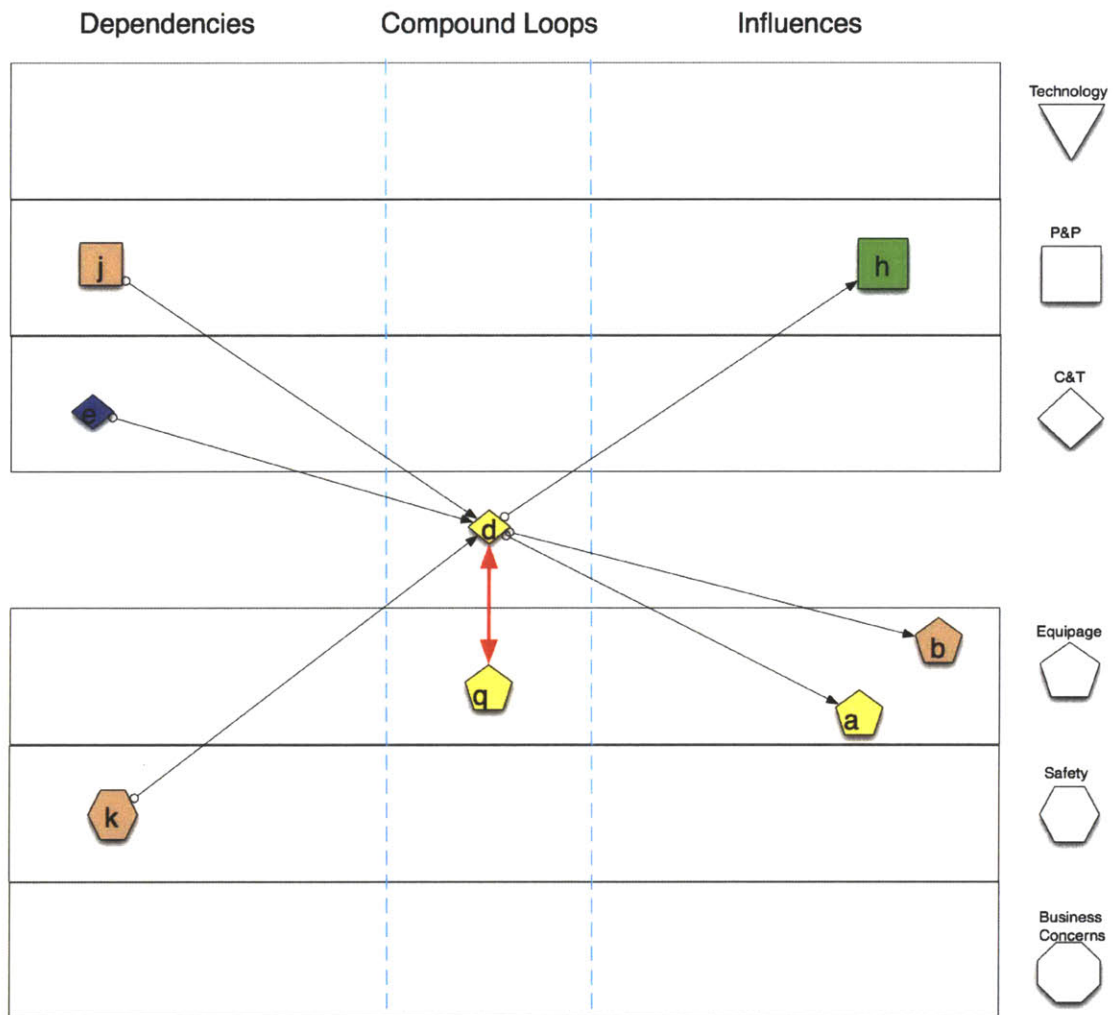
The impact to Operator Costs is stated as medium. These costs can come from unanticipated requirements for equipping, unscheduled aircraft downtime to equip and, from the increase in fuel burn from flying routes designated for unequipped aircraft. Late completion of the data link mandate plan can force operators into any or all of those three scenarios if they do not have enough time to comply.

The respondents did not indicate an impact of this risk to Operator revenue.

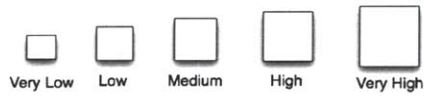
D.4 Direct Risk Dependencies, Influences & Outcomes

The dependencies of Risk D are shown in Figure 22 and Figure 23. Risk D affects both the mandate and reduced separation initiatives. Risk D is a coordination and timing risk that has both dependencies and influences in the policy and procedure category, coordination and timing, equipage and safety.

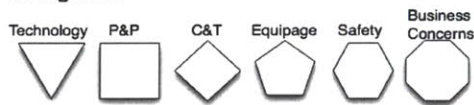
Figure 22: Risk D Dependencies and Influences (Mandate Only)



Likelihood



Categories



Impact

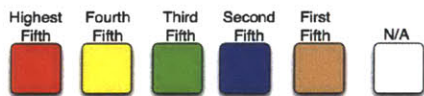
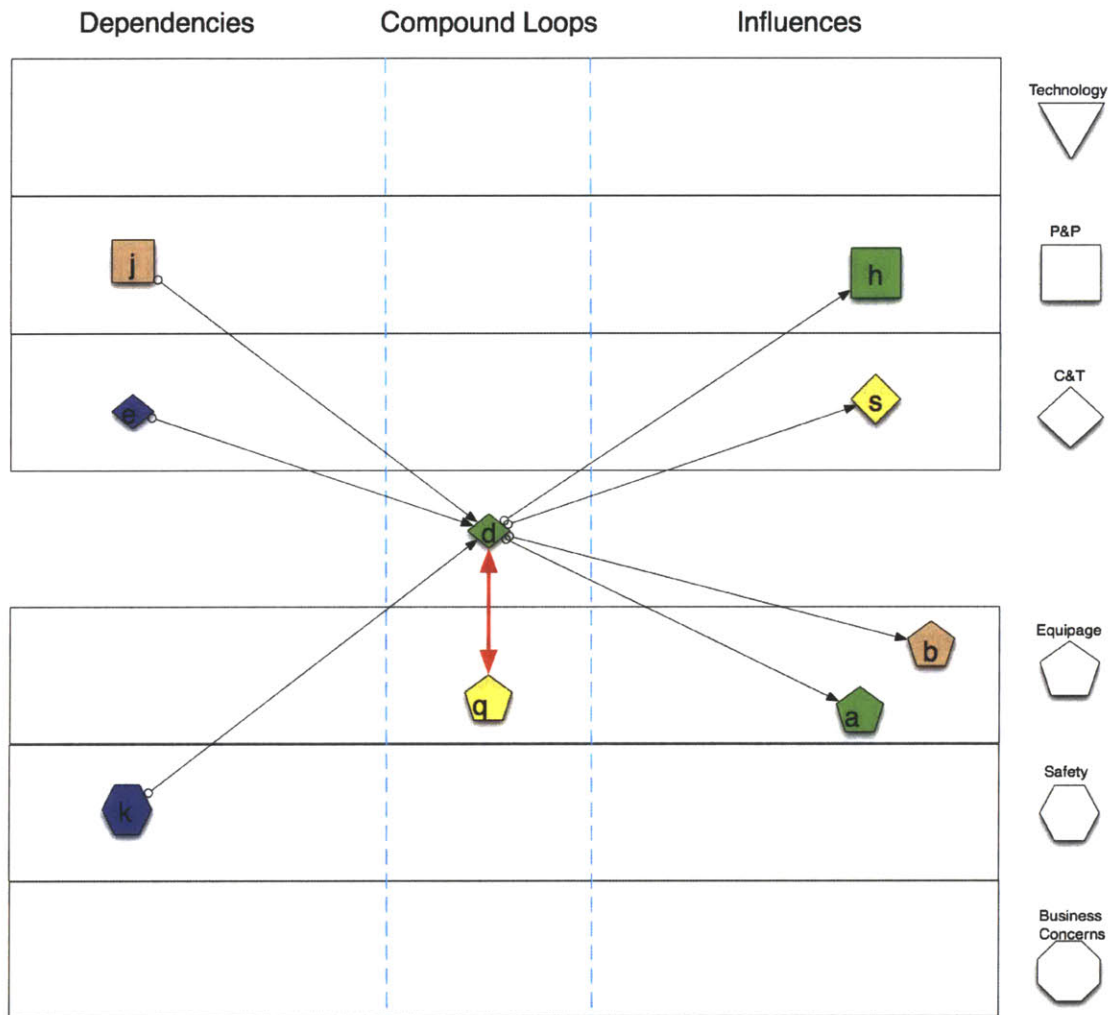
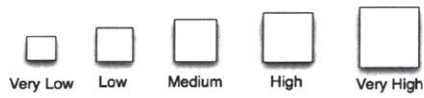


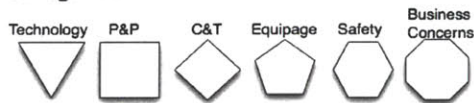
Figure 23: Risk D Dependencies and Influences, Mandate and Reduced Separation



Likelihood



Categories



Impact

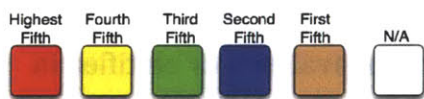


Table 23: Risk D Direct Dependencies

| | |
|--------|---|
| Risk E | Failure to achieve effective coordination with other ANSPs (harmonization of technical methods and operating methods) |
| Risk J | Operators choosing to operate in areas where other types of surveillance are provided. |
| Risk K | Increased traffic in MNPS routes other than OTS routes. |

Risk E is a coordination and timing risk that describes a failure to adequately coordinate with other ANSPs to facilitate handoffs and other types of communication. If the proper coordination between ANSPs is not in place or, if there are barriers preventing from occurring then the data link mandate plan must be postponed, causing the occurrence of Risk D.

Risk J is a policy risk that describes a possible scenario in which many aircraft choose to operate routes with radar coverage if they are forced to operate outside of the OTS. Risk J however would only occur if unequipped operators were forced to operate outside the OTS by policy because flying in area with radar coverage represents a large, uneconomical path diversion. It is a safety risk because it could result in too much traffic using a specific route (blue spruce route) which could cause congestion and delays. The likely occurrence and consequences of risk J occurring could force changes to the data link mandate plan that result in delayed implementation.

Risk K is a safety risk that describes an increased number of aircraft operating outside of MNPS airspace as a possible consequence of the mandate and reduced separation procedures. If the occurrence of risk K is determined to have a high likelihood and pose a significant safety risk, the data link mandate may need to be revised and could pose a significant delay to implementation.

Table 24 shows the

Table 24: Risk D Direct Influences

| | |
|--------|--|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
|--------|--|

| | |
|--------|---|
| Risk B | Potential delays in manufacturers delivering aircraft |
| Risk H | Restricted access to airspace for unequipped aircraft |
| Risk S | Late completion of 25NM lateral separation planning tasks |

Risks A and B are equipage risks that depend on a clear data link mandate plan that instructs operators and manufactures how to equip. Delays in completing the data link mandate plan can cause delays down stream in creating the equipment (Risk A) and delivering equipped aircraft (Risk B).

Risk H is a policy risk that encompasses the implications of restricted airspace for unequipped operators. These restrictions will come in the final data link mandate plan and the 25NM reduced separation plan.

Risk S is a coordination and timing risk describing the late completion of the 25NM lateral separation planning tasks. The 25NM lateral separation initiatives depend on the CPDLDC and ADS-C technology that is required in the datalink mandate plan. If the data link mandate plan is delayed, the 25NM lateral planning tasks could also be delayed.

The compound loop for Risk D is listed in Table 25.

Table 25: Risk D Compound Loops

| | |
|--------|---|
| Risk Q | Failure to achieve percentage of equipped flights needed to move forward with phases of 25NM lateral separation |
|--------|---|

Risk Q is an equipage risk that was identified as a compound risk with Risk D. Risk Q can influence the occurrence of risk D because increasing the number of equipped aircraft is the main objective of the data link mandate. If it is clear that the plan will not sufficiently increase the number of equipped aircraft then the plan could be altered or delayed. Conversely, the success of the data link mandate plan, including its timeliness influences the number of equipped aircraft and the operators who are deciding to equip.

D.5 Mitigation

The mitigation difficulty for Risk D is described in Table 26. The detection difficulty is very low because the data link mandate plan will be published by ICAO and all of the operators and ANSPs will be made aware any changes or delays.

Respondents rated corrective action as “high” and coordination as “very high”. This is likely due the complexity of technical and procedural dependencies surrounding the data link plan. The technical details and the procedural details need to be agreed upon by all of the ANSPs to work effectively. The 25NM lateral plan has timelines that also depend on the successful implementation of the data link mandate plan. Respondents did mention that coordination is the best way to mitigate against a possible delay of the data link plan.

The respondents felt Risk D had a medium likelihood of occurrence. They noted that while there is a timeline for the data link plan in place, the details and flight levels still aren’t clear. They also noted that they would like to see the timelines harmonized with the timelines from European CPDLC mandates.

Table 26: Risk D Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Very Low | High | Very High | Medium |

E.0 Description

Risk E is described as “Failure to achieve effective coordination with other ANSPs (Harmonization of technical systems and operating methods)”. Coordination is needed between ANSPs to facilitate handoffs and collision detection as aircraft move from one ANSP region of airspace to another. Handoffs are exchanges of information about an aircraft that is transferred from one ANSP to another and contain speed, altitude, flight plans, call signs and other information. The operating methods need to be harmonized to minimize human error amongst operators who are flying between ANSPs and to reduce the need for duplicate CPDLC equipment on board the aircraft. Failure to properly coordinate could result in lower operational efficiencies and possibly higher costs to ANSPs.

E.1 Background

ANSPs around the world have various procedures for issuing clearance, assigning flight paths and cruising altitudes, and for communicating with pilots and ANSPs. As CPDLC became more widely adopted by operators and ANSPs, the messages between ANSPs and pilots became digital and the different procedures and message formats were used in different parts of the world. The message format describes the content of the messages, the formats in which they are sent, and other technical details of how the messages are exchanged. Different communication procedures and message formats in different regions of the world can be confusing to pilots and lead to human error. With specific regard to reduced separation procedures, not all flight management computers support the display of the half-degree tracks required when reduced separation procedures are in place.

E.2 Root Causes

Risk E has several root causes that are related to coordination with stakeholders and incompatibilities with technical specifications and delays in software upgrades:

E.2.1 Inadequate Coordination with Stakeholders:

The ANSPs must coordinate with all of the stakeholders to ensure that the technical systems and procedures are compatible and operate efficiently. Some coordination between North Atlantic ANSPs is facilitated by ICAO but it must also be done on the local level with domestic, adjacent ANSPs. If proper coordination with domestic ANSPs is not present, technical problems could come up during testing and implementation that could delay the initiatives and result in reduced operational efficiency.

E.2.2 Delays in system software upgrades

Delays to the system software upgrades can delay or prevent efforts to harmonize with other ANSPs. It is possible that each ANSP will choose a unique software vendor to perform upgrades and it may not be clear until the upgrade is complete or partially done that a system integration effort with adjacent ANSPs needs to take place. Failure to recognize and plan for the systems integration work could add delays to the harmonization between ANSPs.

E.2.3 Incompatible technical specifications

Incompatible technical specifications between ANSPs can also be a root cause. Some of the technical specifications need to change to facilitate entry of the half-degree tracks for reduced separation, and to harmonize the CPDLC message sets and procedures worldwide. If the same standards are not adopted by all ANSPs, then it is possible that information between ANSPs may not be exchanged properly.

E.3 Impact to Stakeholder Value Metrics

The impact of Risk E to stakeholder values is shown in Table 27.

Table 27: Risk E Impact to Stakeholder Values

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Medium | High | Medium | None | None | None |

Respondents gave the impact of Risk E a medium safety impact. Having different procedures can increase the likelihood of human error by the pilots. It is possible for pilots to confuse the procedures between ANSPs and regions during flight path changes. There could also be a higher likelihood of human error if ANSP staff perform handoffs manually by hand if their software systems can't communicate.

The operational efficiency impact was listed as "high". Impacts to operational efficiency can come at the transition points between two ANSPs if different procedures are used and different systems are used. The transition time can take longer if it needs to be carried out manually and that may cause the need for more aircraft separation which decreases the operational efficiency. Local ANSPs may not support the same separation standards which could force an adjacent ANSP that participates in reduced

separation procedures to increase the space between aircraft close to the transition point.

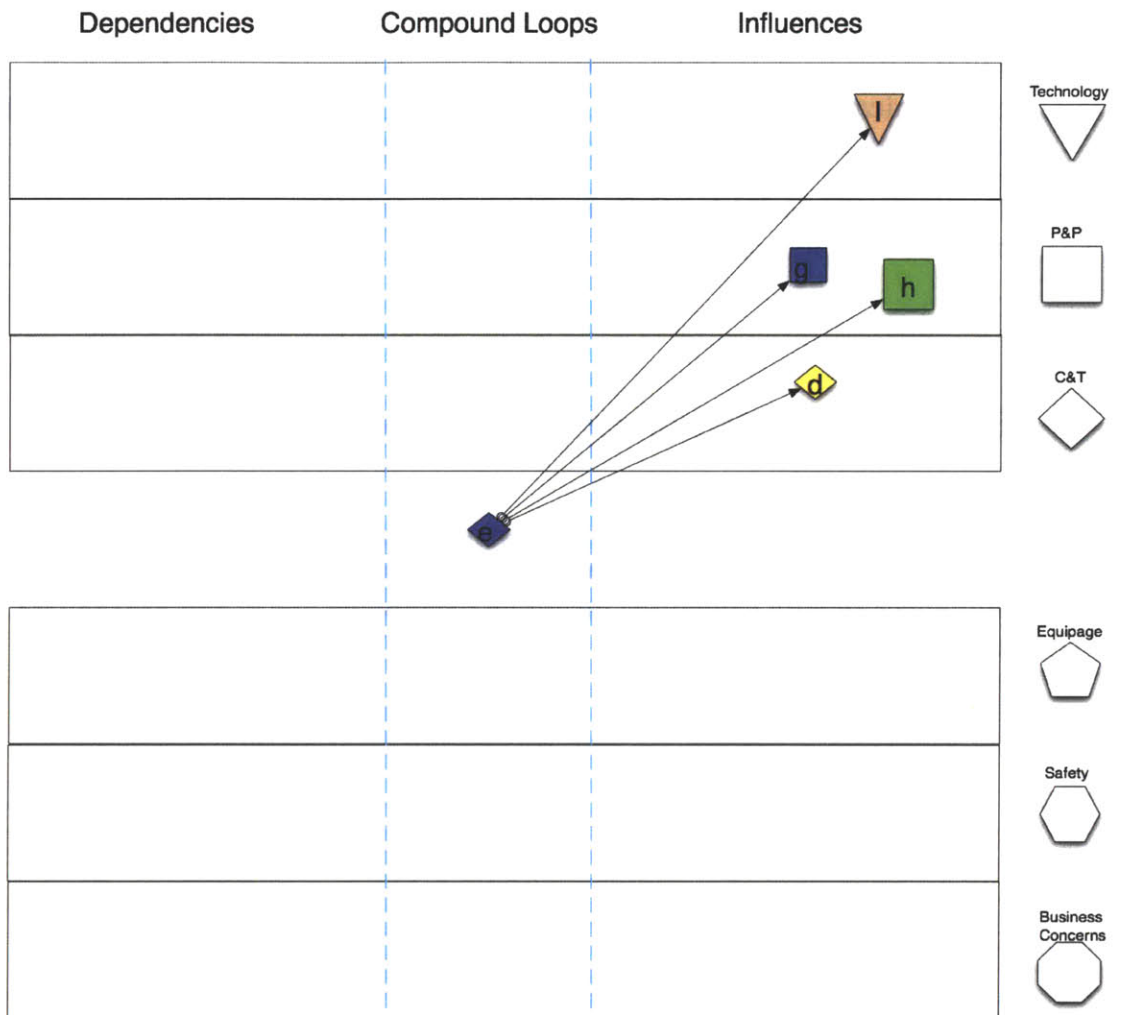
ANSP cost impact could be medium if extra staffing is required to handle communications with adjacent ANSPs or if unanticipated software upgrades are needed to facilitate automatic communication with adjacent ANSPs.

The respondents did not indicate an impact to ANSP revenues, operator costs, or operator revenues.

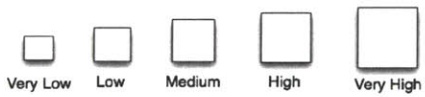
E.4 Direct Risk Dependencies, Influences & Outcomes

The dependencies of Risk E are shown in Figure 24, and Figure 25. Risk E is a coordination and training risk with only one direct dependency and influences several categories including technology policy and procedures, and, coordination and timing.

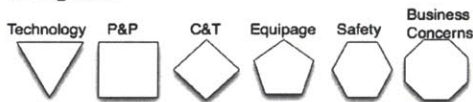
Figure 24: Risk E Dependencies, Mandate Only



Likelihood



Categories



Impact

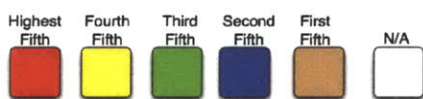
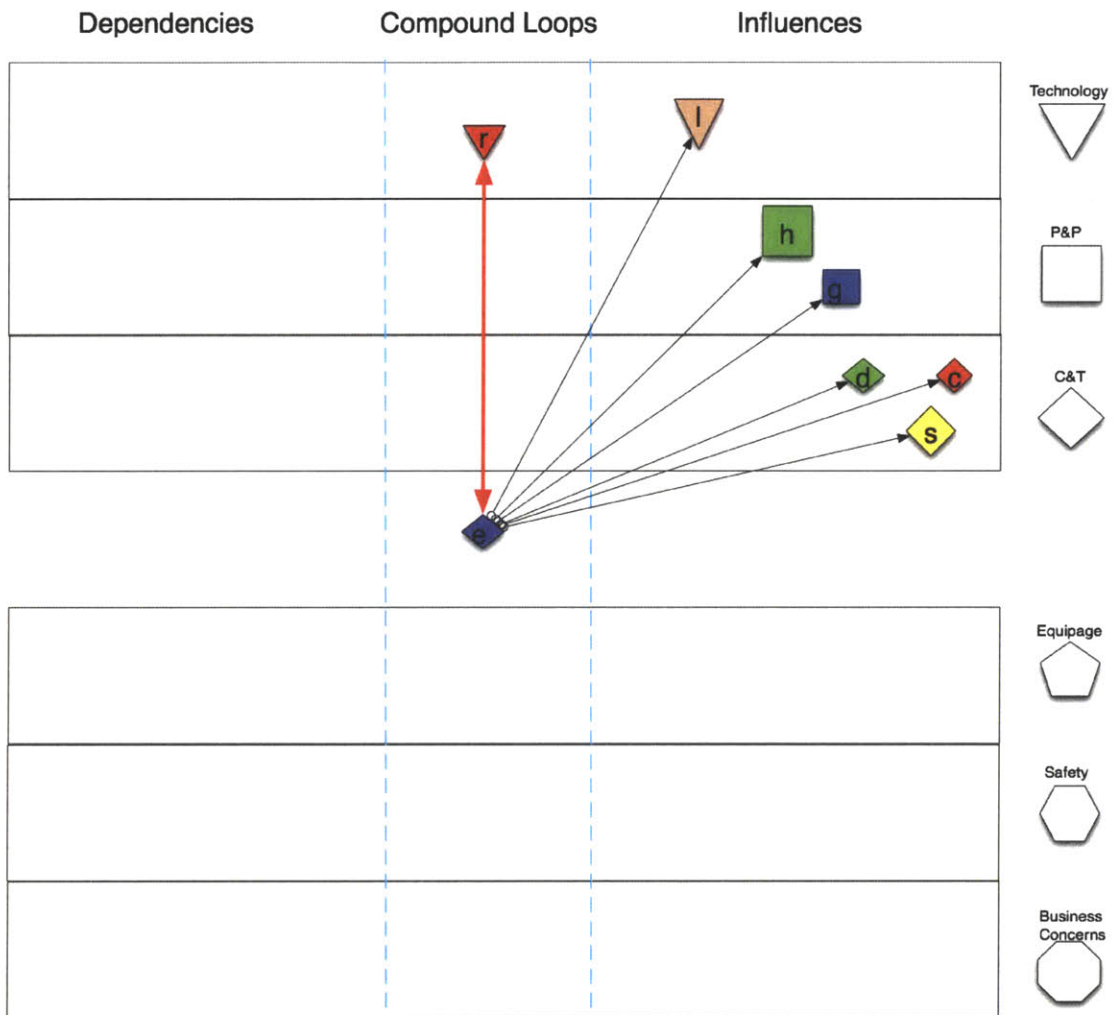
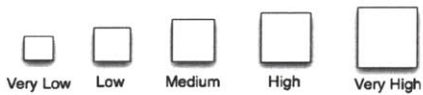


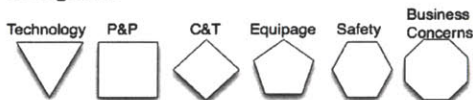
Figure 25: Risk E Dependencies, Mandate and Reduced Separation



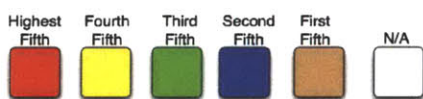
Likelihood



Categories



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Risk E does not have any direct dependencies although forms a compound loop with Risk R.

Risk E has several direct influences in the technology, policy and procedure and coordination and timing categories.

Risk L describes a failure to determine a communication standard for 25NM lateral separation. Although RCP 240 has been defined, it still needs to be tested to verify that it is satisfactory for 25NM lateral separation and that all of the equipment can maintain the standard with large volumes of traffic. These tests require coordination between ANSPs to conduct.

Risks H and G are policy risks that describe the operating implications for unequipped aircraft. Risk H describes restricted access to airspace for unequipped operators and Risk G represents a failure to develop measures for unequipped aircraft. The ANSPs must coordinate and agree on how to handle the volume of unequipped aircraft that may be restricted from using parts of the North Atlantic when the initiatives take effect. If Risk E occurs, the procedures for handling unequipped aircraft could consequently become, complex, inefficient and force the occurrences of risks H and G.

Risk E also influences other coordination and timing risks that are critical to the planning tasks that involve ANSPs and must be completed before the initiatives can take effect. The data link mandate plan (Risk D) and the 25 NM lateral separation plan (Risk S) require ANSPs to agree on procedural and technical requirements. The automation systems (Risk C) also need to be linked with those from adjacent ANSPs to ensure readiness for the initiatives.

Table 28: Risk E Direct Influences

| | |
|--------|---|
| Risk L | Failure to establish a plan or go forward with mitigation to meet RCP240. |
| Risk H | Restricted access to airspace for unequipped operators |
| Risk G | Failure to develop measures to accommodate unequipped aircraft |
| Risk D | Late completion of data link mandate plan |
| Risk C | ANSP failure to automation systems ready |
| Risk S | Late completion of 25NM lateral separation |

Risk E has one compound loop with Risk R as shown in Figure 25 and Table 29. Risk R is a technology risks that represents a failure to produce technology standards for 25NM reduced separation. These standards are needed by the ANSPs to properly tune the software that assists air traffic controllers and to ensure their hardware can meet the target level of performance specified in the standards.

Table 29: Risk E Compound Loops

| | |
|--------|--|
| Risk R | No ICAO standards to support implementation of 25NM reduced separation |
|--------|--|

E.5 Risk E Mitigation Difficulty

The mitigation difficulty for Risk E is show in Table 30. The detection difficulty was given a medium rating. The detection of the issues stemming from a lack of ANSP coordination will take time to detect as the problem materializes.

The respondents indicated that communication takes place between the stakeholders but that the appropriate action is much more difficult to accomplish. The high ratings for corrective action and coordination are likely a result of this perceived difficulty to take action. In some cases, respondents felt that action was hard to take because of the long time scales required for the coordination, testing, and appropriate analysis to be completed.

Respondents felt that Risk E had a “medium” likelihood of occurrence. They did recognize that ANSPs participate in the NAT meetings but that they could be constrained by time and resources to take the appropriate corrective action.

Table 30: Risk E Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Medium | High | High | Medium |

F.0 Description

Risk F is described as “Rulemaking to support datalink mandate and 25NM lateral separation (if required by ANSP) not completed within mandate timeframe”. Rulemaking is a process that is sometimes required by local authorities to certify new equipment and operating procedures. Even though the ICAO certification process could be complete, the local rulemaking process could still delay the implementation of 25NM lateral separation.

F.1 Background

Rulemaking is an analysis and approval process performed by local authorities in order to allow new operating procedures or equipment into local airspace. In some cases local authorities may elect to add requirements after their own independent rulemaking process in addition to the work that is done by international organizations such as ICAO. There are also cases where local rulemaking is required and not optional. The local authorities have the final say with regard to which regulations and procedures will be used in their respective regions. Failure to complete rulemaking could delay the implementation of 25NM initiatives because they depend in part on agreement between authorities in all of the North Atlantic regions.

F.2 Root Causes

Respondents felt that the only root cause for Risk F occurring is that the rulemaking process can be time consuming.

F.2.1 Time Consuming Process

The main root cause for this risk is that the rulemaking process can be time consuming. The respondents agreed that the rulemaking process is an important safety step that must be taken when new rules, equipment and or procedures are adopted. They did not give specific timelines or estimates but one ANSP respondent described their rulemaking process as a safety check for local ground equipment software to ensure that it complies with the new rules or procedures set by ICAO. They said that live tests would be performed along with a separate safety analysis. It is possible for the rulemaking process to vary across ANSPs so some processes may be more time consuming than others.

F.3 Impact on Stakeholder Values

The impact on stakeholder values for risk F is shown in Table 31.

Table 31: Risk F Impact on Stakeholder Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | High | Low | Low | Medium | Medium |

Respondents gave Risk F a low safety impact. Although rulemaking is required to ensure local safety standards are met, the new processes won't be implemented until local rulemaking actually occurs and the processes are locally certified. The low impact could come from other safety risks associated with having other regions operate with new procedures while rulemaking is completed in separate region or, subsequent lower levels of equipped air traffic due to delays in implementing the initiatives.

The impact to operational efficiency can be high if the 25NM lateral initiatives are delayed or if the initiatives are partially implemented. Delayed implementation of the initiatives coupled with traffic increases over time could result in more congestion and thus reduced operational efficiency.

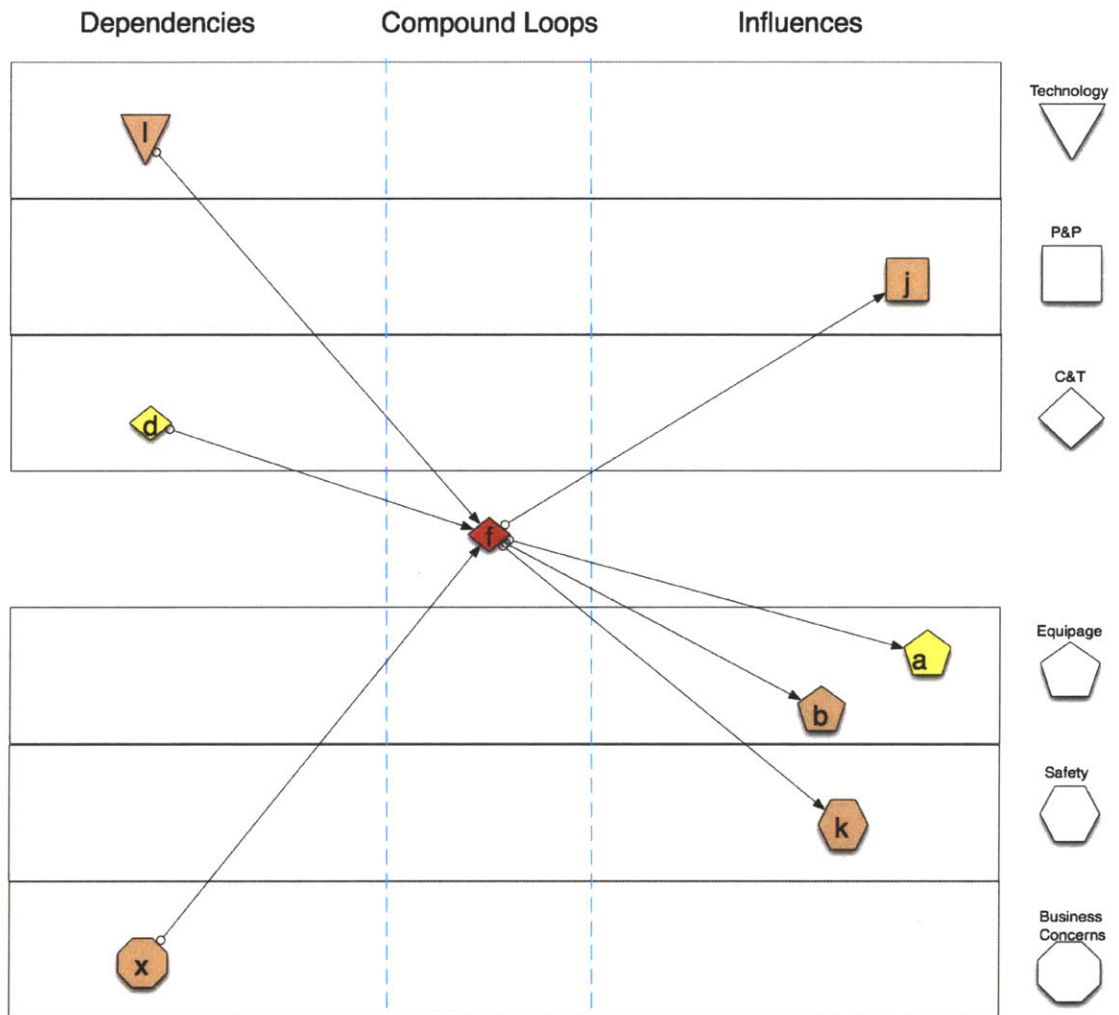
ANSP costs are low due to the possible increases preparation costs that can come from delays. The operator costs are medium due to an inability to recoup back the investment in equipment from not using 25NM reduced separation procedures while the initiatives are delayed.

ANSP Revenue and Operator Revenue impact are low and medium respectively. These impacts would be due to the possible delays into the increases in traffic and airspace capacity that would be possible if initiatives weren't delayed by the rulemaking process.

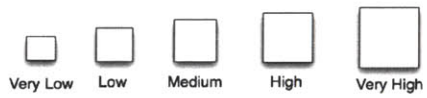
F.4 Direct Risk Dependencies, Influences & Outcomes

The dependencies, influences and compound risks of Risk F are shown, in Figure 26 and Figure 27. Risk F is a coordination and timing risk with direct dependencies and influences in several categories including technology, policy and procedures, coordination and timing, and business concerns.

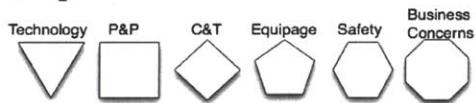
Figure 26: Risk F Direct Dependencies and Influences



Likelihood



Categories



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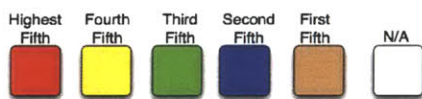
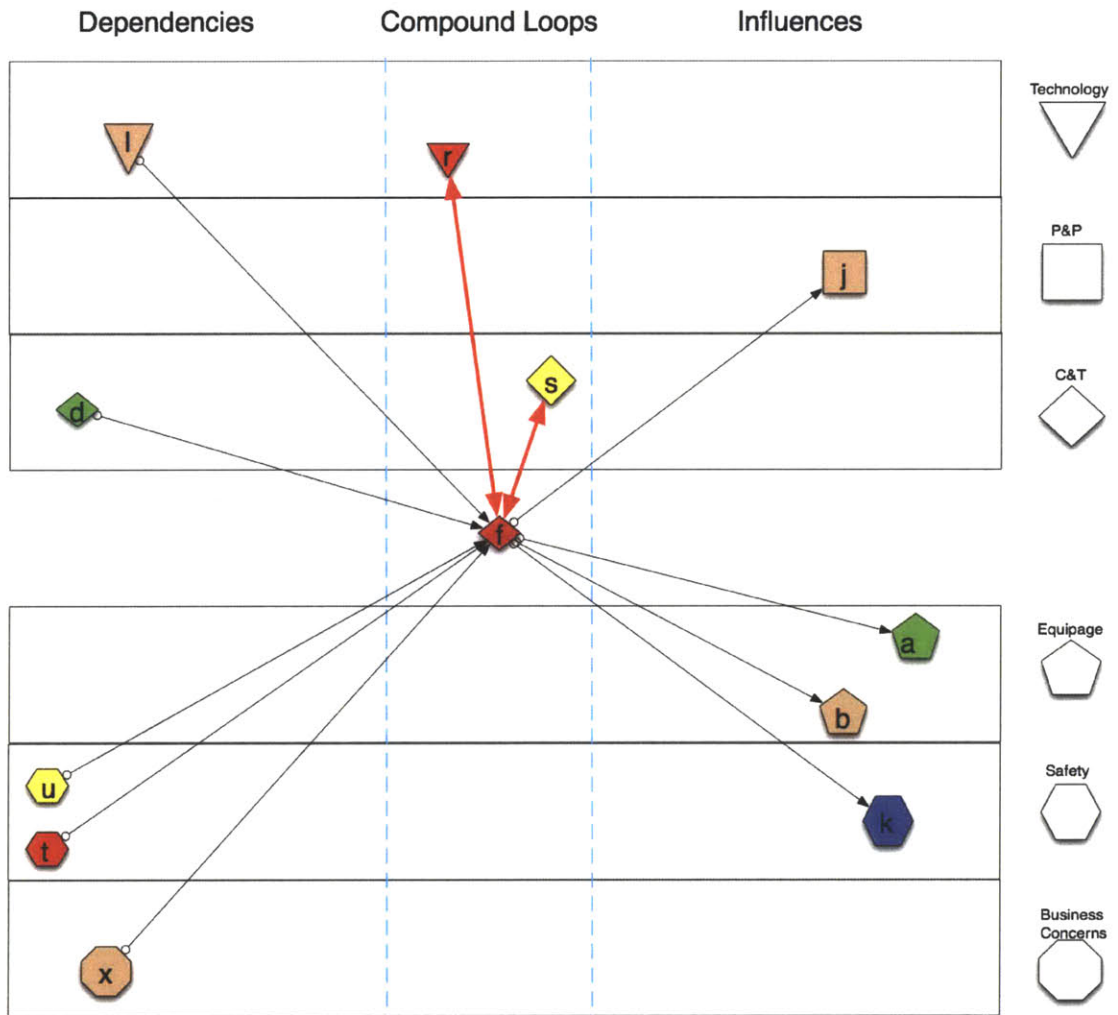
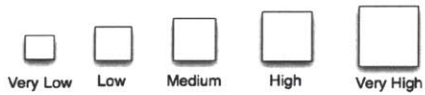


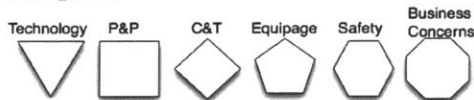
Figure 27: Risk F Direct Dependencies and Influences (Mandate and Reduced Separation)



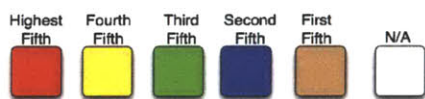
Likelihood



Categories



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Risk F has a dependence on the technology risk L (meeting & verifying RCP240 for the safety case) because the rulemaking process needs a standards definition to accurately verify and test.

Risk F has a dependence on the coordination and timing risk D also because the rulemaking process needs a standards definition to accurately verify and test. Although the datalink equipment requirements are defined, the harmonization of procedures could change the message formats and the correct message formats are needed for local rulemaking.

Risk F has a dependence of the safety risks U (25NM lateral vertical safety case failure after implementation) and T (25NM lateral safety case after implementation). ***Is this possible? Doesn't rulemaking need to be completed before 25NM lateral is implemented in a given region?***

Risk F also has a dependence on the business case risk X (Cost benefit analysis may show costs outweigh the benefits of initiatives). If the costs due in outweigh the benefits for the data link mandate or 25NM lateral separation, the ANSPs and local authorities may elect not to proceed with the rulemaking process. This decision would likely be influenced by ICAO and the intentions of other ANSPs after the cost benefit analysis is completed.

Table 32: Risk F Direct Dependencies

| | |
|--------|---|
| Risk L | Failure to establish a plan or go forward with mitigation to meet RCP240. |
| Risk D | Late completion of Data link Mandate plan |
| Risk U | Failure to control vertical risk when 25NM lateral separation is implemented |
| Risk T | Failure to meet safety case for 25NM lateral separation. |
| Risk X | Cost benefit analysis may show that costs outweigh the benefits of implementing the data link mandate and/or 25NM lateral separation. |

Table 33 shows the direct influences of Risk F.

Risk F can influence the policy and procedure risk J (Operators choosing to operate in areas where other types of surveillance are provided) and the safety risk K (Increased traffic in MNPS routes other than OTS routes). The restrictions imposed by rulemaking and by ICAO can eventually force unequipped aircraft out of the OTS or out of MNPS airspace, both including optimal flight levels for most aircraft. If the rulemaking process results in upholding or extending the 2015 restrictions in the initiatives for the entire MNPS airspace, unequipped operators may indeed be forced to operate in

areas where surveillance is provided, causing the occurrence of Risk J. If there are restrictions that affect certain oceanic entry points during climb and descent flight phases, unequipped operators may choose alternate routes outside the OTS accordingly causing the occurrence of risk K. The respondents however noted that the main cause of risk K was the ability of the airlines to monitor winds in realtime while the OTS is only updated twice the day. The realtime wind information sometimes leads operators filing flight plans outside of the OTS to take advantage of recent or expected wind changes.

Risk F can also influence the equipment risks A (Business Operator equipage not available) and B (delays in delivering retrofit equipment) if the rulemaking process changes the airspace restrictions of the equipment requires for operating in a local region. Such changes could cause an operator to ask for changes to the retrofit equipment which could in turn cause delays. One possible example is the additional requirement for onboard datalink recording that came from a rulemaking process. The equipment to due the recording wasn't part of the ICAO initiatives and ordering could delay the delivery of the equipment or the aircraft.

Table 33: Risk F Direct Influences

| | |
|--------|---|
| Risk J | Operators choosing to operate in areas where other types of surveillance are provided |
| Risk A | Equipage for business operators not available or certified in time. |
| Risk B | Potential delays in manufacturers delivery aircraft data link retrofit packages to satisfy demand |
| Risk K | Increased traffic on MNPS routes other than OTS routes |

Risk F has two compounds loops (related reduced separation only) as shown in Figure 27 and Table 34. Risk R is a technology risk that describes a failure of ICAO to define and agree on all of the standards needed to go forward with 25NM lateral. These standards are needed for rulemaking and a failure to complete them quickly enough would result in the occurrence of risk F. Alternatively, the results from the local rulemaking process in each region could influence and update these standards causing Risk R to occur.

Risk S is a coordination and timing risk that describes a failure to complete the planning tasks for 25NM lateral separation. Risk S can depend on or influence Risk F depending on when the planning tasks fall behind schedule. The technical standards and restrictions are needed for the rulemaking process to initially take place. If the process for defining these standards and restrictions fall behind schedule, then Risk F will likely occur. Alternatively,

if the rulemaking process leads changes in the standards or restrictions, the remaining planning tasks for 25NM lateral separation could also be delayed while the revisions take place, causing Risk S to occur.

Table 34: Risk F Compound Loops

| | |
|--------|---|
| Risk R | No ICAO standards available for 25NM Separation |
| Risk S | Late completion of 25 lateral separation planning tasks |

F.5 Risk F Mitigation Difficulty

The mitigation difficulty for Risk F is shown in Table 35. The detection difficulty was given a low rating. Most of the delays coming from the rulemaking process won't take affect until the actual process but will likely be apparent in the planning process.

The respondents indicated that corrective action difficulty will be high. They suggested that the best mitigation strategy against rulemaking delays is to allow an appropriate amount of time to complete the process before setting an implementation date for the initiatives. Any changes to the standards or equipment coming from rulemaking would also be difficult to correct. One possible example would be changing the separation distances if RCP240 doesn't meet the safety criteria for 25NM lateral or if the Iridium satellites don't meet RCP240. Changing the standard would require resources, coordination and time to implement and analyze.

Respondents also indicated the coordination difficulty will be high. The ANSPs will need to coordinate with ICAO when and how their rulemaking processes will occur. The ANSPs may also need to coordinate with local ANSPs. The overall process can take time because ICAO must address all of the concerns of each ANSP that may come from rulemaking. One possible strategy is to gather the necessary information is to survey the ANSPs about their rulemaking processes. The coordination difficulty will also be high if changes to the datalink or reduced separation standards are needed.

Respondents felt that Risk F had a "medium" likelihood of occurrence. They indicated that the rulemaking process can be time consuming and it has inherent uncertainties. The uncertainties can include the time to address new concerns, and the time to secure the resources to perform the testing.

Table 35: Risk F Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | High | Medium |

G.0 Description

Risk G is described as a “failure to develop measures for unequipped aircraft”. When the reduced separation procedures are implemented, aircraft that do not have FANS 1/A based CPDLC and ADS-C equipment will not be able to safely operate close to equipped aircraft that are using the procedures. A failure to develop measures to accommodate these unequipped aircraft could have many undesirable outcomes for those operators and could also create congestion and unsafe operating conditions if there are too many unequipped aircraft operating in a confined geographical area.

G.1 Background

Unequipped aircraft will not be able to utilize reduced separation procedures because they lack the CPDLC equipment needed to send automatic position reports over the North Atlantic and the ADS-C equipment needed to receive position information from nearby aircraft. However, it is important to develop measures for unequipped aircraft because there will likely be a significant number of aircraft that aren't equipped either because equipment is unavailable, is uneconomical, or the aircraft is too old to justify the expense. As many as 50 percent of the aircraft that use the North Atlantic could be unequipped so if the measures to accommodate them don't exist, many operators could be affected.

The reduced separation plan as currently written gradually phases out the airspace in the North Atlantic that unequipped aircraft can use. In addition to having measures to accommodate unequipped aircraft, the measures must also ensure that a strain is not put on a single ANSP or that there aren't excessive levels of congestion at points where the unequipped aircraft are forced to operate. Some respondents also interpreted this risk as the inability for unequipped aircraft to get access to optimum flight levels.

Possible ways to accommodate unequipped aircraft economically include issuing waivers or setting aside airspace for unequipped aircraft to operate. Some operators have indicated that their aircraft need to use the optimal tracks in order to complete their missions.

G.2 Root Causes

The respondents identified two root causes for a failure to develop measures to accommodate unequipped aircraft: the inability for the NAT stakeholders

to agree on measures to equip aircraft and, as a consequence of the requirements of safe reduced separation flight.

G.2.1 Agreement between the stakeholders

Agreement between the stakeholders of the North Atlantic airspace (NAT) (operators, ANSPs and regulators) must take place in order to implement at NAT wide strategy for accommodating unequipped aircraft. The nuances of each ANSPs geography, oceanic entry points, and the ability of the aircraft to complete their routes with various restrictions could all make NAT-wide agreement difficult to achieve. In the case that an agreement is not reached, there are negative implications for the operational efficiency in the North Atlantic. Waivers may be needed by operators on a case by case basis, delays and controller workload could increase if large volumes of aircraft are forced to fly in an area that is too confined, or, some aircraft may not be able to complete their routes.

G.2.2 Regulator Consequence

One operator viewed the restriction of optimum flight paths from unequipped aircraft the risk instead of a failure to produce an accommodation strategy. In order to ensure that safety requirements are met, unequipped aircraft must fly sufficiently far away from equipped aircraft when equipped aircraft are using reduced separation procedures. So the decision to implement reduced separation in the North Atlantic could itself prevent unequipped aircraft from operation on optimum flight routes.

G.3 Impact on Stakeholder Values

The impact on stakeholder values for risk G is shown in Table 36.

Table 36: Risk G Impact to Stakeholder Values

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | Medium | Very Low | None | High | None |

The safety impact for the Risk G is low and operational efficiency impact is medium. The possible outcomes of Risk G that could lead to a safety and operational efficiency impact include an excessive number of waivers for unequipped aircraft inclusion in reduced separation airspace, excessive unequipped traffic in narrow corridors, and non implementation of the initiatives.

The ANSP Cost impact is very low. An outcome of Risk G that could lead to a cost impact on ANSPs is non-implementation of the initiatives. Non-implementation would possibly force ANSPs to maintain the costs of HF and increase staffing as traffic increases.

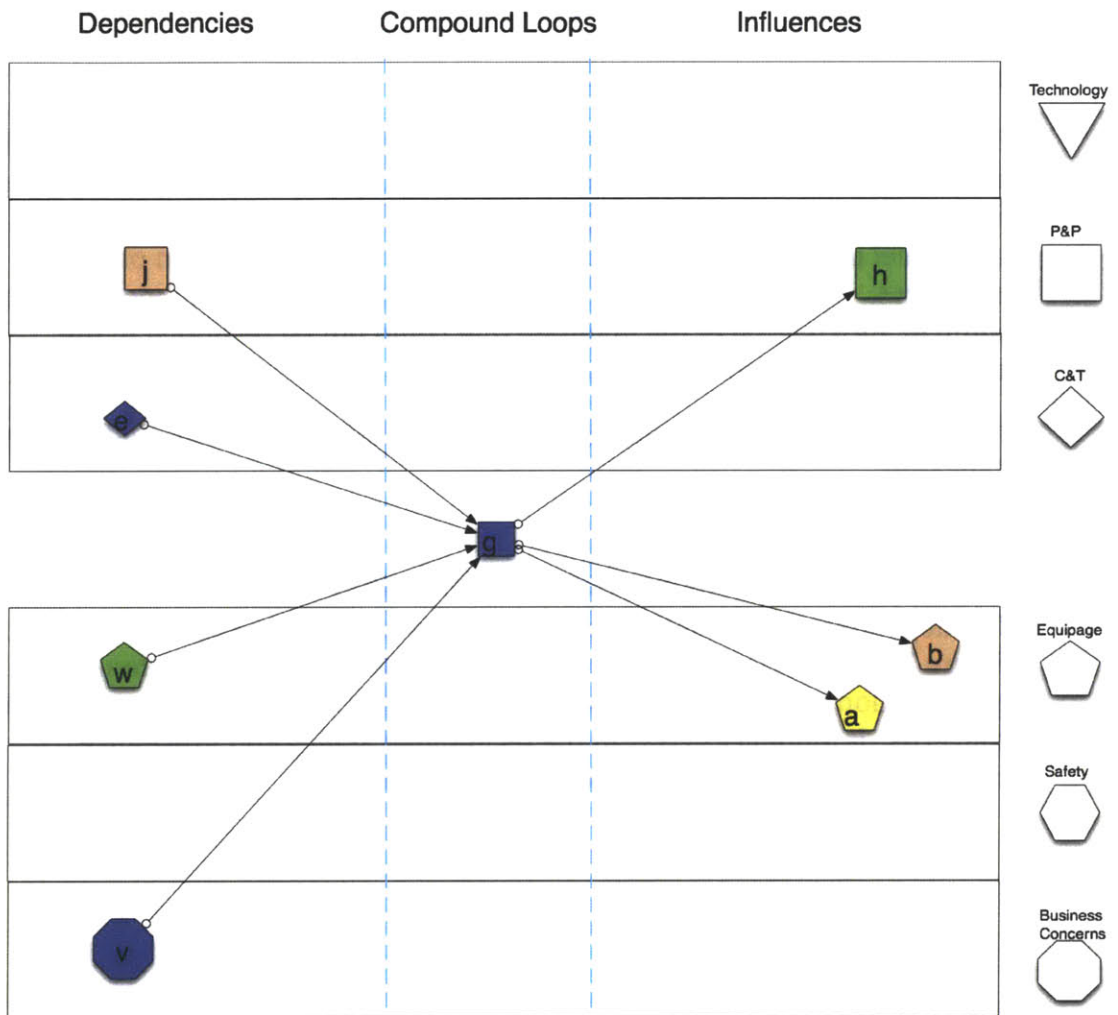
The operator cost impact is high. The cost impact comes from two possible outcomes: For unequipped aircraft, their flight paths could be forced out of the OTS or, into suboptimal flight levels. Both of these outcomes result in a larger fuel burn. The second outcome is a non-implementation of the initiatives. The operator cost impact would come from the money spent to equip in anticipation of the mandate that could not be recouped in the anticipated fuel burn cost savings.

The respondents did not indicate an impact to ANSP Revenues and Operator Revenues.

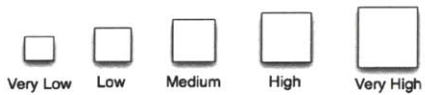
G.4 Direct Risk Dependencies, Influences & Outcomes

The dependencies and influences of Risk G are shown in Figure 28, and Figure 29. Risk G is a policy and procedure risk that has dependencies on coordination and timing risks, other policy risks, equipage risks and business concerns. It influences risks in the technology, policy and procedure, coordination and timing, and equipage categories.

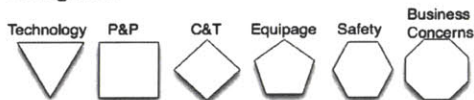
Figure 28: Risk G Direct Dependencies and Influences (Mandate Only)



Likelihood



Categories



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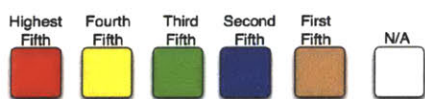
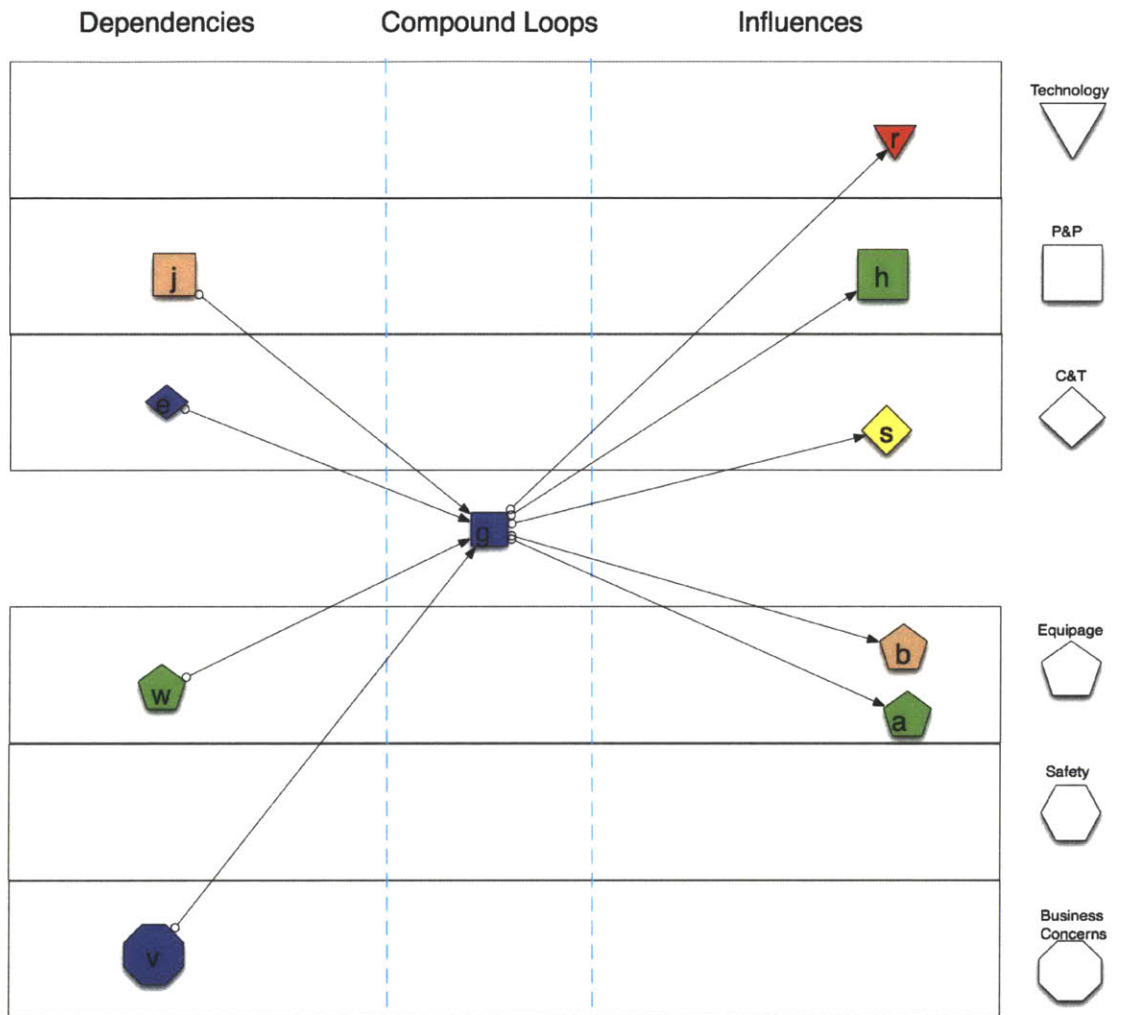
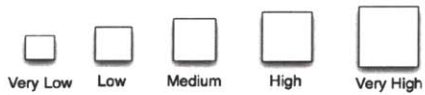


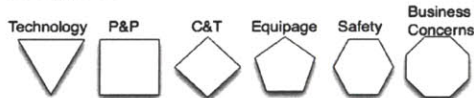
Figure 29: Risk G Direct Dependencies and Influences (Mandate and Reduced Separation)



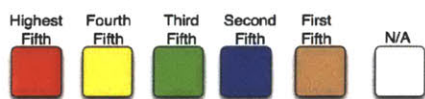
Likelihood



Categories



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Risk G has dependencies in several categories. These dependencies result in two outcomes that affect risk G. The first outcome is a reduction in the perceived need for unequipped aircraft accommodations. The second outcome is a limitation on the possibilities of the accommodations.

There are several risks that can contribute to a change in the perceived need for unequipped aircraft accommodations (either positively or negatively). Risk W is an equipage risk describing the late delivery of new aircraft orders that replace unequipped aircraft. If operators are going to replace their aircraft soon, there may be less pressure on regulators to find new accommodations. Risk V (high costs preventing operators from equipping) will have the opposite effect of increasing the need for unequipped aircraft accommodations. If the costs to equip are too high, there will be an increased amount of pressure on regulators to come up with regulations because there will be more unequipped aircraft.

Risk E is a coordination risk that describes a failure in coordination for ANSPs. ANSP coordination is needed across the NAT so that accommodations for unequipped aircraft can be agreed upon and implemented. Accommodation strategies such as waivers, and using unequipped tracks require the coordination of ANSPs and a failure to coordinate would make implementing these strategies more difficult or impossible. Risk J is a policy risk that describes a set of regulations that would force unequipped aircraft into areas with radar coverage. If these regulations are implemented, it may be more difficult for regulators to find economical ways to accommodate unequipped aircraft. Radar coverage routes such as the blue spruce route are uneconomical for many routes so it could be crucial to have accommodation strategies that allow unequipped aircraft to fly within the OTS.

Table 37: Risk G Direct Dependencies

| | |
|--------|---|
| Risk J | Operators choosing to operate in areas where other types of surveillance are provided |
| Risk E | Failure to achieve effective coordination with other ANSPs |
| Risk W | Late delivery of new aircraft orders replacing unequipped aircraft |
| Risk V | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25NM lateral |

| | |
|--|------------|
| | separation |
|--|------------|

The Risk G direct influences are shown in Table 38. Risk R, Risk H, and Risk S can be thought of as simultaneous consequences of not sufficiently completing regulations. Risk R encompasses all of the standards needed for 25NM lateral which include the accommodations for unequipped aircraft. Risk H, restricted airspace for unequipped aircraft, is a consequence of the occurrence of Risk G, and the implementation of the regulations as currently written which restrict MNPS airspace. Risk S, late completion of 25NM lateral standards can also be a consequence of an inability to resolve the needs of unequipped aircraft.

Risks A and B are equipment risks that depend on the accommodations for unequipped aircraft. Not having regulations for unequipped aircraft or having them completed at a late date can affect decision to develop equipment for business operators (Risk A) and create delays in delivering the equipment (Risk B).

Table 38: Risk G Direct Influences

| | |
|--------|--|
| Risk R | No ICAO communication, navigation, surveillance standards available to support implementation of 25NM lateral separation |
| Risk H | Restricted access to airspace for unequipped aircraft |
| Risk S | Late completion of 25NM lateral separation planning tasks |
| Risk A | Equipment for business operators not available or certified in time to meet mandate |
| Risk B | Potential delays in manufacturer's delivery aircraft data link retrofit packages to satisfy demand. |

G.5 Mitigation Difficulty

The mitigation difficulty for risk G is shown in Table 39. The detection difficulty is low because all the regulations affecting unequipped aircraft will need to be published by ICAO. The anticipated corrective action required for Risk G is medium. Possible corrective actions include issuing a limited number of waivers, not proceeding with the later phases of 25NM lateral separation that restrict the OTS and MNPS airspace, or, setting aside special airspace for unequipped aircraft. All corrective actions will require some level of coordination (listed as medium) with ANSPs and operators. The difficulty will be in finding a solution that is both economical for unequipped aircraft and maintains the intended level of safety. Respondents indicated that risk G has a low likelihood. There are a significant number of unequipped aircraft operation in the North Atlantic and there are aircraft

that will be exempt such as state aircraft, and aircraft that cannot equip so it is unlikely that accommodations for unequipped aircraft will not be made.

Table 39: Risk G Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Very Low | Medium | Medium | Low |

H.0 Description

Risk H is a policy risk described as “Restricted access to airspace for unequipped operators”. The data link mandate and the reduced separation initiatives both have implementation phases that progressively restrict airspace for unequipped operators. The final phase airspace restriction as currently written encompasses all MNPS airspace in the North Atlantic which would prohibit unequipped aircraft from flying at their optimal flight levels with the exception of the blue spruce route which is out of the way for most destinations. The main outcome of concern of Risk H is that the restrictions may make transatlantic routes uneconomical for a larger number of unequipped aircraft, which may be necessary for safety reasons when 25NM lateral separation is implemented.

H.1 Background

The safe operation of reduced separation procedures relies on separation of unequipped aircraft from the reduced separation airspace. There are analysis models and tests which determine safe separating distance between equipped aircraft and non-equipped aircraft. Additionally, reduced separation procedures will increase the capacity of the North Atlantic for equipped aircraft as well as operational efficiency. The reduced separation procedures therefore require some restrictions to achieve the goals in a safe manner. Operators that are unequipped may be forced to use routes across the North Atlantic that are uneconomical and may not be able to continue operation. Additionally, these operators can make up a significant percentage of the operators using the North Atlantic so the restrictions could significantly reduce the utility of the North Atlantic for air travel.

H.2 Root Causes

The respondents identified “consequence of regulations” as the root cause. The regulations or policies ultimately determine whether or not airspace is restricted. The regulations are influenced by a number of stakeholders including operators, regulators, and ANSPs. The regulations also must meet safety standards to prevent possible collision and other hazardous scenarios.

H.3 Impact to Stakeholder Value Metrics

Table 40 shows the impact of the occurrence of Risk H on stakeholder values.

Table 40: Risk H Impact to Stakeholder to Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | High | Medium | Low | Medium | Medium |

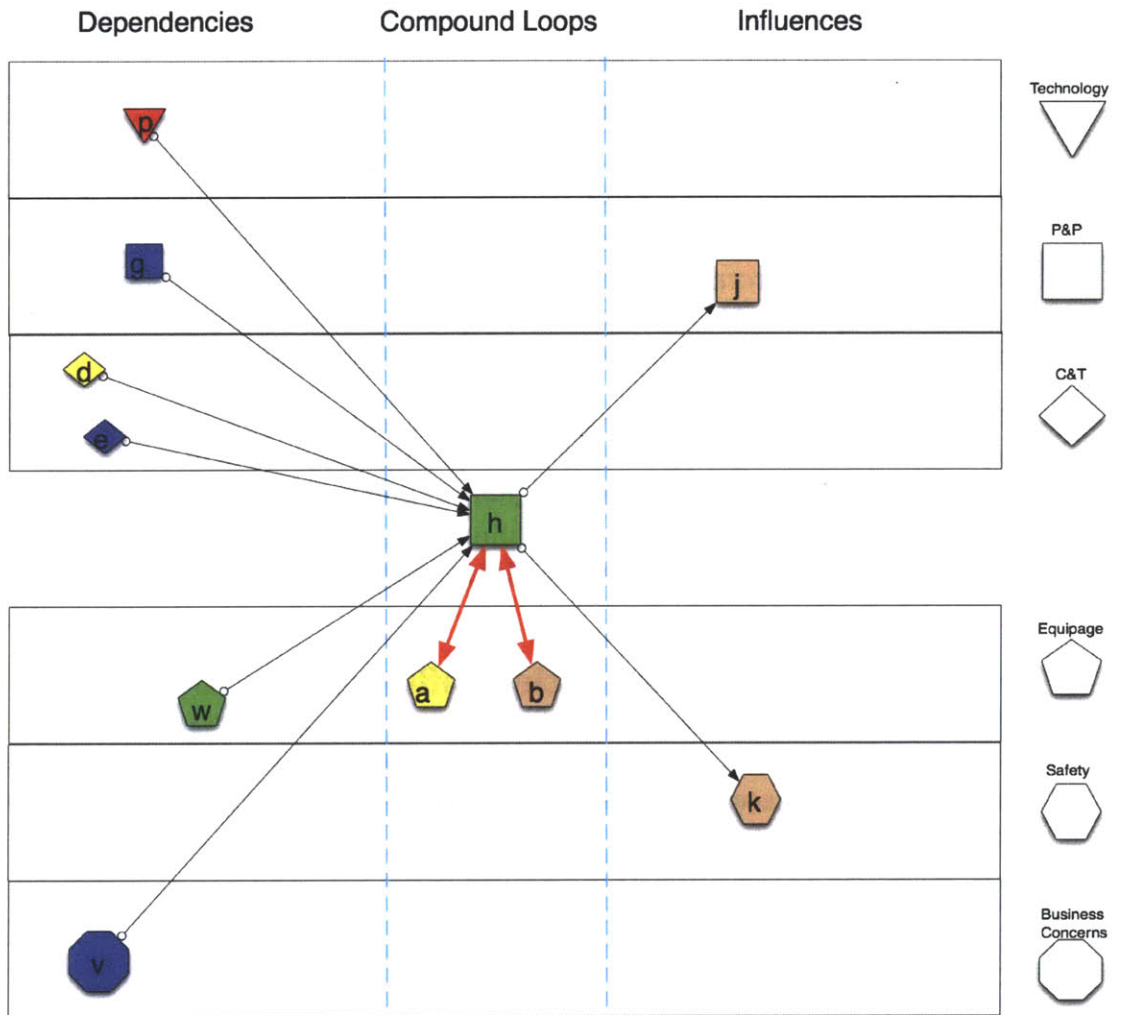
The Safety impact and the ANSP Revenue impact were rated as “low” for Risk H. Restricting airspace for unequipped operators will have a safety impact if the unequipped aircraft create congestion in the places where they are allowed to fly. The ANSP revenue and Operator revenues can be impacted by the changes in traffic that take place due to the restrictions.

The operational efficiency impact is listed as high. Operational efficiency can be impacted by congestion from handling large volumes of unequipped aircraft. Operator costs along with their individual operational efficiency can also be impacted specifically for unequipped aircraft operators who must operate at sub optimal altitudes or flight paths to cross the North Atlantic.

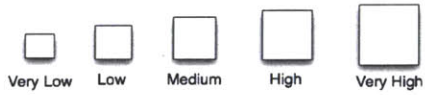
H.4 Direct Risk Dependencies, Influences & Outcomes

The dependencies and influences for Risk H are shown in Figure 30, and Figure 31. Risk H is a policy and procedures risk that has risk dependencies in all categories except for safety. It influences one safety risk and one policy risk.

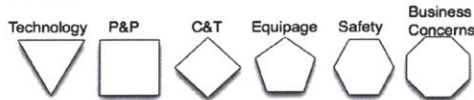
Figure 30: Risk H Dependencies and Influences (Mandate Only)



Likelihood



Categories



Impact

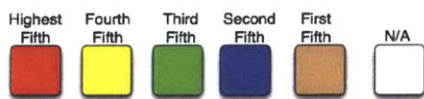
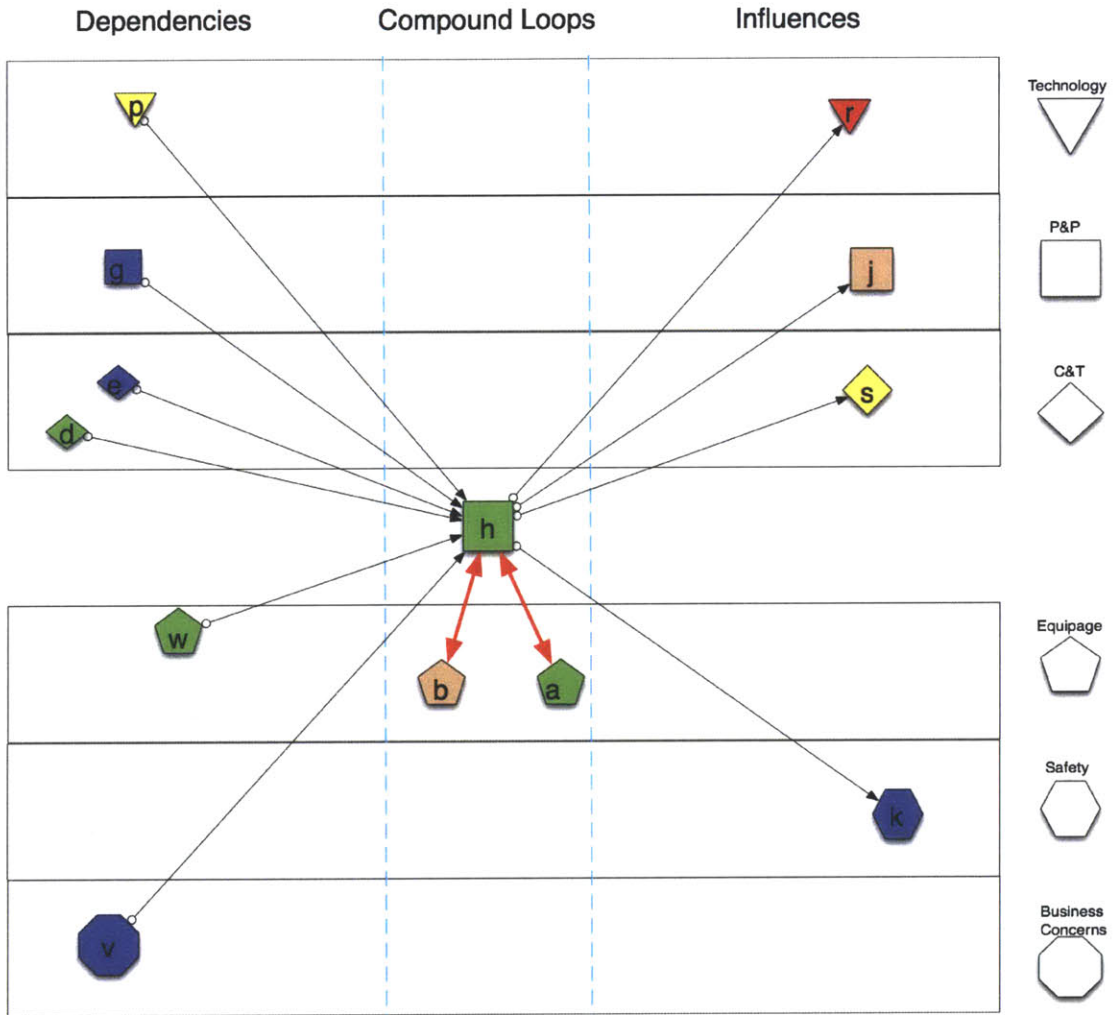


Figure 30 shows the dependencies and influences for Risk H for the reduced separation plan. Risk S, a coordination and timing risk and Risk R a technology risk policy and procedure risk are now present as direct influences.

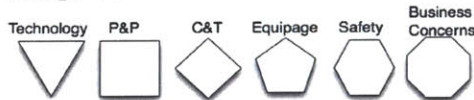
Figure 31: Risk H Dependencies and Influences (Reduced Separation)



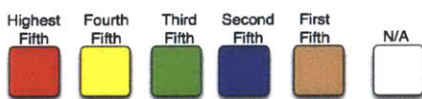
Likelihood



Categories



Impact



H.4.1 Risk H Direct Dependencies

Risk H has several dependencies shown in Table 41 that can affect both the likelihood of its occurrence and the scale of its impact. The policy for unequipped aircraft will depend on the number of unequipped aircraft that seek to operate in the NAT, and whether or not there is a consensus amongst ICAO members on the technical limitations and possible restrictions. The number of unequipped aircraft will influence the amount of airspace needed for unequipped aircraft and scale to which the procedures for accommodating them or not accommodating them can be implemented. Consensus is needed amongst the ICAO members to ensure that all aircraft and ANSPs meet the technical standards needed and that the all ANSPs enforce the same rules throughout the NAT.

The technology (Risk P), policy (Risk G), equipage (Risk W) and business concern (Risk V) risks all affect the number of the of unequipped operators in the North Atlantic. The occurrence of Risk P could render many aircraft that are equipped iridium satellite hardware for CPDLC unequipped. The occurrence of Risk G, “failure to develop measures for unequipped aircraft” will leave many unequipped aircraft without a clear way to traverse the North Atlantic. The late deliveries of equipped aircraft (Risk W) will prolong the use of unequipped aircraft scheduled for replacement in the North Atlantic. The high costs for retrofitting (Risk V) could also keep operators from ordering retrofit kits or new equipped aircraft. The occurrence of all these risks could substantially influence the level of equipage and the regulation strategy for accommodating unequipped aircraft.

There also risks that can influence the coordination tasks needed in order to implement restrictions or accommodations for unequipped aircraft. A failure to coordinate between ANSPs (Risk E) can delay the approval of more restrictions. These risks can delay the coordination tasks which can in turn delay the approval of more restrictions or accommodations. Late completion of the data link mandate plan (Risk D) can also cause delays to the approval of accommodations or restrictions.

Table 41: Risk H Direct Dependencies

| | |
|--------|---|
| Risk B | Potential Delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand |
| Risk P | Uncertainty in approval of Iridium-based equipage |

| | |
|--------|---|
| Risk G | Failure to develop measures to accommodate unequipped aircraft |
| Risk E | Failure to achieve effective coordination with other ANSPs (Harmonization of technical systems and operating methods) |
| Risk D | Late completion of data link mandate plan. Not enough time for commercial and business operators to plan and comply with mandate (e.g. determination of entire flight level spectrum and OTS tracks where mandate is to be applied etc) |
| Risk W | Late delivery of new aircraft orders that are replacing older, unequipped aircraft. |

H.4.2 Risk H Direct Influences

Risk H has several direct influences as shown in Table 42. The outcomes of Risk H can be a delay in approval of restrictions and approval restrictions that force unequipped aircraft outside of the OTS and MNPS airspace. Delays in restrictions can influence the timely completion of other restrictions such as those for 25 NM planning tasks (Risk S) and 25NM reduced lateral separation standards (Risk R).

The restrictions that come from Risk H can also influence the paths that unequipped aircraft have available to take through the NAT. Unequipped aircraft could be restricted from the OTS (Risk K) or restricted from MNPS airspace (Risk J).

Table 42: Risk H Direct Influences

| | |
|--------|---|
| Risk R | No ICAO communication, navigation and surveillance standards available to support implementation of 25NM lateral separation |
| Risk J | Operators choosing to operate in areas where other types of surveillance are provided |
| Risk S | Late completion of 25NM lateral separation planning tasks |
| Risk K | Increased traffic in MNPS routes other than OTS routes |

H.4.3 Compound Loops

As shown in Table 43, Risk H has two compound loops with risks in the equipage category: Risk A and Risk B. The business case affecting equipage for business operators (Risk A) and retrofit kits (Risk B) are influenced by the level of restriction resulting from Risk H. Conversely, the possible

restrictions that can emerge from the occurrence of Risk H are influenced by the number of unequipped aircraft that will need to use the North Atlantic.

Table 43: Risk H Compound Loops

| | |
|--------|---|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential Delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand |

H.5 Mitigation

The mitigation difficulty for risk H is shown in Table 44. The detection of Risk H is listed as low. Any restrictions for unequipped aircraft would need to be published by ICAO and observed by the operators and ANSPs. The corrective action difficulty is medium. Corrective action would require coordination amongst the stakeholders to get regulations or accommodations approved and enforced within the North Atlantic. The level of coordination required is high. There must be coordination between ANSPs, regulators and operators in order to get new regulations or accommodations approved. The regulatory process can also be time consuming because it requires ICAO approval and local rulemaking. The likelihood is listed as high. It is already known the CPDLC and ADS-C will be required to implement reduced separation procedures so some level of restriction will be required to prevent unequipped aircraft from using airspace for reduced separation procedures.

Table 44: Risk H Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | Medium | High | High |

I.0 Description

Risk I is an equipage risk described as “Mixed equipage environment during transition”. The percentage of equipped operators depends on a number of factors, including costs and availability. It is likely that during transition, some operators will have data link equipage and some will not during the transition to reduced lateral separation. A mixed transition environment can have negative outcomes including reduced operational efficiency, and a reduced level of safety.

I.1 Background

Operators that use the North Atlantic are required to have the proper navigation equipment specified for Minimum Navigation Performance Airspace (MNPS) airspace. The minimum level of navigation performance will increase to include Controller Pilot Data Link (CPDLC) and Automatic Surveillance (ADS-C) when the initiatives are implemented. The process for equipping can take a significant amount of time and requires resources from stakeholders so it is foreseeable that all operators may not be able to equip before the phases and final implementation resulting in a mixed equipage environment. A mixed equipage environment will require air traffic controllers to ensure a safe level of separation between equipped aircraft and unequipped aircraft. Exemptions, waivers, and accommodations for exempt aircraft in the airspace could complicate the task of maintaining safe separation resulting in reduced operational efficiency and possible safety concerns.

I.2 Root Causes

Risk I has two root causes that were identified by the respondents. The respondents felt that both the plans of operators who make up a significant percentage of the NAT airspace, and the possible measures to equip unequipped aircraft would be root causes for Risk I.

I.2.1 Operator Plans

Operators who occupy a significant percentage of NAT operations can have a correspondingly significant effect on the equipage levels depending on their equipment upgrade plans and current status of equipage. Several economic and technical factors will go in to the operators decision such as cost and equipment availability. If enough operators decide not to equip or decide to wait long periods of time before equipping, the chances of Risk I occurring will increase.

I.2.2 Measures to Accommodate Unequipped Aircraft

Measures to accommodate unequipped aircraft (Non-occurrence of Risk G) can also be a root cause for risk I. The operators will likely make their decisions to equip based on a number of economic and technical factors. The economic incentives to equip such as reduced fuel burn could be reduced if there are measures to accommodate unequipped aircraft and may in turn influence operators to wait longer to equip, increasing the likelihood of risk I.

I.3 Impact to Stakeholder Value Metrics

The impact of Risk I to stakeholder value metrics is shown in Table 45.

Table 45: Risk I Impact to Stakeholder Values

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Medium | Medium | Low | None | High | Medium |

The safety impact is given as medium. One possible outcome that could impact safety is the possible mixing of unequipped aircraft and equipped aircraft in MNPS airspace. Some unequipped aircraft may be given waivers to use the North Atlantic airspace or, possible navigation errors can lead an unequipped aircraft into restricted airspace. The unequipped aircraft report their position less frequently so a navigation error could take longer from an unequipped aircraft to detect than an error from a CPDLC equipped aircraft.

The operational efficiency impact is listed as medium. The impact to operational efficiency can come as a result of the need to handle large volumes of unequipped aircraft. These large volumes of aircraft will be allowed to take progressively fewer flight paths across the North Atlantic as the phases of Reduced Separation and the Mandate plan take affect. Large volumes of unequipped aircraft confined to small parts of the airspace could lead to congestion, delays in clearance, or could make the available routes across the North Atlantic uneconomical to operate for unequipped operators.

The ANSP cost impact is listed as low. ANSP costs could be impacted by increased levels of staffing needed to handle the remaining volumes of unequipped aircraft during transition.

The operator costs are indicated as high. The congestion and delays from accommodating both unequipped and equipped aircraft with different separation procedures can result in significant fuel burn penalties for the

operators. These fuel burn penalties can result in a high impact depending on the price of the fuel and the extent to which the aircraft cannot operate at its optimal path and altitude.

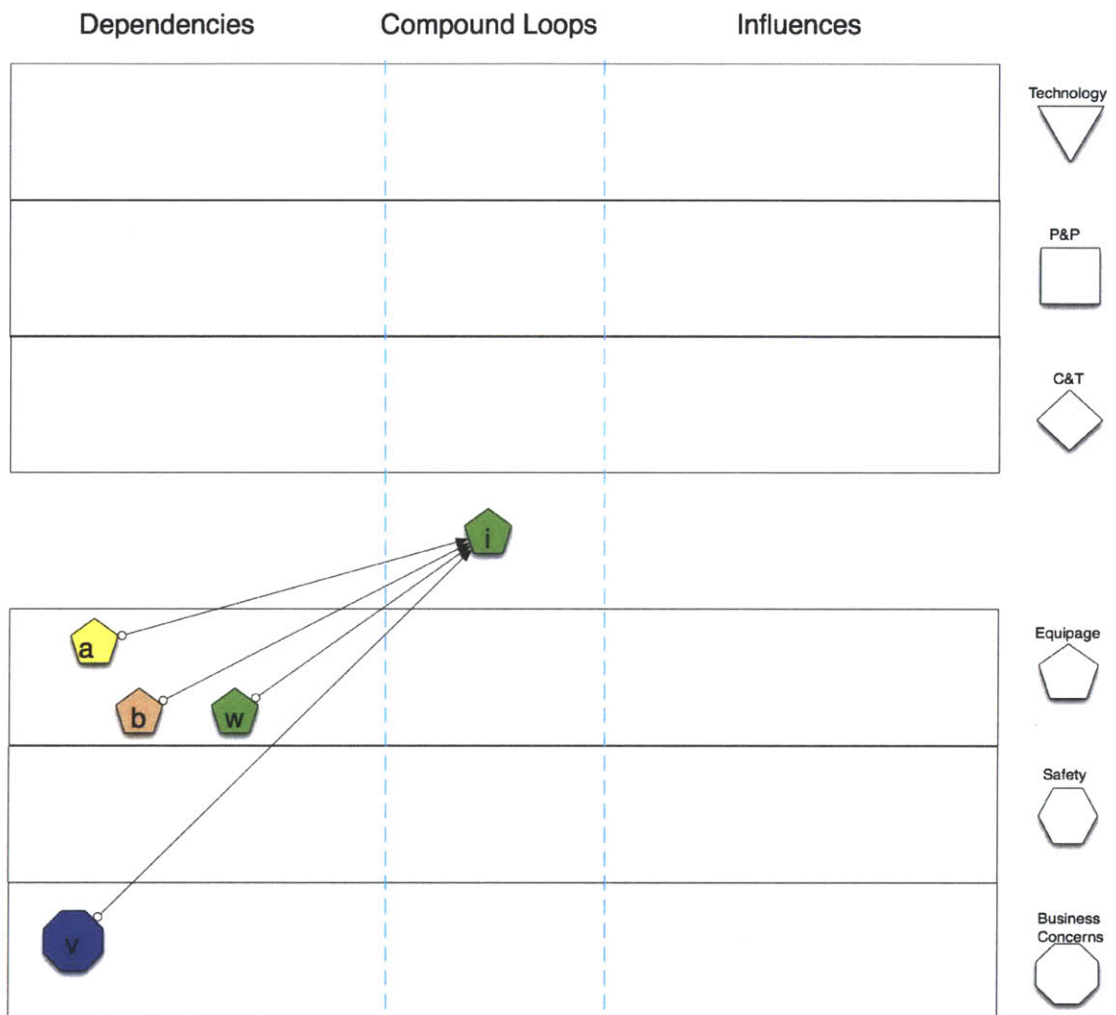
Operator revenues are listed as medium. Operator revenue can be impacted by the traffic fluctuations that come as a result of the new regulations for flying in the North Atlantic. Traffic could decrease if operators potentially choose to retire aircraft that don't meet the regulations or the cost of equipping to be too high. Traffic could increase if the additional capacity from reduced separation is used to add more planes and service across the North Atlantic.

The respondents did not indicate an impact to ANPS revenues.

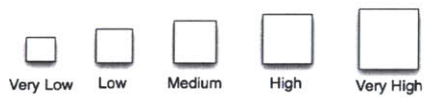
I.4 Direct Risk Dependencies, Influences & Outcomes

The risks that directly influence Risk I and are influenced by Risk I are shown in Figure 32, and Figure 33. Risk I is an equipage risk with direct dependencies on other equipage risks and a business concern risk.

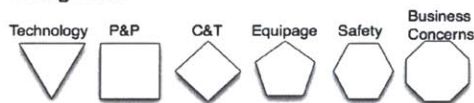
Figure 32: Risk I Direct Dependencies and Influences (Mandate Only)



Likelihood



Categories



Impact

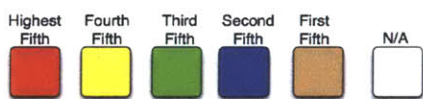
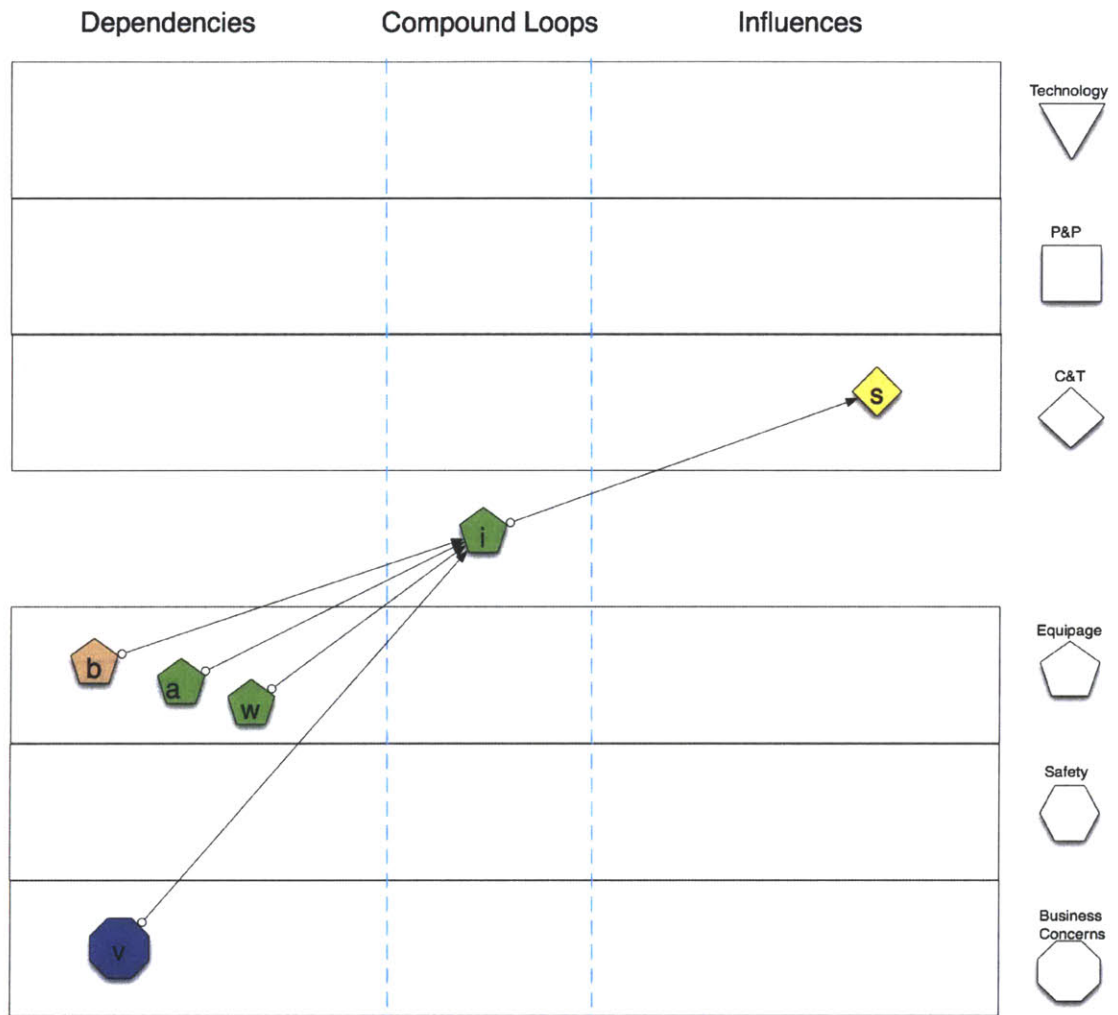
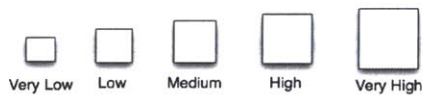


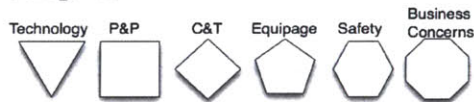
Figure 33: Risk I Direct Dependencies and Influences (Mandate and Reduced Separation) [add risk S]



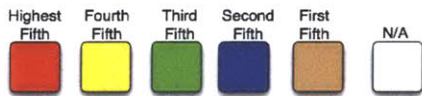
Likelihood



Categories



Impact



I.4.1 Risk I Direct Dependencies

Risk I has several direct dependencies as indicated in Table 46. All of these risks affect the equipage level in the North Atlantic which will increase the likelihood of a mixed equipage environment. The occurrence of the equipage risks A (equipage for business operators not available) and B (delays in manufacturers delivering data) affects the availability of equipment to operators. The occurrence of Risk W (late delivery of new aircraft) will affect the time that unequipped aircraft remain in the North Atlantic before they are replaced or, temporarily increasing the equipage levels. The occurrence of Risk V (high costs preventing operators from equipping) can temporarily reduce the equipage level in the North Atlantic until the new aircraft are delivered.

Table 46: Risk I Direct Dependencies

| | |
|--------|---|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential Delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand |
| Risk W | Late delivery of new aircraft orders that are replacing older, unequipped aircraft. |
| Risk V | High Costs preventing operators from retrofitting to meet requirements |

I.4.2 Risk I Direct Influences

Risk I has one direct influence as shown in Table 47. Risk I can influence the coordination and timing risk S (Late completion of 25NM lateral separation planning tasks) if mixed equipage levels result in the delayed implementation of 25NM lateral implementation. If the equipage levels are below the expected level at the time of implementation, regulators may choose to set aside fewer tracks or implement measures to increase the equipage levels.

Table 47: Risk I Direct Influences

| | |
|--------|--|
| Risk S | Late completion of 25NM lateral separation planning tasks. |
|--------|--|

I.5 Mitigation

The mitigation difficulty for Risk I is shown in Table 48. The detection is listed as low because aircraft must indicate their equipage level when filing for flight plans. It is possible to use the data from filed flight plans to measure the equipage levels in the North Atlantic. The corrective action is listed as high. Some possible corrective actions include changing the regulations, providing subsidies for equipage, and changing the dates for enforcement for each phase. All of these actions and other corrective would require considerable economic and human resources to implement. Additionally, the time required to change the equipage level or the regulations would also be significant. The coordination required is listed as medium. Increasing the availability of equipage will require coordination between the operators and manufactures. Changing the regulations will require coordination between operators, manufacturers and ANSPs. The likelihood is listed as high. There are currently many aircraft operating in the North Atlantic that are equipped. There are also several aircraft that do not have available equipage for operators that wish to equip so it is likely that the level of equipage during transition will not be 100%. The actual equipage level during transition will be influenced by the extent to which the barriers to equip such as high costs, and equipment availability affect the operators opportunity to equip and the operators decision to equip.

Table 48: Risk I Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | Medium | High |

J.0 Description

Risk J is a policy risk described as “Operators choosing to operate in areas where other types of surveillance are provided”. There will be airspace restrictions imposed to keep unequipped aircraft from unsafely operating in 25NM reduced separation airspace. However, due to many barriers to equipping, there will likely be a significant number of unequipped aircraft operating in the North Atlantic. If Risk J occurs, unequipped aircraft may not have an economical way to cross the North Atlantic or, they may be forced into constricted airspace which could cause excessive levels of congestion.

J.1 Background

The Flight Information Regions in the North Atlantic are shown in Figure 34. An example of Organized Track System (OTS) overlaid on the North Atlantic is shown in Figure 35. The OTS is meant to organize traffic flying between Europe and North America. Each phase of the Mandate Plan and the 25NM Reduced Separation Plan progressively reduce the number of tracks and the overall airspace that unequipped aircraft can use. If the data link mandate plan is implemented as currently written (Table 50), it will represent an occurrence of Risk J: unequipped operators who are not exempt must use the areas where radar is provided *if* their aircraft wish to operate at the cruising altitudes covered by MNPS airspace. The occurrence of risk J could make crossing the North Atlantic uneconomical for these operators because of the need to travel further North to Sondrestrom and Reykjavik FIRs instead of flying through the Gander and Shanwick FIRs.

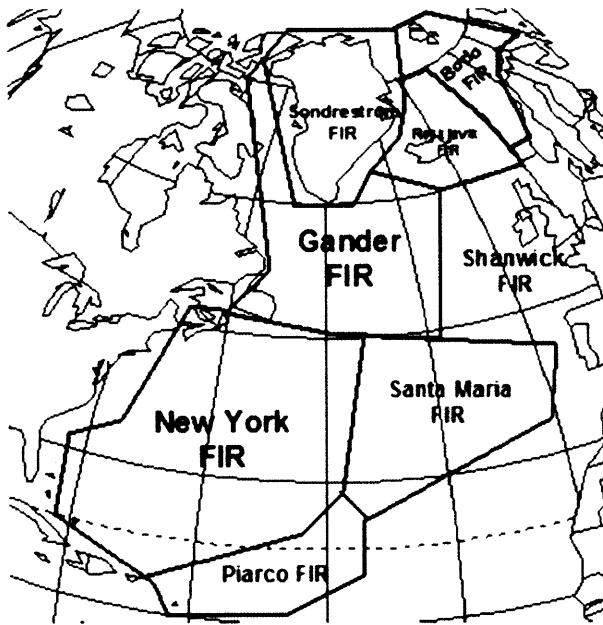


Figure 34: North Atlantic Flight Information Regions

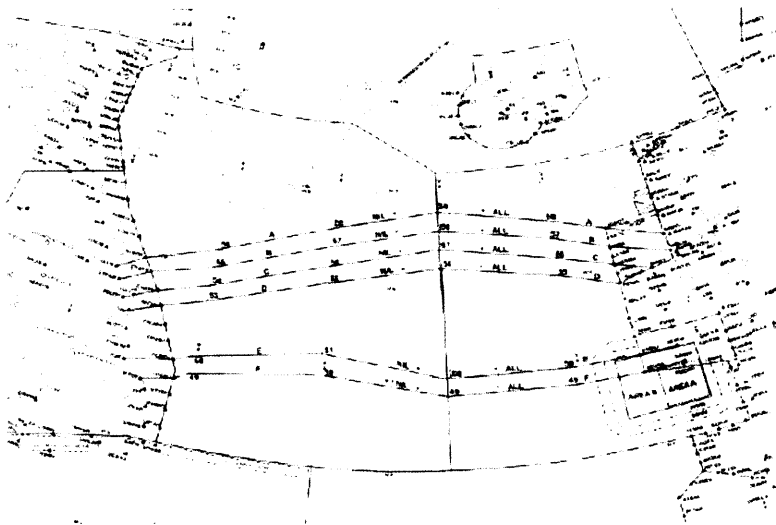


Figure 35: West-Bound Organized Track System Example

J.2 Root Causes

The respondents associated two root causes with Risk J. They are: a consequence of the restrictions in the data link mandate and the 25NM

lateral Separation Plan, and, non-compliance with the data link mandate. The data link mandate plan and 25NM lateral separation both impose restrictions on airspace for unequipped aircraft which can limit the routes operators have available to cross the North Atlantic, possibly to places where radar coverage is available. In compliment to the restrictions, operator non-compliance can result in an operators' subsequent decision to operate in places where radar coverage is provided.

J.2.1 Policy Restrictions

The data link mandate and 25NM reduced separation plan have restrictions that can limit the routes an unequipped operator has to cross the North Atlantic—possibly to the places where radar coverage is available. The 25NM reduced separation plan has a phased introduction which progressively restricts airspace as shown in Table 49. The last phase imposes restrictions on targets of opportunity outside the OTS in MNPS airspace. These targets of opportunity could possibly limit operators to routes where radar coverage is available such as the blue spruce route.

Table 49: 25NM Reduced Separation Plan

| Date | Separation Reduction | Data Link Comm Requirement | Nav Requirement | Surveillance Requirement |
|-----------------|--|--|-------------------------------------|--|
| 2012 Phase 1 | *25 NM lateral on 2 OTS tracks between 350-400 (inclusive) | FANS 1/A CPDLC meeting appropriate standards | RNP tbd (Note: anticipate RNP 4) | FANS 1/A ADS-C meeting appropriate standards |
| 2013 Phase 2 | *25 NM lateral on <u>all</u> OTS tracks between 350-400 (inclusive) | FANS 1/A CPDLC meeting appropriate standards | RNP tbd (Note: anticipate RNP 4) | FANS 1/A ADS-C meeting appropriate standards |
| 2015 Phase 3 | 25 NM lateral expanded to targets of opportunity in NAT Region between 350-400 (inclusive) | FANS 1/A CPDLC meeting appropriate standards | RNP tbd (Note: anticipate RNP 4) | FANS 1/A ADS-C meeting appropriate standards |

The data link mandate plan shown in Table 50 has two phases that progressively restrict airspace. The last phase also could limit operators to routes where radar coverage is available because it restricts all of MNPS airspace to aircraft that are equipped with data link.

Table 50: Data Link Mandate Plan

| Year | Airspace Where Applicable | Flight Levels Where Applicable | Remarks |
|------------|------------------------------|--------------------------------|---|
| 7 Feb 2013 | *To-be-determined OTS tracks | *To-be-determined FL's | Aircraft to be equipped <u>in order to operate</u> at specified FL's, however, NAT SPG to explore measures to accommodate non-equipped aircraft |
| 5 Feb 2015 | *MNPS Airspace | *To-be-determined FL's | Remark above applies |

J.2.2 Non-Compliance

Non-compliance with equipment requirements for the data link mandate and the 25 NM lateral separation plans can cause operators to operate in places where radar coverage is provided. Noncompliance can occur for several types of reasons including economic circumstances, resource and equipment availability, or delivery delays of new aircraft or equipment. Non-compliance can severely limit the available airspace an operator can use, especially if they need to fly within the flight levels that are specified in the restrictions.

J.3 Impact to Stakeholder Metrics

Table 51 shows the impact of the occurrence of Risk J on stakeholder value metrics.

Table 51: Risk J Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | Low | None | None | None | None |

Respondents indicated that Risk J would have a low safety and a low operational efficiency impact. One possible outcome risk J that could cause both a safety and an operational efficiency impact is a significant increase in traffic on the “blue spruce” route where radar coverage is required. Increased traffic could result in a significant level of congestion along the routes and at the oceanic entry points. However, the impacts would likely be low because conventional radar coverage is provided.

J.4 Direct Risk Dependencies, Influences & Outcomes

The dependencies and influences for Risk J are shown in Figure 36, and Figure 37 shows the dependencies and influences of risk J for the reduced separation plan. Risk S, a coordination and timing risk are now present as a direct dependence.

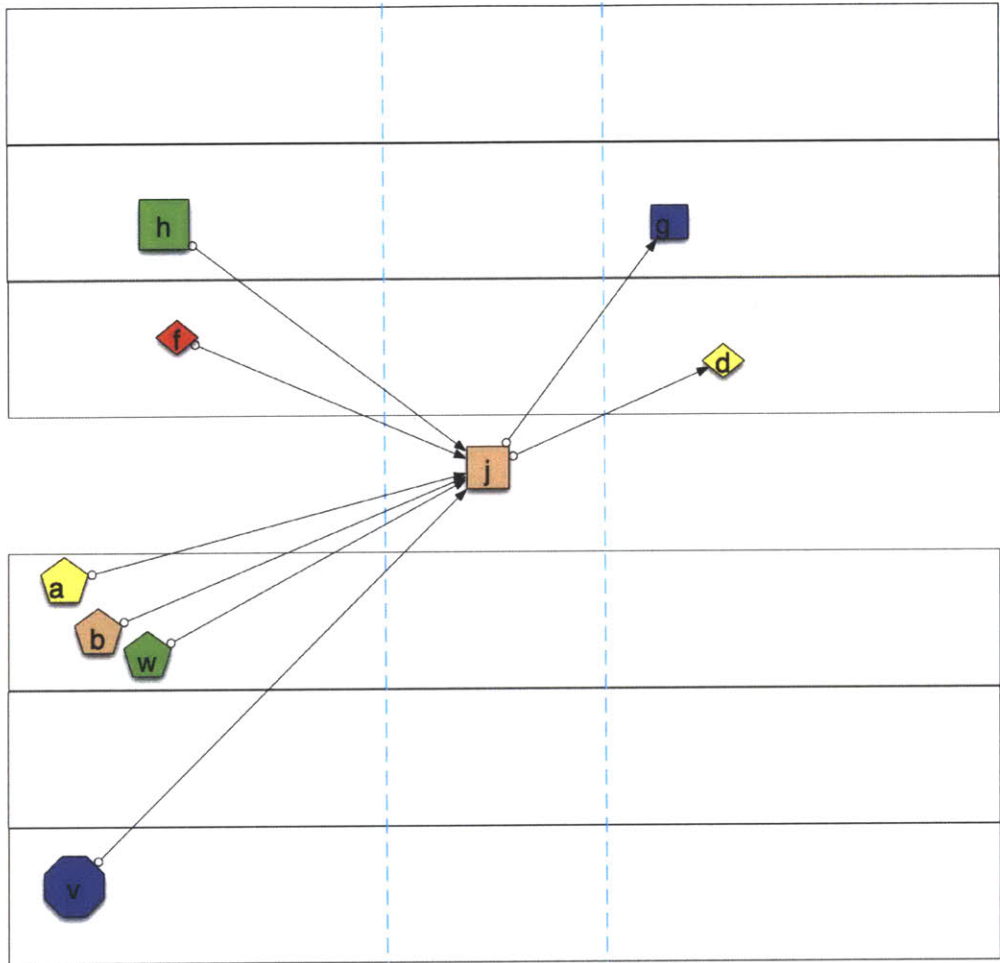
Figure 37. Risk J is a policy risk with dependencies in the coordination and timing, equipment, and business concern categories. There influences in both the policy and coordination and timing categories.

Figure 36: Risk J Dependencies and Influences (Mandate Only)

Dependencies

Compound Loops

Influences



Technology



P&P



C&T



Equipage



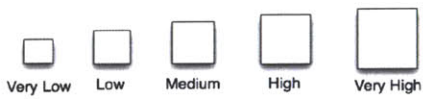
Safety



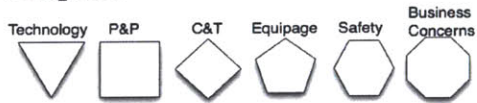
Business Concerns



Likelihood



Categories



Impact

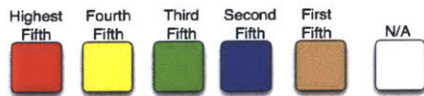
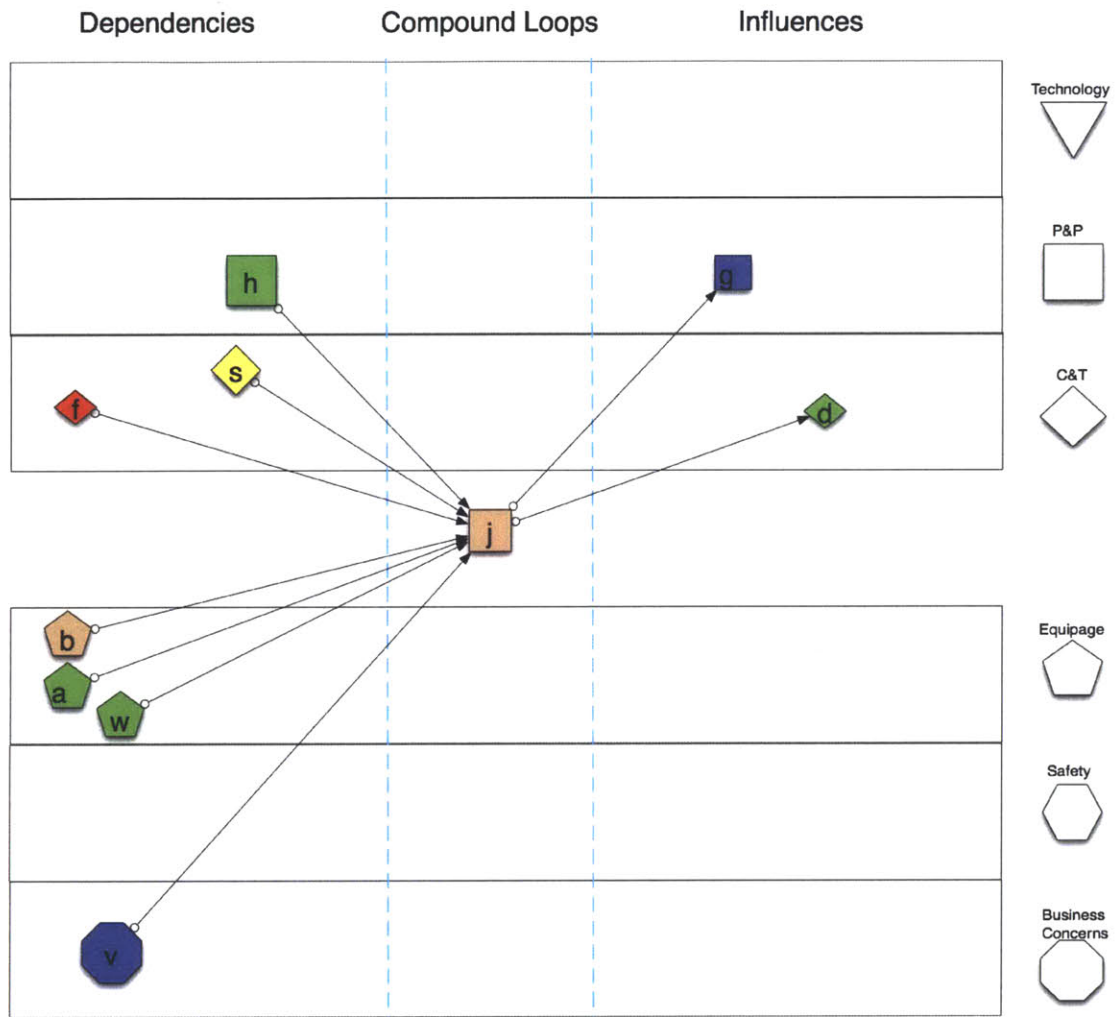
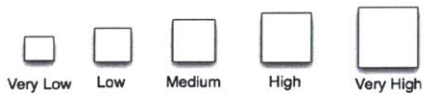


Figure 37 shows the dependencies and influences of risk J for the reduced separation plan. Risk S, a coordination and timing risk are now present as a direct dependence.

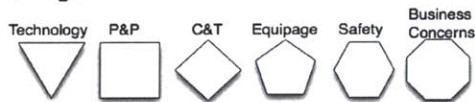
Figure 37: Risk J Dependencies, Influences (Reduced Separation)



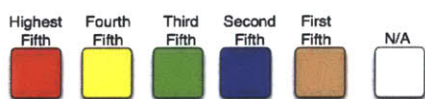
Likelihood



Categories



Impact



J.4.1 Risk J Direct Dependencies

Risk J has several dependencies shown in Table 52 that can affect both the likelihood and impact of Risk J. All of the dependent risks can have an outcome that will affect the number of aircraft in compliance.

The policy risk H (Restricted access to airspace for unequipped aircraft) can force operators to use areas where radar coverage is provided if the restrictions encompass the operators' desired cruising altitude and all of MNPS airspace. The MNPS airspace restriction appears in the second phase of the mandate as shown in Table 50.

The coordination and timing Risks F (Rulemaking to support 25NM lateral Separation) and S (Late Completion of 25NM lateral planning tasks) can result in delays in resolving ambiguities in the mandate. These ambiguities can cause operators to delay their decisions to equip which can result in a lower data link compliance rate. A lower compliance rate would also result in an increased number of unequipped aircraft that will possibly be forced to use areas of radar coverage.

The equipage risks A (Equipage for business operators not available), B (Potential Delays in manufactures delivery data link retrofits), and W (Late delivery of new aircraft orders) can also result in a lower data link compliance rate. Risk A can have a longer effect than Risks B and W because Risk A would constitute an inability to equip while Risks B and W represent delays to equipping. A lower compliance rate due to the equipage risks occurring would also result in an increased number of unequipped aircraft that will possibly be forced to use areas of radar coverage.

The business concern Risk V (high costs preventing retrofits) can also influence the data link compliance rate. The occurrence of Risk V can represent economic cost constraints that keep operators from equipping. These costs can come from the equipment, the aircraft downtime, the certification and training, and low remaining aircraft service life. There are various strategies for mitigating the costs, including purchasing new aircraft to achieve a longer service life of the new equipment. In other cases, resource constraints and also hinder an operators ability to meet the costs, even if there is likely to be a profit in the future. In any case, high costs can prevent operators from equipping which could result in more unequipped aircraft that need to use areas where radar coverage is available.

Table 52: Risk J Direct Dependencies

| | |
|--------|--|
| Risk H | Restricted access to airspace for unequipped aircraft |
| Risk F | Rulemaking to support data link mandate and 25NM lateral separation not completed within mandate timeframe |

| | |
|--------|--|
| Risk S | Late completion for 25NM lateral planning tasks |
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential Delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand |
| Risk W | Late delivery of new aircraft orders that are replacing older, unequipped aircraft. |
| Risk V | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25NM lateral separation |

J.4.2 Risk J Direct Influences

Respondents indicated that Risk J influences one policy and procedure risk (Risk G) and, one coordination and timing risk (Risk D) as shown in Table 53. If Risk J occurs, ambiguity and uncertainty regarding the number of aircraft that will be in compliance, the accommodations that will be needed for unequipped aircraft can arise. These ambiguities can delay or make it more difficult to come up with accommodations for unequipped aircraft (Risk G). These ambiguities can also make it more difficult to complete the final details of the data link mandate plan such as the flight levels for enforcement and the final restrictions (Risk D).

Table 53: Risk J Direct Influences

| | |
|--------|---|
| Risk G | Failure to develop measures to accommodate unequipped aircraft |
| Risk D | Late completion of data link mandate plan. Not enough time for commercial and business operators to plan and comply with mandate (e.g. determination of entire flight level spectrum and OTS tracks where mandate is to be applied etc) |

J.5 Risk J Mitigation Difficulty

The mitigation difficulty for risk J is shown in Table 54. The respondents gave the detection, corrective action, coordination categories low difficulty ratings. Risk J is a policy risk so detection will occur through published regulations. The corrective action could involve changing the regulations to allow more airspace for unequipped aircraft to operate. One possible way to allow more airspace for unequipped aircraft is to suspend subsequent phases of the ether the data link mandate plan or the 25NM lateral separation plan.

Coordination would be required between the ANSPs through ICAO to suspend subsequent phases of the mandate or reduced separation plan.

Respondents listed the likelihood as medium. The airspace restrictions will be influenced by the number of unequipped aircraft that need to cross the North Atlantic. If the number of unequipped aircraft does not fall sufficiently, it may be necessary to suspend the last phases of the mandate and reduced separation plan until more operators can equip.

Table 54: Risk J Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | Low | Low | Medium |

K.0 Description

Risk K is a safety described as “Increased traffic in MNPS routes other than OTS routes”. There will be airspace restrictions imposed for unequipped aircraft to keep them from unsafely operating in 25NM reduced separation airspace. However, due to many barriers to equipping, there will likely be a significant number of unequipped aircraft operating in the North Atlantic. If Risk K occurs, significant numbers of unequipped aircraft may be forced to use random routes within Minimum Navigation Performance (MNPS) airspace. Aircraft flying along these routes are more likely to have gross navigation errors (GNE) which could possibly have a safety impact.

K.1 Background

The Flight Information Region is shown in Figure 34 and an example of Organized Track System (OTS) overlaid on the North Atlantic is shown in Figure 35. The OTS is meant to organize traffic flying between Europe and North America. Each phase of the Mandate Plan and the 25NM Reduced Separation Plan progressively reduces the number of tracks and the overall airspace that unequipped aircraft can use. If the plan is implemented as currently written, it will represent an occurrence of Risk K: unequipped operators who are not exempt must use the areas outside of MNPS airspace. The occurrence of risk K could increase traffic outside of the OTS and increase the number of Gross Navigation Errors because they are more likely to occur on random routes.

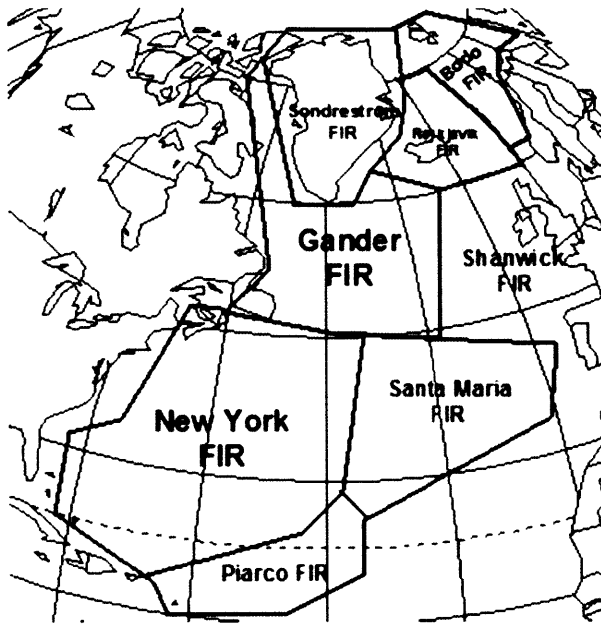


Figure 38: North Atlantic Flight Information Regions

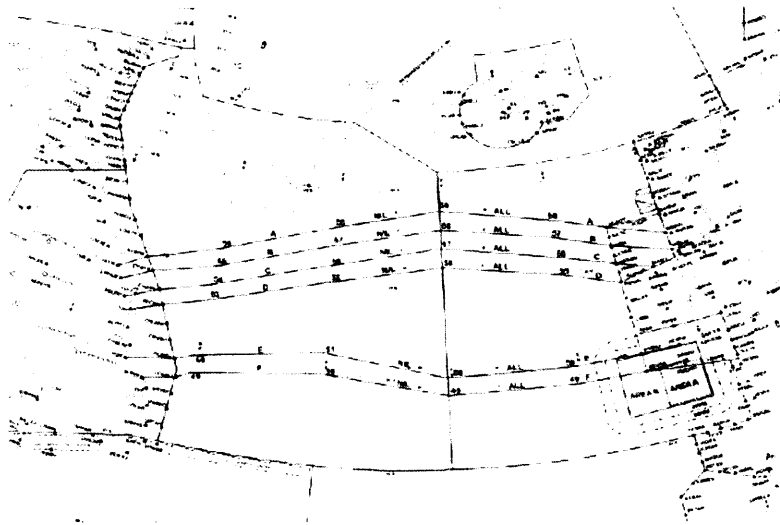


Figure 39: West-Bound Organized Track System Example

K.2 Root Causes

The respondents associated three root causes for risk K. They are: a consequence of the restrictions of in the data link mandate and the 25NM

lateral Separation Plan, operator non-compliance with the data link mandate, and increased sophistication flight planning. The data link mandate plan and 25NM lateral separation both impose restrictions on airspace for unequipped aircraft which can limit the routes operators have available to cross the North Atlantic, to places outside the OTS and possibly to places where radar coverage is available. In compliment to the restrictions, operator non-compliance can result in an operators' subsequent decision to operate in places where radar coverage is provided. Lastly, some operators have increased their sophistication in flight planning by using real-time wind information to compute the optimal routes. This information sometimes favors routes outside of the OTS because the OTS is updated with wind information only twice per day.

K.2.1 Policy Restrictions

The data link mandate and 25NM reduced separation plan have restrictions that can limit the routes an unequipped operator has to cross the North Atlantic. The 25NM reduced separation plan has a phased introduction which progressively restricts airspace as shown in Table 49. The last phase restrictions the entire MNPS airspace which could limit operators to routes where radar coverage is available such as the blue spruce route.

Table 55: 25NM Reduced Separation Plan

| Date | Separation Reduction | Data Link Comm Requirement | Nav Requirement | Surveillance Requirement |
|-----------------|--|--|---|--|
| 2012 Phase 1 | *25 NM lateral on 2 OTS tracks between 350-400 (inclusive) | FANS 1/A CPDLC meeting appropriate standards | RNP tbd (Note: anticipate RNP 4) | FANS 1/A ADS-C meeting appropriate standards |
| 2013 Phase 2 | *25 NM lateral on <u>all</u> OTS tracks between 350-400 (inclusive) | FANS 1/A CPDLC meeting appropriate standards | RNP tbd (Note: anticipate RNP 4) | FANS 1/A ADS-C meeting appropriate standards |
| 2015 Phase 3 | 25 NM lateral expanded to targets of opportunity in NAT Region between 350-400 | FANS 1/A CPDLC meeting appropriate standards | RNP tbd (Note: anticipate RNP 4) | FANS 1/A ADS-C meeting appropriate standards |

| | | | | |
|--|-------------|--|--|--|
| | (inclusive) | | | |
|--|-------------|--|--|--|

The data link mandate plan shown in Table 50 has two phases that progressively restrict airspace. The last phase also could limit operators to routes where radar coverage is available because it restricts all of MNPS airspace.

Table 56: Data Link Mandate Plan

| Year | Airspace Where Applicable | Flight Levels Where Applicable | Remarks |
|------------|------------------------------|--------------------------------|---|
| 7 Feb 2013 | *To-be-determined OTS tracks | *To-be-determined FL's | Aircraft to be equipped <u>in order to operate</u> at specified FL's, however, NAT SPG to explore measures to accommodate non-equipped aircraft |
| 5 Feb 2015 | *MNPS Airspace | *To-be-determined FL's | Remark above applies |

K.2.2 Non-Compliance

Non-compliance with equipment requirements for the data link mandate and the 25 NM lateral separation plans can force operators to operate outside of the OTS and possibly where radar coverage is provided. Noncompliance can occur for several reasons including economic circumstances, resource and equipment availability, or delivery delays of new aircraft or equipment. Non-compliance can severely limit the available airspace an operator can use, especially if they need to fly within the flight levels that are specified in the restrictions.

K.2.3 Real-Time Wind Information

Some of the operators are able to use real-time wind information to aid in flight planning while the OTS is updated twice per day with new wind information. In some cases, the software with updated wind information can show an optimal route that is outside the OTS causing the operator to file for a route in MNPS airspace. The perceived time savings in climbing outside of OTS airspace can also be a factor that can show an optimal path outside of the OTS.

K.3 Impact to Stakeholder Metrics

Table 57 shows the impact of the occurrence of Risk K on stakeholder value metrics.

Table 57: Risk K Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Medium | High | None | None | None/Medium | None |

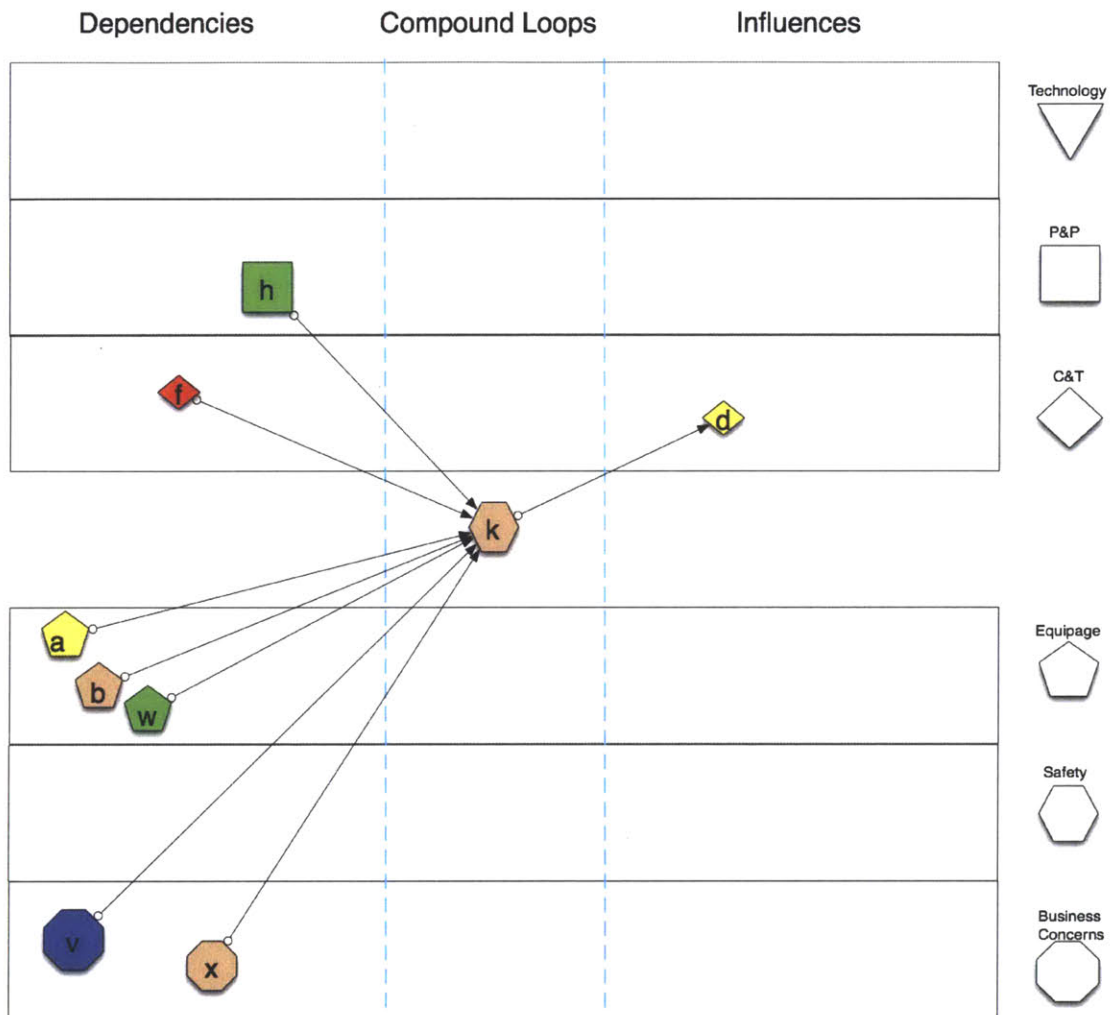
The respondents gave Risk K a medium impact for safety and high impact for operational efficiency. The outcome of Risk K that can affect safety is an increase in gross navigation errors (GNE). Gross Navigation Errors occur when incorrect navigation information is input into the aircraft computer and the airplane flies away from its intended path. They are more likely to occur on routes outside of the OTS because there are no aircraft wakes flying along the same path for reference. Additionally, some airlines have an automatic input capability from the Air Traffic Controller to the aircraft with pilot verification. According to one respondent, this practice helps reduce GNE's.

The operational efficiency and operator cost (Medium impact) can be impacted when there is a significant difference between the optimal paths (which typically lie within the OTS) and the paths that are taken outside the OTS but within MNPS airspace. The increase in fuel used can impact operator costs, and the increase in block time for the oceanic crossing can increase with impacts operational efficiency for the operator. The respondents indicated that there would be no impact to operator costs for the mandate because the restrictions likely wouldn't take affect until reduced separation initiatives are implemented. The ANSP operational efficiency can also be impacted if an increase in operator workload is required to handle unequipped aircraft that fly outside of the OTS in MNPS airspace.

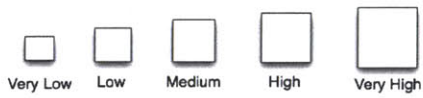
K.4 Direct Risk Dependencies, Influences & Compound Loops

The dependencies and influences for Risk K are shown in Figure 40, and Figure 41. Risk K is a safety risk with dependencies in the coordination and timing, equipment, and business concern categories. There is an influence in the coordination and timing category and one compound loop in the policy category.

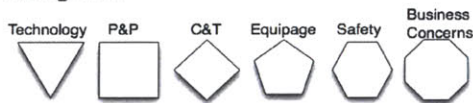
Figure 40: Risk K Dependencies and Influences (Mandate Only)



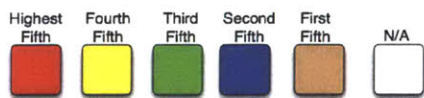
Likelihood



Categories

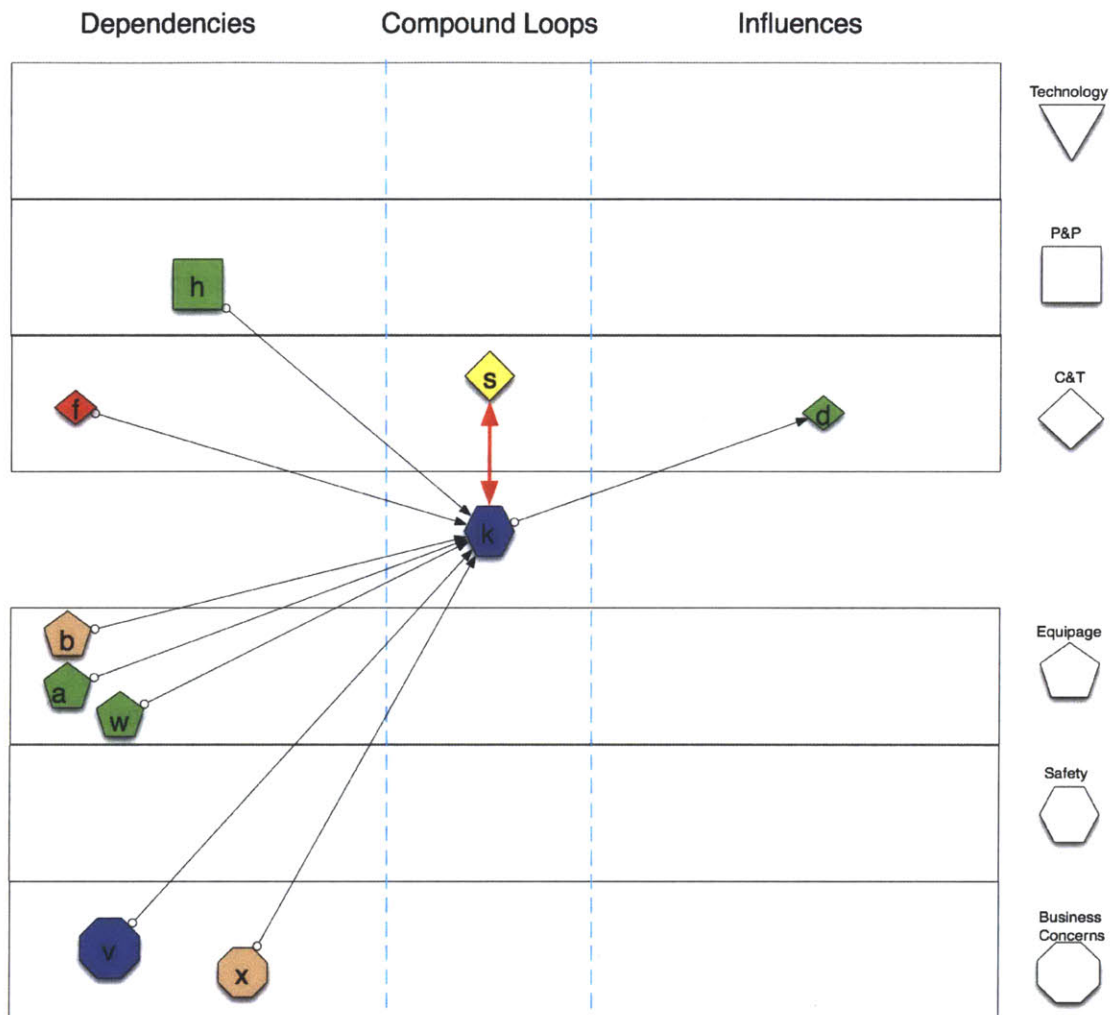


Impact

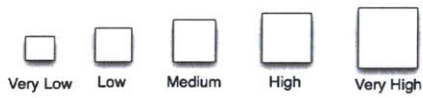


The dependencies and influences of Risk K for the reduced separation initiatives are shown to Figure 41. Risk S, a coordination and timing risk is now present and forms a compound loop with Risk K.

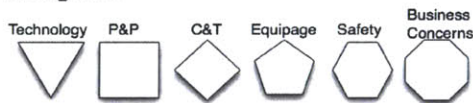
Figure 41: Risk K Dependencies and Influences (Reduced Separation)



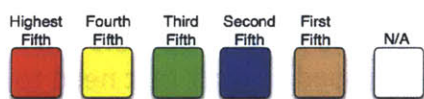
Likelihood



Categories



Impact



K.4.1 Risk K Direct Dependencies

Risk K has several dependencies shown in Table 58Table 52 that can affect both the likelihood and impact of Risk K. Most of the dependent risks have a possible outcome that will affect the number of aircraft in compliance. One of the risks can limit the available airspace for use by unequipped operators.

The policy Risk H (Restricted access to airspace for unequipped aircraft) can force unequipped operators to use areas outside of MNPS airspace. Phase 2 of the 25 NM lateral separation plan (Table 49) restricts the unequipped aircraft from using the OTS and Phase 3 will expand further to targets of opportunity.

The coordination and timing Risks F (Rulemaking to support 25NM lateral Separation) and S (Late Completion of 25NM lateral planning tasks) can result in delays in resolving ambiguities in the mandate. These ambiguities can cause operators to delay their decisions to equip which can the result in a lower data link compliance rate. A lower compliance rate would also result in an increased number of unequipped aircraft that will operate on routes outside the OTS.

The equipage Risks A (Equipage for business operators not available), B (Potential Delays in manufactures delivery data link retrofits), and W (Late delivery of new aircraft orders) can also result in a lower data link compliance rate. Risk A can have a longer effect that Risk B and W because Risk A would constitute an inability to equip while Risks B and W represent delays to equipping. A lower compliance rate due to the equipage risks occurring would also result in an increased number of unequipped aircraft that will possibly be forced to operate on routes outside the OTS.

The business concern Risk V (high costs preventing retrofits) and a cost benefit analysis with unfavorable results (Risk X) can also influence the data link compliance rate. The occurrence or Risk V can present economic constraints that keep operators from equipping. These costs can come from the equipment, the aircraft downtime, the certification and training. The occurrence of Risk X can deter operators from investing in retrofits in favor of absorbing the economic penalties of high fuel burn by not operating in the OTS. It will also make it clearer to regulators that many operators may choose not to or may not be able to equip. There are various strategies for mitigating the costs, including purchasing new aircraft to achieve a longer service life of the new equipment. In other cases, resource constraints can also hinder an operators ability to meet the costs, even if there is likely to be a profit in the future. In any case, high costs can prevent operators from equipping which could result in more unequipped aircraft that need to use areas where radar coverage is available.

Table 58: Risk K Direct Dependencies

| | |
|--------|---|
| Risk H | Restricted access to airspace for unequipped aircraft |
| Risk F | Rulemaking to support data link mandate and 25NM lateral separation not completed within mandate timeframe |
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential Delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand |
| Risk W | Late delivery of new aircraft orders that are replacing older, unequipped aircraft. |
| Risk V | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25NM lateral separation |
| Risk X | Cost benefit analysis may show that costs outweigh the benefits of implementing the data link mandate and/or 25 NM lateral separation |

K.4.2 Risk K Direct Influences

Respondents indicated that Risk K can influence one coordination and timing risk (Risk D). If risk K occurs, ambiguity and uncertainty regarding the number of aircraft that will be in compliance, the accommodations that will be needed for unequipped aircraft can arise. These ambiguities can also make it more difficult to complete the final details of the data link mandate plan such as the flight levels for enforcement and the final restrictions (Risk D).

Table 59: Risk K Direct Influences

| | |
|--------|---|
| Risk D | Late completion of data link mandate plan. Not enough time for commercial and business operators to plan and comply with mandate (e.g. determination of entire flight level spectrum and OTS tracks where mandate is to be applied etc) |
|--------|---|

K.4.3 Risk K Compound Loops

Table 60 shows the compound loops formed with Risk K. Risk K forms a compound loop with Risk S (Late completion for 25NM lateral planning tasks), a coordination and timing risk. The occurrence of Risk S can lead to ambiguity in the restrictions for unequipped aircraft and economic penalties for not equipping. These ambiguities can cause operators to delay their decisions to equip and continue operating unequipped aircraft. They may

also be inclined to operate these aircraft outside of MNPS airspace while the regulations are clarified. The occurrence of Risk K can also lead to the occurrence of Risk S. If more aircraft start to operate outside of the OTS, it may be more difficult to determine targets of opportunity and effectively weigh the airspace demands of unequipped aircraft. These difficulties could result in delays of the 25NM lateral plan.

Table 60: Risk K Compound Loops

| | |
|--------|---|
| Risk S | Late completion for 25NM lateral planning tasks |
|--------|---|

K.5 Risk K Mitigation Difficulty

The mitigation difficulty for risk K is shown in Table 54. The respondents gave the detection, coordination categories low difficulty ratings. Risk K is associated with air traffic patterns so detection would occur through traffic surveys.

The corrective action was rated by respondents as high. Corrective action could involve changing the 25NM lateral separation regulations to include common routes outside of the OTS as targets of opportunity. One possible corrective action is to keep the MNPS airspace restriction for unequipped aircraft that is currently in the data link mandate plan. This would both represent the occurrence of Risk J and force unequipped aircraft outside of MNPS airspace.

Coordination would be required between the ANSPs through ICAO to decide on targets of opportunity and implement 25NM lateral separation outside of the OTS.

Respondents listed the likelihood as high. The respondents indicated that some operators already use MNPS airspace instead of the OTS to take advantage of real time wind information and possibly quicker climb times. The airspace restrictions that may force unequipped aircraft to operate outside of the OTS will be influenced by the number of unequipped aircraft that need to cross the North Atlantic. If the number of unequipped aircraft does not fall sufficiently Risk K will have a higher likelihood of occurrence.

Table 61: Risk K Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | Low | High |

L.0 Description

Risk L is a technology risk described as “Failure to establish a plan or go forward with mitigation to meet RCP240. (This also includes failure of ground infrastructure to support RCP240)”. RCP240 is a communication standard that specifies communication performance standards such as time allowed to exchange communication messages between aircraft and ANSPs. The ANSP ground equipment, the CPDLC/ADS-C equipment on board the aircraft, and the satellite communication service must meet this communication standard. Failure of ANSP infrastructure to meet RCP240 could create delays for the phased implementation of both the mandate and reduced lateral separation. A failure of the satellite(s) to meet RCP240 or, the failure CPDLC/ADS-C equipment to meet the standard could result in costly redesigns and delayed delivery of compliant retrofits. Failure to establish whether RCP240 will be required will create uncertainty, and ambiguity for ANSP ground and CPDLC/ADS-C equipment manufactures who are trying to meet the standards and could also further delay the delivery of compliant equipment. Operators who purchase equipment before knowing the standard may face severe cost overruns if the equipment turns out not to be compliant with the communication standard.

L.1 Background

There are several equipment performance standards that accompany a new set of procedures and separation distances. These standards are there to ensure the appropriate level of safety is maintained with the procedures and separation distances are in use. RCP240 is a standard for the required performance of communications equipment. The communications equipment includes ground equipment, the satellite equipment and the equipment onboard the aircraft must meet these standards in order to be compliant. An occurrence of Risk L would create uncertainty with the equipment manufactures and the ANSPs and Operators who must purchase the equipment. This uncertainty could result in delayed purchasing decisions, and cost overruns if the purchased equipment doesn't meet the future communication standard if either of these could result in delayed compliance.

L.2 Root Causes

The respondents identified several root causes associated with Risk L: failure of the communication standard to meet the safety standard for reduced

separation, the high cost of implementation, and the possible lack of acceptance of the standards by Air Navigation Service Providers (ANSPs).

L.2.1 Failure to Meet Safety Standards

A failure to meet safety standards could cause a modification to the communication standard or an abandonment of the standard altogether. Analytical simulations are performed before the standard is adopted but live flight tests must be completed before the standard can be implemented. A discrepancy between the flight tests and the simulations could cause significant revisions to the standard or the adoption of a stricter standard altogether. Additionally, the infrastructure itself could fail to meet the communication standard. The infrastructure could fail to deliver the messages in time or could fail to function under the increased stress on system as data link usage increases.

L.2.2 Cost of Implementation

The cost of equipment upgrades for implementing RCP240 could be prohibitive for some operations. RCP240 will require ground station upgrades in some regions and will also require the satellites to remain available. The planned Iridium satellite is expected to become operational and compliant with RCP240 a failure to do so (risk P) could result in cost over runs for operators who need switch to the Inmarsat satellite. If the costs for complying with RCP240 are prohibitive, certain ANSPs may choose not to implement RCP240 or a more relaxed standard may need to be used for reduced separation.

L.2.3 Lack of acceptance of RCP240

The ANSPs will be required to accept RCP240 through local rulemaking before implementation. The ANSPs could decide to reject RCP240 if they feel their equipment cannot meet the specification, if the specification is too stringent, or if flight tests indicate the standard is not sufficient.

L.3 Impact on Stakeholder Value Metrics

The impact of risk L on the stakeholder value metrics according the respondents is given in Table 62.

Table 62: Risk L Impact to Stakeholder Value Metrics (Mandate/Reduced Separation)

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| High | Medium/High | None | None | Very Low | None |

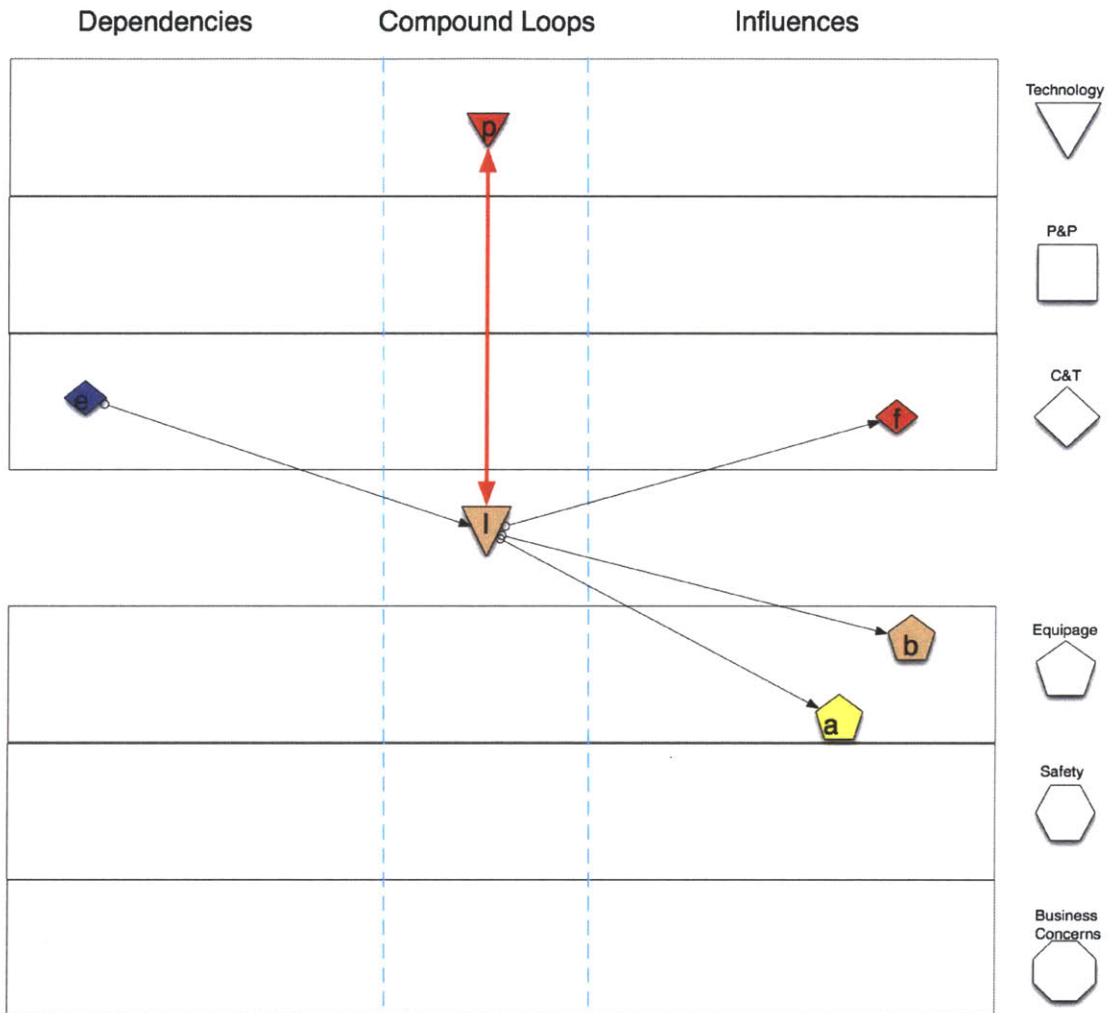
The respondents indicated a high impact for both Safety and Operational Efficiency categories. A possible outcome of Risk L that could impact safety would be the failure of the ground infrastructure under the increased stress of RCP240 and reduced separation procedures. The volume of messages that are sent when reduced separation procedures are implemented could increase significantly relative to the volume of messages sent during the mandate because there may be more aircraft and the procedures would likely require more frequent position updates. The ground and satellite infrastructure will still be required to meet RCP240 with the increase in message volume and a failure to meet RCP240 could pose safety risks to the aircraft operating in the airspace. The respondents did indicate that they did not feel reduced separation procedures would be implemented without establishing a communication standard. Operational efficiency could also be impacted by a failure of the ground infrastructure. A failure would force a reversion back to the 60 mile separation and increase times needed to receive climb clearance and reduce the number of aircraft that can operate on optimal flight path tracks within the Oceanic Track System (OTS). A medium impact to Operational Efficiency is listed for the mandate only because aircraft would already be in 60NM/60NM separation.

The respondents also indicated a very low impact to operator costs. A cost impact could come from either a failure of the ground infrastructure in flight which would cause a reversion back to the HF system, or, from a difference in the required number of messages as a result of RCP240 or reduced separation procedures.

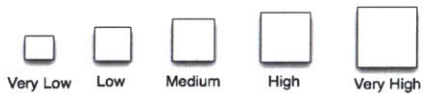
L.4 Direct Risk Dependencies, Influences & Outcomes

The dependencies and influences for Risk L are shown in Figure 42, and Figure 43. Risk L has two dependencies in the coordination and timing category, one compound loop with a technology risk, and, it influences a coordination and timing risk and two equipage risks.

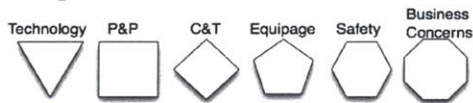
Figure 42: Risk L Dependencies and Influences (Mandate Only)



Likelihood



Categories



Impact

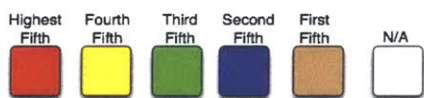


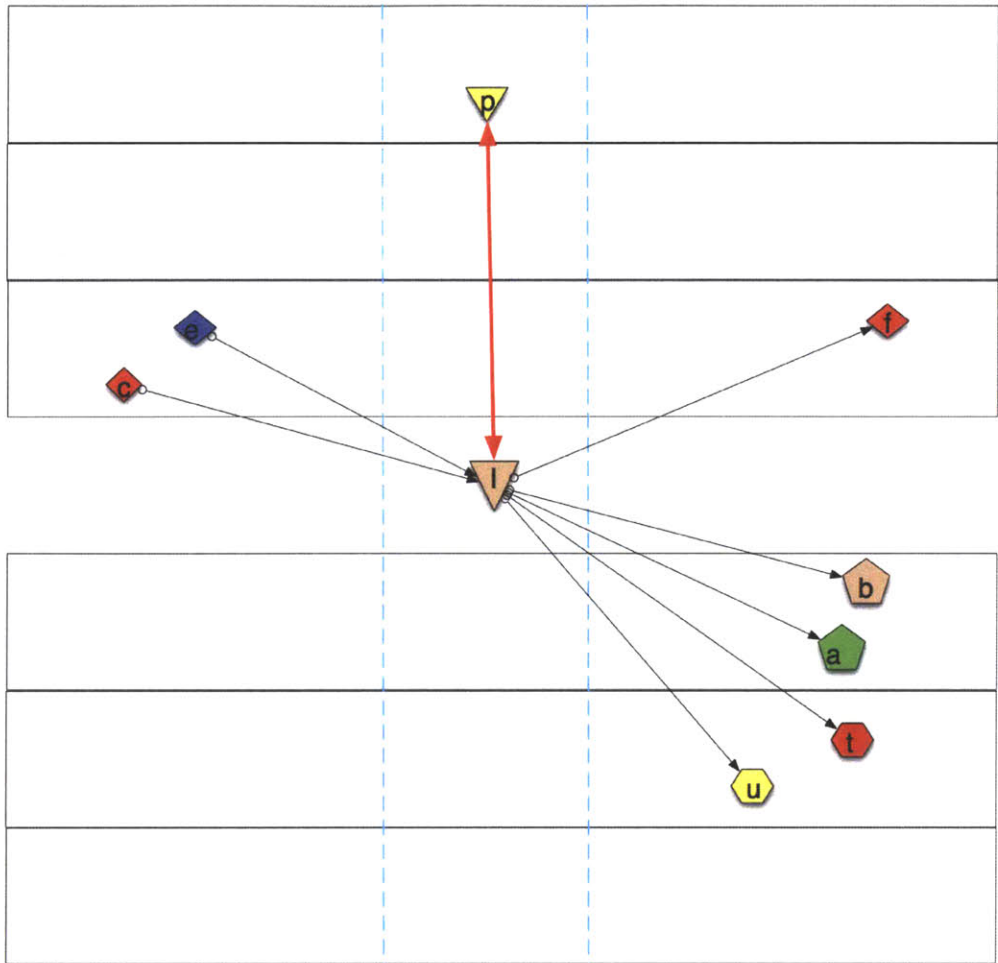
Figure 43 shows Risk L's dependencies and influences for both the mandate and reduced separation initiatives. The coordination and timing Risk C is added as a dependency and, the safety risks T and U are added as influences when reduced separation initiatives are considered.

Figure 43: Risk L Dependencies and Influences (Mandate and Reduced Separation)

Dependencies

Compound Loops

Influences



Technology



P&P



C&T



Equipage



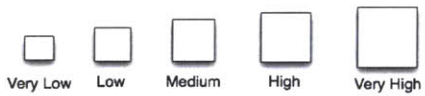
Safety



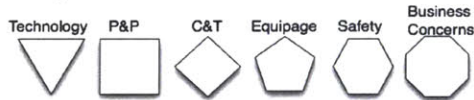
Business Concerns



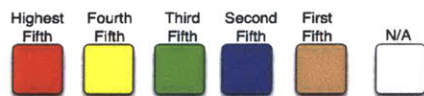
Likelihood



Categories



Impact



L4.1 Risk L Direct Dependencies

Risk L has two direct dependencies listed in Table 63, both in the coordination and timing category. Risk C, ANSPs failure to have automation systems ready for 25NM lateral separation, can result in inadequate ground infrastructure for RCP240 which would cause an occurrence of Risk L. It is possible however that RCP400, a less stringent standard than RCP240 could be accepted for 25NM lateral separation. Risk E, failure to achieve effective coordination with other ANSPs could have the outcome of the ANSP software not being ready for RCP240. The software is responsible for communicating with adjacent ANSPs, collision warnings and processing datalink messages. If the software can't communicate other ANSPs, it could become more difficult to meet RCP240 at the transition points between ANSPs.

Table 63: Risk L Direct Dependencies

| | |
|--------|--|
| Risk C | ANSPs failure to have automation, other technologies, or local rulemaking ready for implementation of 25NM lateral separation. |
| Risk E | Failure to achieve effective coordination with other ANSPs (harmonization of technical methods and operating methods) |

L4.2 Risk L Direct Influences and Associated Outcomes

Risk L influences one coordination and timing risk, two equipage risks and two safety risks which are listed in Table 64. The equipage risks A (Equipage for business operators not certified in time to meet mandate) and B (Delays in delivery CPDLC retrofit packages) will likely occur if the communication requirements for the data link equipment are not agreed upon by the ICAO participants and local rulemaking authorities. The communication requirements will feed directly into the design requirements for new CPDLC systems and could affect changes to existing systems that are delivered for retrofit. The coordination and timing Risk F (Rulemaking to support data link and 25NM lateral separation not completed in time) also requires agreement on communication standard. The communication standard is an important part of the standards set for both the mandate and 25NM lateral separation and is needed by ANSPs and local authorities for consistency: they need to test the same standards that will be implemented. As with Risk F, the communication standard is needed to evaluate the safety case described in Risk T (failure to meet safety case for 25NM lateral separation). If RCP240 can't be met, the safety case for 25NM may also suffer or need to be relaxed. The safety Risk U (failure to control vertical risk when 25NM lateral separation is implemented) can be affected by the ability of the aircraft and

ground infrastructure to meet RCP240. Although it is unlikely that vertical risk will be difficult to control, the risk would increase if the messages weren't not exchanged as quickly as assumed in the safety case and described in RCP240.

Table 64: Risk L Direct Influences

| | |
|--------|--|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand. |
| Risk F | Rulemaking to support data link mandate and 25NM lateral separation (if required by ANSP) not completed within mandate time frame. |
| Risk T | Failure to meet safety case for 25NM lateral separation |
| Risk U | Failure to control vertical risk when 25NM lateral separation is implemented |

L4.3 Risk L Compound Loops

Risk L forms one compound loop with the technology risk P (Uncertainty in approval of Iridium-based equipage to meet requirements for data link mandate and 25NM lateral reduced separation). The communication standard that is set for RCP240 and 25NM lateral reduced separation will be the standard that Iridium is tested against. If the Iridium satellite cannot meet the RCP240 standard, it will force all operators equipped, with RCP240 to switch satellite receivers could significantly delay the implementation of 25NM lateral reduced separation. Conversely, a failure of Iridium to meet RCP240 would likely influence what communication standard used for 25NM lateral and the mitigation strategies for meeting RCP240. If Iridium does not meet RCP240, ANSPs may be forced to upgrade their ground infrastructure to make up for the time lag.

Table 65: Risk L Compound Loops

| | |
|--------|---|
| Risk P | Uncertainty in approval of Iridium-based equipage to meet requirements for data link mandate and 25NM reduced lateral separation. |
|--------|---|

L.5 Mitigation

Table 66 shows the reported mitigation difficulty for Risk L. The respondents indicated a low detection difficulty for Risk L. The detection of issues coming up with RCP240 would come up either during flight testing, or in the ICAO supporting analysis and would be reported in the ICAO meetings. The respondents indicated that corrective action for the occurrence of Risk L would be very difficult. Possible corrective actions include upgrading ANSP ground infrastructure, switching to the Inmarsat satellite communication service, and changing the communication requirement for 25NM lateral separation. Each of these corrective actions would require at least one stakeholder (operators, ANSPs, ICAO, or local regulatory authorities) to invest significant amounts of time and financial resources. Any of these changes made would also need to have their performance verified through both a safety analysis and live testing. The respondents listed the coordination required as very high. Any changes to the communication standard would need to be approved by all of the ANSPs that participate in ICAO local authorities and be implemented by aircraft manufacturers and airlines. The respondents indicated a high likelihood for Risk L. They did not believe that there would be a significant mitigation effort in place to meet RCP240 but they also indicated that they believed RCP240 would be met by both the ground infrastructure and both satellite communication services (Inmarsat and Iridium).

Table 66: Risk L Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | Very High | High | High |

M.0 Description

Risk M is a policy and procedures risk described as “Lack of harmonization in technologies and procedures: ATN (Air Telecommunication Network) Controller Pilot Data link (CPDLC) mandate in Europe vs. FANS-1/A mandate in the North Atlantic Airspace (NAT). These two CPDLC technologies are incompatible with each other because they use different message sets (predefined message formats for communication between pilot and air traffic controller) and different ways to transmit communications with the ground. To date, aircraft manufacturers have not been able to install dual ATN and FANS 1/A systems or “dual stacks” on a single aircraft and operators have had to choose between one technology or the other. However, some manufacturers have plans to give new aircraft dual stack capability in the future. The conflict in the two mandates could effectively prevent aircraft that enter service after 2015 from servicing routes between the North Atlantic and Europe. The difference in procedures between the two regions can also encourage human errors when pilots must operate in both regions.

M.1 Background

There are currently two Controller Pilot Data link (CPDLC) technologies in existence: FANS 1/A and ATN. FANS 1/A is noted for its compatibility with space based satellites, making it the best candidate for over water operations. It is currently mandated under the North Atlantic Mandate plan for use starting in 2013 and has been in use on select routes in the Pacific Ocean. The Pacific Ocean region does however use different procedures than the North Atlantic. ATN is already an ICAO certified standard and has been adopted for over-land use in Europe and other regions. ATN is also mandated for future use in Europe starting in 2013 in the European Air Traffic Management plan adapted from the Single European Sky plan (SESAR ATM). To date, the two technologies are incompatible and cannot be installed simultaneously on the same aircraft. There have been attempts to harmonize the CPDLC technology globally but the ATN technology would still need to undergo fundamental hardware in order to communicate with satellites.

The two mandates, the North Atlantic Mandate and the European Mandate need to be harmonized in order to ensure CPDLC equipped aircraft can service routes between North American and Europe. The North Atlantic mandate cannot provide exceptions for ATN use because ATN does not work over water. The European Mandate does provide some exceptions for FANS 1/A equipped aircraft as long as they are made before 2015. After 2015, both mandates, as currently written, would effectively disallow all aircraft

built after 2015 from servicing routes between North America and Europe with the Ocean Track System (OTS) unless they were equipped both FANS 1/A and ATN CPDLC equipment. Additionally, the different procedures, message sets and formats need to be harmonized to reduce human error for pilots that are used to using one CPDLC technology and that need operate in regions where another CPDLC technology is in use.

A graphical description of which aircraft will be allowed to fly where and when is shown in Figure 44 (Mandate only), Figure 45 (reduced separation before 2015), and Figure 46 (reduced separation after 2015). A green box indicates that the aircraft is allowed to fly in that region. A yellow box indicates that the aircraft can fly in some parts of that region. A red box indicates that the aircraft cannot fly in that region within the specified altitudes.

Figure 44: Aircraft-Airspace Compatibility (Mandate Only)

| Data link Equipage | Airworthiness | US before 2015 | NAT OTS Before 2015 FL350-FL400 | | NAT Non-OTS Before 2015 FL350-FL400 | | Euro Before 2015 IFR FL285+ | |
|--------------------|---------------|----------------|---------------------------------|------------|-------------------------------------|------------|-----------------------------|----|
| | | | 7 Feb 2013 | 5 Feb 2015 | 7 Feb 2013 | 5 Feb 2015 | P1 | P2 |
| None (HF Only) | After 1997 | Yes | 7 Feb 2013 | 5 Feb 2015 | 7 Feb 2013 | 5 Feb 2015 | P1 | P2 |
| None (HF only) | Before 1997 | Yes | 7 Feb 2013 | 5 Feb 2015 | 7 Feb 2013 | 5 Feb 2015 | P1 | P2 |
| ATN | Before 2014 | Yes | 7 Feb 2013 | 5 Feb 2015 | 7 Feb 2013 | 5 Feb 2015 | P1 | P2 |
| FANS 1/A | Before 2014 | Yes | 7 Feb 2013 | 5 Feb 2015 | 7 Feb 2013 | 5 Feb 2015 | P1 | P2 |

Figure 45: Aircraft-Airspace Compatibility (Reduced Separation before 2015)

| Data link Equipage | Airworthiness | US before 2015 | NAT OTS Before 2015 FL350-FL400 | | | NAT Non-OTS Before 2015 FL350-FL400 | | | Euro Before 2015 IFR FL285+ | |
|--------------------|---------------|----------------|---------------------------------|----|----|-------------------------------------|----|----|-----------------------------|----|
| | | | P1 | P2 | P3 | P1 | P2 | P3 | P1 | P2 |
| None (HF Only) | After 1997 | Yes | P1 | P2 | P3 | P1 | P2 | P3 | P1 | P2 |
| None (HF only) | Before 1997 | Yes | P1 | P2 | P3 | P1 | P2 | P3 | P1 | P2 |
| ATN | Before 2014 | Yes | P1 | P2 | P3 | P1 | P2 | P3 | P1 | P2 |
| FANS 1/A | Before 2014 | Yes | P1 | P2 | P3 | P1 | P2 | P3 | P1 | P2 |

Figure 46: Aircraft-Airspace Compatibility (Reduced Separation after 2015)

| Data link Equipage | Airworthiness | US After 2015 | NAT OTS After 2015 FL350-FL400 | NAT Non-OTS After 2015 FL350-FL400 | Euro After 2015 IFR FL285+ |
|--------------------|---------------|---------------|--------------------------------|------------------------------------|----------------------------|
| None (HF Only) | After 1997 | Yes | No | No | No |
| None (HF only) | Before 1997 | Yes | No | No | Must Cease in 2017 |
| ATN | Before 2014 | Yes | No | No | Yes |
| FANS 1/A | Before 2014 | Yes | Yes | Yes | Yes |
| FANS 1/A | After 2014 | Yes | Yes | Yes | No |
| ATN | After 2014 | Yes | No | No | Yes |

M.2 Root Causes

The respondents identified three root causes associated with the occurrence of Risk M. The first is the European Air Traffic Master Plan which mandates the use of the ATN CPDLC technology in European domestic airspace at the typical cruising altitudes for commercial aircraft. The second is the existing ICAO endorsement of the ATN CPDLC technology in contrast to FANS 1/A which is not currently endorsed by ICAO. Lastly, they identified the technical and procedural incompatibilities between the two CPDLC message sets and the operating procedures in the North Atlantic and Europe.

M.2.1 2015 Compliance Deadline in the European Air Traffic Master Plan

The European Air Traffic Master Plan is a result of a definition plan (Single European Sky Air Traffic Management Plan (SESAR)) and has been Endorsed by the European Union. The plan currently includes a mandate for aircraft to use the ATN CPDLC technology at certain altitudes. The European mandate is included in section M.6 of this appendix. The plan does include exceptions for FANS 1/A aircraft but does requires all aircraft entering service after 2015 to be equipped with the ATN CPDLC technology.

M.2.2 Existing ICAO Endorsement of ATN

The ATN CPDLC technology is currently an endorsed ICAO standard. This endorsement could make it difficult to merge the two standards or encourage airlines and operators that use ATN to switch to a different CPDLC technology.

M.2.3 Incompatible Message Sets and Procedures

FANS 1/A and ATN both have message sets that are displayed to the pilot on the instrument panel and specific procedures for communicating with ground controllers. These messages contain clearance information, flight path information and other information critical to the pilot. The messages have different formats so an ATN message sent a FANS 1/A aircraft may not display correctly and, a FANS 1/A message sent to an ATN aircraft may also not display correctly. Additionally, there are regional procedures in place for communicating with the air traffic controllers that include but aren't limited to logging in to the data link system, send and receiving clearances, requests to climb and descend, and acknowledgement of received messages. Minor differences in these procedures will also need to be resolved before the systems can be merged and to prevent human errors. The GOLD document started by the FAA is intended to harmonize these messages sets and procedures.

Lack of over water compatability of ATN? (Not highlighted as a root cause but this is the reason the Mandate can't have exceptions for ATN).

M.3 Impact on Stakeholder Value Metrics

The impact of Risk L on the stakeholder value metrics according the respondents is given in Table 67.

Table 67: Risk M Impact on Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | Medium | Low | Low | Medium | Medium |

The respondents indicated low impacts to Safety, ANSP Costs, and ANSP Revenues. Safety can be impacted by human errors that come from differences in procedures and messages sets between the North Atlantic and Europe. One respondent indicated that there is a significant potential for human error due to truncation of the latitude and longitude displays on the flight management computers of some aircraft. The truncation makes the half-degree tracks needed for 25NM lateral separation indistinguishable from the whole degree tracks that are currently used unless the pilot manually down selects the waypoint for verification on the flight management computer. Manual pilot verification of waypoints is a mandatory procedure with some airlines but not with all airlines. Not

verifying the half-degree track waypoints could make a human error in entering the waypoint harder or take longer to detect. The possibility for human error can be reduced by having the ANSPs send flight plan changes directly to the aircraft and airline *without* a second manual entry needed from a dispatcher or pilot and, by making waypoint verification mandatory for all operators. Additionally, if the differences in procedures between the European Domestic Airspace, and the North Atlantic remain, there could be significant confusion and congestion at European oceanic entry points (OEPs).

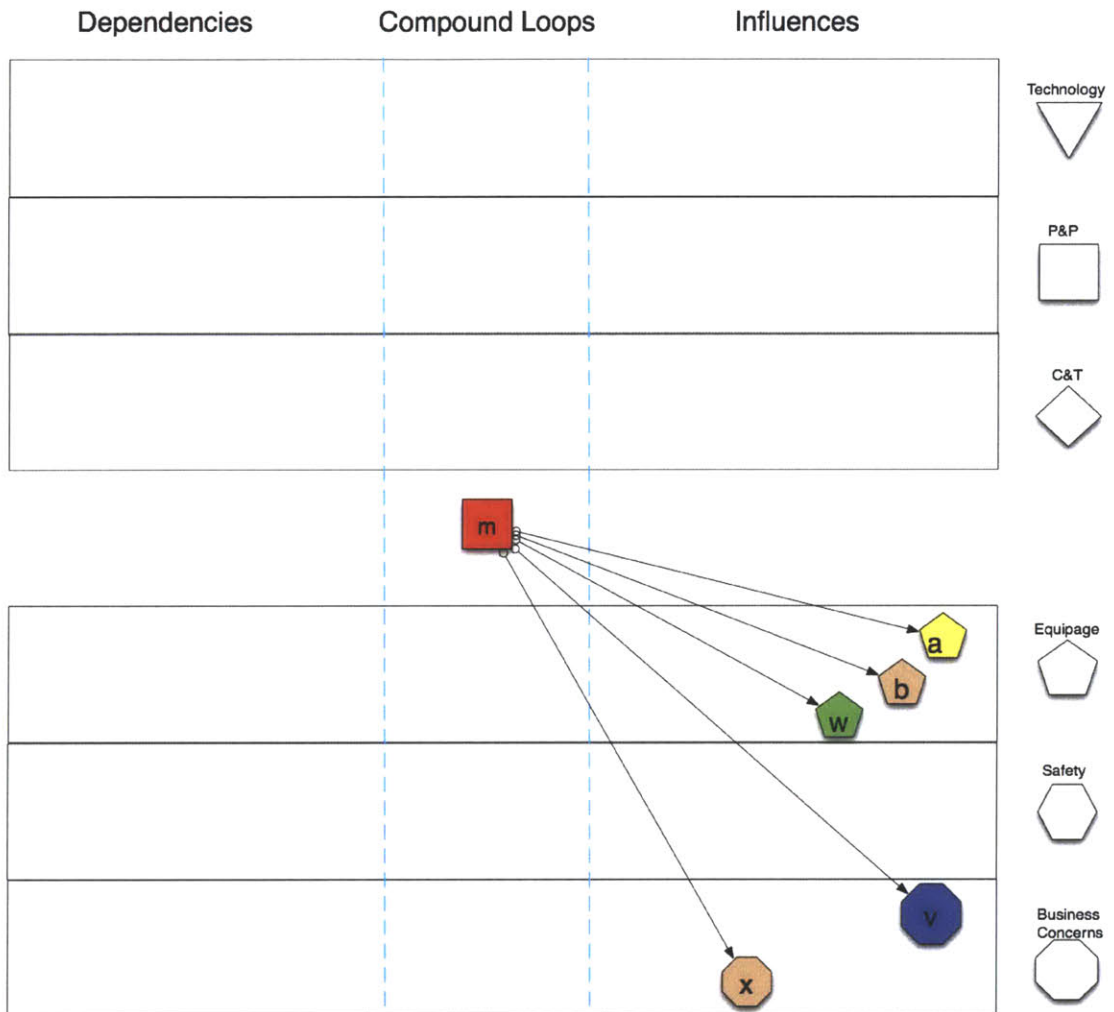
ANSP costs, European ANSP costs specifically can be impacted by the need to support two CPDLC message sets, FANS 1/A and ATN. These ANSPs would be required under the European Mandate to accommodate ATN and the North Atlantic Mandate to accommodate FANS 1/A. They will need to coordinate with their domestic ANSPs and have software that accommodates both message sets. ANSP revenues can be impacted if the volume of messages changes as a result of not resolving the differences between ATN and FANS 1/A mandates. Aircraft that are ATN equipped may need to revert back to HF over the North Atlantic which could result in them sending fewer messages than FANS 1/A equipped aircraft operating under reduced separation procedures.

The respondents indicated medium impacts to Operational Efficiency, Operator Costs, and Operator Revenues. Operational Efficiency can also be affected by human errors stemming from using different procedures. One respondent mentioned that at OEPs in Europe where the procedures switch, there could be considerable congestion due to possible errors or incompatibilities. This respondent mentioned that harmonization efforts such as the GOLD document were the best way to mitigate against these errors. Operator costs and revenues can be impacted by the need to add future “dual stack” equipment that would support both ATN and FANS 1/A, and, the possible restrictions that could prevent service to city pairs that were previously served by an operator.

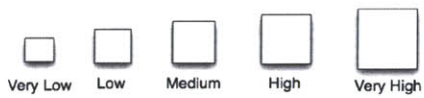
M.4 Dependencies and Influences

The dependencies and influences for Risk M are shown in Figure 47 and Figure 48. Risk M does not have any dependencies or compound loops but influences two coordination and timing risks, three equipage risks, and two business concern risks.

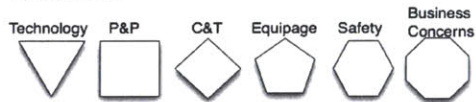
Figure 47: Risk M Direct Dependencies and Influences (Mandate Only)



Likelihood



Categories



Impact

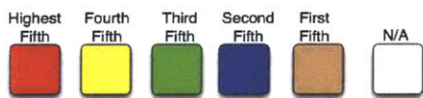
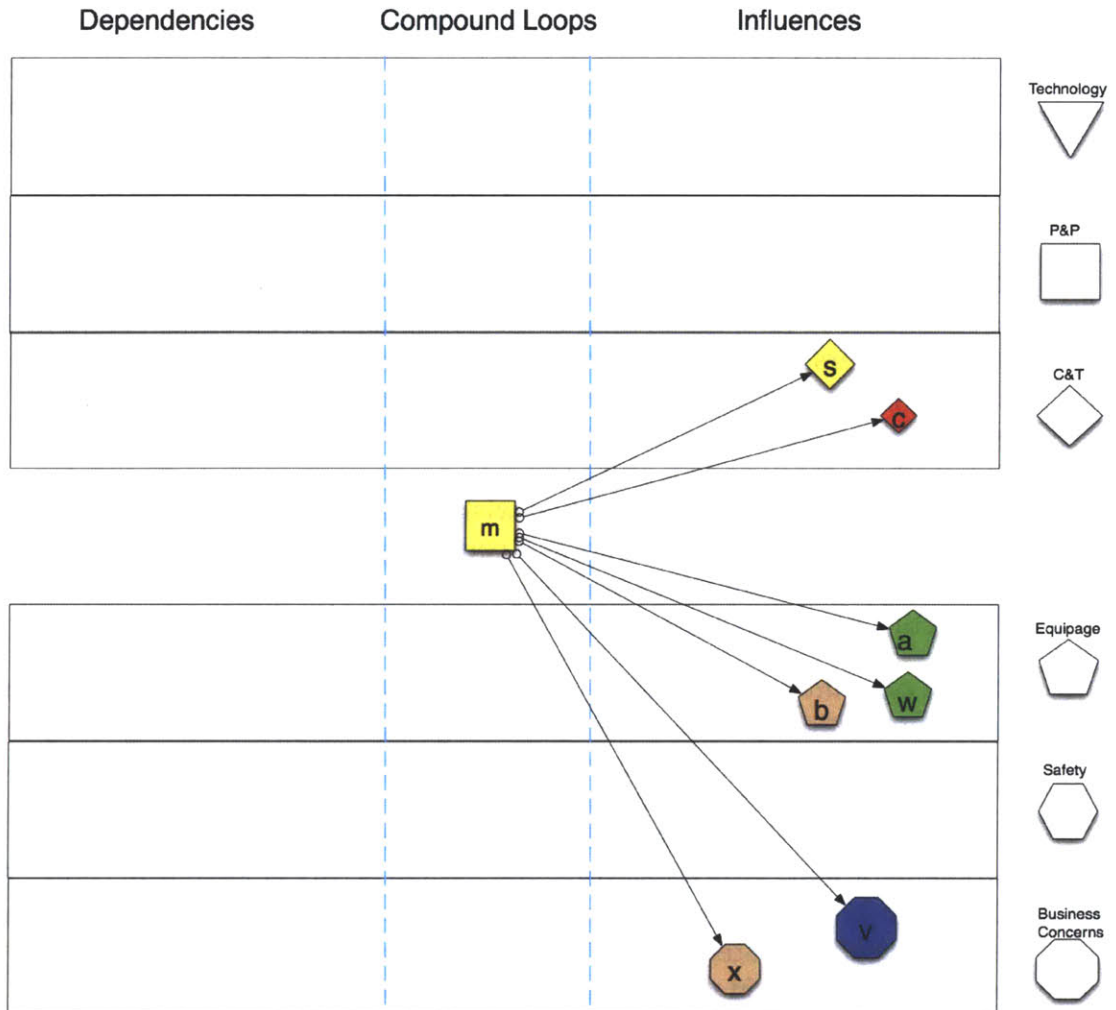
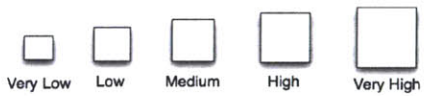


Figure 48 shows Risk M's dependencies and influences for both the mandate and reduced separation initiatives. The coordination and timing risks C and S are added as influences.

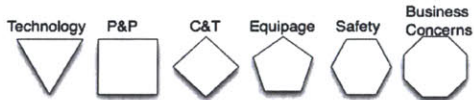
Figure 48: Risk M Direct Dependencies and Influences (Mandate and Reduced Separation)



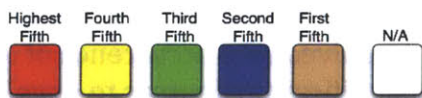
Likelihood



Categories



Impact



M4.1 Risk M Direct Influences and Associated Outcomes

Risk M has several direct influences as shown in Table 68. The influential outcomes of Risk M are, uncertainty for operators in whether to equip with FANS 1/A, or a dual stack that also supports ATN, conflicting or incompatible procedures with domestic ANSPs that use the ATN CPDLC technology, and a dramatic increase in the cost of for equipping if a dual stack or software upgrades for harmonization and human error mitigation are required.

Risk M can influence the equipage risks A (Equipage for business operators not available or certified in time to meet mandate) B (Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand), and W (Late Delivery of new aircraft orders that are replacing older, unequipped or unequippable aircraft) if there is uncertainty in the requirement for dual ATN and FANS 1/A equipment or “dual stacks” for aircraft that enter service 2015 that wish to serve Europe and North America. A dual stack configuration could require significant changes to the aircraft system architecture and insight delays in delivery (Risk B, and Risk W) certification, and availability (Risk A).

Risk M can influence the coordination and timing risks C (ANSPs failure to have automation systems, other technologies or local rulemaking ready for implementation of 25NM reduced separation), and S (Late completion of 25NM lateral separation planning tasks) if the differences in procedures between the North Atlantic and European domestic ANSPs become problematic and cause congestion and human errors at European OEPs. The European ANSPs are however expected to support FANS 1/A aircraft because of the exceptions listed in the European Mandate (Appendix 6). Although the occurrence of Risk M would represent a lack of harmonization, harmonization efforts could delay 25NM lateral implementation (Risk S) and the timing of ANSP compliance (Risk C).

Risk M can influence the business concern risks V (High costs preventing operators from retrofitting to meet requirements for data link mandate and 25NM lateral reduced separation) and W (Cost benefit analysis may show that costs outweigh the benefits) if future aircraft are required to have dual stack capability, or, if current FANS 1/A and ATN equipped aircraft are required to undergo software upgrades for harmonization and to mitigate against human errors. Although the European mandate does currently allow for FANS 1/A aircraft to operate at the optimal flight levels, FANS 1/A only aircraft that enter service after 2015 will still be prohibited unless this conflict is resolved. If the conflict goes unresolved (the occurrence of Risk M), the manufacturers will need to invest significant resources to develop

dual stack capabilities which will drive up the cost of equipage for operators (Risk V). Risk M could also cause unanticipated costs for operators if there are aircraft that were scheduled for delivery before 2015 but are delayed until after 2015 because those operators may need to add equipment to fly their intended routes. These costs could be prohibitive (Risk V and Risk W) and significantly weaken the business case for CPDLC equipment.

Table 68: Risk M Direct Influences

| | |
|--------|---|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand. |
| Risk C | ANSPs failure to have automation systems, other technologies or local rulemaking ready for implementation of 25NM reduced separation. |
| Risk S | Late completion of 25NM lateral separation planning tasks |
| Risk V | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25NM lateral reduced separation. |
| Risk W | Late Delivery of new aircraft orders that are replacing older, unequipped or unequippable aircraft. |
| Risk X | Cost benefit analysis may show that costs outweigh the benefits |

M.5 Mitigation

Table 66 shows the reported mitigation difficulty for Risk M. The respondents indicated a very low difficulty for detection. The two policies that would control the occurrence of Risk M, the European CPDLC Mandate, and the North Atlantic CPDLC Mandate will both be published before they are implemented. The respondents indicated a high difficulty of corrective action. Possible corrective actions include the harmonization of procedures and messages through the data link GOLD document, adding exceptions to the European mandate for FANS 1/A aircraft that enter service after 2015, policy harmonization between the European and North Atlantic CPDLC requirements, and, possible software and hardware upgrades for aircraft to accommodate both ATN and FANS 1/A equipment. All of these corrective actions would require significant amounts of coordination to implement and

some would require significant financial resources. The respondents indicated that the coordination difficulty to mitigate or correct against Risk M would be very high. Risk M is a policy risk and, ICAO and all of the domestic aviation regulatory authorities must approve any changes to the policies. In the case of Risk M, it is also necessary to coordinate with aircraft manufacturers so that they produce software and hardware that is compatible with the set of procedures that will be adopted. The respondents indicated that Risk M has a high likelihood. They mentioned that ATN is an ICAO approved standard and that it is unlikely to be rolled back in the European mandate. Additionally, ATN can't be used over water so the North Atlantic ANSPs must use FANS 1/A in order to have a CPDLC capability. All of the respondents who mentioned risk M did say that establishing world wide CPDLC standard and set of procedures would be the best way to confront Risk M and differences between the CPDLC operating procedures in the North Atlantic, the Pacific, and Europe.

Table 69: Risk M Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Very Low | High | Very High | High |

M.6 European Mandate

EURO MANDATE:

3.3.1.1 All concerned aircraft operating flights as general air traffic in accordance with instrument flight rules in the airspace defined below shall be equipped with context management (CM) and controller-pilot data link communications (CPDLC) applications capable of supporting the following data link services: data link initiation capability, air traffic control clearance, air traffic control communications management and air traffic control microphone check:

a) from 7 February 2013, in the following FIRs/UIRs above FL285:

Amsterdam FIR, Wien FIR, Barcelona UIR, Brindisi UIR, Brussels UIR, Canarias UIR, France UIR, Hannover UIR, Lisboa UIR, London UIR, Madrid UIR, Milano UIR, Rhein UIR, Roma UIR, Scottish UIR and Shannon UIR; and

b) from 5 February 2015, in the following FIRs/UIRs above FL285:

Bratislava FIR, Bucuresti FIR, Budapest FIR, Kobenhavn FIR, Ljubljana FIR, Nicosia FIR, Praha FIR, Sofia FIR, Warszawa FIR, Finland UIR south of 61°30', Hellas UIR, Malta UIR, Riga UIR, Sweden UIR south of 61°30', Tallinn UIR, Vilnius UIR.

Note.— Requirements for the CM and CPDLC applications to support the data link services described are contained in RTCA DO-280B/EUROCAE ED-110B Interoperability Requirements Standard For ATN Baseline 1 (INTEROP ATN B1) and RTCA DO-290/EUROCAE ED-120 Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace (Continental SPR Standard), including Changes 1 and 2, with the exceptions that:

a) Uplink message 135, CONFIRM ASSIGNED LEVEL, and Uplink message 233, USE OF LOGICAL ACKNOWLEDGMENT PROHIBITED, will not be used by the ground systems; and

b) Downlink message 38, ASSIGNED LEVEL (level), is not required by the aircraft.

3.3.1.2 Conformance to the equipage requirement and operator's approval shall be verified by the State of Registry or the State of the Operator, as appropriate.

3.3.1.3 Aircraft are exempted from the requirement stipulated in 3.3.1.1 in the following cases:

a) aircraft with an individual certificate of airworthiness first issued before 1 January 2011 are exempted until 5 February 2015;

b) aircraft with an individual certificate of airworthiness first issued before 1 January 2014 and fitted with data link equipment certified against requirements specified in RTCA DO-258A/EUROCAE ED-100A (or ED-100) are exempted for the life of that particular airframe;

c) aircraft which have a certificate of airworthiness issued before 31 December 1997 and which will cease operation in the airspace referred to in Paragraph 3.3.1.1 before 31 December 2017 are exempted from the requirement stipulated in 3.3.1.1;

d) state aircraft;

e) aircraft flying in the airspace referred to in Paragraph 3.3.1.1 for testing, delivery and for maintenance purpose; and

f) operators of types of aircraft reaching the end of their production life and being produced in limited numbers, or types of aircraft for which re-engineering costs required would be disproportionate due to old design, may, based on this criteria, request from the appropriate authority the granting of an exemption. Such requests shall be made prior to 30 September 2012 and include detailed information justifying the need for the granting of the exemption.

End of new text

- END - APPENDIX A: NAT SPG Initiatives

Rev 3 (27 Feb 10)

N.0 Description

Risk N is a policy and procedure risk described as “Impact of ICAO Annex 6 data link communications airborne recording standard”. Annex 6 Section 6.3 (Section N.6) requires aircraft with Controller-Pilot Data link (CPDLC) capability to record all data link messages on board the aircraft. Annex 6 first went into effect for aircraft that were certified after 2005 and then for all aircraft. Many aircraft however, were designed without a capability for recording data link messages. Operators of these aircraft may face an additional cost of complying with the data link mandate if Annex 6 remains in effect and other operators could decide the cost of equipping is too high.

N.1 Background

The Annex 6 recording standard is a standard issued by the ICAO that requires aircraft that are data link equipped to record all data link messages sent between the aircraft and the air traffic controller. The standard was issued after many aircraft were built and those aircraft consequently do not have the capability to record the messages on board. There are substantial costs associated with adding that capability and some unequipped operators could be deterred from equipping. Removing the Annex 6 recording standard could encourage quicker adoption of data link equipment amongst operators. There may also be a new version of Annex 6 that could potentially add further costs.

N.2 Root Cause: Enforcement of Annex 6

The respondents listed the enforcement of the Annex 6 policy itself as the root cause. They noted that although the policy has been written, it has not yet been enforced and, that very few if any operators have the data link recording capability onboard the aircraft. The respondents indicated that the Annex 6, if it were enforced, would likely be enforced through local rulemaking. Operators that are based or operate in the rulemaking regions that enforced the rule would be forced to comply or suspend data link operations.

N.3 Impact on Stakeholder Value Metrics

The impact of Risk N on stakeholder value metrics according to respondents is given in Table 70.

Table 70: Risk N Impact on Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | High | None | None | High | None |

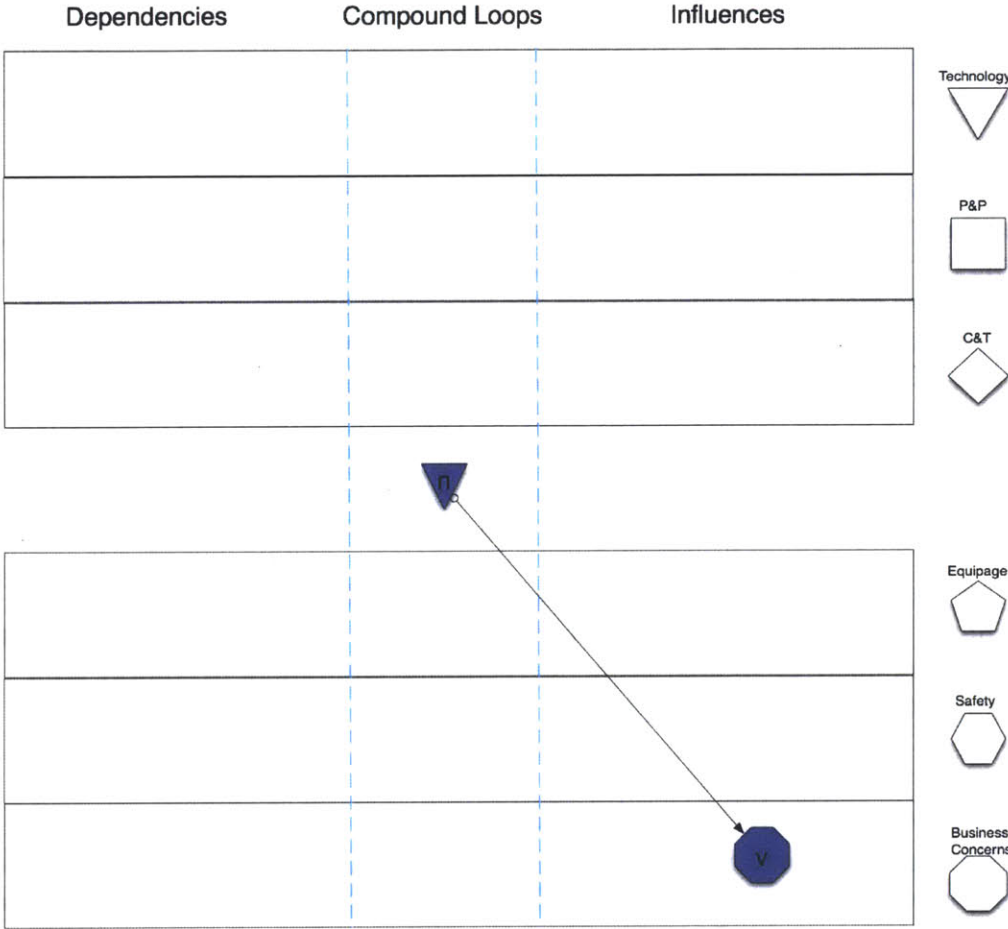
The respondents indicated the occurrence of Risk N would have a low impact to Safety. Risk N can reduce the percentage of equipped aircraft operating in the North Atlantic and in turn, reduce the level of Safety if operators are forced to stop flying until they get the recording equipment. Operational Efficiency (High Impact) would also be affected because the operators would have to temporarily suspend their data linked equipped aircraft from operating in the North Atlantic until the recording equipment is designed, delivered and installed. This assumes that the restrictions that would be in place in 2016 are consistent with the current mandate and reduced separation plan.

The respondents indicated the occurrence of Risk N would have a high impact to Operational Costs. The impact to costs would come directly from the costs incurred in upgrading the recording equipment to comply with Annex 6.

N.4 Dependencies and Influences

The dependencies and outcomes for Risk N are shown Figure 49. Risk N does not have any dependencies and influences one Business Concern risks. The dependencies and influences of Risk N and their relative impacts are identical for both the mandate only and, when both the mandate and reduced separation are considered so only one graph is pictured.

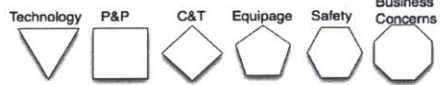
Figure 49: Risk N Direct Dependencies and Influences (Mandate only and Mandate + Reduced Separation)



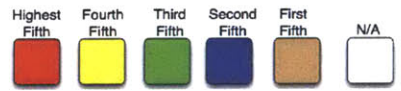
Likelihood



Categories



Impact



N4.1 Risk M Direct Influences and Associated Outcomes

Risk M has one direct influence as shown in Table 71. Risk N influences the business concern risk V (High costs preventing operators from retrofitting to meet requirements for data link mandate and 25NM lateral reduced separation) by increasing the cost of retrofitting an aircraft to meet the data link mandate. The increase in cost comes from the need to purchase recording equipment and associated down time for installation.

Table 71: Risk N Direct Influences

| | |
|--------|---|
| Risk V | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25NM lateral reduced separation. |
|--------|---|

N.5 Mitigation

The mitigation difficulty for Risk N is listed in Table 72. The respondents indicated a low difficulty for detection. The operators would be notified of the enforcement of Annex 6 through ICAO and local rulemaking authorities. The corrective action, coordination and likelihood were all given “High” ratings by the respondents. Possible corrective actions include giving the ANSPs the only recording responsibilities or, subsidizing the data link recording equipment for the operators. There would be a substantial amount of coordination required for both of the suggested corrective actions. The local rule makers would likely require some sort of analysis to show that ANSPs recordings would be sufficient in a safety investigation and, possibly an ICAO committee to put out a ruling on the matter. The funds to subsidize recording equipment would be substantial and would need to be pooled from either ICAO or local government funds. It may also be possible to penalize aircraft that don’t have recording equipment and use those funds to subsidize new equipment purchases. The respondents listed the likelihood as high. They felt that local rule makers did see a safety benefit in recording on board the aircraft in addition the ground recordings and would likely enforce the Annex 6 in the future.

Table 72: Risk N Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | High | High |

N.6: ICAO Annex 6 - Operation of Aircraft, Section 6.3.1.5

6.3.1.5 All aeroplanes for which the individual certificate of airworthiness is first issued after 1 January 2005, which utilize data link communications and are required to carry a CVR, shall record on a flight recorder, all data link communications to and from the aeroplane. The minimum recording duration shall be equal to the duration of the CVR, and shall be correlated to the recorded cockpit audio.

6.3.1.5.1 From 1 January 2007, all aeroplanes which utilize data link communications and are required to carry a CVR shall record on a flight recorder, all data link communications to and from the aeroplane. The minimum recording duration shall be equal to the duration of the CVR, and shall be correlated to the recorded cockpit audio.

6.3.1.5.2 Sufficient information to derive the content of the data link communications message and, whenever practical, the time the message was displayed to or generated by the crew shall be recorded.

Note.- Data link communications include, but are not limited to, automatic dependent surveillance (ADS), controller-pilot data link communications (CPDLC), data link flight information services (D-FIS) and aeronautical operational control (AOC) messages

O.0 Description

Risk O is an equipage risk described as “End of service life of I3 satellite services expected about 2016. New equipage may be required to use classic aero services via I4 satellites”. The need for new equipment would affect operators who have had the I3 satellite communication equipment for FANS 1/A installed. When the new I4 satellites enter service, those aircraft that were previously data link compliant would become noncompliant and/or be forced to purchase an upgraded communications service and, replace the previous equipment. There is a possibility that the current equipment could be supported by the new system, but ICAO does not have a standard or jurisdiction over the communication protocol for the satellites. The possibility of replacing existing data link software onboard the aircraft and purchasing a new communications service could result in significant cost overruns for the operators and decrease the number of equipped aircraft operating in the North Atlantic.

O.1 Background

I3 and I4 are low earth orbit satellites that operate in a constellation to provide telecommunications coverage for various applications including FANS-1/A data link messages over the North Atlantic. The current I3 satellites are scheduled for replacement in 2016, or, one year following the last phases of the mandate and reduced separation. The replacement satellites may use a different communications protocol which would result in a requirement to upgrade equipment on existing fleets. There is also a possibility that a service upgrade would be required to communicate with the new I4 satellites. The service upgrade and equipment upgrade could both result in significant cost incursions for the airlines and temporarily reduce the number of equipped aircraft operating in the North Atlantic.

O.2 Root Causes

The respondents indicated two root causes for the occurrence of Risk O: the lack of ICAO authority or control over satellite service policies, and, the technical requirements for communicating with upgraded satellites.

O.2.1 Lack of ICAO Authority over Satellite Service Policies

The service policy of no longer supporting Classic Aero Services, which are currently used on the I3 satellites, will be enforced by the satellite provider. ICAO does not have the regulatory leverage to over turn the policy. Additionally, the bandwidth used for data link operations is only a small percentage of the satellite total bandwidth. There is a competing satellite

service, Inmersat, but it requires different equipment, including a heavier transmitter. The I4 satellites will use the Swift Broadband services which should provide some enhancements relative to the Classic Aero Service.

O.2.2 Technical Requirements for communicating with I4 satellites

The I4 satellite constellation is expected to offer enhanced capabilities over the I3 satellites. There may be corresponding technical requirements for offering these enhancements such as a different satellite communications protocol and/or a different transmitter. Both of these requirements would cause the operators to incur significant costs that are related to upgrading the equipment as soon as the I3 satellites are shut down.

O.3 Impact to Stakeholder Value Metrics

The impact of Risk O on stakeholder value metrics according to respondents is shown in Table 73.

Table 73: Risk O Impact on Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| High | High | None | None | High | None |

The respondents indicated Risk O would have a high impact to Safety and a medium impact Operational Efficiency. The occurrence of Risk O would significantly but temporarily reduce the number of equipped aircraft in the North Atlantic and thus significantly impact safety. Many data linked equipped aircraft use the Classic Aero Services with I3 satellites because the fees are lower and the transmitter is lighter than the competing service used with the Inmersat satellite. The time to equip with new transmitters could be significant and that downtime would impact the operational efficiency of the operators.

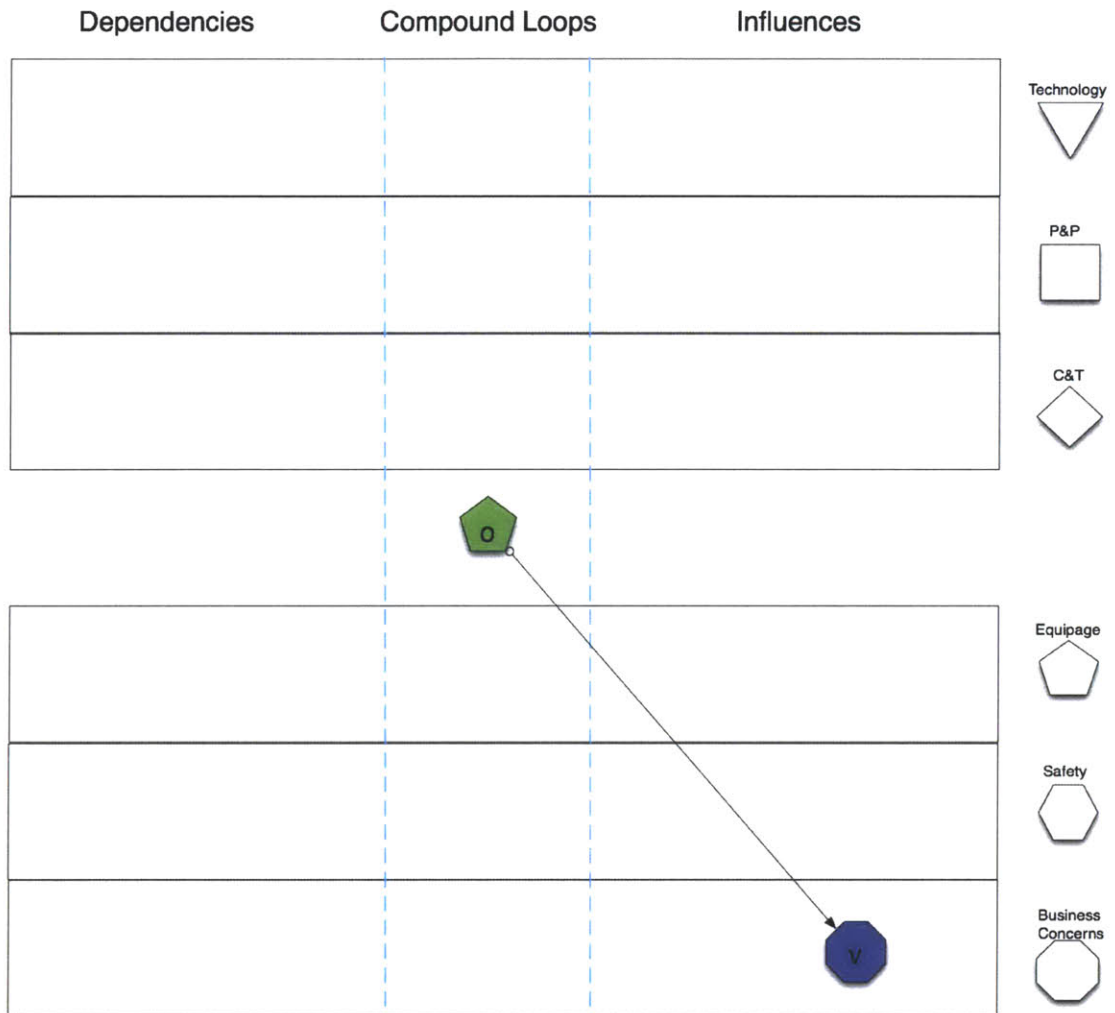
The respondents also indicated there would high impact to Operator Costs. These costs would come from the lost revenue due to aircraft downtime, the equipment costs for new transmitters, and the increase in service fees for the Swift Broadband Service.

O.4 Dependencies and Influences

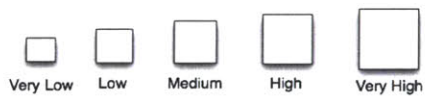
The dependencies and influences of Risk O are shown in Figure 50 and Figure 51 shows Risk O's dependencies and influences for both the mandate and reduced separation initiatives. The safety risk T is added as an influence.

Figure 51. Risk O does not have any dependencies or compound loops. It influences one business concern risk (V) and one safety risk (T).

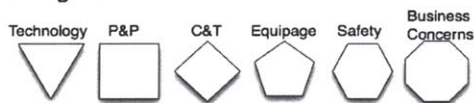
Figure 50: Risk O Direct Dependencies and Influences (Mandate Only)



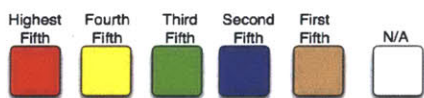
Likelihood



Categories

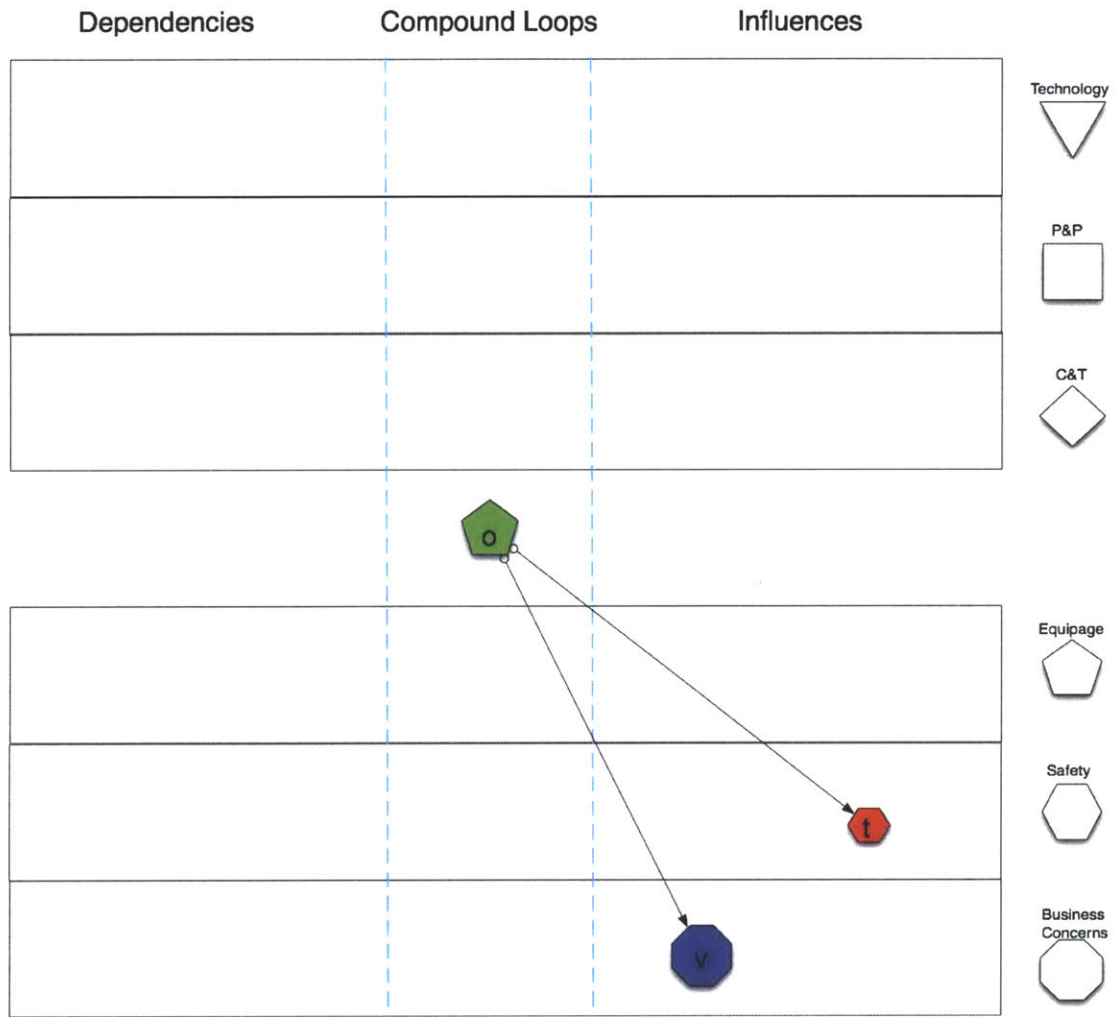


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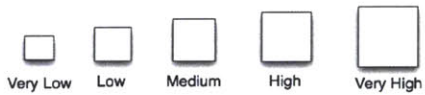


] and reduced separation initiatives. The safety risk T is added as an influence.

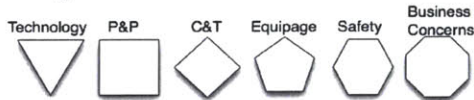
Figure 51: Risk O Direct Dependencies and Influences (Mandate and Reduced Separation)



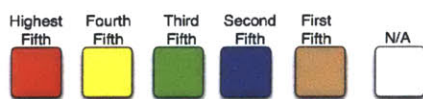
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O4.1 Risk O Direct Influences and Associated Outcomes

Risk O has two direct influences shown in Table 74. The influential outcomes of Risk O are a new satellite protocol that would require a many aircraft to buy new data link equipment, and a temporary reduction in the number of equipped aircraft operating in the North Atlantic.

Risk O can influence the safety risk T (Failure to meet safety case for 25 NM lateral separation) with both of its outcomes. First, the new satellite protocol, although intended to outperform the classic aero services, may harm the safety case for 25NM lateral after 2015 if it does not meet the communication standard implemented at that time. Second, the temporary reduction in the number of equipped aircraft inherently reduces the level of safety because more network stress will be put on the High Frequency Voice (HF) network.

Risk O can influence the business concern risk V (High costs preventing operators from retrofitting to meet requirements for data link mandate and 25NM lateral reduced separation) by increasing the costs needed to comply with the data link mandate and 25NM reduced separation initiatives. The costs would come from the cost of the new transmission equipment needed aboard the aircraft, and the cost associated with installing the equipment.

Table 74: Risk O Direct Influences

| | |
|--------|---|
| Risk T | Failure to meet safety case for 25 NM lateral separation (Feasibility analysis may find that better performance is needed. Actual performance may not meet feasibility analysis expectations) |
| Risk V | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25NM lateral reduced separation. |

O.5 Mitigation

The mitigation difficulty for Risk 0 is listed in Table 75. The respondents indicated a very low difficulty of detection. The satellite providers would need to notify operators with sufficient time to get them to convert to their new service offering. The respondents gave both the corrective action difficulty and the coordination difficulty a “high” rating. They noted that it was risky for ICAO to mandate satellite based data link without any control over the satellites themselves. In particular ICAO is not in a position to enforce satellite availability requirements or the pricing of service plans. Any corrective action would result in the satellite provider changing the policy of stopping Classic Aero Services. The difficulty is that the satellite provider has no regulatory or financial incentive to change the policy. The respondents listed the likelihood as high. They did not see a reason why the satellite provider would change the policy in 2016 and felt that all aircraft using the I3 satellites would need to undergo the costly upgrades and switch to Swift Broadband.

Table 75: Risk 0 Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Very Low | High | High | High |

P.0 Description

Risk P is a technology risk described as “Uncertainty in approval of Iridium-based equipage to meet requirements for data link mandate and 25NM reduced lateral separation”. The Iridium satellite is a new satellite that has recently entered service as part of a larger constellation. It is currently undergoing flight tests with aircraft to ensure that the satellite meets the communications requirements for the data link mandate and 25NM reduced lateral separation. Some aircraft are already equipped with Iridium based equipage and could face costly re-equiping with a different satellite service if the Iridium satellite doesn’t meet the requirements.

P.1 Background

The Iridium satellite service is a low earth orbit satellite constellation that was recently put into orbit. The service uses a lighter transmitter and lower service fees than the competing Inmarsat service because Inmarsat is a Geosynchronous satellite where as Iridium is a Low Earth Orbit Satellite. The testing for Iridium will ensure that the new satellites meet the requirements for both the data link mandate and 25NM lateral separation. The satellites were designed to the same specifications as the satellites that are currently servicing 30NM-30NM separation in the Pacific region because the requirements are identical to those for 25NM lateral separation. The operators are currently equipped or purchased equipment with Iridium face the risk of having to re-equip with a different satellite service and a different transmitter if the Iridium satellites do not meet the requirements. There are substantial costs with replacing a transmitter, including a weight penalty for the heavier Inmarsat transmitter.

P.2 Root Cause: Insufficient technical performance

Risk P has a single root cause: insufficient technical performance of the Iridium based satellite service. The final verification of the performance of Iridium can only occur through flight-testing so the financial investments had to be made with some level of uncertainty. The respondents did indicate that the first flight tests went well and that some operators had already received authorization to use Iridium in data link operations. They also indicated that the Iridium company has ordered new spacecraft in 2014 to replace the current aircraft and upgrade the network.

P.3 Impact on Stakeholder Value Metrics

The impact of Risk P on the stakeholder value metrics according to respondents is given in Table 76.

Table 76: Risk P Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | High | None | None | High | Very High |

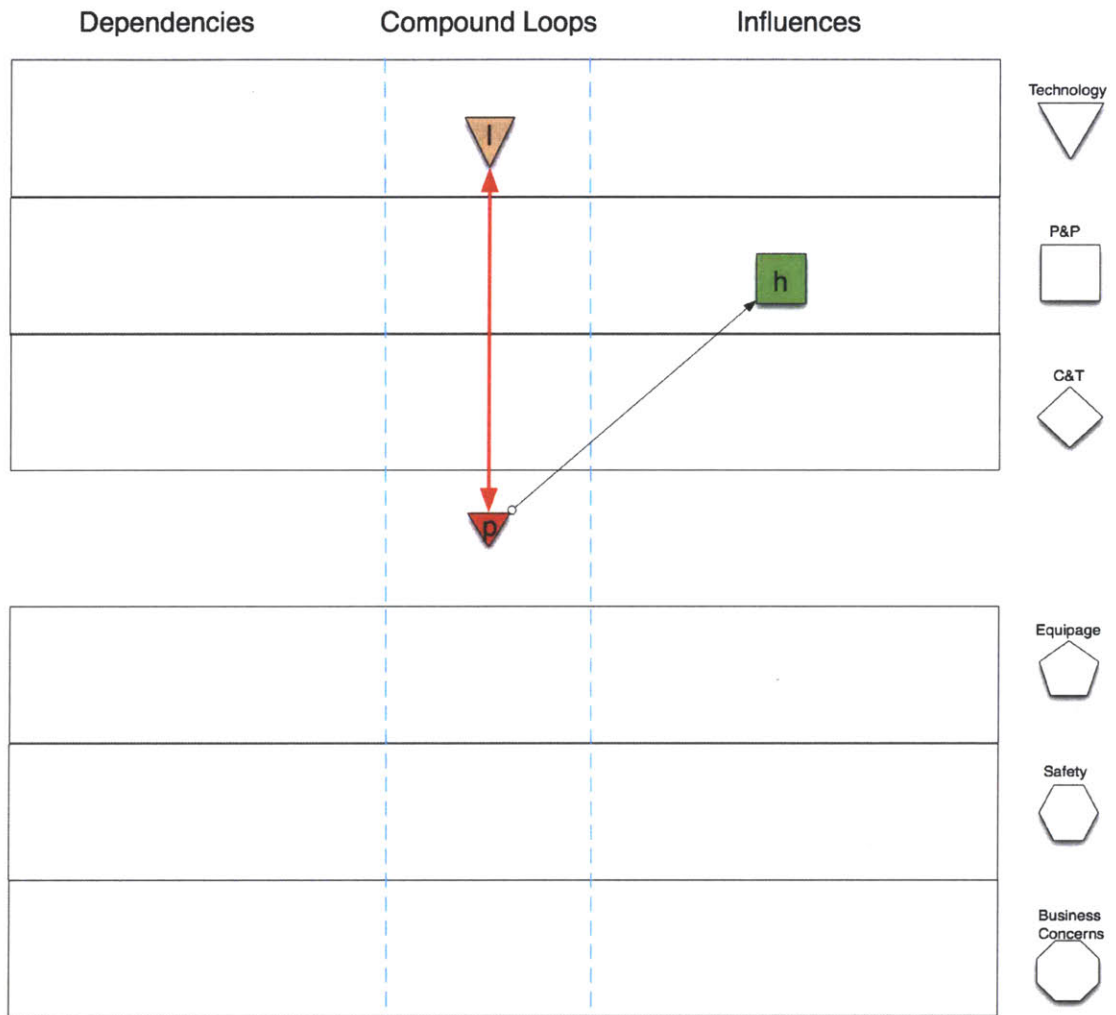
The respondents indicated a low impact to safety. Risk P can impact safety if the number of equipped aircraft goes down while Iridium equipped aircraft re-equip with a different satellite service. The respondents indicated a high impact to operational efficiency. Operational efficiency can be impacted by a reduction and in the number of the equipped aircraft, and by the complications an operator would face in having to switch satellite services. Other satellite services high heavier transmitters and the equipment costs for both services are substantial. The time needed to re-equip could also be substantial. During that time, the operators would have to yield to the restrictions for unequipped aircraft. The respondents also indicated a high Operator Cost impact. The operator costs would also be impacted by the cost of reequipping with a different satellite service, and extra fuel needed to carry the heavier transmitters. The impact to Operator Revenues was indicated as very high. In some cases with short-range aircraft such as the A318, the heavier transmitters are too heavy and will keep the aircraft from completing its North Atlantic missions. The respondents did not indicate an impact to ANSP costs or ANSP revenues.

P.4 Dependencies and Influences

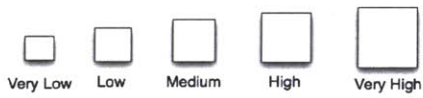
The dependencies and influences for Risk P are shown in Figure 52, and Figure 53 shows Risk P's dependencies and influences for both the mandate and reduced separation initiatives. There are no additional risks present when reduced separation initiatives are considered however Risk P's aggregated impact relative moves from the highest fifth to the fourth highest fifth.

Figure 53. Risk P has one compound loop with a technology risk and influences one policy and procedure risk.

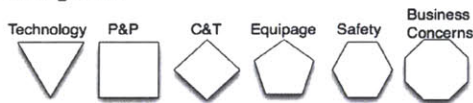
Figure 52: Risk P Direct Dependencies and Influences (Mandate Only)



Likelihood



Categories



Impact

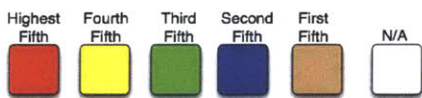
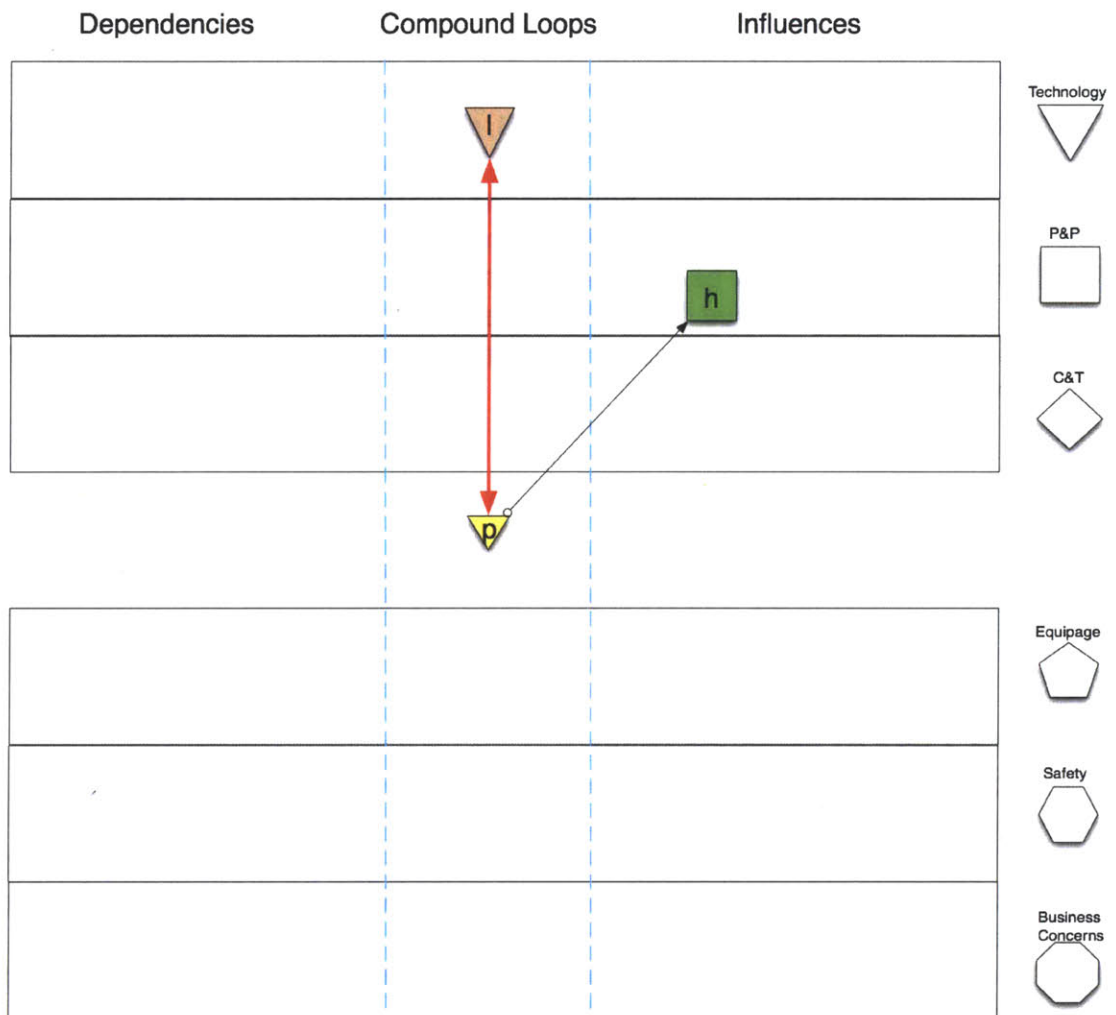
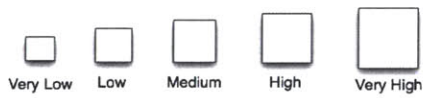


Figure 53 shows Risk P's dependencies and influences for both the mandate and reduced separation initiatives. There are no additional risks present when reduced separation initiatives are considered however Risk P's aggregated impact relative moves from the highest fifth to the fourth highest fifth.

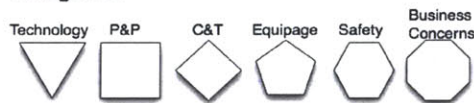
Figure 53: Risk P Direct Dependencies and Influences (Mandate and Reduced Separation)



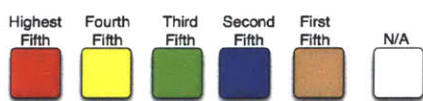
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P.4.1 Risk P Direct Influences and Associated Outcomes

Risk P has one direct influence, Risk H, shown in Table 77. Risk H is a policy risk described as “Restricted access to airspace for unequipped aircraft”. The occurrence of Risk P could influence the likelihood of Risk H if there are significant number of aircraft that were previously equipped with Iridium that would no longer be equipped. The progression of restricted airspace access (Risk H) may be delayed in order to allow the Iridium aircraft to reequip and prevent excessive numbers of unequipped aircraft on restricted routes.

Table 77: Risk P Direct Influences

| | |
|--------|---|
| Risk H | Restricted access to airspace for unequipped aircraft |
|--------|---|

P.4.2 Risk P Compound Loops

Risk P forms one compound loop with the technology Risk L (Failure to establish a plan or go forward with mitigation to meet RCP240) as shown in Table 78. Risk P can influence the occurrence of Risk L if the Iridium satellite can meet a performance standard that works well enough for 25NM reduced lateral separation but does not meet RCP240. Adopting a different performance standard would reduce the cost for operators that are already equipped with Iridium. Conversely, failing to establish a communication standard (Risk L) or changing the communication requirements could make the requirements for Iridium ambiguous and influence the likelihood of Risk P.

Table 78: Risk P Compound Loops

| | |
|--------|---|
| Risk L | Failure to establish a plan or go forward with mitigation to meet RCP240. This also includes failure of ground infrastructure to support to RCP240. |
|--------|---|

P.5 Mitigation

Table 79 shows the reported mitigation difficulty for Risk P. The respondents gave Risk P a low detection difficulty. Insufficient performance of Iridium would be detected during the testing conducted by the Performance-Based Operations and Aviation Rulemaking Committee Communications Working Group (PARC CWG). The respondents listed the corrective action for occurrence of Risk P as “high”. Possible corrective actions include increasing the separation distance, restricting the use of Iridium, and replacing aircraft equipage. All of these corrective actions are difficult to complete because of the cost and coordination that would be needed to execute them. Any changes to the regulations would require approval by the ICAO authorities and a supporting technical analysis. Any changes to the technical requirements would require costly redesigns and could add further delays and long lead times for parts and development. The respondents indicated the coordination difficulty as “high”. Any technical or regulatory changes would require coordination between the ICAO members, the operators and manufacturers. The respondents indicated a medium likelihood. However, one respondent indicated that Iridium already has operational authorization for several Boeing aircraft and that the PARC CWG tests for FANS 1/A were going well.

Table 79: Risk P Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | High | Medium |

Q.0 Description

Risk Q is an equipage risk described as “Failure to achieve percentage of equipped flights needed to move forward with phases of 25NM lateral separation”. Increasing the percentage of equipped flights produces corresponding increases in safety and reductions in the airspace needed for unequipped aircraft. . However, the respondents indicated that there is not an established equipage percentage level that is needed to move on with the phases of 25NM lateral. Also, each phase of the 25NM lateral initiative progressively restricts more airspace for the exclusive use of equipped aircraft. If the percentage of equipped aircraft does not increase sufficiently, then the phases of 25NM lateral separation may need to be delayed until there are enough aircraft that can make use of the increase in airspace.

Q.1 Background

The percentage of equipped aircraft is an important metric that can be used to measure the milestones needed to move forward with 25NM lateral separation. Each progressive phase of 25NM lateral separation reduces the airspace available to unequipped aircraft and increases the airspace available to equipped aircraft. If there is an over allocation of 25NM lateral airspace, unequipped operators could be subject to unnecessary decreases in operational efficiency, and, there would be increases in congestion at the oceanic entry points next to the unequipped flight paths and tracks. However, It is important to progressively increase the airspace 25NM lateral separation so that the increase in operational efficiency and reduction in fuel costs can be realized by the operators that made the initial investments to comply with the data link mandate.

Q.2 Root Causes

The respondents identified three root causes associated with Risk Q. The first is the lack availability of data link equipment for common aircraft. The second is the high cost associated with acquiring the equipment and the aircraft downtime needed to install the equipment. The last is a failure of the data link aircraft to meet the required navigation performance while in service.

Q.2.1 Availability of Equipment

The lack of availability of data link equipment was cited was one of the root causes. Data link equipment may not be available for several reasons including the aircraft systems architecture (glass cockpits are required), insufficient demand from aircraft operators to justify development, or, a lack

of manufacturing capacity. Aircraft that are unequipped will likely face some operating restrictions but if equipment is not available, these aircraft will remain unequipped and the percentage of equipped aircraft will only increase if new aircraft are introduced.

Q.2.2 Cost of Equipment and Installation

The high costs of data link equipment and the installation can prevent operators from having a justifiable business case for equipping. The costs of data link equipment along can exceed \$1 Million dollars depending on the aircraft type and current level of equipage. Additionally, there is a significant cost reflected in the loss of revenue when the aircraft is taken out of service for the installation. These costs can in some cases exceed the resources of the operator and or exceed the expected benefits in fuel burn from operating in preferred airspace. The aircraft’s remaining service life, if it is too short, could also make the costs of equipping unjustifiable.

Q.2.2 Failure to meet RNP Requirements

The 25NM reduced lateral separation procedures have a Required Navigation Performance (RNP) standard that must be met by each aircraft participating in the procedures. The RNP standard is a method of quantifying the probabilistic distance error of the aircraft’s sensed position relative to its actual position and then using that information to safely space aircraft apart from one another. Although an analysis has shown that data link equipped aircraft should be able to achieve the RNP required for 25NM lateral separation, all of the aircraft must achieve it in flight. If there are persistent problems with aircraft not reaching the RNP needed for 25NM lateral, the percentage of equipped aircraft effectively decreases and the phases will likely need to be delayed.

Q.3 Impact on Stakeholder Value Metrics

The impact of Risk Q on stakeholder value metrics according to respondents is given in Table 80.

Table 80: Risk Q Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | Medium/High | Medium | Medium | Medium | None |

The respondents indicated a low impact to safety. Risk Q can impact safety because it represents a decrease in the number of equipped aircraft. The

respondents indicated a high impact to Operational Efficiency. Operational Efficiency can be impacted if the 25NM lateral phases are delayed. Consequently, the respondents indicated a medium impact to Operational Efficiency in a mandate only scenario because of the separation distances wouldn't change but with fewer equipped aircraft, there would be a longer time lag for communications. The standard 60NM procedures are less efficient for the ANSPs because more workload is required to communicate with the aircraft, and for the operators because they cannot enjoy the reduced fuel burn related benefits of 25NM lateral separation. The respondents indicated a medium impact to ANSP Costs. ANSP Costs can be impacted by the cost required to maintain the infrastructure needed to support the original 60NM separation such as HF voice and radio. Although HF voice will likely serve as a backup system for data link, the ANSP staffing needed would increase if the number of equipped aircraft did not reach the percentages needed to move on with the later phases of 25NM lateral separation. The respondents indicated a medium impact to ANSP Revenues. ANSP Revenues can be impacted by any changes in aircraft traffic volume or traffic patterns that result from a failure to achieve the necessary percentage of equipped aircraft to move forward with 25NM lateral separation. If these percentages are not achieved, more aircraft may be forced to "outlier" tracks or other less direct routes which could drive traffic and thus revenue from one ANSP to another. The respondents indicated a medium impact to Operator Costs. Operator Costs can be impacted if operators are forced to fly less optimal routes if less airspace were available for 25NM lateral separation procedures. Flying less optimal routes will increase the fuel burn and thus the fuel cost to the operators. The respondents did not indicate an impact to operator revenues.

Q.4 Dependencies and Influences

The dependencies and influences for Risk Q are shown in Figure 54 and Figure 55. Risk Q has four dependencies, two equipage risks one technology risk, and one coordination and timing risk. It also has one compound loop with a coordination and timing risk.

Figure 54: Risk Q Direct Dependencies and Influences (Mandate Only)

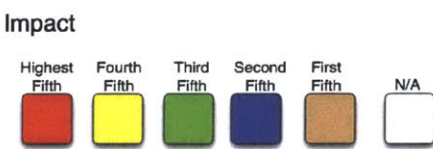
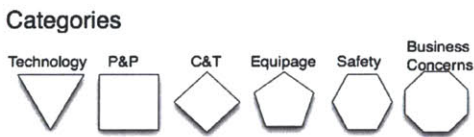
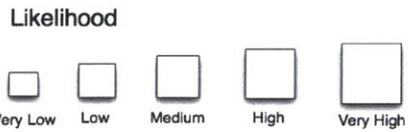
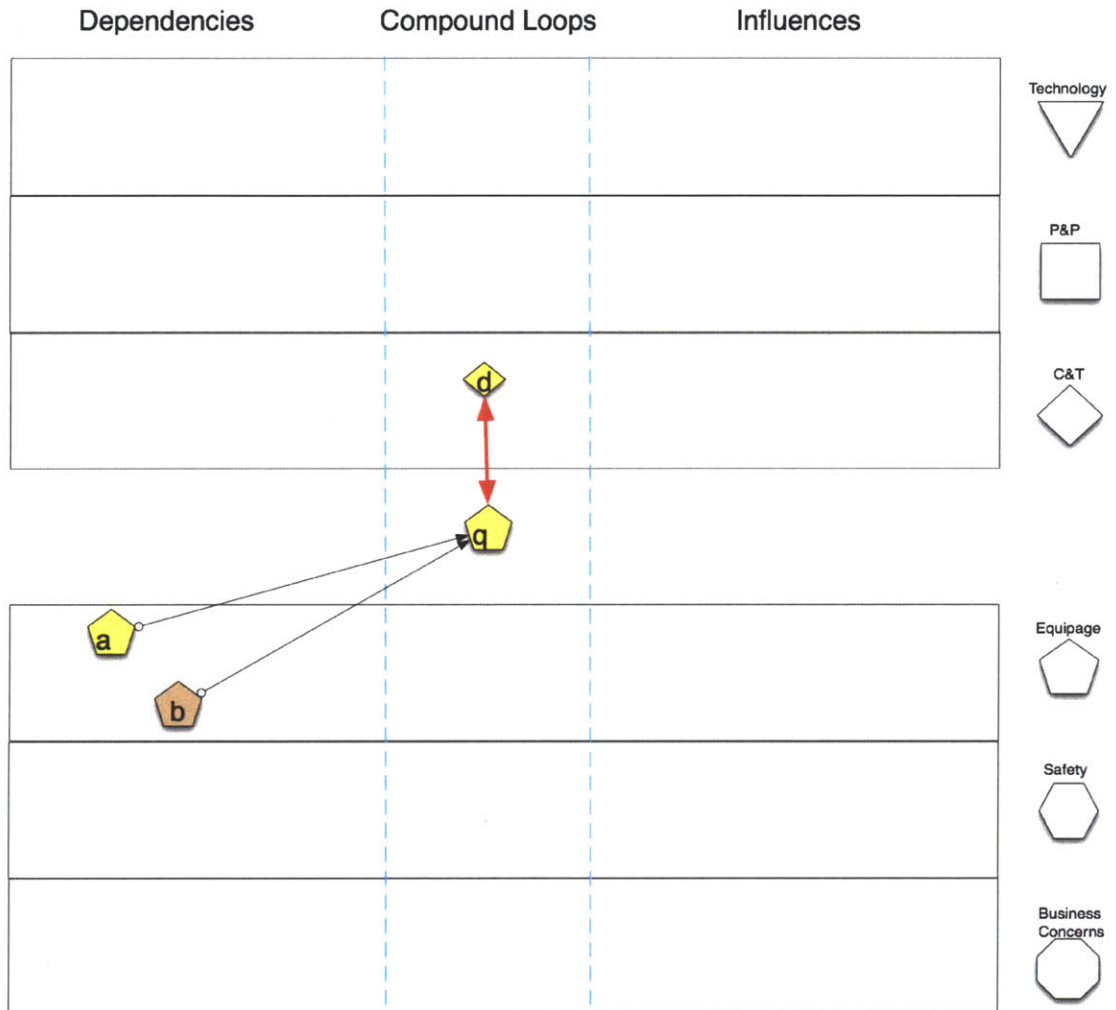
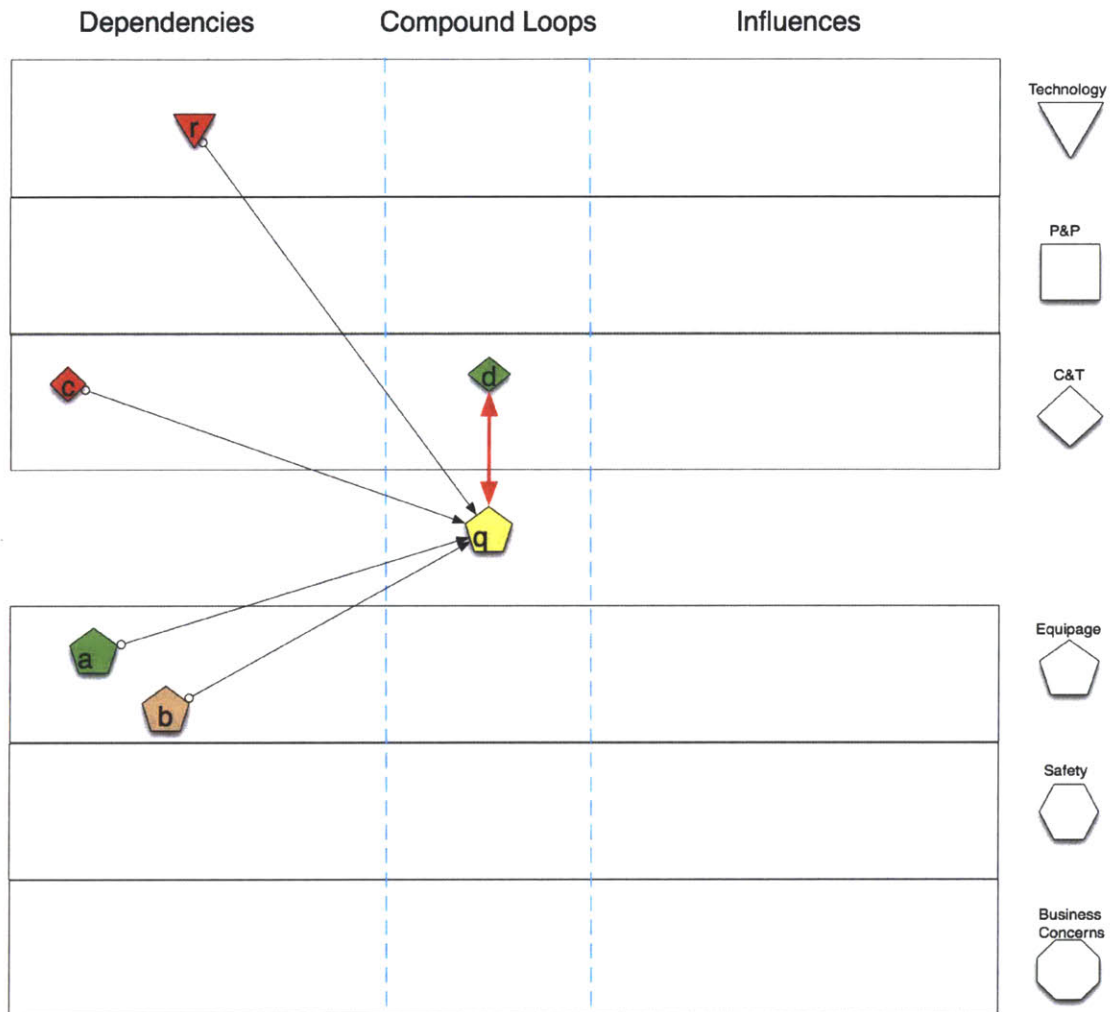
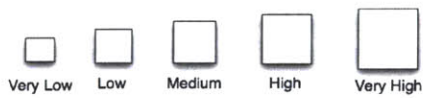


Figure 55 shows Risk Q's dependencies and influences for both the mandate and reduced separation initiatives. The coordination and timing risk C and the technology risk R are added when reduced separation initiatives are considered.

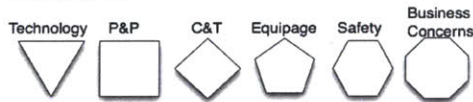
Figure 55: Risk Q Direct Dependencies and Influences (Mandate and Reduced Separation)



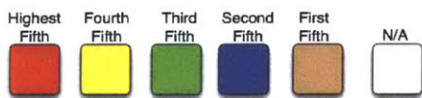
Likelihood



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Q4.1 Risk Q Direct Dependencies

Risk Q has several direct dependencies as shown in Table 81. These dependencies influence the likelihood of Risk Q by influencing barriers to equipping and thus the number of equipped aircraft.

The equipment risks A (Equipage for business operators not available or certified in time to meet mandate) and B (Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand) influence the availability of equipment. Business operators make up approximately 9% of North Atlantic traffic and have different constraints to equipping than commercial operators (see risk Appendices A and B) such as lack of sufficient demand and older system architectures. If equipment for business operators isn't available (Risk A) or, there are delays in delivering the equipment (Risk B), fewer operators will have the opportunity to equip.

The coordination and timing Risk C (ANSPs failure to have automation systems, other technologies or local rulemaking ready for implementation of 25NM reduced separation) can influence an operator's timing in equipping. An occurrence of risk C would force regulators to delay the implementation of 25NM lateral separation in the affected regions because of the insufficient ground infrastructure. In some cases, an affected region could force a delayed implementation in the entire North Atlantic. If the operators are aware of these delays, they may elect to delay equipping or they may instead decide not to equip if the aircraft service life decreases too much during the period of the delays.

The technology Risk R (No ICAO communication, navigation, and surveillance standards available to support implementation of 25NM lateral separation), can delay efforts to equip if the communication equipment requirements change or become uncertain. The aircraft equipment communication requirements specifically were established based on a safety analysis and are identical to the requirement for 30NM-30NM separation in the Pacific Ocean airspace region. Changes in these requirements for any reason, would force equipment manufacturers to make costly and long lead time design changes. The operators may decide not to equip based on the increase in costs or, could decide to significantly delay equipage until the requirements and implementation dates are less uncertain.

Table 81: Risk Q Direct Dependencies

| | |
|--------|---|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand. |
| Risk C | ANSPs failure to have automation systems, other technologies or local rulemaking ready for implementation of 25NM reduced separation. |
| Risk R | No ICAO communication, navigation, and surveillance standards available to support implementation of 25NM lateral separation. |

Q4.2 Risk Q Compound Loops

Risk Q forms one compound loop with the coordination and timing Risk D (Late Completion of data link mandate plan. Not enough time for commercial and business operators to plan to comply with mandate). Risk Q can influence Risk D if it appears that the equipping to a sufficient percentage during current timeline will be infeasible. The regulators may then elect to postpone some of phased implementation or, add incentives to make equipping or complying with the data link mandate easier. Conversely, delaying the data link mandate to make technical changes or other changes may also cause operators to wait to equip, further reducing the percentage of equipped aircraft at a given point in time.

Table 82: Risk Q Compound Loops

| | |
|--------|--|
| Risk D | Late Completion of data link mandate plan. Not enough time for commercial and business operators to plan to comply with mandate (e.g. determination of entire flight level spectrum and OTS tracks where mandate is to be applied) |
|--------|--|

Q.5 Mitigation

Table 83 shows the reported mitigation difficulty for Risk Q. The respondents indicated a low detection difficulty. Detection can be accomplished by taking equipage data from filed flight plans or by surveying operators. However, the respondents indicated that there is not an established equipage percentage level that is needed to move on with the phases of 25NM lateral. The current level of equipage is believed to be around 50%. The corrective action difficulty was indicated as medium. Possible corrective actions include delaying the phased implementation of the mandate to allow more equipment and aircraft to be delivered, and adding more incentives for operators to equip. Several respondents mentioned that harmonizing the implementation dates with the European mandate and, delaying the initiatives to allow specific data link equipment packages to be certified would both reduce costs and allow a higher level of compliance. The coordination difficulty was indicated as high. Any changes to the implementation dates would require coordination and approval ICAO and local rulemaking authorities. The rulemaking process can be time consuming and may require back and forth changes between ICAO and the rule makers. The likelihood was listed as “high”. The respondents felt that the high costs and the short timeline posed significant barriers for operators trying to equip and that the equipage level would likely not rise significantly by the time the mandate is scheduled to take effect.

Table 83: Risk Q Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | Medium | High | High |

R.0 Description

Risk R is a technology risk described as “No ICAO communication, navigation, and surveillance standards available to support implementation of 25NM lateral separation (for example, RNP 4 meets navigation criteria for 30 NM). The communication, navigation, and surveillance standards are needed by ANSPs, equipment manufacturers, and operators so they can create and select mandate compliant equipment. For operators, the uncertainty surrounding the standards for compliance can cause significant delays in cost overruns. An operator may have previously invested in what may become non-compliant equipment or, they may be forced to wait longer for an equipment package with the appropriate upgrades. An occurrence of risk R could also result in necessary delays to the 25NM lateral plan to allow the regulators to complete the full set of standards.

R.1 Background

There are several equipment performance standards that accompany a new set of procedures and separation distances. These standards are there to ensure the appropriate level of safety is maintained while the procedures and separation distances are in use. The equipment manufacturers, operators, and ANSPs all need knowledge of these in advance of their implementation in order to create and acquire compliant equipment and systems. The standards need to be approved by ICAO and local rule makers before they can take effect. The standards may change when new knowledge is gained from flight test and could cause costly design changes and new equipment purchases. Additionally, if the standards are not approved in time, the 25NM lateral reduced separation initiative will need to be delayed.

R.2 Root Causes

The respondents identified several root causes occurrence of Risk R. Unexpected results from the safety analysis and/or flight tests could force the development of new performance standards or significant changes to the procedures. The respondents cited the absence of higher performance standards such as RNP2 as a root cause for Risk R. These standards would be needed if the current performance standards do not perform well enough in flight test or the supporting analysis. Lastly, poor coordination amongst regulatory authorities such as ICAO and local rule makers was cited as a possible root cause for the occurrence of Risk R.

R.2.1 Unexpected Results from Safety Analysis or Flight Testing

Unexpected results from the various safety analyses and flight tests can force changes to be made to the navigation and communication performance standards and reveal potential flaws within the existing data link infrastructure. The standards could either be relaxed if safety isn't compromised or, entirely new standards may need to be developed. The uncertainty around the standards that can be created after flight tests or a safety analysis can cause an occurrence of Risk R if the standards need to be changed or reconsidered.

R.2.2 Lack of Developed Alternative Performance Standards

The lack of developed alternative performance standards can cause significant delays if they are found to be necessary either in flight-testing or the support safety analysis. The respondents in particular mentioned that the RNP2 or RNP 3.5 standard would need significant development if it is found that the RNP4 standard is not sufficient. The respondents did not comment on the development time that would be needed for a new performance standard but any new standard would need to go through the same analysis and verification processes that are currently used for 25NM lateral separation.

R.2.3 Poor Coordination

Poor coordination between the regulatory authorities, the ANSPs and the groups responsible for the analysis and flight tests can lead to an occurrence of Risk R. The authorities must define the acceptable safety standards, the performance standards that meet the safety standards, and a timeline for implementation. The ANSPs and the operators need enough time to upgrade the infrastructure so the local verification flight tests can be conducted by local rulemakers. All of these tasks are critical and share dependencies between each other. Poor coordination could cause serious delays and cause the occurrence of Risk R.

R.3 Impact on Stakeholder Value Metrics

The impact of Risk R on stakeholder value metrics according to respondents is given in Table 84.

Table 84: Risk R Impact to Stakeholder Value Metrics

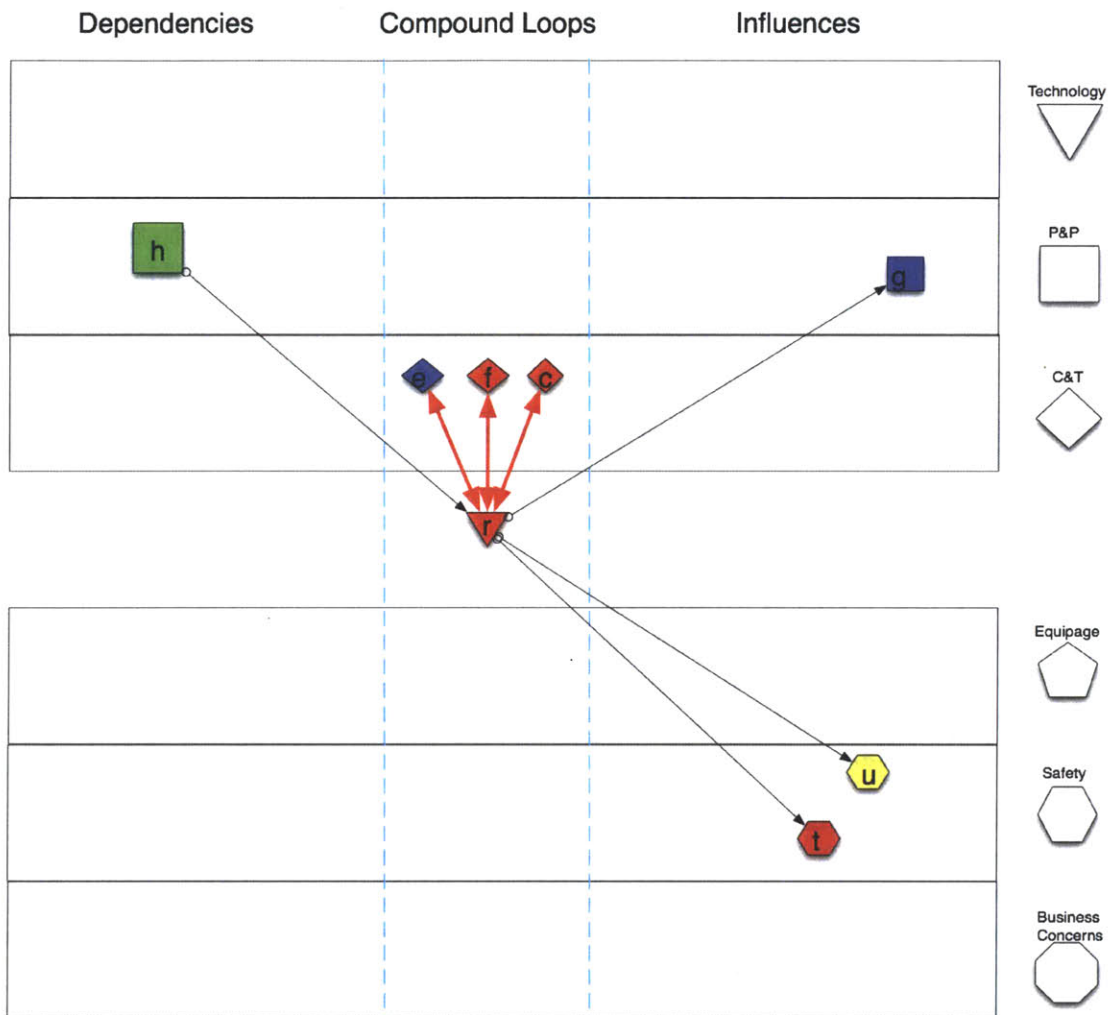
| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | High | Medium | Low | Medium | Medium |

The respondents indicated a low impact to safety. An occurrence of Risk R can impact safety if it results in a decrease in the percentage of CPDLC equipped aircraft operating in the North Atlantic. Without the 25NM lateral standards, operators may consequently choose not to or wait long periods of time before equipping. The respondents also indicated a low impact to ANSP revenues. Revenues can also be impacted by changes in traffic volume that come as a consequence of the occurrence of Risk R. The respondents indicated a high impact to Operational Efficiency. The delay of 25NM lateral implementation represents a substantial impact to operational efficiency because operators that are equipped will not be able to realize the 25NM lateral efficiency gains such more use optimal tracks, faster climb times, and smaller separation distances. Risk R can cause a delay to 25NM lateral because the standards are need to be set before 25NM lateral can be implemented. The respondents indicated Risk R would have a medium impact to both ANSP Costs and Operator Costs. The impact to costs can come if the standards are changed after equipment has been purchased. ANSPs must purchase ground equipment and Operators must purchase aircraft equipment. All of the equipment must work together to achieve the navigation and performance standards so there will be some uncertainty remaining until the final flight tests have been completed. In some cases, new standards may need to be developed and in these cases, it is more likely that new navigation or communications equipment will need to be developed or purchased. One respondent mentioned the RNP2 as an undeveloped standard that could cause such changes if RNP4 performance standard does not meet the safety standard in practice. Lastly, the respondents indicated a medium impact to Operator Revenues. Operator Revenues can be impacted if the North Atlantic reaches capacity constraints due to the delay of 25NM lateral from Risk R, and the positive growth in traffic. Operators may have to decrease or hold back on planned increases in service until the standards are set and 25NM lateral is implemented.

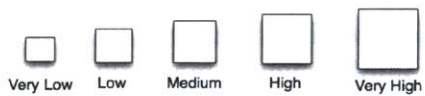
R.4 Dependencies and Influences

The dependencies and influences for Risk R are shown in Figure 56. Risk R has one dependency with a policy and procedure risk. It also has three compound loops, all with coordination and timing risks and influences three risks, one policy and procedure risk and two safety risks.

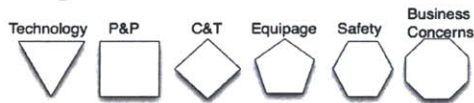
Figure 56: Risk R Direct Dependencies and Influences (Reduced Separation)



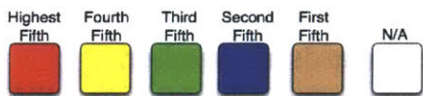
Likelihood



Categories



Impact



R4.1 Risk R Direct Dependencies

As shown in Table 85, Risk R has one direct dependency with Risk H, a policy and procedure risk described as “Restricted Access to airspace for unequipped operators. Risk H can influence the occurrence of Risk R because the distances between the airspace of equipped and unequipped aircraft are in part a function of the required navigation performance. The desired restrictions could in add an unforeseen requirement to the 25NM lateral RNP standard that could delay the approval of the 25NM lateral performance standards.

Table 85: Risk R Direct Dependencies

| | |
|--------|---|
| Risk H | Restricted Access to airspace for unequipped aircraft |
|--------|---|

R4.2 Risk R Direct Influences

Risk R has three direct influences as shown in Table 86. The influential outcomes of Risk R are a lack of performance standard definitions for navigation performance communication performance and RNP standards, a of surveillance standards.

Risk R can influence the policy and procedure risk G (Failure to develop measures to accommodate unequipped aircraft) if the navigation and communication standards are not in place. The navigation and communication standards are needed to analytically evaluation and set safe operating boundaries between the airspace for equipped an unequipped aircraft.

Risk R can influence the safety risk U (Failure to control vertical risk when 25 NM lateral separation is implemented) if the 25NM lateral standards are undefined or are not enforced and followed. While it is unlikely that 25NM lateral could be implemented without a complete performance standard definition, the vertical risk probability does depend on all of the aircraft’s abilities to maintain those standards.

Risk R can influence the safety risk T (Failure to meet safety case for 25 NM lateral separation) because the safety case cannot be evaluated without a standards definition to test against. Additionally, failure to meet the standards once 25NM lateral is implemented can cause an occurrence of Risk T, or, non-definition of the performance standards all together.

Table 86: Risk R Direct Influences

| | |
|--------|---|
| Risk G | Failure to develop measures to accommodate unequipped aircraft |
| Risk U | Failure to control vertical risk when 25 NM lateral separation is implemented |
| Risk T | Failure to meet safety case for 25 NM lateral separation (Feasibility analysis may find that better performance is needed. Actual performance may not meet feasibility analysis expectations) |

R4.3 Risk R Compound Loops

Risk R forms three compound loops as shown in Table 87.

Risk C represents a failure of ANSPs to have automation systems ready. ANSPs may need to implement new software and hardware depending on standards. An occurrence of risk R (lack of standards) would complicate this effort and likely result in an occurrence of Risk C because ANSPs won't have the requirements necessary to procure compliant equipment. Conversely, local rulemaking can reveal changes that need to be made the standards which could complicate ANSP readiness and then result in an occurrence of Risk R.

Risk E is a coordination and timing risk represents a failure of ANSPs to coordinate with each other. The performance standards are needed by the ANSPs to properly tune the software that assists air traffic controllers and to ensure their hardware can meet the target level of performance specified in the standards. Not having these standards (Risk R) can prevent the secondary coordination steps from taking place. Conversely, the ANSPs need coordinate with each other before the standards are defined to ensure that the enroute procedures and hand off procedures are compatible and don't constrain the standards. If an ANSP does submit an unforeseen constraint on the performance standards during rulemaking or another process, the standards may not be fully defined when 25NM lateral is scheduled to be implemented.

The 25NM lateral performance standards that are encompassed in Risk R are needed for rulemaking and a failure to complete them quickly enough would result in the occurrence of risk F. Conversely, the results from the local rulemaking process in each region could influence and update these standards causing Risk R to occur.

Table 87: Risk R Compound Loops

| | |
|--------|---|
| Risk C | ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation (e.g. ensuring that deviations from norm are captured quickly, etc.) |
| Risk E | Failure to achieve effective coordination with other ANSPs (harmonization of technical systems and operating methods) |
| Risk F | Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe |

R.5 Mitigation

Table 88 shows the mitigation results for Risk R. The respondents gave risk R a “low” detection difficulty because the ICAO standards are published and the ANSPs and operators participate in the process for creating the standards. The respondents indicated a “High” corrective action difficulty. Possible corrective actions include creating new standards, relaxing the standards, and delaying 25NM lateral implementation to finish creating the standards. Any changes to the standards will need to go through the analysis processes that are completed by the NAT Planning groups, possible equipment fixes, and flight tests. Delaying the implementation of 25NM lateral can have implications on equipage levels if operators choose to wait

longer to equip or need to change their equipment. Additionally, delaying the initiatives could complicate efforts to harmonize CPDLC procedures throughout the world while other competing standards are implemented. The respondents indicated a “Very High” rating for the coordination difficulty of Risk R. All of the corrective actions would require extensive coordination between the ANSPs, Operators, ICAO planning groups and local regulatory authorities because each stakeholder has tasks that are dependant on the tasks of other stakeholders being completed. The respondents indicated a medium likelihood for Risk R. They noted that while the flight testing and analysis supporting the current performance standards is moving forward, there was still a possibility for a change in the navigation standard to RNP2 and a change the communication standard back to RCP400.

Table 88: Risk R Mitigation

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | Very High | Medium |

S.0 Description

Risk S is a coordination and timing risk described as “Late completion of 25NM lateral separation planning tasks”. The 25NM lateral planning tasks including setting rules, standards, implementation dates, and completing the supporting flight testing and economic and safety analysis. These tasks are critical to the implementation and safe execution of the 25NM lateral separation procedures. The regulators (ICAO and local rulemakers) will need all of these tasks to be completed before they can approve 25NM lateral separation procedures. The operators need the tasks to be completed as soon as possible in order to plan compliance tasks with long lead times such as acquiring new equipment or aircraft, and scheduling equipment installation on existing aircraft. Without the completion of all of these tasks, the implementation is likely to be delayed and the uncertainty around the implementations dates and equipment standards could generate prohibitive and substantial cost overruns.

S.1 Background

There are several critical planning tasks that must be completed before new air traffic policies or procedures are introduced. These tasks include completing implementation timelines, performing supporting safety and economic analysis, and setting standards for equipment, communications, and procedures. The implementation timelines drive purchasing and other economically significant decisions such as installation and aircraft scheduling. If the timelines conflict with initiatives in other regions, or the available equipment and economic resources, then the operators could be put in a position to endure significant delays in compliance and cost overruns. The safety and economic analysis are needed to set the technical requirements for the equipment, the operating procedures for the aircraft, and to properly implement the policy in a way that will not cause undue economic burdens. As with timing, there can be significant cost overruns and delays if the analysis are not completed before the regulations are determined. Lastly, the operating procedures determined, and verified before the final regulations are put into place. In many cases, the economic investments will need to be made with enough lead time and with a low risk. Flight testing is the last place that significant technical changes could present themselves before the regulations are approved. Flight testing is also the last risk reduction measure and its successful completion can drive the purchasing the decisions for operators. There must be enough lead time allowed between the flight tests and implementation to allow the possible changes to be made to the regulations and to allow the operators to purchase and install compliant equipment. These planning tasks require a deep level

of coordination between stakeholders such as aircraft operators, regulatory authorities such as ICAO, the European Union, and local rulemakers, and aircraft and equipment manufacturers such as Boeing, Airbus, Honeywell, Bombardier, and Gulfstream.

S.2 Root Causes

The respondents identified several root causes for Risk S. Delays in modifying the air traffic control software and hardware and training new personnel can cause delays to 25NM lateral implementation because all of the ANSPs must be ready before implementation can take place. Additionally, poor coordination between ICAO and the ANSPs was also listed as a root cause. The supporting analysis that determine the appropriate performance criteria (navigation, and communication) for the equipment must also be completed with enough lead time to allow the manufactures to make deliver and install compliant equipment. Any changes to the anticipated to the criteria can be a root causes if the changes require a substantial amount of time to comply with. Lastly, any delays in the local authorities' granting of permission of the ICAO standards and procedures for 25NM lateral separation, could also create delays. Some rule makers require their own independent safety and flight testing analysis while others will accept the analysis done by ICAO.

S.2.1 Late Completion of ANSP 25NM Lateral Infrastructure

Late completion of the air traffic control infrastructure needed to support 25NM lateral separation could delay other planning tasks and the implementation altogether. The flight tests for performance verification and local rulemaking verification tests need the ground infrastructure to be completed before they can take place. Some ANSP respondents did mention that some hardware and software changes were still taking place. Additionally, the training of personnel must also take place before the verification testing planning tasks can be completed.

S.2.2 Poor ANSP Coordination

Poor coordination between the regulatory authorities, the ANSPs and the groups responsible for the analysis and flight tests can lead to an occurrence of Risk R. The authorities must define the acceptable safety standards, the performance standards that meet the safety standards, and a timeline for implementation. The ANSPs and the operators need enough time and resources to comply with the timeline but can't do so until there is enough certainty with regard to what performance standards will be used. Lastly, the local rulemakers and ICAO regulators must verify the standards work with analysis and flight tests. All of these tasks are critical and share

dependencies between each other. Poor coordination could cause serious delays and cause the occurrence of Risk S.

S.2.3 Late Completion of Supporting Analysis

Late completion of the supporting safety and economic analysis could delay other planning tasks and implementation altogether. The safety analysis is needed to set performance standards which are then used to create equipment and verified in flight test. The economic analysis is needed to set appropriate timelines, incentives, and penalties that accompany the policy change. Late completion of either of these analyses could delay other planning tasks such as performance verification along with an operators’ decision or timeline for equipping.

S.2.4 Changes to Performance and Safety Standards

Unexpected results from the various safety analyses and flight tests can force changes to be made to the navigation and communication performance standards and reveal potential flaws within the existing data link infrastructure. The standards could either be relaxed if safety isn’t compromised or, entirely new standards may need to be developed. The uncertainty around the standards that can be created after flight tests or a safety analysis can cause an occurrence of Risk S if the standards need to be changed or reconsidered.

S.3 Impact on Stakeholder Value Metrics

The impact of Risk S on stakeholder value metrics according to the respondents is given in Table 89.

Table 89: Risk S Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | High | Low | Low | Low | Medium |

The respondents mainly felt that an occurrence of Risk S would very likely delay the implementation of 25NM lateral separation. They indicated that Risk S would likely have a low impact to safety. An occurrence of Risk S can impact safety if it results in a decrease in the percentage of CPDLC equipped aircraft operating in the North Atlantic. If the implementation of 25NM lateral separation procedures is delayed, operators may consequently choose not to or wait long periods of time before equipping. The respondents also indicated a low impact to ANSP revenues. Revenues can also be impacted by changes in traffic volume or traffic patterns that come as a consequence of

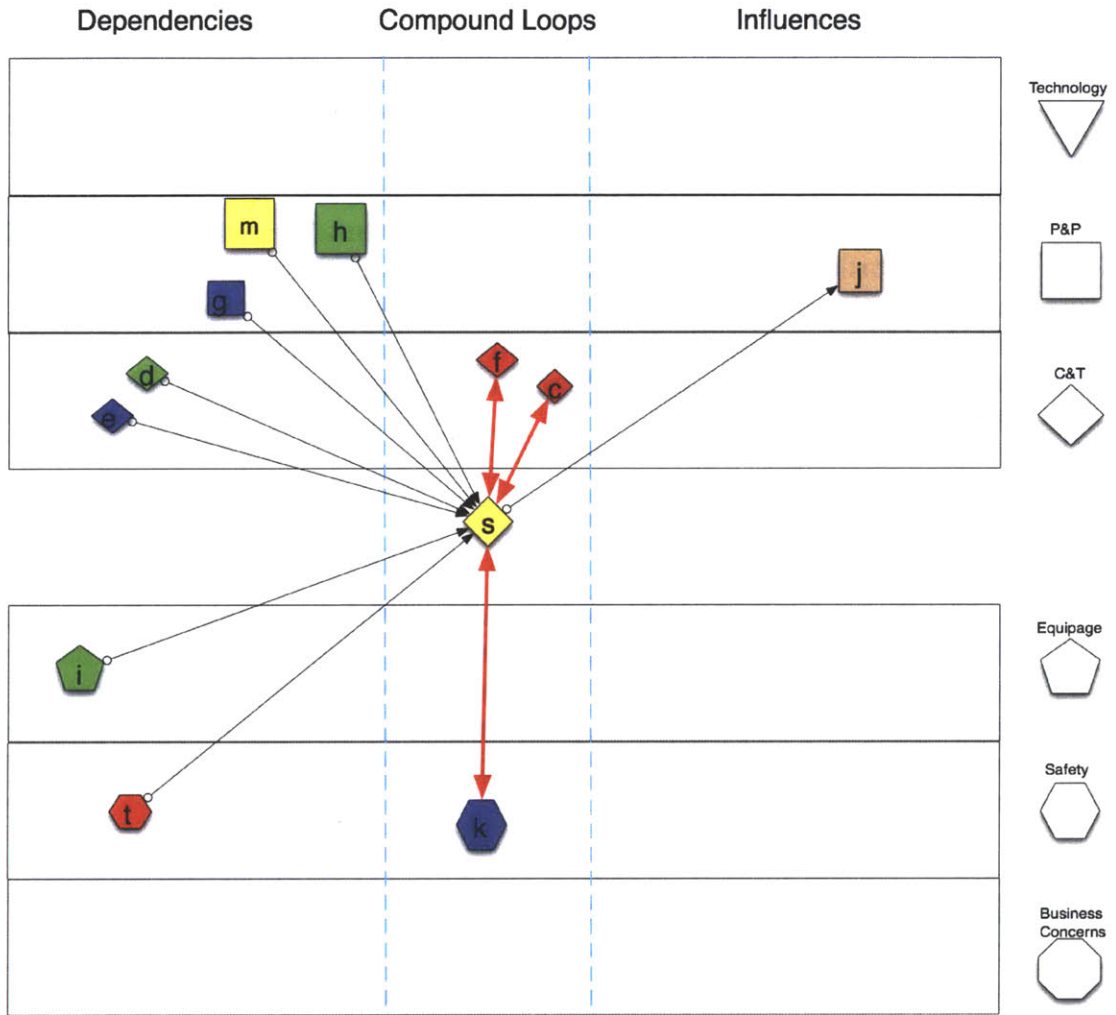
the occurrence of Risk S. The respondents indicated a high impact to Operational Efficiency. The delay of 25NM lateral implementation represents a substantial impact to Operational Efficiency because operators that are equipped will not be able to realize the 25NM lateral efficiency gains such as more use optimal tracks, faster climb times, and smaller separation distances. The respondents indicated a low impact to Operator Costs and ANSP costs. ANSP costs can be impacted if there are increased equipment and staffing associated with a delay to 25NM lateral implementation. If the planning tasks are not complete, the ANSPs may not know their true costs until after the planning delays are over. Similarly, Operator Costs can be impacted by unanticipated costs coming from late planning, and, the fuel burn costs associated with the longer continuation of the current 60NM lateral separation.

Lastly, the respondents indicated a medium impact to Operator Revenues. Operator Revenues can be impacted if the North Atlantic reaches capacity constraints due to the delay of 25NM lateral from Risk R, and the positive growth in traffic. Operators may have to decrease or hold back on planned increases in service until the standards are set and 25NM lateral is implemented.

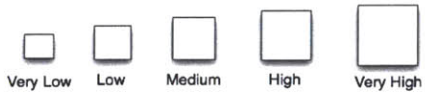
S.4 Dependencies and Influences

The dependencies and influences of Risk S are shown in Figure 57. Risk S has seven dependencies: three policy and procedure risks, two coordination and timing risks, one equipment risk and one safety risk.

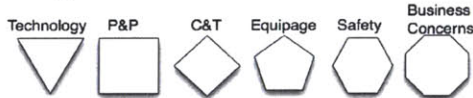
Figure 57: Risk S Direct Dependencies and Influences (Reduced Separation Only)



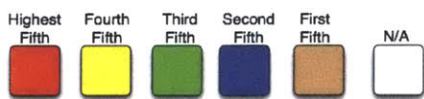
Likelihood



Categories



Impact



S4.1 Risk S Direct Dependencies

Risk S forms many direct dependencies as shown in Table 90. There are three policy and procedure risks, two coordination and timing risks, one equipage risk and one safety risk that are dependencies of Risk S.

The policy and procedure risks G, M, H can influence the likelihood of Risk S if they result in delays to important policy and standards definitions. An occurrence of Risk G (Failure to develop measures to accommodate unequipped aircraft) can effectively reduce or eliminate the airspace that will be available for 25NM lateral operations because unequipped aircraft cannot safely conduct 25NM lateral separation procedures and there may still be a significant number of them that need to operate in the North Atlantic. Risk M (Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT) can result in the difference in data link procedures and communications protocols between Europe and the North Atlantic to go unresolved. While there are exceptions that would allow aircraft to only comply with FANS 1/A until 2015, regulators may elect to wait for the GOLD document to be completed before implementing 25NM lateral. If these efforts are delayed, it could result in an occurrence of Risk S. The outcomes of Risk H (Restricted access to airspace for unequipped aircraft) can result also delay in approval of restrictions and approval restrictions that force unequipped aircraft outside of the OTS and MNPS airspace. Delays in restrictions can influence the timely completion of other restrictions such as those for 25 NM planning tasks (Risk S).

The coordination and timing risks D and E encompass critical time oriented tasks that can influence the occurrence of Risk R by delaying other dependent tasks. The 25NM lateral separation initiatives depend on the readiness of the CPDLDC and ADS-C technology that is required in the datalink mandate plan. If the data link mandate plan is delayed (Risk D), the 25NM lateral planning tasks could also be delayed. Risk E, (Failure to achieve effective coordination with other ANSPs) can cause delays to ANSP coordination tasks such as setting handoff procedures, local rulemaking and participating in ICAO planning tasks. These tasks all need to be completed before 25NM lateral is implemented because they are critical to maintaining the safety and operational efficiency benefits.

The equipage Risk I (Mixed equipage environment during transition) can affect the timely completion of 25NM planning tasks because a certain percentage of equipped aircraft may be required to go forward with the implementation. If the equipage level is too low, regulators may not be able to set aside enough airspace for equipped aircraft or, they may need to spend extra time to plan ways to accommodate unequipped aircraft.

Lastly, the safety risk T (Failure to meet safety case for 25 NM lateral separation) can result in a need to change the navigation and communication performance standards. Changing the navigation standards requires analysis time plus possibly more time for new equipment to be developed, installed, and tested. In effect, an occurrence of risk T could temporarily drive the percentage of equipped aircraft low enough to cause a delay to the implementation of 25NM lateral.

Table 90: Risk S Direct Dependencies

| | |
|--------|--|
| Risk D | Late completion of data link mandate plan. Not enough time for commercial and business operators to plan and comply with mandate (e.g. determination of entire flight level spectrum and OTS tracks where mandate is to be applied, etc.). |
| Risk E | Failure to achieve effective coordination with other ANSPs (harmonization of technical systems and operating methods) |
| Risk G | Failure to develop measures to accommodate unequipped aircraft |
| Risk H | Restricted access to airspace for unequipped aircraft |
| Risk I | Mixed equipage environment during transition |
| Risk M | Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT |
| Risk T | Failure to meet safety case for 25 NM lateral separation (Feasibility analysis may find that better performance is needed. Actual performance may not meet feasibility analysis expectations) |

S4.2 Risk S Direct Influences

Risk S can influence the policy and procedure risk J (Operators choosing to operate in areas where other types of surveillance are provided) as shown in Table 91 if the planning tasks don't incorporate alternative measures for unequipped aircraft. Increasing amounts of airspace are scheduled to be set aside for CPDLC equipped aircraft in the phased implementation of 25NM lateral. If in the last phase when all MNPS airspace is set aside for equipped aircraft, measures to equip unequipped aircraft aren't developed, then unequipped operators will likely have to resort to flying to areas with radar coverage.

Table 91: Risk S Direct Influences

| | |
|--------|---|
| Risk J | Operators choosing to operate in areas where other types of surveillance are provided |
|--------|---|

S4.3 Risk S Compound Loops

Risk S forms three compounds loops that are listed in Table 92, two in the coordination and timing category and one in the safety category. Risks C (ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation) and F

(Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe) are high impact coordination and timing risks. The ANSPs depend on ICAO standards definitions (Risk C) to procure automation systems and other technologies in support of new procedures. A failure to define these standards could create delays in procuring the equipment and would represent an occurrence of risk C and risk F because the local rulemaking cannot proceed until a standards definition is in place. Conversely, the standards do need to be flight tested to satisfy local rulemaking requirements. A failure to have the systems ready for testing could delay other planning tasks and represent an occurrence of Risk S.

The safety risk K (Increased traffic in MNPS routes other than OTS routes) can occur if an occurrence of Risk S results in the incompleteness of planning tasks for handling unequipped aircraft. Conversely, because 25NM lateral is undergoing a phased implementation, the increase in traffic in MNPS routes (risk K) can slowly build to a point where congestion and safety concerns arise. A failure to address these concerns could then result in an occurrence of Risk S if further planning tasks are needed for unequipped aircraft.

Table 92: Risk S Compound loops

| | |
|--------|---|
| Risk C | ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation (e.g. ensuring that deviations from norm are captured quickly, etc.) |
| Risk F | Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe |
| Risk K | Increased traffic in MNPS routes other than OTS routes |

S.5 Mitigation

The mitigation difficulty for Risk S is shown in Table 93. The respondents gave risk S a low detection difficulty. Any changes in procedures are

published by ICAO and sent to operators and ANSPs. These changes would include any changes to the implementation dates for 25NM lateral separation so a change (Risk S) would not be difficult to detect. The respondents listed the corrective action as high. If the 25NM lateral initiatives are delayed, possible corrective actions include pushing back the mandate timelines to give operators more time to comply, implementing the procedures on fewer tracks in the Oceanic Tracking System (OTS), or harmonizing the dates and procedures with the European Mandate. The respondents indicated a “very high” rating for the coordination difficulty of Risk S. All of the corrective actions would require extensive coordination between the ANSPs, Operators, ICAO planning groups and local regulatory authorities because each stakeholder has tasks that are dependant on the tasks of other stakeholders being completed. The respondents indicated a high likelihood for Risk S. They noted that while the flight testing and infrastructure tasks were going well, conflict resolution with the European mandate and finalizing the restrictions for unequipped aircraft are tasks that still need to be completed.

Table 93: Risk S Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | Very High | High |

T.0 Description

Risk T is a safety risk described as: Failure to meet safety case for 25 NM lateral separation (Feasibility analysis may find that better performance is needed. Actual performance may not meet feasibility analysis expectations). The safety case for 25NM lateral includes many system level performance specifications including those for communication availability, navigation precision and many others. The equipment performance standards are initially evaluated against the safety case analytically, tested live in flight test, and then monitored while the new procedures are in operation. If the safety case is not met, it may be necessary to implement new performance standards or suspend 25NM lateral procedures.

T.1 Background

The safety case for new procedures serves as a check to ensure the desired level of safety can be met and is being met. The respondents indicated that much of the analytical or simulation based safety case for 25NM lateral has already been evaluated against the current performance standards with the follow up flight tests taking place soon. After the 25NM lateral procedures have been approved by ICAO, it will be more difficult make changes and the most feasible corrective action for persistent safety case violations would be to suspend the 25NM lateral operations. If the safety case is violated before 25NM lateral is implemented, the system performance standards can be changed. These changes could then possibly result in costly equipment changes.

T.2 Root Causes

The respondents identified two root causes associated with Risk T. The first root cause is a failure of the performance standards to satisfy the safety case. Such a failure would be detected during an analytical analysis or simulation. The second root cause was described as a failure of the equipment in meeting the performance standards that were used to satisfy the safety analysis.

T.2.1 Performance Standards don't satisfy safety case

The performance standards can fall short of satisfying the safety case either in flight test or during the analytical simulations used to verify the performance standards. One respondent indicated that RNP4 on its own did not satisfy the safety requirements in the simulations and that RNP 3.5 or RNP2 might need to be developed. The respondent also noted that the simulation did not consider containment at 2*RNP 4 or 8 NM at 10^{-5} or the communication (CPDLC/RCP 240) and surveillance (ADS-C/type 180) to augment the

navigation performance. GNSS may be used as an alternate requirement but it is technology based and not performance based.

T.2.2 Equipment doesn't meet Performance Standards

Operational and technical navigational errors that occur in flight are continuously monitored and evaluated by ICAO and local rulemakers. Technical errors are errors that are caused by either malfunctioning or low performing equipment. Exceeding the required navigation precision envelope would be one such error. Operational errors are human errors made by either ANSPs, pilots or other technical persons that help process flight plan changes. These errors reduce the level of safety because they effectively increase the probability of a collision. These errors are also counted to evaluate the achieved level of safety in the North Atlantic each year. The 25NM lateral procedures require ½ degree tracks which must be manually interrogated to be verified on some FMC's instead of being verified by visual inspection for 1 degree tracks. If the errors accumulate too quickly during 25NM lateral operations, regulators may conclude that the vertical risk isn't being sufficiently controlled.

T.3 Impact to Stakeholder Value Metrics

Table 94 shows the impact of risk T on stakeholder value metrics.

Table 94: Risk T Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Medium | High | Medium | Low | Low | Medium |

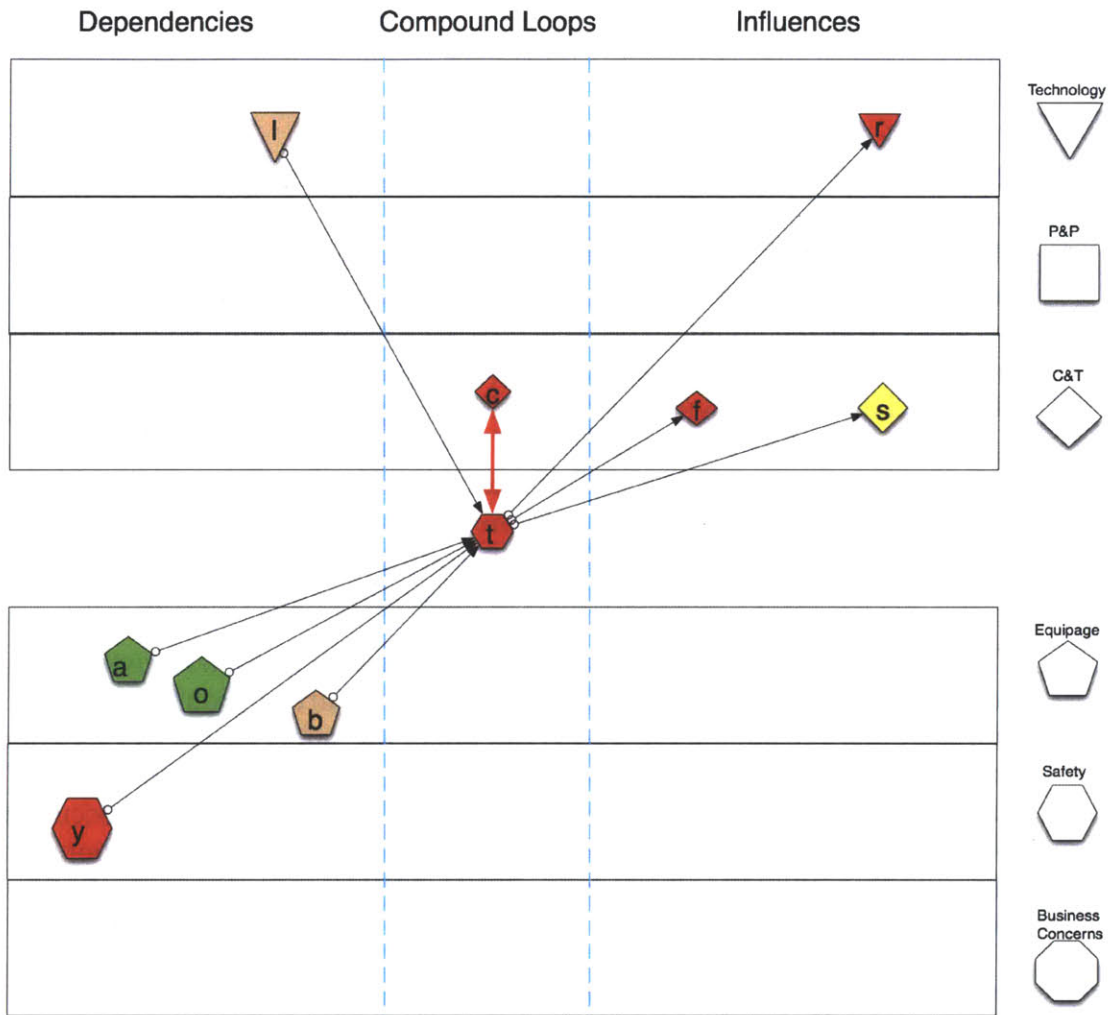
The respondents indicated a medium impact to Safety. Safety would be impacted if the safety case is violated during 25NM operations. The degree of the impact would depend on how often operational (human errors) or technical errors (low equipment performance) occur. The respondents indicated a high impact Operational Efficiency. Navigation Errors that cause safety case violations can cause other aircraft to be rerouted, change speed, or make evasive maneuvers. Additionally, if the safety case is violated, 25NM lateral procedures may be suspended along with the corresponding efficiency gains. The data link mandate however, should not be affected by a suspension of 25NM lateral operations. The respondents indicated a medium impact to ANSP costs. ANSP costs can be impacted if ANSPs need to add new equipment or staffing in order to improve the overall safety performance during 25NM lateral separation. The respondents indicated a low impact to ANSP Revenues. ANSP Revenues can be impacted if the traffic

patterns change as a result of a safety case violation: either from a suspension or delay of 25NM lateral operations, or from regulated changes to the 25NM lateral airspace. The respondents indicated a low impact Operator Costs. Operator Costs can be impacted if 25NM lateral is suspended or delayed because the operators may not be able to be realized the anticipated efficiency gains associated with the new procedures. The respondents indicated a medium impact to Operator Revenues. Operator Revenues can be impacted if the 25NM lateral is delayed and capacity limits for North Atlantic Operations are reached. Operators may not be able to carry planned additions to service or may even be forced to reduce existing service.

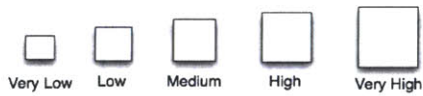
T.4 Dependencies and Influences

The risk dependencies and influences of Risk T are shown in Figure 58. Risk T is a 25NM lateral only risk, has one technology risk dependency, three equipage risk dependencies, and one safety risk dependency. Risk T also influences two coordination and timing risks, one technology risk, and forms one compound loop with a coordination and timing risk.

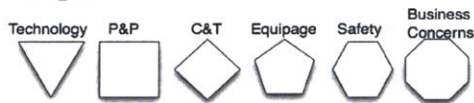
Figure 58: Risk T Direct Dependencies (Reduced Separation Only)



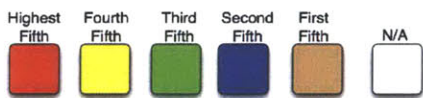
Likelihood



Categories



Impact



T.4.1 Risk T Direct Dependencies

Risk T has three equipage risk dependencies. Risk A (Equipage for Business operators not available or certified in time to meet mandate), Risk B (Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand), and Risk O (End of service life of I3 satellite services expected about 2016. New equipage may be required to use classic aero services via I4 satellites) can all impact CPDLC equipage levels in the North Atlantic. Equipage levels can fall if equipment is not available (Risks A and B) or if satellite service is reduced for some existing aircraft (Risk O). If the equipage levels fall, the level of safety outside of 25NM lateral airspace is also reduced because it increases in the communication delay with the HF system. The occurrence of risk T will be affected if these equipage levels fall below the necessary threshold level to implement 25NM lateral.

The technology risk L (Failure to establish a plan or go forward with mitigation to meet RCP240. This also includes failure of ground infrastructure to support RCP240) can affect the safety case if RCP240 does not satisfy the safety standards in simulation or if the ground equipment cannot satisfy RCP240 after it is established. Risk L can cause an occurrence of Risk T in the simulation stage or in the flight test stage. One respondent did note that RCP240 is in place for 30NM-30NM separation in the Pacific region.

An occurrence of the safety risk Y (HF system may not be able to handle future air traffic levels as a backup system) can jeopardize the safety case during 25NM lateral separation. In the event of a ground station or satellite failure, all operators and ANSPs using data link will need to revert to the HF system which can handle fewer messages at a time, and takes longer to exchange messages between pilots and air traffic controllers. If the HF system can't handle the increases in network load from 25NM lateral, then the level of safety would fall and operators would need to rely on on board equipment to prevent collisions until air traffic controllers can increase their separation back to a level where HF can meet the safety constraints.

Table 95: Risk T Direct Dependencies

| | |
|--------|---|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand |
| Risk L | Failure to establish a plan or go forward with mitigation to meet RCP240. This also includes failure of ground infrastructure to support RCP240 |
| Risk O | End of service life of I3 satellite services expected about 2016. New equipage may be required to use classic aero services via I4 satellites. |
| Risk Y | HF system may not be able to handle future air traffic levels as a backup system. |

T.4.2 Risk T Direct Influences

The direct influences of risk T are shown in Table 96. An occurrence of Risk T can result in a failure to satisfy the safety case for 25NM lateral ether in simulation or in flight testing. These two outcomes can influence one technology risk and two coordination and timing risks.

Both outcomes of Risk T can influence the technology risk R (No ICAO communication, navigation, and surveillance standards available to support implementation of 25NM lateral separation). If the safety case is not satisfied during simulation, the ICAO standards for 25NM lateral may need to be changed and will remain uncertain. If the safety case is not satisfied in flight test, the standards may need to be changed along with the ground and aircraft equipment.

Risk T can affect the coordination and timing risks F (Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe) and R (No ICAO communication, navigation, and surveillance standards available to support implementation

of 25NM lateral separation (for example, RNP 4 meets navigation criteria for 30 NM) if the delays in the safety case delay other critical tasks for 25NM lateral implementation. If the equipment fails to satisfy the safety case in the simulation stage, local rulemaking cannot proceed (Risk F) until a new performance standard is set. Local rulemaking may also encompass the flight testing of the approved performance standards. Rulemaking can also be delayed if these flight tests do not prove the equipment is working properly. If the safety case is not satisfied in either the simulation or during the flight tests, other planning tasks must be added to fix the remaining technical issues. Other 25NM planning tasks may need to be delayed (Risk S) such as setting restrictions or unequipped aircraft, until the safety case is satisfied.

Table 96: Risk T Direct Influences

| | |
|--------|---|
| Risk F | Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe |
| Risk R | No ICAO communication, navigation, and surveillance standards available to support implementation of 25NM lateral separation (for example, RNP 4 meets navigation criteria for 30 NM) |
| Risk S | Late completion of 25NM lateral separation planning tasks. |

T.4.3 Risk T Compound Loops

Risk T forms one compound loop with the coordination and timing Risk C (ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation) as shown in Table 97. Risk C can influence the occurrence of Risk T because the ANSPs automation systems are needed to test the equipment to see if the safety case

is satisfied for local rulemaking. Conversely, Risk T can influence the occurrence of Risk C. If the flight tests show that the safety case isn't satisfied, the ANSPs may need to reconfigure their automation systems or other technologies before the implementation of 25NM lateral separation.

Table 97: Risk T Compound Loops

| | |
|--------|---|
| Risk C | ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation (e.g. ensuring that deviations from norm are captured quickly, etc.) |
|--------|---|

T.5 Mitigation

The mitigation difficulty for risk T is shown in Table 98. The respondents indicated Risk T would have low detection difficulty. The safety case is verified in three stages, during simulations, during flight testing, and during operational practice by monitoring aircraft movements. If the safety case isn't satisfied at any of these stages, the ICAO and local rulemaking authorities will be informed and the necessary corrective actions will be taken. The respondents indicated Risk T would have a high difficulty of corrective action. Possible corrective actions include changing or developing new equipment performance standards (relaxing or tightening), purchasing new equipment, and delaying implementation of 25NM lateral procedures. All of these corrective actions would require coordination between ICAO authorities, operators and ANSPs. Additionally, the need for new equipment would also need to be coordinated with aircraft manufactures. The respondent correspondingly indicated Risk T would have a very high level of difficulty in coordinating corrective actions. The respondents indicated that Risk T has a medium likelihood of occurrence. One respondent commented specifically that the RNP4 would likely not be adequate for the safety case and that RNP3.5, or RNP2 may need to be developed. RNP2 in particular has not been approved for any operator. The respondent also mentioned that the simulation only considered the 95% accuracy of RNP4 and that containment of RNP4 (2*RNP4) or the communication and surveillance abilities to augment navigational performance were not considered. The respondent also suggested that there is a possibility for relying on a GNSS requirement which is technology based, not performance based.

Table 98: Risk T Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | High | Very High | Medium |

U.0 Description

Risk U is a safety risk described as “Failure to control vertical risk when 25 NM lateral separation is implemented”. The vertical risk describes the risk of two aircraft cruising on roughly same path but at different altitudes colliding with each other. The aircraft can be traveling in either the same direction, opposite directions or may deviate from a parallel path. Vertical separation is monitored by the ANSPs and the aircraft’s onboard traffic collision avoidance system and the ADS-C surveillance system. When 25NM lateral separation is implemented, a data link failure could increase the risk of a vertical collision because the position reports and communication exchanges between the ANSPs, aircraft and other aircraft will be delayed.

U.1 Background

Aircraft collisions almost always have catastrophic consequences so it is important to operators and ANSPs maintain a safe level of separation between other aircraft at all times. The separation standards, position reports, and on board traffic detections systems (TCAS and ADS-C) all contribute to the mitigation of a collision risk. The vertical risk specifically refers to an aircraft collision that happens when two aircraft flying on the same path but at different altitudes come too close to each other. Data link equipment further reduces the vertical risk because the accuracy and frequency of the position reports are increased. In fact, the advances in communications provided by data link are what enable 25NM lateral separation procedures to be practiced safely. In the event of a data link ground failure, a backup communication system such as HF radio can be used along with the onboard surveillance systems. Or, if onboard surveillance systems fail, the aircraft should still be able to receive messages from the ANSPs. In any case, the vertical risk must be continuously monitored and mitigated by all of the available communications and surveillance systems.

U.2 Root Causes

The respondents identified three root causes associated with Risk U. The first two are failures to meet required communication or navigation performance respectively. The last root cause is a persistent violation of safety performance during 25NM lateral operations.

U.2.1 Failure to meet required communications performance

The required communication performance standard (RCP) specifies limits on time the it takes for a message to travel from its sender to a destination and back. In data link operations, a message sent between an aircraft and a

ground controller must go through a satellite and ground station first. Alternatively, the High Frequency Voice (HF) method relies on manned radio relay stations to transfer messages. If the message exchange time for the data link controllers isn't met then the detection time for navigation errors increases which can increase the chances of a vertical collision.

U.2.2 Failure to meet required navigational performance

The required navigation precision standard (RNP) specifies limits on the size of aircrafts navigational position error. In order to safely conduct reduced separation procedures, each aircraft must be within the maximum allowed distance from its calculated position. Deviations from the aircraft's calculated position can increase the risk of collision with other aircraft because the separation distance can become narrower and the error can only be automatically detected by onboard surveillances and navigation systems.

U.2.3 Incidence of operational and technical errors greater than max acceptable.

Operational and technical errors that occur in flight are continuously monitored and evaluated by ICAO and local rulemakers. These errors are reduce the level of safety because they effectively increase the probability of a collision. They are also used to evaluate the achieved level of safety in the North Atlantic each year. These errors are typically human errors of entering in the wrong coordinates or wrong altitude. 25NM lateral procedures also require ½ degree tracks which must be manually interrogated to be verified on some flight management computers (FMC's) instead of being verified by visual inspection for 1 degree tracks. If the errors accumulate too quickly during 25NM lateral operations regulators may conclude that the vertical risk isn't being sufficiently controlled.

U.3 Impact to Stakeholder Value Metrics

Table 99 shows the impact of risk U to stakeholder value metrics.

Table 99: Risk U Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|-----------|------------------------|------------|---------------|----------------|-------------------|
| Very High | High | Medium | None | Medium | None |

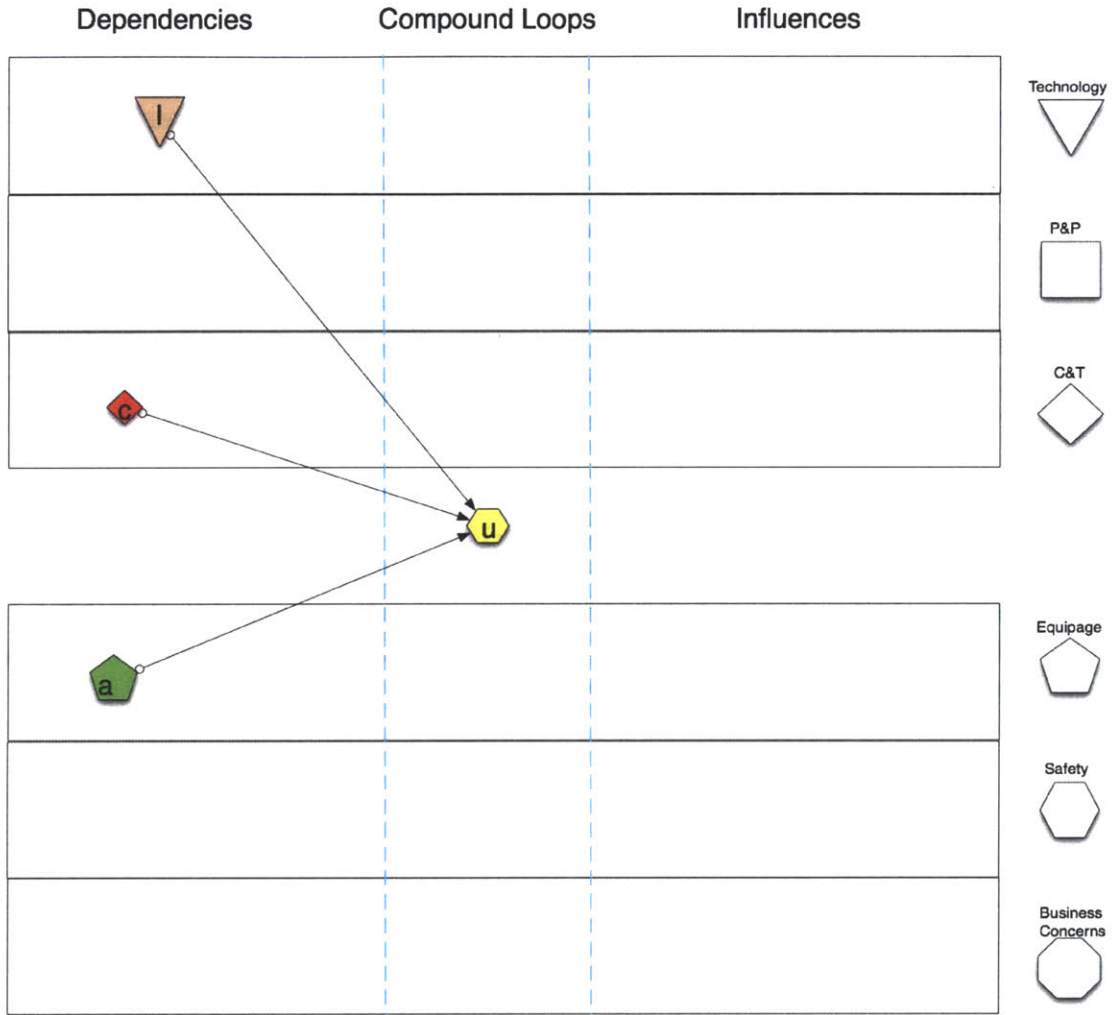
The respondents indicated a very high impact to Safety. Vertical Safety is a critical component of the overall safety case. When separation reduced, the

margin of safety is reduced but a reduction beyond a certified level in the safety case would cause the need for immediate changes to be made. The respondents indicated a high impact to Operational Efficiency. Operational Efficiency can be impacted if 25NM lateral operations are suspended or, if aircraft need to be rerouted to restore an acceptable level of vertical risk. The respondents indicated a medium impact to ANSP costs. ANSP costs can be impacted if ANSPs need to add new equipment or staffing in order to improve the overall safety performance during 25NM lateral separation. The respondents indicated a medium impact Operator Costs. Operator Costs can be impacted if 25NM lateral is suspended or delayed because the operators may not be able to realize the anticipated efficiency gains associated with the new procedures. The respondents did not indicate an impact to ANSP revenues or Operator Revenues.

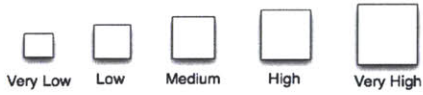
U.4 Dependencies and Influences

The dependencies and influences of Risk U are shown in Figure 59. Risk U has one technology risk dependency, one coordination and timing risk dependency, and one equipage risk dependency. Risk U does not have any influences or form compound loops.

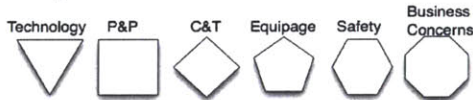
Figure 59: Risk U Direct Dependencies and Influences (Reduced Separation Only)



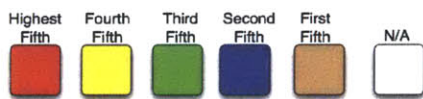
Likelihood



Categories



Impact



U.4.1 Risk U Direct Risk Dependencies

Risk U has three direct risk dependencies as shown in Table 100. The equipage risk A (Equipage for business operators not available or certified in time to meet mandate) and, the coordination and timing risk C (Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand), can affect the CPDLC equipage levels in the North Atlantic if they occur on a large scale. Although the unequipped aircraft will not be allowed to participate in 25NM lateral procedures, the safety case does in part depend on the equipage levels in the North Atlantic. If these equipage levels fall below a threshold, the vertical risk safety level may not be satisfied, possibly where equipped airspace and unequipped airspace meet.

The technology risk L (Failure to establish a plan or go forward with mitigation to meet RCP240. This also includes failure of ground infrastructure to support RCP240) could increase the detection time for navigational (Vertical or Horizontal) errors relative to what is possible with RCP240 if the communication standard is relaxed to a lower standard such as RCP400. However, it is unlikely that 25NM lateral separation would be implemented unless the communications standard satisfied the safety case.

Table 100: Risk U Direct Dependencies

| | |
|--------|---|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk C | Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand |
| Risk L | Failure to establish a plan or go forward with mitigation to meet RCP240. This also includes failure of ground infrastructure to support RCP240 |

U.5 Mitigation

The mitigation difficulty for risk U according to respondents is shown in Table 101. The respondents indicated that Risk U would have a medium detection difficulty. Vertical risks typically increase with human errors which may be difficult to account for in simulation. Vertical risk is also monitored and evaluated in operational practice which is where a detection of a persistent problem would most likely occur. The respondents indicated the corrective action difficulty for Risk U would be high. Possible corrective actions include mandating the use of ADS-C to monitor vertical navigation conformance, auto-load capability to reduce position change entry errors, increasing the separation between unequipped and equipped aircraft and increasing 25NM lateral separation to 30NM-30NM lateral separation or a large distance. The regulatory changes would require coordination between operators, ANSPs, ICAO and local rulemakers. The Auto-load capability would require coordination between operators, ANSPs and possibly regulators depending if a regulatory mandate is needed. If the vertical risks occur when an unequipped aircraft crosses into the 25NM lateral OTS on a random route, closer monitoring or stricter restrictions for unequipped aircraft may be needed as well. The respondents correspondingly indicated that the coordination difficulty to correct Risk U would be high. The respondents listed the likelihood of Risk U as medium. They noted that ICAO would not approve 25NM lateral if there were an unacceptable vertical risk but they did acknowledge that vertical risk would increase relative to using CPDLC in 60NM-60NM or 30NM-30NM separation because the separation distance would go down to 25NM.

Table 101: Risk U Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Medium | High | High | Medium |

V.0 Description

Risk V is a business concern risk described as “High costs preventing operators from retrofitting to meet requirements for data link mandate and 25 NM lateral separation”. There are several operator costs associated with equipping for data link including equipment costs, aircraft downtime costs, training costs. These costs can be prohibitive for several reasons including lack of available resources, lack of available benefits, and insufficient remaining aircraft service life. If many operators encounter high costs that are prohibitive to equipping, the equipage level in the North Atlantic may either stagnate, decrease, miss targets needed to implement 25NM lateral separation.

V.1 Background

The respondents indicated that the costs of data link equipage can vary from a few hundred thousand dollars to over one million dollars depending on the level of equipage the aircraft currently has. They also indicated that aircraft manufacturers are in the process of rolling out complimentary improvements to equipment needed for data link such as increased storage for the flight management computer and updates to the global positioning system. Equipping with these complimentary improvements after investing in data link compliant can also add costs relative to waiting to do all the updates at once. The operators could face fuel burn penalties due to operating route restrictions but these may not outweigh the costs of not equipping.

V.2 Root Cause

The respondents identified three root causes associated with Risk V: The costs of data link could be unjustifiable if the benefits to do not scale with the costs. Also the low demand for data link upgrade go drive prices up or make operators reluctant to offer upgrades. Lastly, the need for other future upgrades may present an opportunity for operators to reduce costs by waiting to complete all upgrades at one time.

V.2.1 Unjustifiable Equipment Costs

The costs for data link equipment may be unjustifiable if there is not enough aircraft remaining service life or sufficient fuel burn savings to get a return on the investment. The level of fuel burn improvement, the aircraft’s remaining service life, and the aircraft’s current level of equipage are all variables that can determine the time an operator has to recoup the costs through fuel savings and efficiency improvements. However, if the costs of

the aircraft are too high compared to the benefits and the available time needed to use those benefits, the costs may be unjustifiable.

V.2.2 Low Data Link Equipment Demand

In addition to high equipment acquisition costs, there are also high costs associated with the development of data link packages. The avionics and aircraft manufacturers can only justify these costs if there is sufficient demand for the packages from operators. One respondent estimated that as many as 12% of the aircraft in the North Atlantic do not have data link upgrade packages, possibly due to a lack of demand. If the development costs for data link equipment are too high, then operators may be permanently left without a way to equip their aircraft.

V.2.3 Future Upgrade Packages

Future upgrade packages may be available at a later date than the data link mandate and make a short term investment for an intermediate, less comprehensive data link upgrade unjustifiable. More than one respondent commented that one aircraft manufacturer’s flight management computer does have a data link upgrade package available but also needs other upgrades for increased memory storage and other features that will be available at a later date. They commented that upgrading the flight management computer temporarily could not be justified and would create operational headaches because the extra data needed would force the operators to reload other route data every time the aircraft switches from an eastbound flight to a westbound flight. The future upgrade would not only add additional space to the flight management computer but also include all of the necessary data link features integrated in a way that would not affect the aircraft turnaround times. They also commented that performing both upgrades would add a significant cost burden compared to waiting for the complete upgrade, even with the unequipped aircraft restrictions.

V.3 Impact on Stakeholder Value Metrics

The impact of Risk V to stakeholder value metrics according to respondents is shown in Table 102.

Table 102: Risk V Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | High | Low | None | Medium | None |

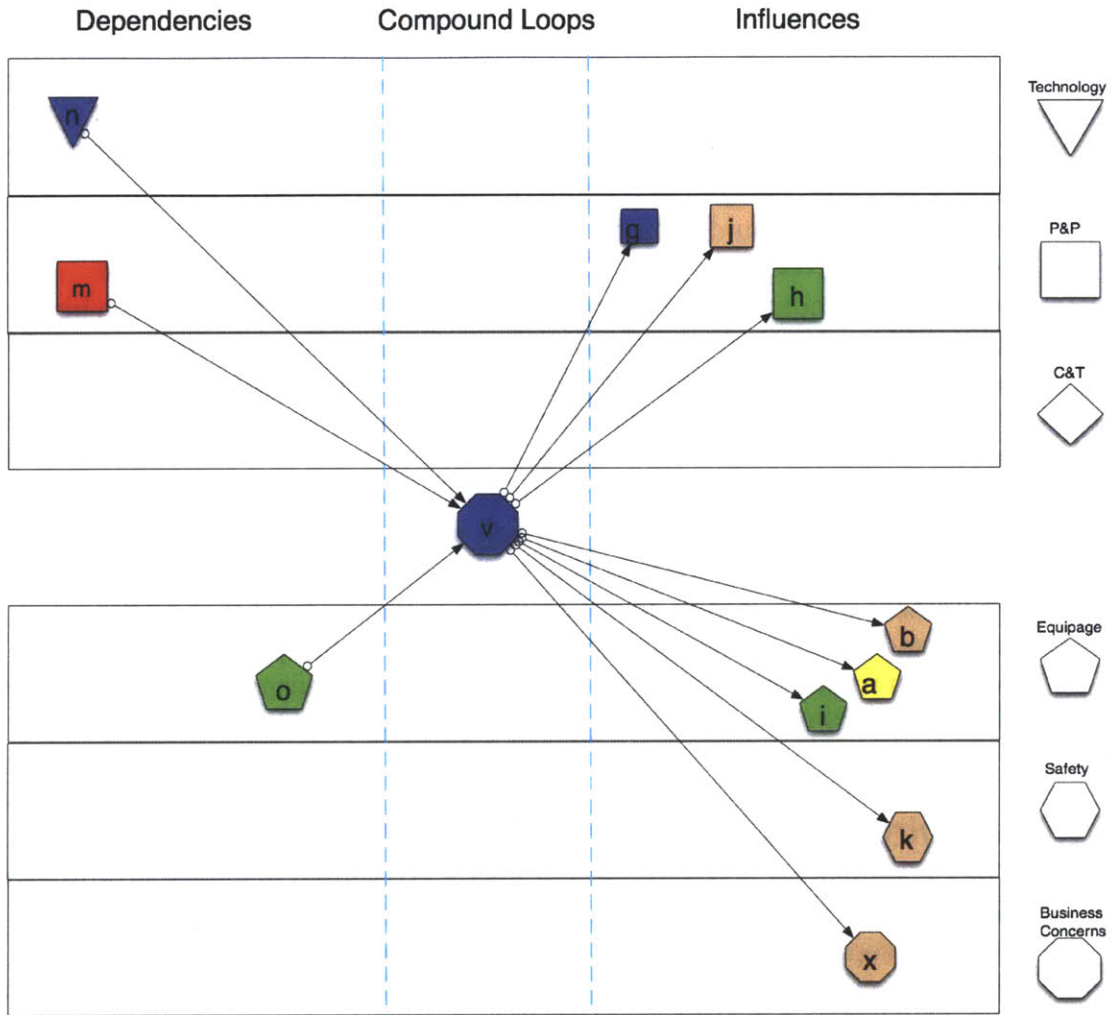
The respondents indicated a low impact to safety. Safety can be impacted if the high costs prevent the equipage levels from reaching their maximum potential. The margin of safety in the North Atlantic increases if more aircraft use data link because the communication latency between aircraft and ANSPs is reduced. The respondents indicated a high impact to Operational Efficiency. Operational Efficiency can be impacted if 25NM lateral becomes delayed as a result of the fewer operators equipping. A delay to 25NM lateral would prolong use of the less efficient 60NM-60NM operations currently in place for operators who are equipped. The respondents indicated a low impact to ANSP Costs. ANSP Costs can be impacted by the need to maintain HF as a backup. The costs of keeping HF as a backup system include the equipment costs and staffing costs. In some cases, rolling back HF capabilities may be part of the ANSP business case to invest in data link but if HF is needed, there will not be a cost reduction. The respondents indicated a medium impact to Operator Costs. Operator Costs can be impacted in two ways as a result of high data link equipment costs. If the operators choose to equip, they will be impacted by paying the high equipment costs. If they do not equip, they will be impacted by the increased fuel costs due to the restrictions for unequipped aircraft on optimum tracks and in all MNPS airspace in later phases. The respondents did not indicate an impact to Operator Revenues or ANSP Revenues.

V.4 Direct Risk Dependencies, Influences & Outcomes

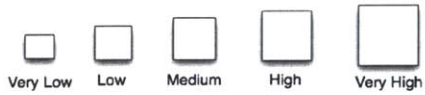
The dependencies and outcomes of Risk V are shown in Figure 60 and Figure 61 shows Risk V's dependencies and influences for both the mandate and reduced separation initiatives. There are not any additional risks dependencies are influences present when reduced separation initiatives are considered but the relative aggregate impacts of the risks do change because more risks that affect reduced separation only are considered.

Figure 61. Risk V has three direct dependencies, one technology risk, one policy and procedure risk, and one equipage risk. Risk V influences eight risks: three policy and procedure risks, three equipage risks, one safety risk, and one business concern risk.

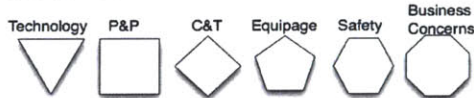
Figure 60: Risk V Direct Dependencies and Influences (Mandate Only)



Likelihood



Categories



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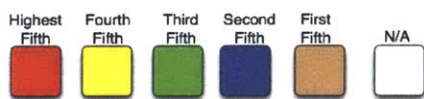
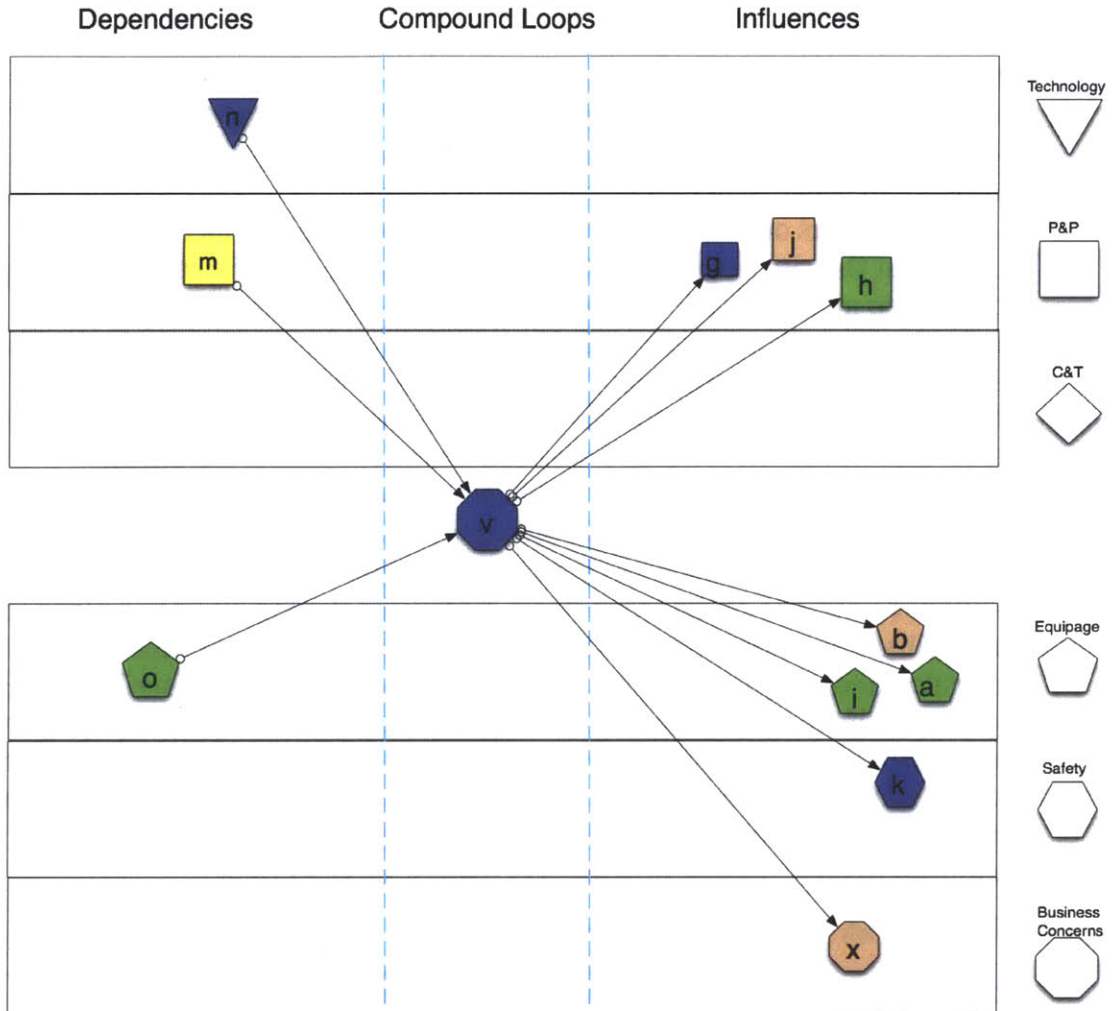
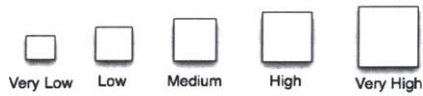


Figure 61 shows Risk V's dependencies and influences for both the mandate and reduced separation initiatives. There are not any additional risks dependencies are influences present when reduced separation initiatives are considered but the relative aggregate impacts of the risks do change because more risks that affect reduced separation only are considered.

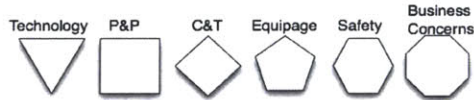
Figure 61: Risk V Direct Dependencies and Influences (Mandate and Reduced Separation)



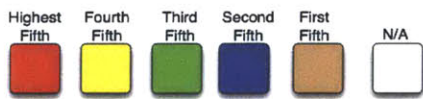
Likelihood



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V4.1 Risk V Direct Dependencies

Risk V has three direct dependencies as shown in Table 103. Risk N, a technology risk described as “Impact of ICAO Annex 6 data link communications airborne recording standard” can add to the costs of equipage by forcing operators to order additional data link recording software in order to operate in the North Atlantic. While many respondents noted that costs of the recording hardware would be significant, they also noted that they were unsure if the standard would be enforced even though it has been made official. The policy Risk M (Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT) can also result in a substantial cost increase. The European and Data Link Mandates as currently written will require aircraft that enter service after 2015 that will connect North American Destinations and European Destinations to have both ATN and FANS 1/A equipment. Feasibility studies have shown that the two technologies are not currently compatible and will require significant systems architecture changes to aircraft that are currently equipped with one of the technology. So far, the Boeing 787 has a planned capability to support both systems simultaneously although other aircraft may also undergoing upgrades. Risk O is an equipage risk described as (End of service life of I3 satellite services expected about 2016. New equipage may be required to use classic aero services via I4 satellites). An occurrence of Risk O can result in an increase in costs if operators are forced to pay for a more expensive satellite service, or, if new aircraft satellite equipment is required to ether switch providers or switch services to I4.

Table 103: Risk V Direct Dependencies

| | |
|--------|---|
| Risk M | Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT |
| Risk N | Impact of ICAO Annex 6 data link communications airborne recording standard (See Appendix B) |
| Risk O | End of service life of I3 satellite services expected about 2016. New equipage may be required to use classic aero services via I4 satellites |

V4.2 Risk V Direct Influences and Associated Outcomes

The high costs that can be associated with the occurrence of Risk V can have three associated outcomes that can influence other risks: uncertainty in equipage levels, reduced demand for data link packages and reduced equipage levels in the North Atlantic.

The uncertainty in equipage levels can make it difficult for the regulator to predict the demand for unequipped airspace and can subsequently influence

the occurrence of the policy and procedure risks G, J, and H. Risk G (Failure to develop measures to accommodate unequipped aircraft) can occur if operators underestimate the demand for unequipped aircraft. If the demand for unequipped airspace is thought to be low, there may be reduced, insufficient measures or airspace set aside for unequipped aircraft. Low equipage levels can also cause more unequipped operators to use routes where surveillance is provided (Risk J) due to the airspace restrictions (Risk H) that are necessary for safety reasons.

High costs for data link equipment as a result of the occurrence of Risk V can reduce operator demand and cause the occurrence of other equipage risks. If operator demand for data link equipment is low, avionics and aircraft manufacturers may choose to devote fewer resources to development which could delay development and certification (Risk A) or, delay deliveries of new packages (Risk B). A mixed equipage environment (Risk I) can also result from lower demand levels.

Lastly, the high costs of data link equipage can rise to the point where they out-scale the available economic benefits (Risk X). Many respondents indicated that the costs for some single data link components such as the satellite communication hardware were likely to out-scale the benefits on their own due to their expensive nature. They also indicated that the scale of the benefits would be due in part to the price of fuel.

Table 104: Risk V Direct Influences

| | |
|--------|--|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand. |
| Risk G | Failure to develop measures to accommodate unequipped aircraft |
| Risk H | Restricted access to airspace for unequipped aircraft |
| Risk I | Mixed equipage environment during transition |
| Risk J | Operators choosing to operate in areas where other types of surveillance are provided (e.g. radar, ADS-B) |
| Risk X | Cost benefit analysis may show that costs outweigh the benefits of implementing the data link mandate and/or 25 NM lateral separation. |

V.5 Mitigation

The mitigation difficulty for Risk V is shown in Table 105. The respondents gave risk V a low detection difficulty. High costs are likely to be detected in several ways including reporting to ICAO by operators for the cost benefit analysis. The respondents gave Risk V a medium correction difficulty. Possible corrective actions include adjusting the timelines for the mandate and reduced separation initiatives, and subsidizing the costs of equipping to operators. Additional corrective actions include gaining pricing and regulatory control over the pricing of satellite services, and coordinating lower data fees. The respondents indicated a medium coordination difficulty for Risk V. Adjusting the timelines would require coordination between ICAO, ANSPs local rulemakers, and possibly the European Union if there is a desire to harmonize the timelines with the European Mandate. Subsidizing the costs for data link mandate would also require coordination between ICAO, ANSPs, Operators, and local rulemakers to determine the source of funds and the allocation of funds. The respondents indicated that risk V would have a high likelihood of occurrence. Several respondents went as far to say that the current cost of equipage is already prohibitive for most operators and significantly outweigh the fuel burn benefits.

Table 105: Risk V Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | Medium | Medium | High |

W.0 Description

Risk W is an equipage risk described as “late delivery of new aircraft orders that are replacing older, unequipped or unequippable aircraft”. Some operators plan to comply with the mandate by purchasing new aircraft that are compliant to replace older aircraft with low remaining service life that aren’t compliant. Late deliveries of these aircraft could force operators to continue operating with unequipped aircraft despite making an investment in data link equipment. Additionally, if the problem is widespread, the North Atlantic may not reach the target data link equipage levels when 25NM lateral is scheduled for implementation.

W.1 Background

New aircraft typically have lead times for delivery in the range of one to five years. The delivery schedules vary with demand for new aircraft, other market conditions, and sometimes assembly line delays. New aircraft programs in particular are vulnerable to long technical delays during the certification process. Operators that have elected to comply with the mandate by purchasing new aircraft are vulnerable to these delays and may have to operate unequipped aircraft longer than anticipated. It may also be more difficult to implement 25NM lateral if the equipage levels remain low while operators wait for new aircraft to be delivered.

W.2 Root Causes

The respondents identified two main root causes associated with Risk W. Some aircraft manufacturers, especially business jet manufacturers have not completed development of data link packages which may not be available in the mandate time frame. Secondly, late regulatory changes could delay equipment production rates if equipment changes need to be made.

W.2.1 Data link Packages not Available in Mandate Timeframe

The avionics and aircraft manufacturers without data link packages will incur development costs before a new data link package certified. There are several aircraft, mainly business aircraft that don’t have a large enough customer base that uses the North Atlantic to potentially justify these costs, or, in some cases, the development time for some aircraft data link packages may be longer than the mandate time frame. In these cases, the operators may be forced to wait longer for the delivery of new data link equipped aircraft or individual upgrades. One respondent estimated that as many as 12% of the aircraft in the North Atlantic do not have available data link upgrade packages, possibly due to a lack of demand.

W.2.2 Last Minute Regulatory Changes

Last minute regulatory changes can force equipment changes to aircraft and or data link packages that may already be on an assembly line or in the process of obtaining certification. Navigation and communications requirements in particular are both carry some uncertainty and could force some operators to make significant changes to GPS positioning equipment or, the satellite communications equipment.

W.3 Impact on Stakeholder Value Metrics

The impact of risk W to stakeholder value metrics is shown in Table 106.

Table 106: Risk W Impact to Stakeholder Value Metrics

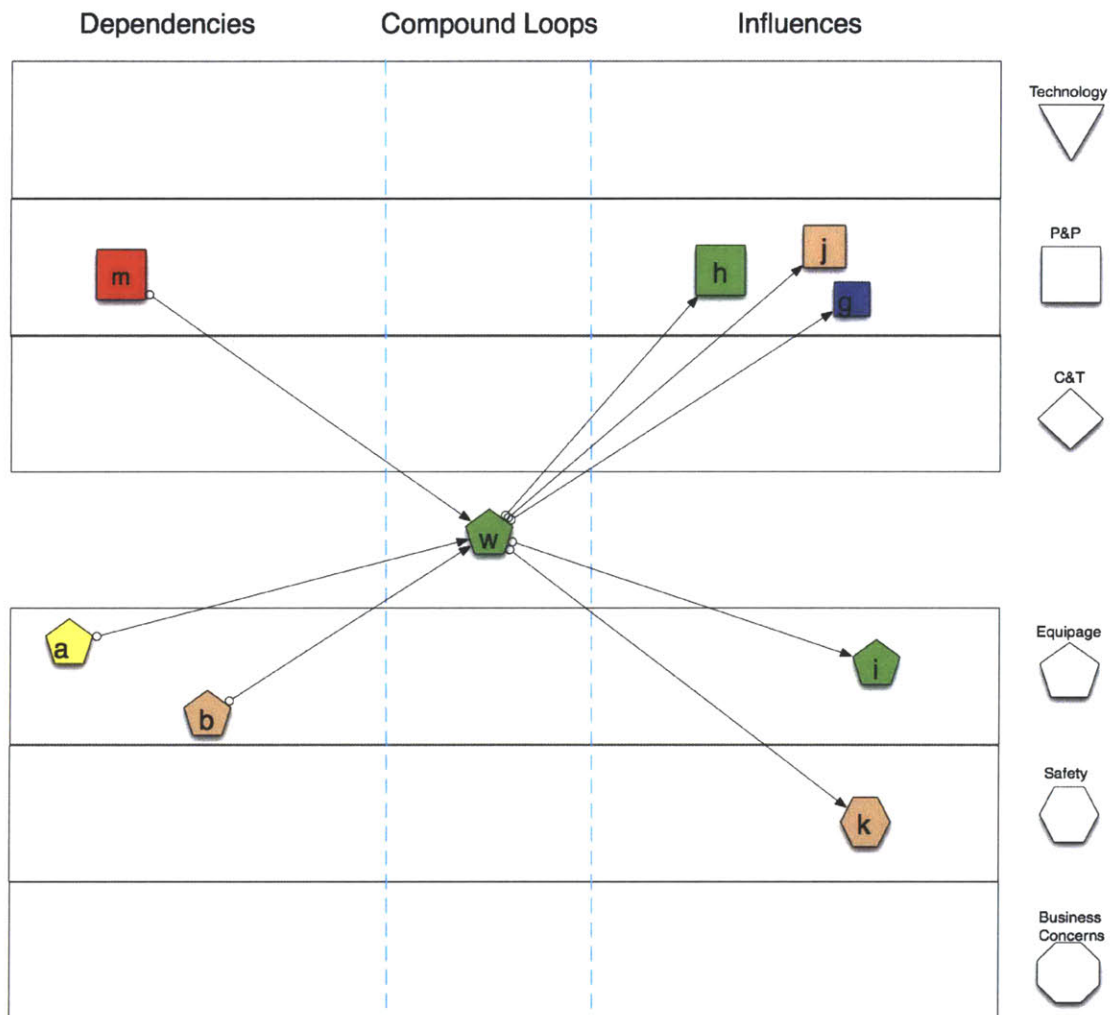
| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Medium | High | Low | None | Medium | None |

The respondents indicated a medium impact to Safety. Safety can be impacted if the late deliveries delay the equipage levels from reaching their maximum levels. The margin of safety in the North Atlantic increases if more aircraft use data link because communication latency between aircraft and ANSPs is reduced. The respondents indicated a high impact to Operational Efficiency. Operational Efficiency can be impacted if 25NM lateral becomes delayed as a result of the fewer operators equipping. A delay to 25NM lateral would prolong use of the less efficient 60NM-60NM operations currently in place for operators who are equipped. The respondents indicated a low impact to ANSP Costs. They indicated that there could be “indirect costs” but did not specify what those costs were in more detail. Possible costs include increases in staffing for a higher HF capacity. The respondents indicated a medium impact to Operator Costs. Operator costs can be impacted from higher fuel burn penalties of using older aircraft on less optimal routes due to airspace restrictions. The respondents did not indicate an impact to ANSP Revenues and Operator Revenues.

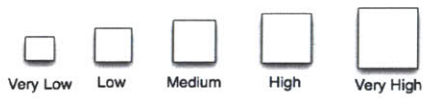
W.4 Direct Risk Dependencies, Influences & Outcomes

The direct dependencies and influences for Risk W are shown in Figure 62 and Figure 63. Risk W has three dependencies, one policy and procedure risk, and two equipage risks. Risk W also influences five risks: three policy and procedures risks, one equipage risk, and one safety risk.

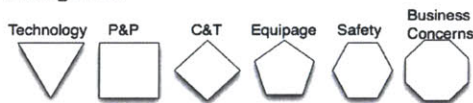
Figure 62: Risk W Direct Dependencies and Influences (Mandate Only)



Likelihood



Categories



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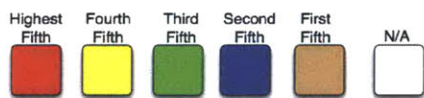
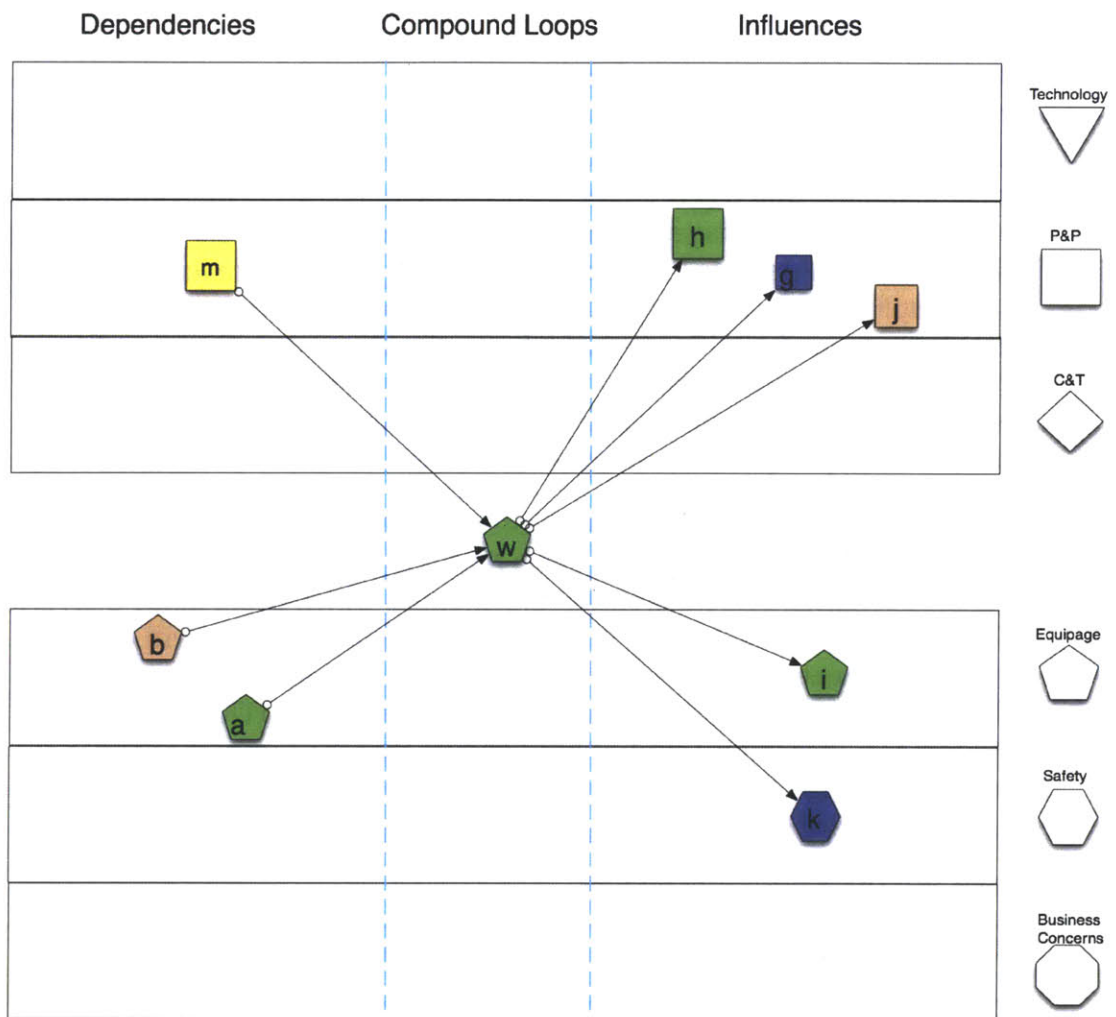
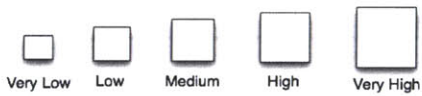


Figure 63 shows Risk W's dependencies and influences for both the mandate and reduced separation initiatives. There are not any additional risks dependencies are influences present when reduced separation initiatives are considered but the relative aggregate impacts of the risks do change because more risks that affect reduced separation only are considered.

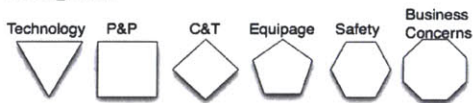
Figure 63: Risk W Direct Dependencies and Influences (Mandate and Reduced Separation)



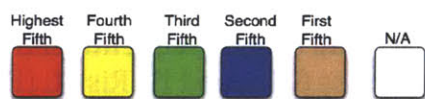
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W4.1 Risk W Direct Dependencies

Risk W has three direct dependencies as shown in Table 107. The equipage risks A (Equipage for business operators not available or certified in time to meet mandate) and B (Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand) can cause delays in the supply chain that delivers data link equipment packages. If a data link package does not exist for an aircraft (Risk A) there will be a long lead time needed for development and certification which can also depend on the aircraft's current systems architecture. If there are delays in manufacturing the equipment or certifying the equipment, delivery of the retrofit packages could be delayed (Risk B) and operators may not be able to equip in time.

The policy Risk M (Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT) can also result in the need to make substantial system architecture changes which could delay deliveries. The European and Data Link Mandates as currently written will require aircraft that enter service after 2015 that will connect North American Destinations and European Destinations to have both ATN and FANS 1/A equipment. Feasibility studies have shown that the two technologies are not currently compatible and will require systems architecture changes to aircraft that are currently equipped with one of the technology.

Table 107: Risk W Direct Dependencies

| | |
|--------|--|
| Risk A | Equipage for business operators not available or certified in time to meet mandate |
| Risk B | Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand. |
| Risk M | Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT |

W4.2 Risk W Direct Influences

The late aircraft deliveries that are associated with Risk W can result in uncertainty in equipage levels and, reduced equipage levels or an increased number of unequipped operators.

The uncertainty in equipage levels can make it difficult for the regulator to predict the demand for unequipped airspace and can subsequently influence the occurrence of the policy and procedure risks G, J, I, and H. Risk G (Failure to develop measures to accommodate unequipped aircraft) can occur if

operators underestimate the demand for unequipped aircraft and develop insufficient accommodations for unequipped aircraft. If the demand for unequipped airspace is thought to be low, there may be reduced or insufficient measures and airspace set aside for unequipped aircraft. Low equipage levels can also cause more unequipped operators to use less optimal routes where surveillance is provided (Risk J) due to the airspace restrictions (Risk H) that are necessary for safety reasons and inherently result in a mixed equipage level (Risk I). The restrictions in phases one and two of the 25NM lateral could also work with high costs to cause increased presence in MNPS airspace (Risk K).

Table 108: Risk W Direct Influences

| | |
|--------|---|
| Risk G | Failure to develop measures to accommodate unequipped aircraft |
| Risk H | Restricted access to airspace for unequipped aircraft |
| Risk I | Failure to control vertical risk when 25NM lateral separation is implemented |
| Risk J | Operators choosing to operate in areas where other types of surveillance are provided (e.g. radar, ADS-B) |
| Risk K | Increased traffic in MNPS routes other than OTS routes |

W.5 Mitigation

The respondents indicated a low detection difficulty for risk W. Airplane delivery rates are published by aircraft manufacturers and the operators would likely communicate delays during the ICAO working meetings. The respondents indicated a high corrective action difficulty. Possible corrective actions include adjusting the timelines for the mandate and reduced separation initiatives, or granting exemptions to operators that are suffering late aircraft arrivals. The respondents indicated a high coordination difficulty for Risk W. Adjusting the timelines or granting exemptions would require coordination between ICAO, ANSPs local rulemakers, and possibly the European Union if there is a desire to harmonize the timelines with the European Mandate. The respondents indicated a high likelihood for Risk W. They noted that there are new aircraft programs that are behind schedule and that the global recession has also slowed production rates of existing aircraft.

Table 109: Risk W Mitigation Difficulty

| | | | |
|-----------|-------------------|--------------|------------|
| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|

| | | | |
|-----|------|------|------|
| Low | High | High | High |
|-----|------|------|------|

X.0 Description

Risk X is a business concern risk described as “Cost benefit analysis may show that costs outweigh the benefits of implementing the data link mandate and/or 25 NM lateral separation”. Before implementing any policy changes, ICAO will perform a cost benefit analysis. The cost benefit analysis is used to assess the economic impacts to all stakeholders including operators, ANSPs, and aircraft and avionics manufacturers. The cost benefit analysis is then used to make informed policy decisions that will best achieve the goals set by ICAO. If the cost benefit analysis shows that costs outweigh the benefits for the data link mandate and reduced separation initiatives, then operators may choose not to equip and regulators may be forced to make changes in order to make implementation economically feasible.

X.1 Background

A cost benefit analysis is used to assess the costs of a policy relative to the benefits of a policy. The ICAO planning group’s cost benefit analysis for the data link mandate plan and 25NM lateral separation will assess the operator and ANSP costs of complying with the mandate, and the expected benefits of both the mandate and reduced separation procedures. The expected costs include aircraft data link equipment, ground data link equipment, data link messaging fees, ANSP staffing costs, aircraft downtime costs, and possible HF legacy costs. The benefits the data link mandate are primarily safety related. The benefits for the reduced separation are mostly economic and include increased operational efficiency and reduced fuel burn from using optimal routes, tracks and faster climb times.

X.2 Root Causes

The respondents indicated two root causes associated with Risk X. The operators may face high acquisition costs of data link equipment depending on what data link components the aircraft already has and possibly a low remaining aircraft service life. The ANSPs will incur higher costs by operating data link for several reasons including the need to maintain HF as a backup communications system. In both cases the economic benefits of upgrading to datalink may simply be too small compared to the costs of equipping, creating a prohibitively long or negative return on the investment of capital.

X.2.1 High Operator Costs

The costs for data link equipment may be unjustifiable if there is not enough aircraft remaining service life or sufficient fuel burn savings to get a return on the investment. Additionally, equipped operators will pay higher messages costs because data link operations typically use more messages per flight than HF operations. The level of fuel burn improvement, the aircraft's remaining service life, and the aircraft's current level of equipage are all variables that can determine the scale of the benefits relative to the costs.

X.2.2 High ANSP Costs

The respondents cited high ANSPs costs as a possible root cause although there is not an indication that an ANSP may not equip. The higher ANSP costs come from hardware upgrades, satellite service charges, and legacy costs from maintaining data link. The ANSPs may choose to recoup these costs by charging higher fees for data link messages to operators or by seeking subsidies from ICAO or state governments.

X.3 Impact on Stakeholder Value Metrics

The impact of Risk X on stakeholder value metrics is shown in Table 110.

Table 110: Risk X Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| Low | Medium | None | None | High | None |

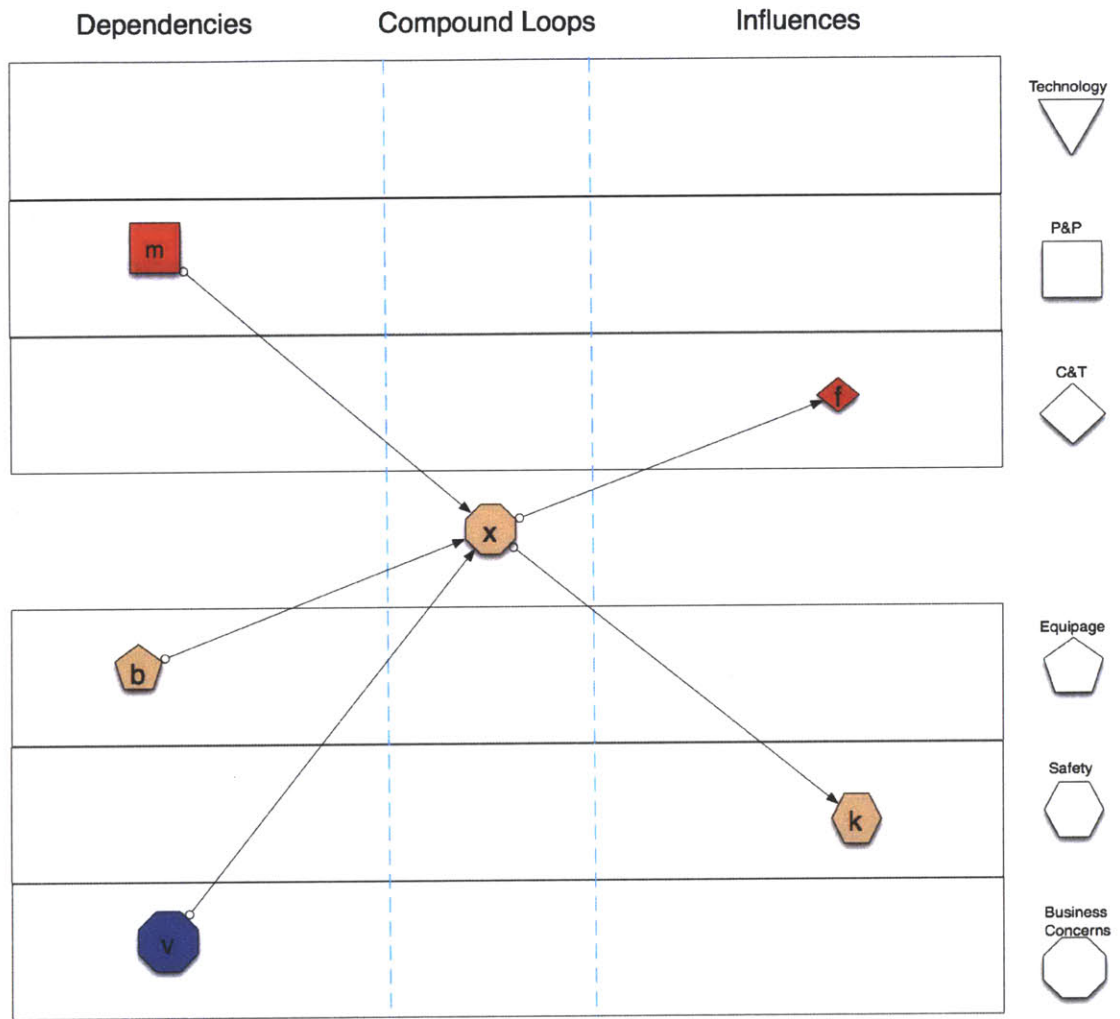
The respondents indicated a low impact to safety. Safety can be impacted if the high costs prevent the equipage levels from reaching their maximum potential. The margin of safety in the North Atlantic increases if more aircraft use data link because the communication latency aircraft and ANSPs is faster. The respondents indicated a medium impact to Operational Efficiency. Operational Efficiency can be impacted if 25NM lateral becomes delayed as a result of the cost benefit analysis showing an inadequate benefit. Some operators also felt that the safety benefit offered by datalink would not be practically meaningful because the probability of a collision is already extremely low. A delay to 25NM lateral would prolong use of the less efficient 60NM-60NM operations currently in place for operators who are equipped. The respondents indicated a low impact to ANSP Costs. ANSP Costs can be impacted by the need to maintain HF as a backup. The costs of keeping HF as a backup system include the equipment costs, staffing costs, and satellite service fees. In some cases, rolling back HF capabilities may be part of the ANSP business case to invest in data link but if HF is needed, there

will not be a cost reduction. The respondents indicated a high impact to operator costs. Operator costs can be impacted if demand is reduced and equipment prices as a result of poor cost benefit results, the increase message fees from ANSPs attempting to recoup their upgrade costs, and if the benefits are not as large as anticipated. The respondents did not indicate an impact to ANSP Costs, ANSP Revenues, or Operator Revenues.

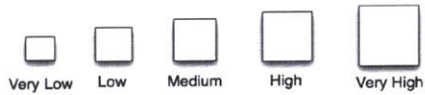
X.4 Direct Risk Dependencies, Influences & Outcomes

The direct dependencies and influences for Risk X are shown in Figure 64 and Figure 65. Risk X has three direct dependencies: one policy and procedure risk, one equipage risk, and one business concern risk. Risk X also influences one coordination and timing risk and one safety risk.

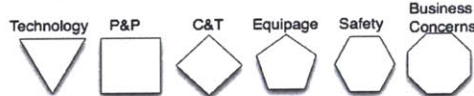
Figure 64: Risk X Direct Dependencies and Influences (Mandate Only)



Likelihood



Categories



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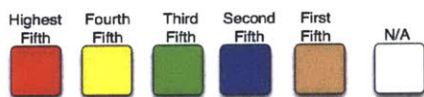
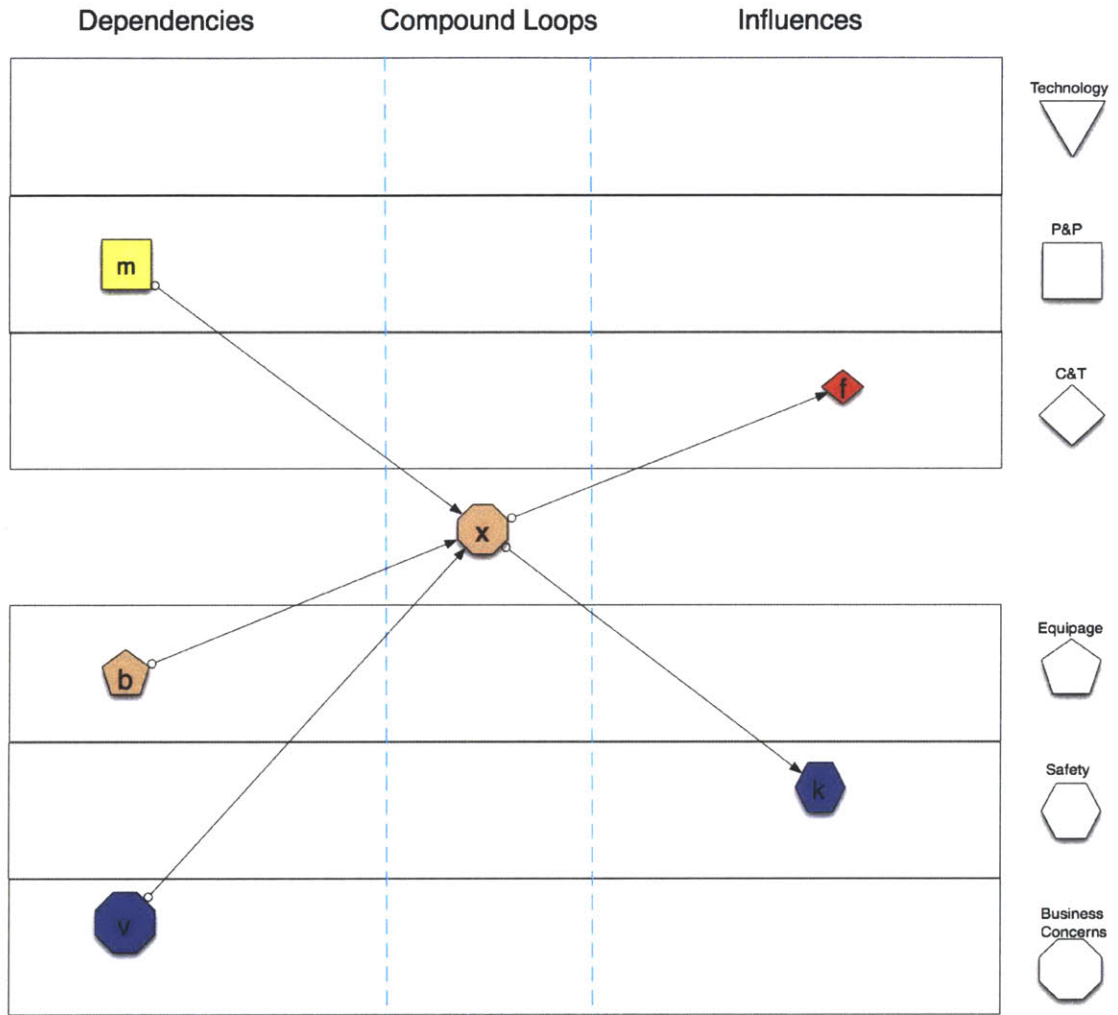
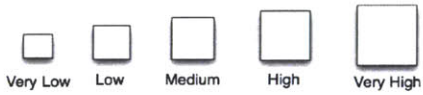


Figure 65 shows Risk X's dependencies and influences for both the mandate and reduced separation initiatives. There are not any additional risks dependencies are influences present when reduced separation initiatives are considered but the relative aggregate impacts of the risks do change because more risks that affect reduced separation only are considered.

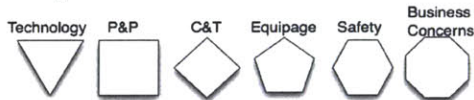
Figure 65: Risk X Direct Dependencies and Influences (Mandate and Reduced Separation)



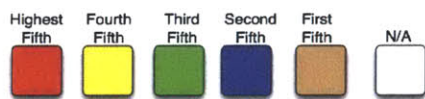
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X4.1 Risk X Direct Dependencies

The direct dependencies for Risk X are shown in Table 111. The equipment Risk B can reduce the scale of the benefits available to operators if the aircraft service life is reduced to a level that makes the upgrade unprofitable during the equipment delivery delays. The remaining service time may be insufficient in scaling the fuel burn benefits to a level that will allow the airlines to recoup the costs of investment.

The policy Risk M (Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT) can result in a substantial cost increase (Risk V) that may outweigh the benefits for operators. The European and Data Link mandates as currently written will require aircraft that enter service after 2015 that will connect North American Destinations and European Destinations to have both ATN and FANS 1/A equipment. Feasibility studies have shown that the two technologies are not currently compatible and will require costly systems architecture changes to aircraft that are currently equipped with one of the technology. So far, the Boeing 787 has a planned capability to support both systems simultaneously although other aircraft may also be undergoing upgrades however the plans for other new aircraft are not known at this time.

Table 111: Risk X Direct Dependencies

| | |
|--------|---|
| Risk B | Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand. |
| Risk M | Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT |
| Risk V | High costs preventing operators from retrofitting to meet requirements for data link mandate and 25 NM lateral separation |

X4.2 Risk X Direct Influences

The direct dependencies for Risk X are shown in Table 112. The outcomes associated with Risk D that can influence other risks are possible policy changes to improve the costs to benefits ratios for operators and ANSPs, and, a large number of operators choosing not to equip as a result of the cost benefit analysis showing costs greatly outweigh the economic benefits.

If policy changes are made as a result of Risk X, the coordination and timing Risk F (Rulemaking to support data link mandate and 25 NM lateral

separation (if required by ANSP) not completed within mandate timeframe) could occur if these changes result in more or delayed local rulemaking verification procedures. An equipment standards change for instance, would need to be re-tested by local rulemakers before implementation can take place.

If the cost benefit analysis shows that the costs will outweigh the benefits, there may be operators that subsequently choose not equip and accept the fuel burn penalties of not equipping. The operators may file random routes (Risk K) instead of using the Oceanic Tracking System (OTS) to minimize the impact of the air space restrictions on fuel burn

Table 112: Risk X Direct Influences

| | |
|--------|---|
| Risk F | Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe |
| Risk K | Increased traffic in MNPS routes other than OTS routes |

X.5 Mitigation

The mitigation difficulty for Risk X is shown in Table 113. The respondents indicated a low detection difficulty for Risk X. Risk X would most likely be detected when the ICAO planning groups communicate the results of the cost benefit analysis to ICAO members. The respondents indicated a medium corrective action difficulty. Possible corrective actions include rolling back HF capability or substituting it for SATCOM voice services, changing the dates of implementation or harmonizing with the European Mandate to reduce costs, or possibly subsidizing operators that equip with data link. The respondents indicated a high level of coordination would be required to correct an occurrence Risk X. Switching to SATCOM voice services for unequipped operators, harmonizing the implementation dates, and subsidizing operators would all require an extensive amount of coordination between ICAO operators, ANSPs, and possibly the European Union. The respondents indicated that Risk X would have a high likelihood of occurrence. They indicated that the equipment costs alone would likely outweigh any fuel burn benefits. They also indicated that they did not know what the economic value of increasing the safety margin would be.

Table 113: Risk X Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | Medium | High | High |

Y.0 Description

Risk Y is a safety risk described as “HF system may not be able to handle future air traffic levels as a backup system”. High Frequency Voice (HF) is the current communication technology used for exchanging positioning reports, clearances, and flight path changes between aircraft over the North Atlantic and Air Traffic Controllers. The messages are sent from the aircraft or ANSPs to radio relay stations where a person must then relay the message on to its intended destination. The latency of the message (the time it takes to send and receive a message back) with HF radio can be as long as eight minutes. The data link messaging system is a satellite based text messaging system that is intended to replace data link as the primary technology for message exchanges. Depending on the availability ratings of the satellite based system and the overall equipage levels in the North Atlantic, HF may still be needed as a back up system in the case of a data link failure. However, if the HF system cannot handle an increase in traffic from a data link failure, there could be a risk to safety and operational efficiency. Additionally, if the capacity of HF is reduced as a result of data link implementation, then a data link failure that causes operators to switch back to HF could also result in a network overload.

Y.1 Background

The HF voice system is a communication system that relies on manned relay stations to facilitate communication between aircraft and ANSPs. The long latency time constrains both the allowable aircraft separation distances, and aircraft climb schedules both of which can constrain fuel efficiency. The reduced separation initiatives are meant to address these inefficiencies and have been successfully implemented in the Pacific Ocean region. If the capacity of HF is reduced as a result of data link implementation, or if the HF capacity is insufficient to handle a traffic load (even if it is not reduced) then a data link failure that causes operators to switch back to HF could also result in a network overload.

Y.2 Root Causes

The respondents identified three root causes associated with Risk Y. North Atlantic Regions with high traffic volumes that use data link services could experience an overload if these volumes are too high for the HF infrastructure that is currently in place. The safety case may have assumptions based on the availability of HF or lack of availability of HF as a backup system that may be incorrect and as a consequence, potential

capacity issues may go unnoticed. Lastly, when some satellite service providers change the terms of service or the hardware needed to communicate with their satellites, many operators could simultaneously be left without a data link capability.

Y.2.1 HF Phaseout

One respondent indicated that the assumptions made in the safety case may cause a HF capacity issues to go undetected. If the safety case assumed a sufficient availability for data link services, then HF would only be needed in restricted airspace and outside of MNPS airspace. However in the case of a failure, the equipped operators could revert back to HF even though HF was not intended to be used as back up system to data link. The ANSPs may have reduced HF staffing to only handle unequipped operators and to save costs.

Y.2.2 Satellite Service Transition

One respondent indicated that the transition of the Inmarsat Satellite Service from I3 to I4 services will temporarily render eliminate the data link capability of I3 equipped aircraft. This respondent felt that the downtime to modify these aircraft would be cost prohibitive and that an unexpected increase in demand for HF communications would be a long term and short term result.

Y.2.3 Increased Traffic Volume

Increased future traffic volume due to economic growth can be handled by data link but may be too large for the HF network, especially if HF staffing is scaled back as more aircraft use data link. The increased traffic volume could overload the HF network in the case of a data link failure

Y.3 Impact on Stakeholder Value Metrics

The stakeholder value metrics for Risk Y are shown in Table 114.

Table 114: Risk Y Impact to Stakeholder Value Metrics

| Safety | Operational Efficiency | ANSP Costs | ANSP Revenues | Operator Costs | Operator Revenues |
|--------|------------------------|------------|---------------|----------------|-------------------|
| High | High | High | None | High | None |

The respondents indicated that Risk Y would have a high impact to safety. In the event of a data link failure, there could be a large number of aircraft that are operating in reduced separation procedures that no longer have the communication ability needed to maintain the desired level of safety. If Risk Y occurs and HF becomes overloaded, the aircraft will need to rely on their

surveillance technology to maintain safe separation distances until the communications networks (HF and data link) can be resorted. One respondent commented that he felt HF would not be capable of handling a data link failure in the Irish airspace while another felt HF would be sufficient to handle a failure in the Norwegian airspace because of a lower volume of traffic. Similarly, Operational Efficiency (High Impact) would be dramatically reduced because the aircraft will need to be re-separated to larger distances and possibly hold until the ANSPs can sort out the congestion and the HF network can be brought back online. In low traffic levels, a data link failure would not have a high safety or efficiency impact but in a high traffic levels, there could be significant impacts to operational efficiency. The respondents indicated a very high impact to ANSP Costs. ANSP Costs can be impacted by the need to maintain HF as a backup. The costs of keeping HF as a backup system include the equipment costs and staffing costs. The ANSPs may also need to train HF operators to handle an increase in traffic in the event of a data link failure. In some cases, rolling back HF capabilities may be part of the ANSP business case to invest in data link but if HF is needed, there will not be a cost reduction. The respondents indicated a high impact to operator costs. Operator costs can be impacted by the higher message fees from ANSPs attempting to recoup their upgrade costs and the legacy costs for maintaining HF as a backup system. They may also endure fuel burn costs from holding in air traffic congestion during a data link failure. The respondents did not indicate an impact to ANSP Revenues, or Operator Revenues.

Y.4 Direct Risk Dependencies, Influences & Outcomes

The direct dependencies and influences for Risk Y are shown in Figure 66 and Figure 67. Risk Y does not have any dependencies or influence other risks that affect the both mandate and reduced separation. Risk Y does influence one safety risk that affects the 25NM lateral initiatives only.

Figure 66: Risk Y Direct Dependencies and Influences (Mandate Only)

Dependencies

Compound Loops

Influences

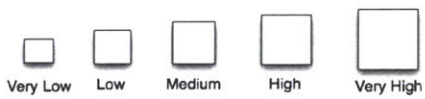
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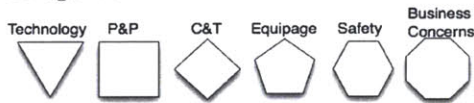
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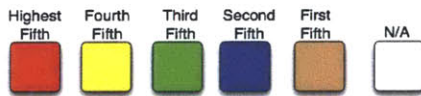
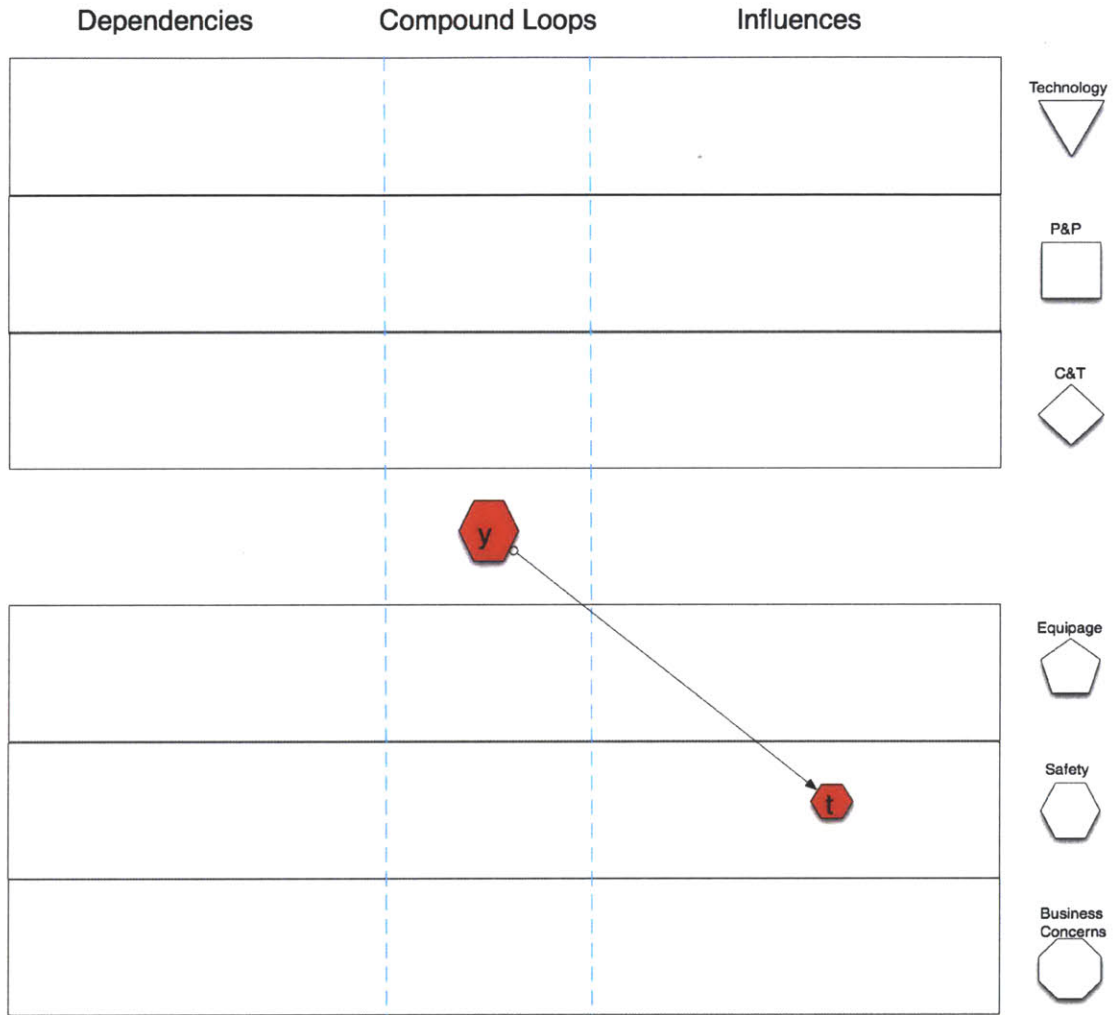
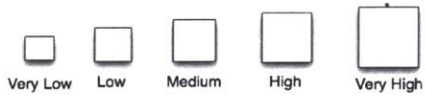


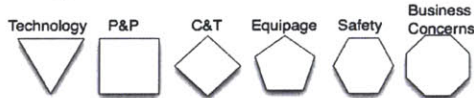
Figure 67: Risk Y Direct Dependencies and Influences (Mandate Only)



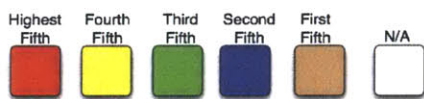
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Impact



Y.2.1 Direct Influences

Risk Y influences the safety risk T as shown in Table 115. Risk T describes a failure to meet the safety case for reduced separation. If a data link failure occurs during data link procedures and HF is used as a backup, the capacity limitations of HF could further increase the latency of communications between operators and ANSPs. The safe separation distance given by the safety case is in part driven by the communication latency. If the expected latency is exceeded, then the margin of safety could fall below the desired level while the aircraft are using reduced separation distances.

Table 115: Risk Y Direct Influences

| | |
|--------|---|
| Risk T | Failure to meet safety case for 25 NM lateral separation (Feasibility analysis may find that better performance is needed. Actual performance may not meet feasibility analysis expectations) |
|--------|---|

Y.5 Mitigation

The mitigation difficulty for Risk Y is shown in Table 116. Risk Y is a risk that was added by one of the respondents and consequently only two respondents were asked to assess it. The respondents indicated only “Very High” likelihood for Risk Y because they felt the United Kingdom region in particular would not be able to handle an increase in HF traffic from a data link failure. They did give mitigation data for the other mitigation categories. They felt that an HF capacity rollback as suggested during the Aeronautical Communications Group (ACG) would not prevent operators from switching back to HF in the event of a data link failure but that this event was not considered in the safety case. Possible corrective actions include using contingency procedures, increasing AIRINC staffing, and a Satellite Voice capability (most expensive) that can be used in a data link failure, possibly with an alternate satellite or ground service, or requiring availability and performance guarantees from the satellite providers. The respondents noted that adding performance guarantees was a successful approach that was used when the Global Positioning System was being considered for civilian use. They also noted that the staffing level, and the level of traffic played an integral roll in how quickly the aircraft could be separated in the event of a data link failure. The coordination difficulty for both these corrective actions is high since they would also involve negotiations with satellite companies in addition to the ICAO participants. Although one could argue that this risk has already been “detected”, the safety case should consider the event of a data link failure with a corresponding rollback of HF capacity. The operators must have an alternative way to communicate that

will not overload a reduced or an unreduced HF network in the event of a data link failure.

Table 116: Risk Y Mitigation Difficulty

| Detection | Corrective Action | Coordination | Likelihood |
|-----------|-------------------|--------------|------------|
| Low | Medium | High | High |

NAT Data Link Project Risk Event Impact Research: Interview Instrument

April 15, 2010

MIT is conducting research on the impact of various program risk events involved with the NAT SPG Initiatives for 25 NM Lateral Separation and Oceanic Data Link Mandate (see tables in Appendix A). We would appreciate your insights on the below questions.

Part I-b

The list below contains a set of program risk events that might occur in mandating data link and introducing 25 NM Lateral Separation in the North Atlantic airspace. **Are there any risk events not covered on the list**

- a) Equipage for business operators not available or certified in time to meet mandate
- b) Potential delays in manufacturers delivering aircraft data link retrofit packages to satisfy demand
- c) ANSPs failure to have automation systems, other technologies, or local rulemaking ready for implementation of 25 NM lateral separation (e.g. ensuring that deviations from norm are captured quickly, etc.)
- d) Late completion of data link mandate plan. Not enough time for commercial and business operators to plan and comply with mandate (e.g. determination of entire flight level spectrum and OTS tracks where mandate is to be applied, etc.)
- e) Failure to achieve effective coordination with other ANSPs (harmonization of technical systems and operating methods)
- f) Rulemaking to support data link mandate and 25 NM lateral separation (if required by ANSP) not completed within mandate timeframe
- g) Failure to develop measures to accommodate unequipped aircraft
- h) Restricted access to airspace for unequipped aircraft
- i) Mixed equipage environment during transition
- j) Operators choosing to operate in areas where other types of surveillance are provided (e.g. radar, ADS-B)
- k) Increased traffic in MNPS routes other than OTS routes
- l) Failure to establish a plan or go forward with mitigation to meet RCP240. This also includes failure of ground infrastructure to support RCP240
- m) Lack of harmonization in technologies: ATN mandate in Europe vs. FANS-1/A mandate in the NAT
- n) Impact of ICAO Annex 6 data link communications airborne recording standard (See Appendix B)
- o) End of service life of I3 satellite services expected about 2016. New equipage may be required to use classic aero services via I4 satellites.
- p) Uncertainty in approval of Iridium-based equipage to meet requirements for data link mandate and 25 NM reduced lateral separation
- q) Failure to achieve percentage of equipped flights needed to move forward with phases of 25NM lateral separation
- r) No ICAO communication, navigation, and surveillance standards available to support implementation of 25NM lateral separation (for example, RNP 4 meets navigation criteria for 30 NM)
- s) Late completion of 25NM lateral separation planning tasks.
- t) Failure to meet safety case for 25 NM lateral separation (Feasibility analysis may find that better performance is needed. Actual performance may not meet feasibility analysis expectations)
- u) Failure to control vertical risk when 25 NM lateral separation is implemented
- v) High costs preventing operators from retrofitting to meet requirements for data link mandate and 25 NM lateral separation
- w) Late delivery of new aircraft orders that are replacing older, unequipped or unequippable aircraft

x) Cost benefit analysis may show that costs outweigh the benefits of implementing the data link mandate and/or 25 NM lateral separation.

y) HF system may not be able to handle future air traffic levels as a backup system.

Part II

For **each** of the program risks events above that you feel qualified to discuss, please answer the questions below. You do not have to answer questions that you feel unqualified to answer. In addition, please comment whether the answer is different with respect to the two different NAT SPG *Initiatives* being examined (see Appendix A): 1) Oceanic Data Link Mandate, and (2) 25 NM Lateral Separation. Lastly, please indicate whether the answer is different with respect to the various *Phases* planned for each Initiative.

Risk to be described (from list above):

1. Describe in detail the cause(s) of this program risk event. Is/are the cause(s) different for the two different *Initiatives*? Different between the various *Phases*?
2. Describe the outcome(s) of this risk. In other words, what happens when this risk materializes? Are the outcomes different for the two different *Initiatives*? Different between the various *Phases*?
3. Does the occurrence of this risk event depend on the occurrence of other risk events? If so, which ones? Are these dependencies different for the two different *Initiatives*? Different between the various *Phases*?

How difficult is it to detect that this risk event has occurred?

• Very high difficulty • High difficulty • Medium difficulty • Low difficulty • Very Low difficulty

Is this difficulty different for the two different *Initiatives*? Different between the various *Phases*?

4. How difficult is it to implement corrective action once the risk event has occurred?

• Very high difficulty • High difficulty • Medium difficulty • Low difficulty • Very Low difficulty

Is this difficulty different for the two different *Initiatives*? Different between the various *Phases*?

5. What level of coordination is required to implement the corrective action?

• Very high coordination • High coordination • Medium coordination • Low coordination • Very Low coordination

Is this coordination different for the two different *Initiatives*? Different between the various *Phases*?

6. What is the probability or frequency of occurrence of this risk event?

- Very high probability • High probability • Medium probability • Low probability • Very Low probability
- and / or
- Very high frequency • High frequency • Medium frequency • Low frequency • Very Low frequency

Is this frequency and or probability different for the two different *Initiatives*? Different between the various *Phases*?

IMPACT:

Please describe the impact on the following categories and how those impacts are differ between the two initiatives and phases:

Impact on safety:

- Very high impact • High impact • Medium impact • Low impact • Very Low impact • None

Is this impact different for the two different *Initiatives*? Different between the various *Phases*?

Impact on operational efficiency:

- Very high impact • High impact • Medium impact • Low impact • Very Low impact • None

Is this impact different for the two different *Initiatives*? Different between the various *Phases*?

Impact on costs to the ANSP's

- Very high impact • High impact • Medium impact • Low impact • Very Low impact • None

Is this impact different for the two different *Initiatives*? Different between the various *Phases*?

Impact on revenues to the ANSP's

- Very high impact
- High impact
- Medium impact
- Low impact
- Very Low impact
- None

None

Is this impact different for the two different *Initiatives*? Different between the various *Phases*?

Impact on costs to commercial aircraft and business aircraft operators

- Very high impact
- High impact
- Medium impact
- Low impact
- Very Low impact
- None

None

Is this impact different for the two different *Initiatives*? Different between the various *Phases*?

What is the impact on revenues to commercial aircraft and business aircraft operators if this risk event were to occur?

- Very high impact
- High impact
- Medium impact
- Low impact
- Very Low impact
- None

None

Is this impact different for the two different *Initiatives*? Different between the various *Phases*?

EURO MANDATE:

3.3.1.1 All concerned aircraft operating flights as general air traffic in accordance with instrument flight rules in the airspace defined below shall be equipped with context management (CM) and controller-pilot data link communications (CPDLC) applications capable of supporting the following data link services: data link initiation capability, air traffic control clearance, air traffic control communications management and air traffic control microphone check:

a) from 7 February 2013, in the following FIRs/UIRs above FL285:

Amsterdam FIR, Wien FIR, Barcelona UIR, Brindisi UIR, Brussels UIR, Canarias UIR, France UIR, Hannover UIR, Lisboa UIR, London UIR, Madrid UIR, Milano UIR, Rhein UIR, Roma UIR, Scottish UIR and Shannon UIR; and

b) from 5 February 2015, in the following FIRs/UIRs above FL285:

Bratislava FIR, Bucuresti FIR, Budapest FIR, Kobenhavn FIR, Ljubljana FIR, Nicosia FIR, Praha FIR, Sofia FIR, Warszawa FIR, Finland UIR south of 61°30', Hellas UIR, Malta UIR, Riga UIR, Sweden UIR south of 61°30', Tallinn UIR, Vilnius UIR.

Note.— Requirements for the CM and CPDLC applications to support the data link services described are contained in RTCA DO-280B/EUROCAE ED-110B Interoperability Requirements Standard For ATN Baseline 1 (INTEROP ATN B1) and RTCA DO-290/EUROCAE ED-120 Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace (Continental SPR Standard), including Changes 1 and 2, with the exceptions that:

a) Uplink message 135, CONFIRM ASSIGNED LEVEL, and Uplink message 233, USE OF LOGICAL

ACKNOWLEDGMENT PROHIBITED, will not be used by the ground systems; and

b) Downlink message 38, ASSIGNED LEVEL (level), is not required by the aircraft.

3.3.1.2 Conformance to the equipage requirement and operator's approval shall be verified by the State of Registry or the State of the Operator, as appropriate.

3.3.1.3 Aircraft are exempted from the requirement stipulated in 3.3.1.1 in the following cases:

a) aircraft with an individual certificate of airworthiness first issued before 1 January 2011 are exempted until 5 February 2015;

b) aircraft with an individual certificate of airworthiness first issued before 1 January 2014 and fitted with data link equipment certified against requirements specified in RTCA DO-258A/EUROCAE ED-100A (or ED-100) are exempted for the life of that particular airframe;

c) aircraft which have a certificate of airworthiness issued before 31 December 1997 and which will cease operation in the airspace referred to in Paragraph 3.3.1.1 before 31 December 2017 are exempted from the requirement stipulated in 3.3.1.1;

d) state aircraft;

e) aircraft flying in the airspace referred to in Paragraph 3.3.1.1 for testing, delivery and for maintenance purpose; and

f) operators of types of aircraft reaching the end of their production life and being produced in limited numbers, or types of aircraft for which re-engineering costs required would be disproportionate due to old design, may, based on this criteria, request from the appropriate authority the granting of an exemption. Such requests shall be made prior to 30 September 2012 and include detailed information justifying the need for the granting of the exemption.

End of new text

- END - APPENDIX A: NAT SPG Initiatives

Horizontal Separation Reduction Initiatives: NAT SPG/45 June 2009 Report

| Date | Separation Reduction | Data Link Comm Requirement | Nav Requirement | Surveillance Requirement |
|-----------------|---|---|--|--|
| 6 May 2010 | Trial 5-minute longitudinal separation between eligible aircraft pairs in Shanwick FIR. (Gander FIR at a later date) | FANS 1/A CPDLC meeting appropriate standards. | GPS meeting standards for oceanic operations | FANS 1/A ADS-C meeting appropriate standards |
| 2012 Phase 1 | *25 NM lateral on 2 OTS tracks between 350-400 (inclusive) | FANS 1/A CPDLC meeting appropriate standards | RNP tbd (Note: anticipate RNP 4) | FANS 1/A ADS-C meeting appropriate standards |
| 2013 Phase 2 | *25 NM lateral on <u>all</u> OTS tracks between 350-400 (inclusive) | FANS 1/A CPDLC meeting appropriate standards | RNP tbd (Note: anticipate RNP 4) | FANS 1/A ADS-C meeting appropriate standards |
| 2015 Phase 3 | 25 NM lateral expanded to targets of opportunity in NAT Region between 350-400 (inclusive) | FANS 1/A CPDLC meeting appropriate standards | RNP tbd (Note: anticipate RNP 4) | FANS 1/A ADS-C meeting appropriate standards |

***Operational Restrictions.** Operators/aircraft not appropriately equipped and, as required, authorized could be restricted from operation on specified tracks or airspace at specified flight levels.

NAT Data Link Mandate: see next page for proposed plan to mandate data link equipage in NAT MNPS airspace.

Proposed NAT SPG Mandate For Oceanic Data Link Equipage (FANS 1/A CPDLC and ADS-C)

| Year | Airspace Where Applicable | Flight Levels Where Applicable | Remarks |
|------------|------------------------------|--------------------------------|---|
| 7 Feb 2013 | *To-be-determined OTS tracks | *To-be-determined FL's | Aircraft to be equipped <u>in order to operate</u> at specified FL's, however, NAT SPG to explore measures to accommodate non-equipped aircraft |
| 5 Feb 2015 | *MNPS Airspace | *To-be-determined FL's | Remark above applies |

***Operational Restrictions.** Operators/aircraft not appropriately equipped and, as required, authorized could be restricted from operation on specified tracks or airspace at specified flight levels.

Additional Note:

European Air Navigation Planning Group (EANPG) proposed exemption to data link requirement in designated European airspace: aircraft with an individual certificate of airworthiness first issued before 1 January 2014 and fitted with data link equipment certified against requirements specified in RTCA DO-258A/EUROCAE ED-100A (or ED-100) are exempted for the life of that particular airframe.

Appendix B: ICAO Annex 6 - Operation of Aircraft, Section 6.3.1.5

6.3.1.5 All aeroplanes for which the individual certificate of airworthiness is first issued after 1 January 2005, which utilize data link communications and are required to carry a CVR, shall record on a flight recorder, all data link communications to and from the aeroplane. The minimum recording duration shall be equal to the duration of the CVR, and shall be correlated to the recorded cockpit audio.

6.3.1.5.1 From 1 January 2007, all aeroplanes which utilize data link communications and are required to carry a CVR shall record on a flight recorder, all data link communications to and from the aeroplane. The minimum recording duration shall be equal to the duration of the CVR, and shall be correlated to the recorded cockpit audio.

6.3.1.5.2 Sufficient information to derive the content of the data link communications message and, whenever practical, the time the message was displayed to or generated by the crew shall be recorded.

Note.- Data link communications include, but are not limited to, automatic dependent surveillance (ADS), controller-pilot data link communications (CPDLC), data link flight information services (D-FIS) and aeronautical operational control (AOC) messages

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