Historical Explorations – Learning Lessons from the Past to Inform the Future

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Historical Exploration - Learning Lessons from the Past to Inform the Future

Tim Bedford[1], John Quigley, Matthew Revie and Lesley Walls

Executive Summary

This report examines a number of exploration campaigns that have taken place during the last 700 years, and considers them from a risk perspective. The explorations are those led by Christopher Columbus, Sir Walter Raleigh, John Franklin, Sir Ernest Shackleton, the Company of Scotland to Darien and the Apollo project undertaken by NASA. To provide a wider context for investigating the selected exploration campaigns, we seek ways of finding analogies at mission, programmatic and strategic levels and thereby to develop common themes. Ultimately, the purpose of the study is to understand how risk has shaped past explorations, in order to learn lessons for the future. From this, we begin to identify and develop tools for assessing strategic risk in future explorations.

Figure 0.1 (see Page 6) summarizes the key inputs used to shape the study, the process and the results, and provides a graphical overview of the methodology used in the project. The first step was to identify the potential cases that could be assessed and to create criteria for selection. These criteria were collaboratively developed through discussion with a Business Historian. From this, six cases were identified as meeting our key criteria. Preliminary analysis of two of the cases allowed us to develop an evaluation framework that was used across all six cases to ensure consistency. This framework was revised and developed further as all six cases were analyzed.

A narrative and summary statistics were created for each exploration case studied, in addition to a method for visualizing the important dimensions that capture major events. These Risk Experience Diagrams illustrate how the realizations of events, linked to different types of risks, have influenced the historical development of each exploration campaign. From these diagrams, we can begin to compare risks across each of the cases using a common framework. In addition, exploration risks were classified in terms of mission, program and strategic risks. From this, a Venn diagram and Belief Network were developed to identify how different exploration risks interacted. These diagrams allow us to quickly view the key risk drivers and their interactions in each of the historical cases.

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By looking at the context in which individual missions take place we have been able to observe the dynamics within an exploration campaign, and gain an understanding of how these interact with influences from stakeholders and competitors. A qualitative model has been created to capture how these factors interact, and are further challenged by unwanted events such as mission failures and competitor successes. This Dynamic Systemic Risk Model is generic and applies broadly to all the exploration ventures studied. This model is an amalgamation of a System Dynamics model, hence incorporating the natural feedback loops within each exploration mission, and a risk model, in order to ensure that the unforeseen events that may occur can be incorporated into the modeling.

Finally, an overview is given of the motivational drivers and summaries are presented of the overall costs borne in each exploration venture. An important observation is that all the cases – with the exception of Apollo – were failures in terms of meeting their original objectives. However, despite this, several were strategic successes and indeed changed goals as needed in an entrepreneurial way. The Risk Experience Diagrams developed for each case were used to quantitatively assess which risks were realized most often during our case studies and to draw comparisons at mission, program and strategic levels. In addition, using the Risk Experience Diagrams and the narrative of each case, specific lessons for future exploration were identified.

There are three key conclusions to this study:

Analyses of historical cases have shown that there exists a set of generic risk classes.

This set of risk classes cover mission, program and strategic levels, and includes all the risks encountered in the cases studied. At mission level these are Leadership Decisions, Internal Events and External Events; at program level these are Lack of Learning, Resourcing and Mission Failure; at Strategic Level they are Programmatic Failure, Stakeholder Perception and Goal Change. In addition there are two further risks that impact at all levels: Self-Interest of Actors, and False Model.

There is no reason to believe that these risk classes will not be applicable to future exploration and colonization campaigns.

We have deliberately selected a range of different exploration and colonization campaigns, taking place between the 15th Century and the 20th Century. The generic risk framework is able to describe the significant types of risk for these missions. Furthermore, many of these risks relate to how human beings interact and learn lessons to guide their future behavior. Although we are better schooled than our forebears and are technically further advanced, there is no reason to think we are fundamentally better at identifying, prioritizing and controlling these classes of risk.

Modern risk modeling techniques are capable of addressing mission and program risk but are not as well suited to strategic risk.

We have observed that strategic risks are prevalent throughout historic exploration and colonization campaigns. However, systematic approaches do not exist at the moment to analyze such risks.

A risk-informed approach to understanding what happened in the past helps us guard against the danger of assuming that those events were inevitable, and highlights those chance events that produced the history that the world experienced. In turn, it allows us to learn more clearly from the past about the way our modern risk modeling techniques might help us to manage the future – and also bring to light those areas where they may not.

This study has been retrospective. Based on this analysis, the potential for developing the work in a prospective way by applying the risk models to future campaigns is discussed. Follow on work from this study will focus on creating a portfolio of tools for assessing strategic and programmatic risk.

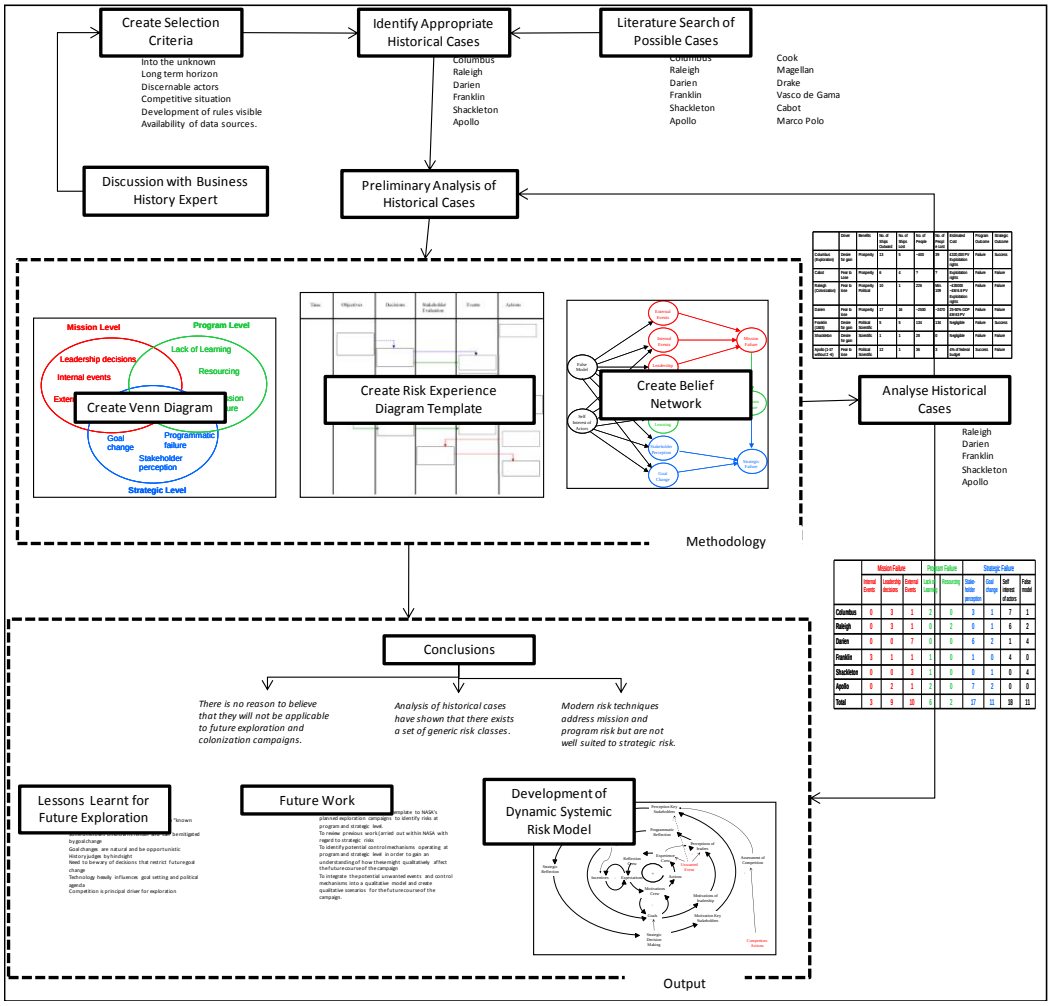

Figure 0.1 – Overview of Methodology Flow Indicating Relationship between Tasks

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1 Aims, Objectives and Scope

The aim of this study is to explore the history of exploration from a risk perspective in order to gain an understanding of the ways in which risk has shaped past exploration and to understand how similar risks may shape future exploration.

The objectives of this study are:

- To describe the risk characteristics of a variety of historical cases which are selected to provide a representative cross-section of exploration characteristics;
- To develop a unified risk typology to allow comparison of the costs, risks and benefits of exploration cases;
- To examine the historical campaigns carried out in pursuit of an exploration goal to assess how risk impacts differently on the operation of the missions and programs as well as at the strategic level of the campaigns;
- To investigate the relative success or failure of each mission and explore the primary conditions required in order to achieve exploration success;
- To appreciate the context in which an exploration campaign took place to inform our understanding of the broad impact of external risks affecting the society's attitudes to exploration.

A number of historical explorations are examined within the scope of this study. The cases have been selected to provide coverage of different periods of time and a variety of exploration characteristics, especially in terms of the mission goal. The cases selected represent mainly British, but also some European and a US exploration campaign, undertaken between the late 15th century and the 20th century and together they represent the common motivations for exploration such as, for example, the expansion of scientific knowledge, the establishment of colonies, and the identification of trade routes to increase economic prosperity or the demonstration of political superiority.

2 Methodology and Process

In this section we consider the process for selecting the cases which provide the data input to the analysis, and the methodological framework developed to support analysis of the case data.

2.1 Criteria for Selection of Historical Cases

In order to gain a richness of data and to capture trends through history, it was decided to use a selection of cases from early European exploration of the New World in the late 15th century to the Apollo missions of the 20th century. More importantly, however, this allows us to assess whether a framework could be formulated that could credibly encompass both early exploration and the current space exploration.

In order to select cases within this frame of reference, a set of criteria were established informed by academic business historians[2]. The criteria are as follows:

- Into the unknown - There exists a high degree of uncertainty in the outcome of the exploration arising because, for example, it is the first occasion in which humans, from the contemporary society commissioning the exploration, visited a new location or carried out a particular type of sortie;
- Long term horizon - Individual missions last several years, and are part of a longer term program, which itself is part of a long term strategic campaign;
- Discernable actors - There are key identifiable figures whose decisions, views, abilities and vision are drivers in the exploration story;
- Competitive situation - There should be a prospect of gain or loss from the exploration, whether this is economic, defensive, political, or simply scientific;
- Development of rules visible - There is a development of "rules of the game" through the exploration campaign, by which the relationships between explorers and other stakeholders, and the rights of explorers in particular, become formalized;
- Availability of data - Data for the exploration is readily available. Note, however, that this research has largely restricted to secondary sources.

[2] These criteria were developed post communications with Professor Charles Harvey, Dean Strathclyde Business School and Editor of the prestigious journal Business History. We would also like to acknowledge useful discussions with Professor Mark Casson, Professor of Economics at Reading University.

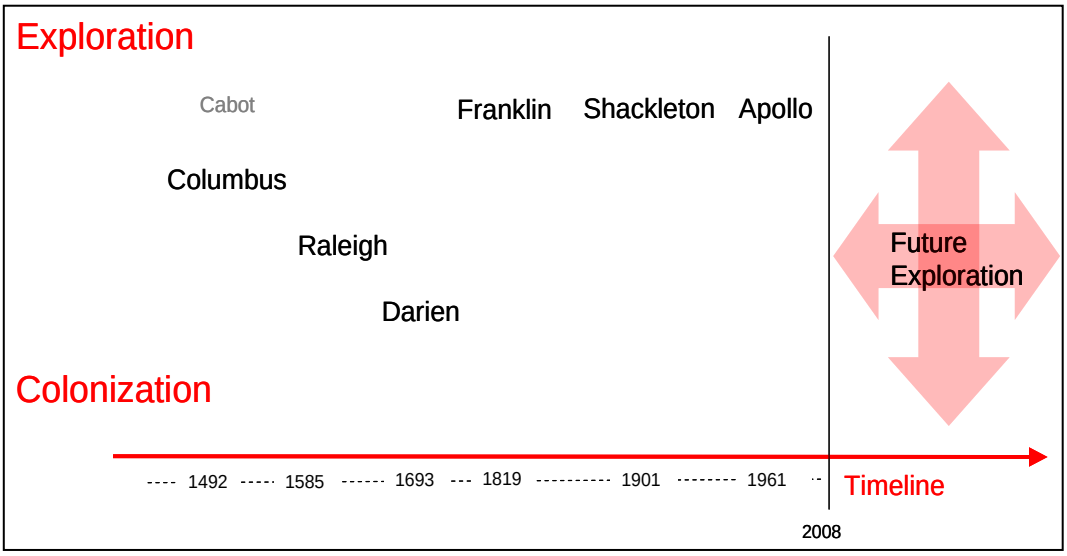

Figure 2.1 – Cases studied identified by time and positioning of exploration and colonization goals

Six major cases were deemed to satisfy our criteria and have been selected for the study. These are the explorations led by Columbus, Raleigh, Franklin and Shackleton, the scheme to form a colony at Darien and the Apollo campaign. The positioning of these cases in calendar time and relative to the poles of exploration through colonization is shown in Figure 2.1. Note that a seventh case, Cabot, is considered in less detail (hence the reduced prominence in Figure 2.1) to provide a comparison with the Columbus case.

In order to inform the development of the framework for analysis, two cases were selected for an initial pilot study - namely Darien and Apollo. These cases represent contrasting goals and calendar time, and hence provide a robust basis upon which to test and develop the methodology before implementation to all cases. The methodology was reviewed again after initial implementation on all cases, and further minor adjustments made. The evolution of the methodological framework is not discussed further, and only the mature version is used in the reported analysis.

2.2 Framework for Analysis

Figure 2.2 shows the framework for analysis. The preliminary analysis of the two pilot cases led us to develop a risk experience diagram to represent the key objectives, decisions and events extracted from the, usually extensive, narrative of the case materials and hence provide a summary characterization to better understand the risks. Two alternative representations of the risk classes have been developed. The simpler is a Venn diagram that represents the types of risks at different levels of the exploration - namely, mission, program and strategic risks, the latter being our terminology for the campaign level. The second is the belief network which aims to capture the influences between the

risks within and between each class. Together these three diagrammatic methods represent the framework for this study, which is used to analyze all six cases and also provides an output insofar as it can be used to support analysis of additional cases in future.

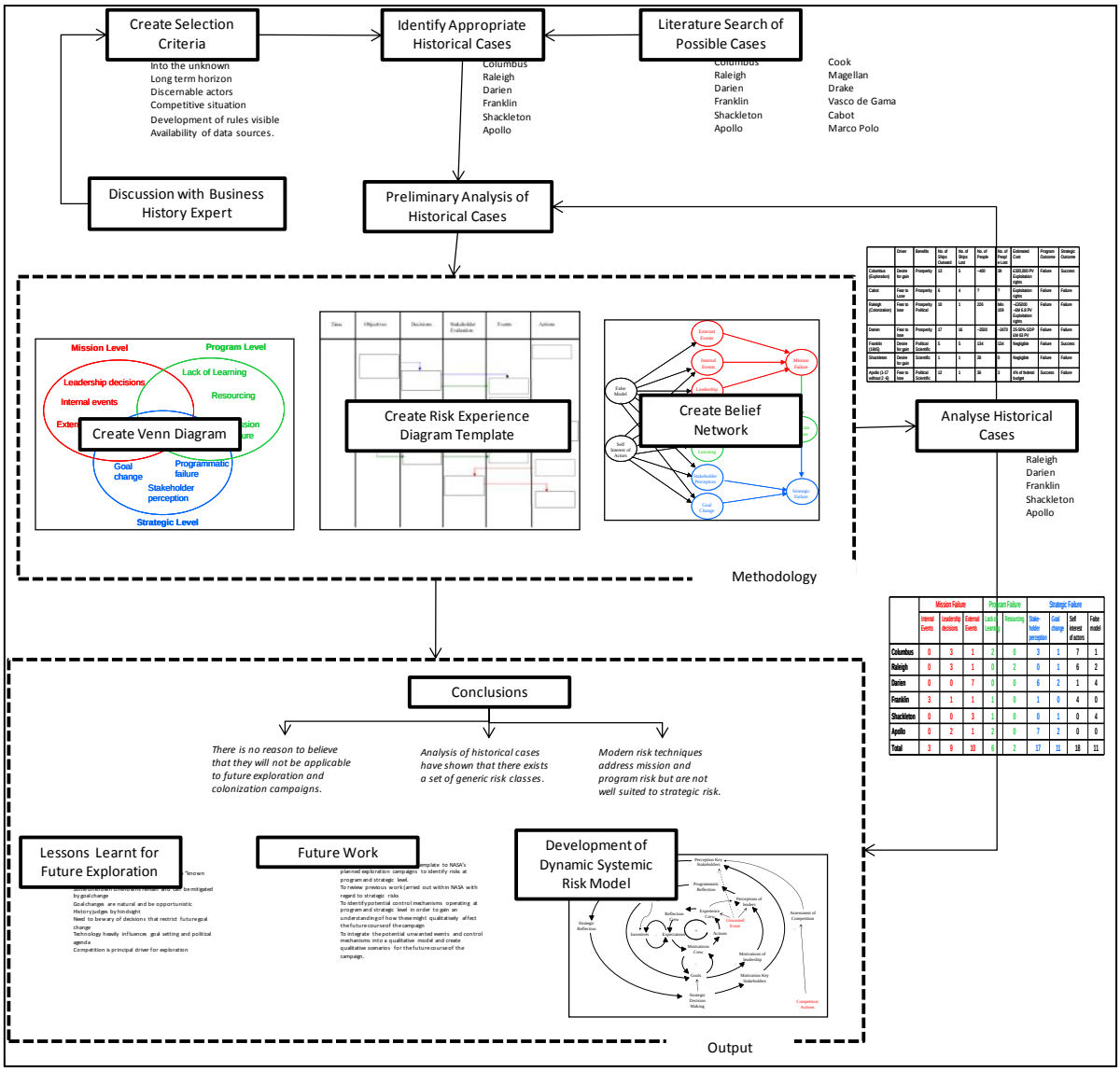

Figure 2.2 – Overview of Methodology Flow Indicating Relationship between Tasks

The process of applying these methods was iterative. As additional sources of material were read and an understanding of the issues developed, the analysis cycled through the stages of this framework. Through analysis of all cases, a model emerged for describing the dynamic relationship between the risks through time and between stages of the exploration. We name this a *Dynamic*

Systemic Risk Model because it captures not only the dynamic elements, but also the systemic aspects of risk, and facilitates deeper understanding of the controllable and uncontrollable factors affecting the chance of exploration success. We consider this model as the main methodological output of the study.

Through application of the aforementioned methods and model, we are able to generate insights into the risk drivers and understand the issues that affected the success, or failure, of missions. Hence we are able to produce the output results of the study.

Each of the method and model components of this framework is described in the subsequent sections of this chapter.

2.2.1 Risk Experience Diagram

The pilot analysis led to the development of the 'Risk Experience Diagram' – see Figure 2.3. This is a visual representation of key experiences emerging from the case narrative through calendar time. The purpose of the diagram is to summarize the main risk characteristics of a case in order to draw comparisons and identify trends. A prototype Risk Experience Diagram, created for the pilot cases, has been revised and improved for use with all six cases.

Each experience is categorized into one of the following: objectives; decisions; stakeholder perception; events; and actions. These five categories allow us to capture the rich case history in terms of the objectives of each stage of the exploration; the decisions taken; the perception of stakeholders; the internal or external events impacting the exploration; and the actions of competitors, crew and other actors. The text boxes provide a description of the identified experience for a given case, although they are empty in the generic diagram in Figure 2.3. For events and actions, a solid box represents an internal experience whilst a dotted-line box represents an external experience. A solid directed line between boxes shows the relationship of one experience upon another. A dashed line represents the relationship between an experience (tail of arrow) that mitigated against a risk (head of arrow). The lines are also color coded according to the level of the risk in terms of its impact on the mission (red line), program (green line) or strategic level (blue line). If a risk encompasses more than one level, it is represented by a black line.

Although there are multiple actors involved in making decisions and taking actions – see Table 2.1 for list of the main types of actor – we do not distinguish between these explicitly within the diagram beyond including appropriate descriptions of the named actors within the experience text boxes.

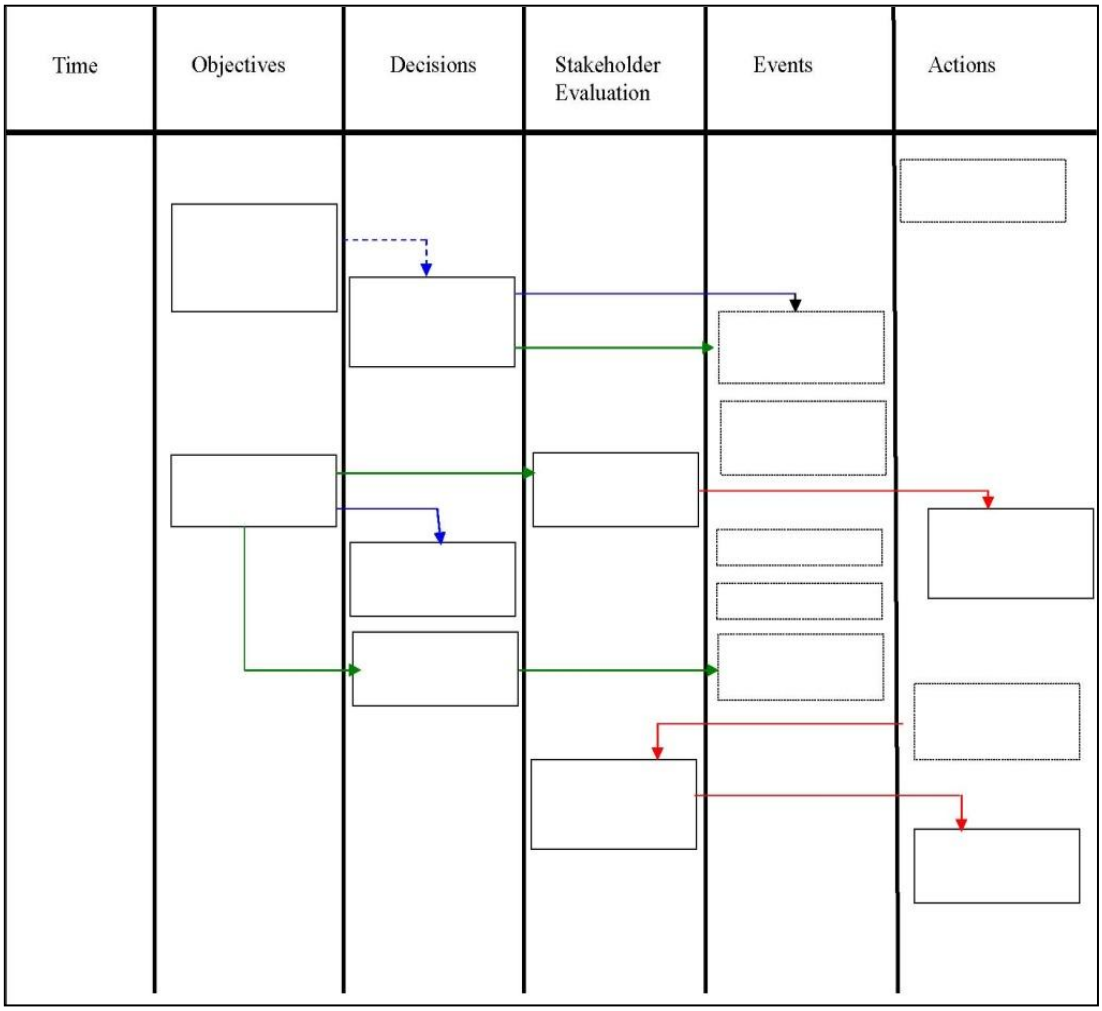

Figure 2.3 – Generic Risk Experience Diagram Capturing Key Elements of Case Studied

Table 2.1 Description of Key Actors within Exploration

Actor	*Description*
Leader	The person, or group, who plays the leading role in defining and executing the exploration venture.
Stakeholder	Those who are engaged with the exploration venture but are not direct participants, for example investors, taxpayers.
Participants	Those who take part in the exploration venture, either directly or indirectly, for example as crew, colonists.
Competitor	Those aligned to a different economic, social or national group, who seek benefit from their own potential or actual expedition ventures.

2.2.2 Venn Diagram of Risk Classes

The constructed risk experience diagram represents the subjective analysis of the researchers based upon consideration of multiple sources of literature and secondary data for each case. From these diagrams it is possible to identify common types of risks at each level of the exploration campaign and indeed it is possible to quantify their occurrence for a given case and to classify them more generally. Figure 2.4 shows a Venn diagram representing the exploration risk classifications developed from the historical cases, while Table 2.2 provides a definition of each risk. Note that "false model" and "self-interest of actors" are considered common to all three levels, hence they are shown at the intersection of the mission, program and strategy classes.

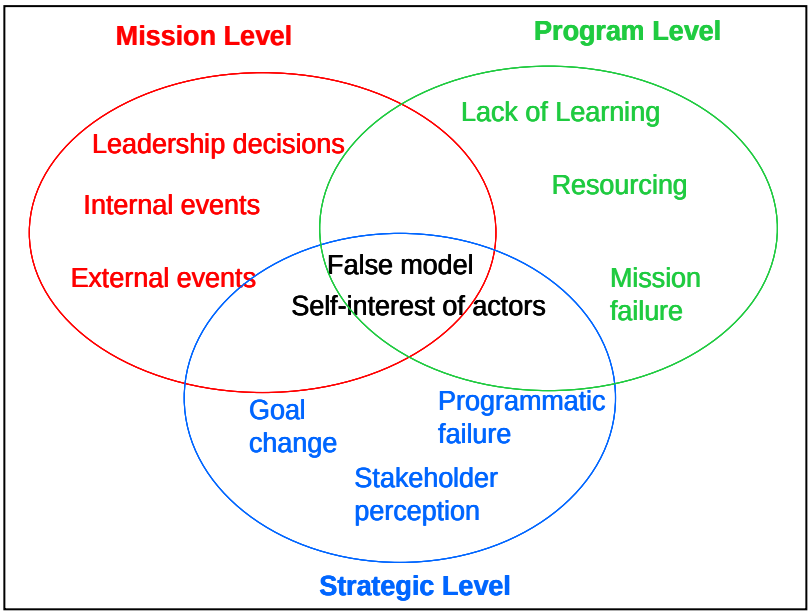

Figure 2.4 – Venn Diagram representing Exploration Risk Classes

Table 2.2 – Definitions of Risks Classes

Risk	*Definition*
Leadership Decisions	This relates to decisions by leaders which appear poor when judged with hindsight on the basis of the criteria apparently in use at the time, and where there are no significant external low probability events affecting the outcome. That is, they are decisions which are intrinsically poor rather than where the decision maker was unlucky.
Internal Events	Risks arising from internal planning and design problems, for example logistic support, whose failure would increase the probability of mission failure.
External Events	Risks arising from external factors, such as the environment, which are not predicted.
Lack of Learning	The ability to adapt and update one's model is crucial for success, hence the inability to do this, whether through lack of available data or through inability to use that data, is a potential risk.
Resources	Lack of provision for funds from the sponsors, or overuse of allocated resources.
Goal Change	The reformulation of goals, either through a re-prioritization of objectives or the introduction of new ones. This is considered a risk because it means that the original goals have been replaced with potential loss of investment aimed at that goal. However, with the benefit of hindsight, history may treat goal change as a positive outcome.
Stakeholder Perception	Stakeholders' views of the expedition venture may change through time and influence the willingness of those stakeholders to provide resources and act in its support.
Self Interest of Actors	The actions of actors who pursue their own direct (possibly short-term) objectives instead of those set by the leadership.
False Model	Misinterpretation of data through making a false set of assumptions, or a false model about the relationship between the data and reality.

2.2.3 Belief Network for Relationship between Risks

From the historical cases, it is clear that there exist influences between the risks within and between each class. Hence a natural extension of the Venn diagram is the construction of a belief network as shown in Figure 2.5. A belief diagram is built up from two elements – a node and an arc. A circular node represents an uncertain variable and the arc represents the dependency of one variable on another. For more information on belief networks, see Clemen (1991). Figure 2.5 shows that internal events, external events and leadership decisions influence the chance of mission failure (or success), which in turn, along with resources and lack of learning, can influence the chance of program failure. The independent nodes, false model and self-interest of actors, may influence all other variables.

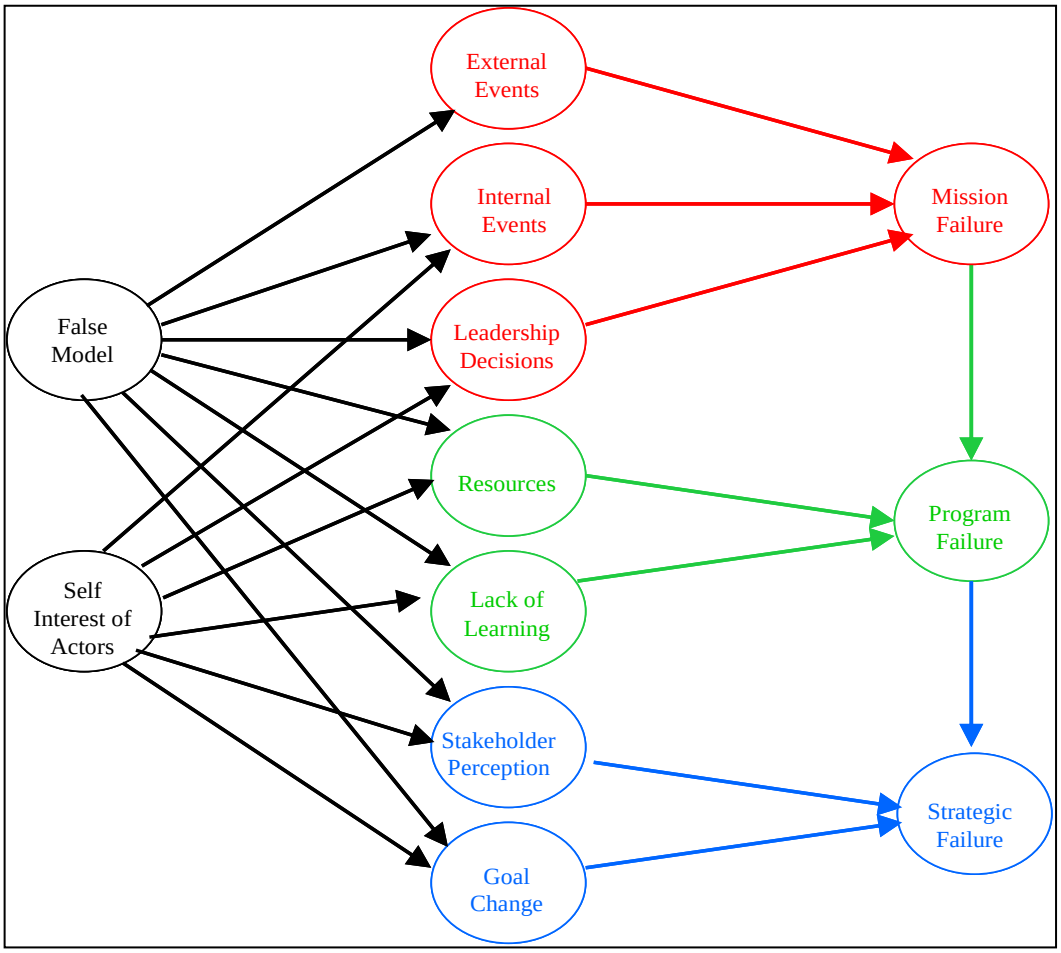

Figure 2.5 – Belief Network of Risk Classes

2.2.4 Concept of System Dynamics

Since explorations evolve dynamically through time, the concepts of system dynamics can also inform our understanding of the relationships between risk variables through control mechanisms to help manage the behavior and actions of the actors. See Appendix 1 for a simple qualitative system dynamics example. For further reading on system dynamics, see Forrester (1961).

We do not use System Dynamics modeling directly within this study. However the concepts as discussed above are used to inform our understanding of the dynamic nature of systemic risks inherent in an exploration and will be introduced within the analysis of relevant cases in Section 4. A general version of a new "Dynamic Systemic Risk" model will be presented in Section 5. This model represents the methodological output of this study and is grounded in the case analyses.

2.2.5 Statistical Data and the Role of the GDP Deflator

For each case, we gather and present a selection of relevant descriptive statistics. These include data regarding the number of ships, participants – both commissioned and surviving – as well as the costs of the exploration. Cost data gathered for each exploration are usually expressed in monetary value at the time of the campaign. In order to compare cases, it is necessary to adjust for inflation in prices, and hence costs, over time. There is no one standard approach to do this. We have chosen to use one common approach which involves removing the effect of inflation by converting the nominal monetary figure to a real figure using the Gross Domestic Product (GDP) deflator.

The general reasoning behind the GDP deflator is as follows. Price changes vary from item to item. Hence to adjust for the effects of inflation we require a price index which is a weighted average of the price changes in various items. The ambiguity in the construction of a price index arises due to the weights applied to the various price changes. Different industrial sectors or individuals within an economy will experience different erosions of the spending power of their currency depending on the commodities they purchase. The weight given to a commodity's price change within the GDP deflator is the percentage of importance in the total GDP, which is the total value of the goods and services produced by a nation within a year.

To illustrate an alternative approach, the Consumer Price Index (CPI) is constructed with weights reflecting a *typical* consumer's expenditure. Table 2.3 provides the UK GDP Deflator and the UK CPI for a selection of 4 different years within the time span of the selected exploration cases using 2006 as a base year. The table shows that an item costing £100 in 2006 could be estimated to have cost £0.17 or £0.27 in 1300 depending upon the adjustment method chosen. Where estimates for specific years are not available, then we approximate with linear interpolation.

Table 2.3 - Example of Price Adjustment using GDP deflator and CPI for British £

Year	*GDP Deflator*	*CPI*
1300	0.17	0.27
1688	0.60	0.68
1759	0.71	0.78
2006	100.00	100.00

Source: www.measuringworth.com

2.3 Summary

In this section, the criteria for selecting the historical exploration cases have been explained and the framework for the subjective analysis has been described. In the following section, we discuss the application of the methods and present the values of the descriptive statistics for each of the 6 cases selected.

3. Summary Analysis of Individual Cases

3.1 Generic Structure for Case Analysis

Each historical case analyzed is presented using the following structure. A short summary will be given of the overall campaign. Next, the goal at the start of the campaign will be described both at a program level and at a strategic level. A short contextual description of the economic and political state of the sponsoring nation will be presented together with the conceptual plan behind the campaign. A description of each mission within the campaign and a discussion of the result of the overall campaign will follow. From this, selected summary statistics will be shown. Note that the detail and accuracy of the statistics presented tends to decrease as we move further back in time. Finally, an overview of the risk lessons learned from the case is discussed. At the end of each chapter, a list of the key references used throughout each narrative is given.

The historical cases are given in chronological order – starting with Christopher Columbus and concluding with Project Apollo.

3.2 The Voyages of Christopher Columbus (1492-1502)

3.2.1 Summary

In 1492 Christopher Columbus set sail west from Spain to identify a trade route linking Europe with the Far East – instead he discovered America. Whilst his campaign could be considered a failure against the original objective, these initial discoveries eventually led to the settlement of Europeans in America and *The Columbian Exchange* – the movement of resources, plants, animals and diseases between Europe and America. In total, Columbus led four voyages from Spain to the New World and established multiple settlements on Hispaniola during this time. Whilst Columbus was considered an excellent mariner, his ability as a colonial administrator was poor. The colonists consistently rioted against his rule, he adopted strict control measures against the natives and, during his third voyage, he was arrested and sent back to Spain, stripped of all powers. Due to his expert knowledge of the area, Columbus was allowed to continue exploring for the Spanish - partly to ensure that he would not take his knowledge to rival countries. Despite the mounting evidence to the contrary, even on his death bed, he refused to believe that the land he discovered was not Asiatic.

3.2.2 Mission Goal

The program goal of Columbus's voyage was to identify a trade route west from Spain to the Far East in order to break the monopoly of Arab and Venetian spice traders. At a strategic level, the aim of the Spanish monarch was to increase its prosperity.

3.2.3 Context

Throughout the 15th century, trade between the Far East and Europe was primarily brought by land and sea along *The Silk Road*. However, the collapse of

the Mongol Empire interrupted this flow and forced Europeans to consider alternative ways of transporting goods. The Portuguese had established a number of trade outposts and fortified bases along the west coast of Africa and had begun to explore the establishment of a trade route from Portugal to China by traveling around the Horn of Africa. Without access to these posts or development of similar ones, it is unlikely that any other European country would have been successful in finding a trade route via the Horn of Africa. Hence, explorers began to investigate alternative ways to reach the Far East.

3.2.4 Concept

As early as 1480, Columbus believed that new trade routes with India and the Far East could be established by sailing west and around the earth as opposed to trekking over land. He conducted extensive research, including living in the Canary Islands and the Azores for months in order to observe the direction and strength of the winds. Initially he appealed to the King of Portugal for funds to support exploration. He requested three ships, to be made "Admiral of the Ocean", be appointed governor of any lands discovered and given one-tenth of all profits from trade or land.

Columbus proceeded to contact Genoa, Venice, the King of England and the King and Queen of Spain. In 1486, the Spanish monarch granted Columbus an audience; however he was rejected on the grounds that he had underestimated the distance to Asia. In order that Columbus did not take his proposals elsewhere, he was given an annual annuity from the Spanish and continued to lobby for their support. In 1492, Spain captured Muslim Granada and was able to turn its attention away from internal conflict towards other lands. After numerous requests for support, Spain decided to finance Columbus on his venture. Whilst protection and part-funding came from the Spanish monarch, half of the financing also came from private Italian investors. Columbus requested of the Spanish the same terms as he demanded of the Portuguese – all of which were granted. This was considered an extremely generous deal, which some believe highlights that the Spanish monarch believed the mission had a low chance of success.

3.2.5 Exploration

On 3rd August 1492, three ships, *The Santa Maria (*a large carrack), *The Nina* and *The Pinta* (two smaller caravels), containing approximately 96 men, began to sail west. The men on board the three ships were a mixture of sailors and pardoned condemned men. As the voyage was one of exploration, there were no soldiers or settlers aboard any of the three ships. The voyage did not begin well. The Spanish monarch had forced Juan de la Cosa, Martin Pinzon and Vicente Pinzon to provide *The Nina* and *The Pinta.* Within 3 days of leaving Spain, the rudder on *The Pinta* broke, and it has been speculated that sabotage was the cause. *The Pinta* was able to limp to the Canary Islands, where the rudder was repaired, the Nina's sails were re-rigged and further provisions were taken on board.

Using the Canary Isles as his departure point is considered to be one of the key reasons for Columbus' success as this gave him the greatest chance of finding

the necessary winds. Typical mariners of the day would set sail against the wind to ensure they had a wind to return. However, Columbus set sail with the wind at his back, a very risky strategy for the time, because he knew he could find a wind to bring him home via the Azores. Ignoring wind, the intuitive choice would be to sail from the Azores or Cape Verde as they lie further west or further south. However, Columbus had gathered knowledge about the winds in each of the three potential locations and believed, correctly, that departing from the Canaries gave him the highest chance of success.

Columbus was wary of managing the expectations of the sailors throughout the voyage. As such, he kept two logs of the distance traveled during the voyage. One was an underestimation of the distance traveled which he allowed the crew to see while the other recorded what he considered to be the true distance traveled. Columbus was understandably worried about the potential for mutiny and as such did not want the sailors to feel as if they were too far away from home. In addition, if land was not where Columbus expected it to be, this would give him additional time without the sailors being suspicious. He was well known for being optimistic and, retrospectively, the distance traveled was closer to the distance he recorded in the log for the sailors than in the log he kept for himself.

On 7th October 1492, land which turned out to be one of the islands in the Bahamas[3] was spotted by Rodrigo de Triana, but later claimed by Columbus. Columbus believed it to be an island off the east coast of Japan. Upon landing, Columbus quickly encountered friendly natives willing to trade and an abundance of food and water. Due to the unexpected availability of these natural resources, Columbus and his men were able to stay in the region for approximately three months and to continue to explore the surrounding islands. As he continued to explore and move west through the islands, he believed that the natives became more civilized – supporting his theory that they had reached the eastern coast of a great empire.

During the exploration, *The Santa Maria* ran aground near Hispaniola and was abandoned. Columbus had begun to establish relationships with the most important native chief he could find and established a permanent settlement on the island as he could not bring all the men home. Thirty nine men were left behind and tasked with building a settlement, collecting gold samples and awaiting a new expedition from Spain. In tangibles, the net result of the voyage was a few gold trinkets, some non-European fruit, the loss of one ship and ultimately, and the lives of the 39 men left behind. While the mission may have been unprofitable, the output that Columbus brought back meant that on his second voyage, a total of 17 ships and 1300 men sailed to America.

The aim of the second mission was colonization as well as exploration. Columbus took 3 ships to continue to explore the region whilst the 14 other ships were there to support colonization. Upon landing at the site of the original settlement, Columbus found all 39 men dead and the fort burned. Natives claimed that the men had mistreated the natives and had been killed. Columbus began the task of establishing a new settlement, Isabella, to the east of the

[3] The exact island is unknown.

original settlement. However, because of the need to quickly establish a settlement for the men, he compromised in choosing a poor location in terms of water and soil. Exploration was still the focus of his attentions and management of the colony was passed to his brothers. Columbus again explored the surrounding area. He had promised the monarch a return on their investment would be forthcoming based on trade with the Far East. However, he was beginning to realize that Cuba was unlikely to be connected to Asia.

On returning to Isabella, he found a colony out of control and war between the Spanish and natives. In order to control the natives and to achieve an immediate return, Columbus began to deport and enslave the natives, as had been the procedure with the Canary Islands rebellion. However, this was not in keeping with the King and Queen of Spain's view and, as such, the slaves were shipped back almost immediately. In addition, crops were not growing in the unfamiliar soil, gold production had almost stopped and provisions from Spain had run out. Columbus had misled the colonists about the standard of living on the island and the climate and because of this, his men were beginning to mutiny. He managed to restore peace to the colony and returned to Spain to answer criticisms of his style of government. Despite his inability to administrate the colony well, Columbus was an excellent mariner and by the end of his second voyage, he had identified the optimal return route. It was not until 1513 when the Gulf Stream was discovered that a faster route was identified.

Columbus was beginning to face pressure to produce an output for his investors and the belief at the time was that land in similar latitudes would have similar minerals. Hence, on his third voyage, Columbus picked a route to the south of the previous two voyages. The Portuguese had discovered gold in Sierra Leone and Columbus intended to travel west along a similar latitude. Columbus eventually reached what is modern day Venezuela and believed that the new continent was sufficiently large that it could not be previously undiscovered. At this point, he still believed that the continent was connected to China. On this voyage, he brought another large contingent of settlers with him, expecting them to strengthen his position in the colony. Once he returned to Hispaniola in 1498, he found the colony in further disarray. He attributed this to the laziness of the Spaniards and not his distorted view of life in the colony. Where Columbus saw fertile soil, willing Indians to serve them, large quantities of gold and a comfortable climate, the men saw harsh soil, constant fighting with the locals, lack of output and hot sticky weather. The situation was so grim that Columbus hung a number of his own crew. The new settlers placed more pressure on the colony's resources and caused further problems. Columbus insisted on bringing skilled men with technical skills, artisans, miners, agriculturists, etc, rather than laborers. Three hundred settlers were brought out with only fifty laborers and only thirty women. As such, Columbus was forced to rely on natives for the hard labor.

More complaints about how Columbus was treating his fellow Spaniards and his management of the colony were reaching the King and Queen of Spain. A new governor, Francisco de Bobadilla, was sent to Hispaniola to take control of the colony. Columbus and his two brothers were arrested and shipped back to Spain. Despite the wealth of evidence supporting the accusations against Columbus and his brothers, the King restored his freedom and his wealth; and,

after much persuasion, agreed to fund Columbus' fourth voyage in order that he not take his knowledge to other nations.

On the fourth and final voyage, Columbus was forced to move away from an administrative role and focus solely on exploration. On this expedition, the aim was to identify a westward passage to the Indian Ocean. Support for Columbus by this point had begun to wane and was highlighted by the fact that the new Governor, Nicolas de Ovando, was equipped with 30 ships whilst Columbus was given 4 small caravels. Columbus was refused access to Hispaniola by the new governor, claiming that if Columbus was to land on the island, it would damage the islands precarious peaceful state. However, a hurricane was forming in the region which Columbus was aware of and he requested refuge whilst warning against any ships leaving the harbor. The Governor ignored his request and continued with his plans to sail. None of Columbus's ships were lost in the storm but a total of 19 of the Governor's ships sunk: the first Spanish treasure fleet to leave the New World, with 500 crewmen lost.

Columbus continued to explore the region, discovering Central America and reaching Panama. Here, Columbus was told stories of a river reaching another ocean. Columbus set up a garrison in the area and continued to explore, however, the garrison was attacked and Columbus left for Hispaniola soon after. On his journey back, his ships were damaged through storm and woodworm and all four ships were forced to beach on the island of Jamaica. With no way of getting news to Hispaniola, two of the crew, assisted themselves by natives, were sent by canoe to get help. Ovando was in no hurry to send assistance and the crew was stranded for just over a year. As with previous encounters, the Spanish and Columbus found it difficult to remain on friendly terms with the natives. As time passed, the natives became more reluctant to provide the Spaniards with food and shelter. With relationships reaching the point of confrontation, Columbus scared the natives by predicting a solar eclipse would occur. The natives, scared by what Columbus was capable of doing, promised to give him and his men food and shelter in return for bringing back the sun. Eventually, Ovando sent ships to rescue Columbus and he returned to Spain via Hispaniola – his last voyage ending in failure.

3.2.6 Dissolution

On his death, Columbus still insisted that he had reached the east coast of Asia. In terms of the initial objective, the four voyages were all (inevitably) failures. However, at a strategic level it is difficult not to underestimate the impact of Columbus's discovery on a European and global scale at the time. For example, the tomato was not introduced into Italy until the mid 16th century when it was imported from South America. Cattle were not found in Texas prior to European settlement and potatoes were not extensively relied upon in Ireland. In addition, the impact of European settlers on the population of the Native Americans was huge. In particular, infectious diseases such as smallpox, wiped out large parts of Native American populations.

3.2.7 Key Statistics

The statistics for the four voyages led by Columbus are given in Table 3.1.

Table 3.1 – Statistics for 4 Columbus Missions (ships devoted in colonization in brackets)

	Ships	*People*	*Ships Lost*	*People Lost*
Voyage 1	3 (0)	~90	1 (0)	39
Voyage 2	3 (14)	~1300	0 (?)	Unknown
Voyage 3	3 (3)	Unknown	Unknown	Unknown
Voyage 4	4 (30)	90	4 (19)	~500

3.2.8 Risk Lessons Learned

If we view Columbus's voyages as a success (not in terms of the program goal but at the strategic level for Spain), then it is necessary to identify, in terms of risk, the potential reasons for this. First, Columbus was obsessive in his preparation and research. Some of his learning was incorrect, such as his trust of Marco Polo's assertion about Japan's distance from China. However his strategy of leaving with the winds at his back was less risky due to his knowledge about the direction of winds at different latitudes.

Columbus was able to gather future support for his ventures based not only on the stories he brought back to Spain, but also on his tangible output. On his first voyage, he returned with gold, natives, non-European fruit and stories that the rivers were lined with gold. Without these items, it is possible that the stories Columbus brought home would not have been believed and his second voyage would not have been so strongly supported.

A risk that Columbus encountered was in negotiating the area around Hispaniola. On his first voyage, a ship ran aground and had to be abandoned. On the return of his second voyage, his ship was caught in doldrums for days. On his fourth voyage, all four of his shops were lost to storm damage and woodworm.

Finally, Columbus was fortunate to identify a location abundant in natural resources and friendly natives. When there was a mission failure and loss of a ship, Columbus had redundancy in the other two ships he had taken, but was able to offer his men a potentially safe haven on the island. It is possible that if Columbus had landed elsewhere, this opportunity would not have been available.

3.2.9 Comparison between Columbus and Cabot

It is instructive to compare the voyages of Columbus with the voyages of John Cabot because both shared a common exploration goal, although different initiating conditions resulted in different event histories.

John Cabot was granted a charter by the English monarch but his voyage was a privately funded venture. He found mainland America in 1497 - one year prior to Columbus – but due to his unwillingness to explore more than a bows length in-land, he was unable to find any natural resources at his destination and he

returned to England with nothing more than stories of land. For his 2nd mission in 1498, he received only 5 ships; small in comparison with Columbus's 17 ships. Historical records show that only one out of the five ships managed to return to England. A graphical comparison between the two voyages underlines the importance that the availability of natural resources at destination has, not only on mission outcome but also at a program level.

From Figure 3.1, we see three messages emerge. First, as Columbus demonstrated that land existed and hence turned an "unknown unknown" into a "known unknown", Cabot was able to undertake the mission with fewer ships than Columbus. Second, Columbus was able to stay at his destination almost three times as long as Cabot could due to the availability of natural resources. Finally, at a program level, the amount of support that is offered for future ventures increases when tangible outputs are returned.

3.2.10 Key references

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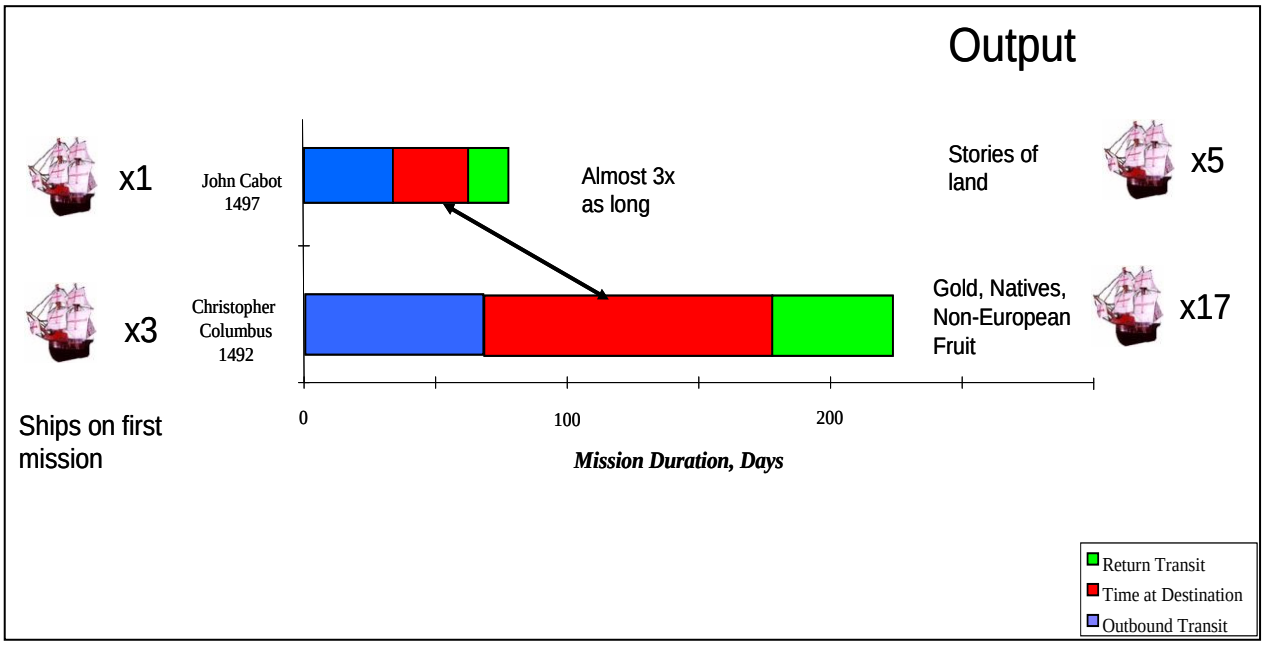

Figure 3.1 – Comparison of Columbus and Cabot Highlighting the Effect of In Situ Resources on Time at Destination and Future Support

3.3 Raleigh's colonization of America (1585-1590)

3.3.1 Summary

England was initially slow in establishing colonies in America. This was due to religious in-fighting taking place in England during the 16th century and the restrictive financial laws at the time that meant that private ventures carried with them a large risk[4]. In 1584, Sir Walter Raleigh dispatched two reconnaissance ships to identify a suitable colony location on the North Carolina coast. In 1585, seven ships were used to bring out 108 men and supplies to establish a settlement on Roanoke Island. Due to food shortages, the colony was initially abandoned and all the colonists returned to England onboard a passing ship. In 1587, 117 men, women and children arrived in three ships at the Roanoke colony. However, a dispute arose within the expedition regarding the location of the colony and how best to move the settlement. The settlement remained temporarily at its location and whilst supply vessels had been ready to return in the spring of 1588 to support its movement, every English ship now was expected to remain and fight the threat of the Spanish Armada to the homeland. John White, the governor, was unable to return to Roanoke until 1590 by which time the colony had disappeared.

3.3.2 Mission Goal

The primary objective of the settlement was never made clear. The settlement had three aims – to serve as a base to explore the surrounding country, a settlement to identify potential problems with living on American soil, and as a port for English privateerers plundering in the Caribbean. However, the way in which the colonists prioritized these aims changed over time. At a strategic level, the goals were prosperity and increased security for England.

3.3.3 Context

During the 16th Century, the English monarchy moved between Catholic and Protestant heads of state, eventually reaching stability under the Protestant Elizabeth I. This constant in-fighting, the unfriendly Scots on her northern border, the constant threat from continental Catholic Europe and the strict financial laws of the day ensured that during the 16th Century, colonization of America was not a high priority. Only when Elizabeth I had been on the throne for 25 years did England begin to look west. The expansion of the Spanish and the Portuguese in America had not been overlooked, and towards the end of the 16th Century, England began to consider colonial expansion.

3.3.4 Concept

Whilst the campaign was carried out by the funding and support of Sir Walter Raleigh, colonization plans began with Sir Humfrey Gilbert. In 1578, Gilbert was granted letter-patents by the Queen to begin the colonization of America. Gilbert spent time identifying a suitable location to colonize in modern Rhode Island and

[4] Private financiers were liable for any debt incurred by the venture. The state was not stable enough that it could finance long-term colonisation plans.

Connecticut. Gilbert was the first to achieve plans for an American settlement but he died on a reconnaissance voyage in 1583. The colonization charter was subsequently passed to his brother-in-law, Sir Walter Raleigh.

Raleigh sent two reconnaissance ships in 1584, piloted by Simao Fernandes, a Portuguese explorer, but focused further south than Gilbert and subsequently identified Roanoke Island, situated in modern day Virginia, as a potential location of any future colonization. The reason for identifying a site further south than originally intended by Gilbert was so that they were sufficiently south that they could attack the Spanish shipping lanes but still far enough north that they could avoid constant attack from the Spanish. Here they encountered friendly natives, good quality soil and weather that they believed could harvest tropical plants such as bananas and pineapples.

3.3.5 Exploration

By early 1585, diplomatic relations between Spain and England had broken down and the Queen had issued a “Letter of Marquee” for plundering Spanish vessels at any opportunity. The Spanish were in the process of transporting riches from America back to Spain and this move by the Queen offered the potential for opportunistic English mariners to get rich quickly by privateering Spanish ships. At the same time, Raleigh had begun to assemble the necessary equipment and men to embark on a colonization mission. On April 9th 1585, seven ships containing approximately 500 men, of which 108 were colonists and the rest made up of soldiers and seamen, sailed from Plymouth to Roanoke Island under the direction of Sir Richard Greenville. The 108 colonists, led by Ralph Lane, were exclusively male, most of whom were “gentlemen” who were unlikely to want to get their hands dirty by building and cultivating.

The colonists began by establishing a fort and a small village. Lane served as Governor and used the men to explore the surrounding area. They initially attempted to survive through cultivation and trade with the natives. However, the garrison was doomed from the beginning. The colonists arrived too late in the season for planting, and supplies were dwindling rapidly. To make matters worse, Lane, who was a military captain, alienated the neighboring Roanoke Indians.

In addition, there were two poor fundamental decisions prior to the situation deteriorating. The first was the latitude of the settlement. The site was chosen for strategic and agriculture reasons. It was assumed that the weather at this location would be similar to that of Italy due to the similar latitude. However, information regarding this area was sparse. English knowledge of the area round Newfoundland and Caribbean was plentiful but for the American coastline it was poor. The only firsthand knowledge regarding the location was that gathered the year previously on the reconnaissance mission. In fact, the microclimate and soil at Roanoke Island was unable to support the crops the English expected to grow.

The location also lacked a suitable harbor. A suitable harbor was essential to supply the settlers, develop commerce in the area and to use as a base to attack Spanish ships. The two harbors in the location were insufficient and only ships between 20 and 70 tons could use the harbors; all other ships had to anchor

several miles out in dangerous waters. Lane realized the need to move to an alternative site with a better harbor and identified Chesapeake Bay as being appropriate. Lane planned to wait until supplies arrived from England and then to move a number of men north to Chesapeake Bay, establish a new base and move the rest of the colonists later.

However, supplies were delayed and in June 1586, due to food shortages, the colonists left on board a passing ship of Sir Francis Drake. Supplies arrived one week later with three ships and inevitably found no one. Part of the charter given to Raleigh was for “continual settlement” and without it, Raleigh would lose his charter. Because of this, Greenville left behind a holding party of 15 men.

In July 1587, Raleigh sent three more ships containing 117 men, women and children with a new Governor, John White. Raleigh wished to move the settlement away from being reliant on supplies from England to being completely self-sufficient. As such, he chose settlers that wanted to build a life in America and land was offered as an incentive for those in England to move.

Lane had communicated to Raleigh the need to move the settlement to a new base further north. White immediately began by attempting to convince the leaders of the expedition, Grenville and Fernandes, to help aid the colonists move the settlement north to Chesapeake Bay. However, Fernandes was not accommodating to the needs of the new governor. White continuously complained about the prioritization of Fernandes on the journey over. White did not wish to place at risk the lives of the colonists, which included his daughter, to attack Spanish ships. However, Fernandes relentlessly attacked Spanish ships at every opportunity.

When the expedition arrived at Roanoke Island, White planned to pick up the group that had been left behind by in the previous year and move the entire group immediately north to Chesapeake Bay. However, there were no survivors from the previous settlement. Fernandes ordered that the fleet of ships would go no further north than Roanoke Island. There are mixed reasons for Fernandes to take such a course of action. While he had experience of the Indians in the Chesapeake Bay region and expected them to be hostile to the establishment of a colony White believed that the reason was more vindictive. The colonists were not happy with the location but were forced to settle there and White left to gather more supplies and transportation from England.

On his return to England, the Spanish Armada attacked England culminating in the Battle of Gravelines in 1588. Whilst the English were successful in defending against the attack, White was unable to get a ship until 1590. When he finally reached Roanoke Island, there was no one at the settlement. There was no sign of distress and the general belief is that the colony had moved inland. Raleigh had an interest in maintaining this belief as he did not wish to lose his charter.

3.3.6 Dissolution

Whilst the initial settlement was not a success, the lessons learned and the boldness of the venture eventually led to the settlement of North America by the English.

3.3.7 Key Statistics

Table 3.2 summarizes the key statistics for the three exploration phases.

Table 3.2 – Statistics for Raleigh Exploration

	Ships	*People*	*Ships Lost*	*People Lost*
Settlement 1	7	109	1	109
Holding Party	Unknown	~15	Unknown	~15
Settlement 2	3	117	Unknown	117

3.3.8 Risk Lessons Learned

The venture was ultimately a failure for a number of reasons. First the number of participants involved in the project was very small – less than 250. This is an indication of the relative wealth of England at that time and the small amount of money that could be directed towards American colonization. In comparison, early Spanish attempts at colonization had more than 1000 settlers.

The site did not have a suitable harbor to carry out the raids they had envisaged or to supply the colony. The lack of harbor also jeopardized the mission at the start. The majority of the first year's provisions were lost as the lead ship ran aground and whilst this did not cause an immediate problem as the settlers were able to obtain food from the natives, it highlighted problems with the site. Ships over 70 tons had to anchor several miles out of the bay. Plans were put in place to move the settlement north to a more suitable harbor once the colony had settled. Raleigh was made aware of these plans and when the second wave of settlers arrived, the plan was to abandon Roanoke and to move to Chesapeake Bay. However, Fernandes appeared unwilling to spend time supporting the colony when he could be profitably plundering Spanish ships. Ultimately the colonists were forced to remain at their location.

Problems of supplying and organizing a military colony miles from its homeland were well known and should not have posed a significant problem. However, as the purpose of the settlement was not clearly established, the strategy of re-supplying the colony was not clear. In the first attempt, all supplies were carried from England to the colony. On future crossings, the ships would stop in the West-Indies en route to trade and collect plants, livestock and salt for the colony. However, the sailors in control of the supply ships did not want to waste valuable space simply on supplies when their primary objective was privateering.

Early developers understood that there were four ways in which to finance the colony:

1) Direct funding by the state (which was not an option in this case);
2) Run a non-profit colony experiment funded by some other money-making enterprise;
3) Have the settlers fund it themselves, paying for supplies for as long as it took before they achieved self-sufficiency;

4) Fund through mineral resources or a highly profitable staple crop, such as tobacco (which ultimately funded the Jamestown venture – the first successful permanent English settlement).

For the first wave of settlers, it is unclear how Raleigh expected to fund the venture in the long-term. He might have expected sailors to use it as a base to attack Spanish ships. He expected the second wave of settlers to be motivated to make a success of the venture, as they were partially funding themselves.

3.3.9 Dynamic Systemic Risk Model

We have proposed using a Dynamic Systemic Risk Model (DSRM) to track strategic level risk during exploration. Figure 3.2 introduces part of the DSRM. The motivation behind the DSRM is to model the dynamic interactions between mission, program and strategic levels. In the DSRM, the inner circle represents the experiences and decisions made by the crew, while the outer circle represents the experiences and decisions made by the leaders of the campaign.

For the inner loop, if the crew is highly motivated, then this can lead to positive actions and to positive experiences. This means the crew reflects well on the experience, the exploration is meeting their expectations and their motivation increases. This is a reinforcing loop. If the crew is unmotivated, then they will start to carry out selfish actions leading to bad experiences for all. The crew then reflects poorly on what they are accomplishing, their expectations are no longer being met and they become further de-motivated.

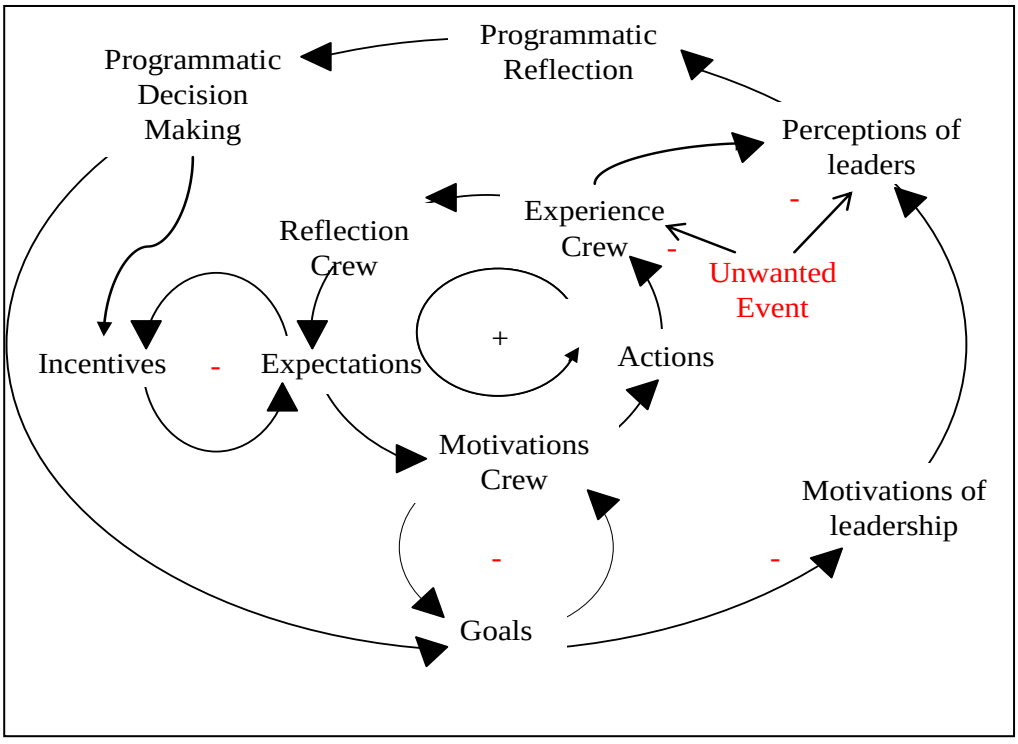

Figure 3.2 – Mission and Program Level of Dynamic Systemic Risk Model

For the outer loop, the leaders of an exploration campaign are motivated to carry out a given task. If the leaders receive relevant information from multiple sources that provides insight into what the exploration might achieve, then this allows them to reflect and take decision focusing upon the goals of the mission and the incentives for the crew.

The two loops do not exist independently. There are two natural control loops in the case of incentives and goals which aim to align the goals and priorities of the leaders with the goals and priorities of the crew.

At this point in its development, the DSRM is a simple system dynamics model which would theoretically follow through with a deterministic analysis. However, the evidence we have gathered, suggests that exploration campaigns rarely follow a deterministic path because there always exists a number of unwanted events that occur randomly that disturb the system.

In the case of Raleigh's colonization plans, the first settlement had many different goals which caused the men to become unmotivated which led to selfish actions. This led to poor experiences and ultimately to the colony not meeting its expectations. In order to address this, Raleigh prepared to send supply ships to stock the men. However the unwanted event was that the supplies were delayed and a ship passed that was willing to take the colonists home. For the second settlement, Raleigh changed the goal to establishing a self-sustaining settlement. In order to align the goals of the crew and himself, he gave land as an incentive to each family. In this case, the unwanted events were the lack of support within the party for moving the colony and the Spanish Armada invading England and delaying supplies.

3.3.10 Key References

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3.4 Darien Scheme: Scottish Colony in Isthmus of Panama (1693-1707)

3.4.1 Summary

The Darien Scheme aimed to develop a colony in the Isthmus of Panama at the end of the 17th century as a means of bringing economic prosperity to Scotland through its management of trade at this strategically important location. The vision for the Scheme is credited to William Patterson. On returning to Scotland, Patterson promoted his vision for Darien. He was passionate about the opportunity that the Darien Scheme would afford Scotland and fluent in the communication of this vision. The result was the passing of an Act of the Scottish Parliament in 1695 to create the Company of Scotland. On raising £400k in subscriptions from Scottish investors only, the Company aimed to enact the vision for the Darien Scheme through two waves of exploration, in 1698 and 1699 respectively. Both explorations failed to establish a colony due to the

effects of both natural and intentional hazards. The consequences of failure were high. More than 2000 of the 2500 men, women and children sent to Darien lost their lives and the £400k invested reputedly equated to between 25%-50% of the wealth of Scotland at the time. It is generally accepted that the failure of Darien led to the formation of the United Kingdom in 1707 and hence was a strategically important event that changed the course of British history.

3.4.2 Mission Goal

The overarching goal of the Darien Scheme was to set up a Scottish Colony on the Isthmus of Panama, which has a strategically important location for trade that would bring economic prosperity to Scotland and ensure its independence. Figure 3.3 shows the location of Darien today.

3.4.3 Context

Seventeenth century Scotland had many decades of political, religious and economic discontent. Scotland also held great resentment against England about economic affairs. Scotland had become poorer following the Union of the Crowns. Scotland was required to get involved in England's wars, and lost her only colony in Nova Scotia compromising her trading privileges. Trade frustrations were further exacerbated by the Navigation Act (which forbade goods to be imported to England or its colonies by ships other than English or the countries from which they originated) and by the monopoly on trade with the East Indies and Africa held by two English Trading Companies, the East India Company and the Royal Africa Company.

Figure 3.3 - Location of Proposed Scottish colony at Darien on Isthmus of Panama
Source: http://www.escapeartist.com

3.4.4 Concept

Against this background, in 1695 Scottish-born William Paterson, a serial promoter of money-making schemes generated an idea that the Scottish Parliament should follow up the 1693 Act for "*Incourageing Forraign Trade*" by granting a monopoly of trade with Africa and the Indies to a Scottish trading company. A key element of the plan was the establishment of a Scottish colony at Darien in Central America where a free port could be set up to allow goods to be exchanged between merchant ships from Africa and Asia across the isthmus. Theoretically, Patterson's proposition that "*Trade will increase trade, and money will beget money ... Thus this door to the seas, and the key of the universe ... will of course enable its proprietors to give laws to both oceans, and to become arbitrators to the commercial world*" is logical.

Patterson presented a persuasive argument in Edinburgh and in 1695 the Scottish Parliament passed an Act establishing "The Company of Scotland Trading to Africa and the Indies". Its capital was to be £600k with 50% of the subscriptions from both England and Scotland. However although the English share was met, the English investors soon withdrew once King William opposed the plan for a Scottish colony in Spanish-claimed territory. Timely lobbying by the Directors of the East India Company of a King who was trying to appease Spain was the cause. Consequently a revised target of £400k was set and the investment was raised entirely within Scotland. Attempts to share the risk of investment in, for example, Hamburg, failed. It is estimated that £400k represented about half of Scotland's available capital and was raised by all sectors of society. The risk of investment was not spread beyond Scotland. It has been suggested that commercial inexperience was a reason for such a naïve approach, however any damages incurred by Company of Scotland would be covered by public monies, hence the risks to the Directors were mitigated.

The decision to site the colony at Darien was influenced by the evidence provided by Wafer. Through the maps, journals, letters and stories presented by Wafer, it is claimed that the Directors were presented with a full set of information about the conditions.

3.4.5 Exploration

The five ships for the expedition were bought in Hamburg and Holland: one was a former French vessel, the *Dolphin*, but the others reflecting the hope of the Scottish expedition – the *Caledonia, St. Andrew, Unicorn* and *Endeavour*. Provisions included cannon, guns, swords, axes, hammers, nails, clothing and household goods. That the expedition was ill-prepared was clear from the goods stocked for trade – combs, bonnets and tartan socks. Crew and colonists were recruited from Scotland. In total, around 1200 people were to take part in the first expedition, including William Paterson. This is estimated to be around 0.12% of Scotland's population of 1 million at the time.

The first expedition left the port of Leith on 18 July 1698. In order to protect the interests of the Company of Scotland, the location of colony remained a secret to crew and emigrants. The sealed orders were opened once the ships were clear of Madeira where they were informed that they were "*to proceed to the Bay of Darien, and make the Isle called the Golden Island….some few leagues to the*

leeward mouth of the great River of Darien….and there make a settlement on the mainland".

They made landfall on 2 November 1698, having lost 70 people during the voyage. They named the jungle peninsula New Caledonia. The site of the first settlement failed to provide a viable fortification, hence a second site, now called Fort St Andrew, was developed. The colonists issued a proclamation declaring freedom of trade and of religion, sent friendly messages to the Spanish Governors and entered into negotiations with the natives for the purchase of the land. News of their safe arrival and settlement arrived in Edinburgh in March 1699 and was widely celebrated. The Colony was governed by a committee of 5, later expanded to 7, from whom a President was selected and rotated on a weekly basis. Representatives were elected from each of the regions of Darien.

However, the reality was that the land was unsuitable for agriculture and the Indians were not interested in the goods brought for trade. Early in 1699 torrential rains led to spread of disease and by March 1699 more than 200 colonists had died, including Paterson's wife, with the death rate rising to over 10 a day. Those surviving were weak and for them life was harrowing – back-breaking labor, lack of food and malaria, yellow fever and dysentery were endemic.

In January 1699, a ship carrying supplies for the colony was dispatched but was shipwrecked on the west coast of Scotland. Two other relief ships sent afterwards but were delayed en route and hence did not reach Darien until several months after their expected arrival. This logistical delay meant no provisions for an already weak population.

Of the ships sent out to trade supplies, all but one returned unsuccessfully with news that all English ships and colonies were forbidden to trade with Scots by order of King William. One, the *Dolphin*, was captured by the Spanish with the imprisonment of its crew. There was discontent that while the colonists were suffering, others were quarrelling as power struggles arose among the elected councilors.

When news arrived that the Spanish were planning to attack, the colony was abandoned. Recent evidence suggests that this attack was fiercer than originally thought. Further, it appears that the Spanish were already preparing a more forceful attack had this first one not being successful at removing the threat of the colony. Of the four ships that fled, only the *Caledonia* made it back to Scotland, with less than 300 people on board. The other ships - the *Endeavour, St Andrew* and *Unicorn* - were sunk in transit due to three independent bad weather events.

Unaware of the fate of the first expedition – reasons include natural communication lags in late 17th century as well as intentional denial of rumors of failure of the first colony – a second expedition left Scotland in autumn 1699. Led by three ships – the *Rising Sun, Duke of Hamilton* and *Hope* – a further 1300 settlers headed to Darien, of these 160 reputedly died en route. The second batch were originally meant to support the original settlers but on finding the colony abandoned, they set about rebuilding the colony, but with no more success than their predecessors relative to whom they were arguably less well

prepared. It is acknowledged that the men and women sent to Darien were completely unprepared for the harshness of the conditions; they were under constant threat of attack from the Spanish and had no support from the English colonies who had been ordered not to aid the Scots. One newly arrived officer, Captain Campbell, persuaded colonists to launch a pre-emptive strike against the Spanish forces massing at Toubacanti on the mainland. While the attack was very successful, the consequence was that the Spanish under the command of Governor-General Pimiento, formed a massive fleet and army besieged Fort St Andrew, which finally surrendered in March 1700. Given the state of the colonists – only 300 were considered fit for duty and the death rate was 16 people per day – the Spanish commander set easy terms of surrender. In April 1700, the surviving colonists were permitted to vacate the fort on board their remaining ships after 4.5 months at Darien. Only a handful ever made it back to Scotland with the *Hope of Bo'ness* being surrendered to the Spanish at Carthegenia and the remaining ships – *Rising Sun, Duke of Hamilton* and *Hope* – sinking in hurricanes in the Caribbean or off the coast of the Carolinas between April and October 1700. Hence, like the first attempt at colonization, more lives were lost from disasters at sea after clearing from Caledonia rather than in the colony itself. It is reputed that only about 30 people returned home.

3.4.6 Dissolution

The Darien venture was a political, economic and social disaster for Scotland. It is claimed that Scotland lost 25% to 50% of its liquid assets. Financially Scotland was unable to retain its independence and on 1 May 1707 joined England as a junior partner in the Act of Union to form the United Kingdom of Great Britain. As part of the deal, Scotland was provided with the rights to free trade and England paid off Scotland's debts with the 'Equivalent', a sum of £398,000, most of which went to cover the Company of Scotland's losses. By Article XV the Company of Scotland was dissolved. Over 2000 people died in the Darien venture. The few returning survivors of Darien were considered "pariahs" and given little support from family and compatriots. Paterson was forced to defend his role and is reputed to have died a disillusioned man. Campbell, although awarded the Toubacanti Medal for his role, never stopped blaming the Company of Scotland for failing to support its colonists. Many Scots believed that their independence had been deliberately sabotaged by the English.

In contrast to the accepted view that Darien was a disaster, Nat Edwards, of the National Library of Scotland, proposed in 2006 that Panama considers Paterson a visionary of their potential for international trade - his image is on a frieze at the mouth of the Panama Canal – and he argued that the governance of the colony represented the first attempt at democracy in the region.

3.4.7 Key Statistics

Table 3.3 shows key statistics for the Darien scheme.

Table 3.3 – Campaign Statistics for Darien Scheme (Monetary values expressed 17th Century prices)

	Inputs		*Outcomes*
	Value	*% Investment*	
Financial Investment	£400K	~40% liquid assets *($140M 2008 silver price)*	-$398K
Number of Ships	17 (9 main, 8 relief)		1 main ship returns
Number of People	~2500	~ 0.12% population	~30 survive ~230 die outward ~1640 die at Darien ~ 600 return trip

3.4.8 Risk Lessons Learned

The mission failed to establish a colony at Darien and the consequences of that failure were catastrophic for a nation. In this section, we explore why and what might be learnt from this experience. Figure 3.4 provides a summary of the main risks in the form of a belief network.

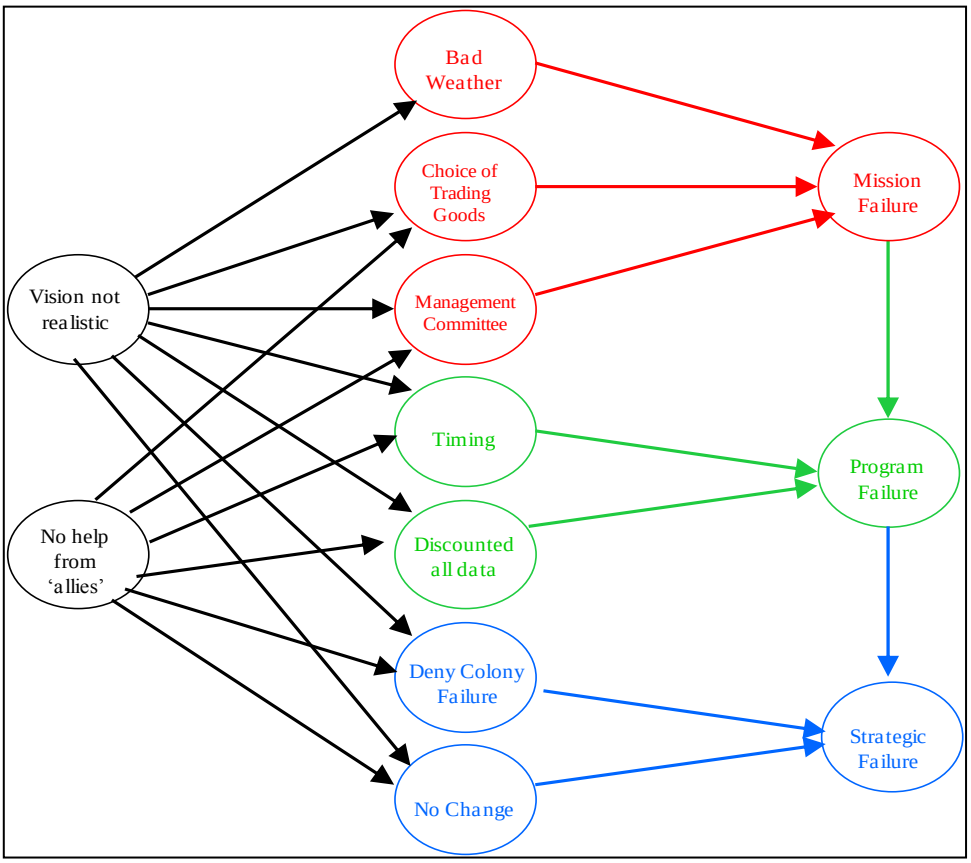

Figure 3.4 – Belief Network Illustrating Relationship between Risk Classes

The governance of the colony was based upon a democratic council with a weekly rotating President. While the key actors in the scheme are identifiable – the investors, the crew, the colonists, the competitors – there was no one leader commanding the venture. Paterson plays a role through all phases – conceptualization, decision-making, journey and colonization – however he influences rather than directs events. The Directors of the Company of Scotland have considerable power, setting the exploration strategy. However they are divorced from the operational activities of the mission, in part because no system of command appears to have been established for leading the mission.

Scotland was following the European trend for colonization and having bought into the vision for Darien, the Directors of the Company of Scotland construct a false model for their scheme. Further, they fail to update their model using the data provided a priori or realized during the mission. Even when news of the failure of Darien reaches Scotland, it is claimed that the propaganda promoting the success of the venture prevailed, until the few survivors returned home. By this time public perception had bought into the false model so strongly that the survivors were blamed for the failure rather than supported as victims of the exploration.

It is accepted that the Company did have incomplete information and that there would have been considerable uncertainty about, for example, the actual environment, the actions of competitors, and the reliability of equipment. However it is clear that learning from experience was poor. For example, a vicious cycle emerges when the strategic goals of the venture and the motivations of the colonists faced with starvation came into conflict leading to changing objectives from colonization to survival. This shift from the original goal triggered the events leading to the loss of the original investment in the scheme.

Originally the colonists' expectations appear to be matched by the incentives offered. However the changing circumstances arising when the weather deteriorates, food supplies dwindle and disease takes hold, initiates another vicious cycle. This is further sustained by the lack of provision for safe havens made after abandoning the colony and, of course, the lack of support from the nation.

The major decisions for Darien appear to be emotionally charged and hence lack a rigorous rational analysis. With hindsight, many of the sources of the uncertainties are recognizable hazards for which mitigation and avoidance strategies could have been developed. This is perhaps particularly true for the operational elements of the transportation and colonization phases. The major failing though in the Darien case is strategic.

3.4.10 Key References

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Prebble J (1968) The Darien Disaster, Mainstream Publishing, Edinburgh.

3.5 John Franklin in Search of the North West Passage (1819-1848)

3.5.1 Summary

John Franklin was an English Rear-Admiral, whose ill-fated mission in 1845 is credited with leading to the discovery of the North-West passage, the Canadian-Arctic waterway connecting the Atlantic and the Pacific. Franklin led three expeditions to the Arctic, first in 1819-1822, then in 1824-1827 before his final mission, which set off in 1845. The investment by the British government increased with each expedition. For example, the number and quality of ships, number and skill of crew and amount and type of supplies increased consistently. None of the explorations were without incident but the final mission was catastrophic with no survivors. Lessons were learnt from earlier missions, although risks identified were conditioned upon the British Navy's world view which was biased by their imperial arrogance and hence failed to appreciate the major environmental and technology risk drivers. Five ships were abandoned and lost in the search for Franklin, although considerable data were discovered during the search. These included the expedition records, which provided a last entry on 25 April 1848, the testimonies of the Inuit and the skeletons of the crew. Pieced together, these data provide a picture of a sequence of events that led to disaster.

3.5.2 Mission Goal

The overarching goal of all missions was to chart and navigate parts of the Northwest Passage. There were dual motivations: initially, to establish trade routes; and later to generate scientific knowledge. The specific goals of the three missions are tabulated below.

Mission	*Dates*	*Goal*
1	1819-22	Chart western coast of Hudson Bay to Arctic
2	1824-27	Chart region between McKenzie River (now Canada) and Point Beechey (now Alaska)
3	1845-	Chart remaining 300 or so miles of the North West Passage not yet mapped.

3.5.3 Context

Franklin's explorations took place within the so-called "imperial century" of the British Empire from 1815-1914 during which time circa 10 million square miles and circa 400 million people joined the empire. After defeating Napoleon, Britain had no serious rivals and the British Royal Navy held supremacy of the sea. Britain was regarded as the global policeman, both directly controlling and indirectly influencing many economies. Retrospectively, this period has become known as Pax Britannica.

Franklin was born in 1786 and joined the Royal Navy at 14 years. He served in various battles, including Trafalgar in 1805, before taking command of the *Trent* in 1818 on the Arctic expedition led by Captain David Buchanan which sought to reach the North Pole.

3.5.4 Concept

On 28 May 1819, Franklin captained the Hudson Bay Company owned ship, the *Prince of Wales*, on its journey from England to Hudson Bay. On 9 September 1819, Franklin led an overland expedition from the western shore of the Hudson Bay to the Arctic Ocean. Between 1819 and 1822, he led the survey of part of the coast to the east of the Coppermine River in the Northwest Territories of Canada. The crew largely comprised voyageurs - boatmen employed by the fur companies. The mission encountered many difficulties, not least was lack of food due to the limited supplies and the lack of opportunity to re-stock on route within the harsh terrain of the Arctic. Of the 29 crew, including Franklin, only 9 survived. Twenty died of starvation. Franklin survived, but became known as the "man who ate his boots" because he is reputed to have resorted to eating leather from his own footwear. Franklin returned to England to recuperate and in 1823 published his story in "*Narrative of a Journey to the Shores of the Polar Sea in the Years 1819, 20, 21 and 22*".

Franklin led a second overland expedition to the same region in 1825-27 although on this occasion the exploration aimed to survey the North American coast westward from the mouth of the MacKenzie River in Northwestern Canada to Point Beechey now in Alaska. This expedition was better equipped and supplied than the previous one. The British Admiralty had invested in four specially built ships: three mahogany and ash vessels; the fourth a light ash-framed canvas boat. Franklin's crew comprised officers, marines and sailors of the British Royal Navy. They were allocated supplies that included non-perishable provisions, such as macaroni and soup, which were packaged well within 3 redundant layers of waterproof canvas. This mission successfully mapped 1200 miles of the coastline without serious incident and the journey was described in the 1828 publication "*Narrative of a Second Expedition to the Shores of the Polar Sea in the Years 1825, 1826 and 1827*". Following this mission, Franklin was knighted in 1829.

3.5.5 Exploration

Franklin, now 55, was second choice to lead the expedition chart the final 300 miles or so of the Northwest Passage. The first choice, Sir James Ross, declined for family reasons. Franklin had spent the intervening years as, amongst other appointments, Governor of what is now known as Tasmania.

The British Admiralty provided Franklin with two seasoned ships, which had just returned from successful missions in the Antarctic, and which were equipped with modern technology such as steam engines, protective mechanisms for the rudder and propellers and a steam heating device for crew comfort. The two ships, the *Erebus* and the *Terror*, were captained by younger, but still experienced veterans of Arctic and Antarctic campaigns, Captain James Fitzjames and Captain Francis Rawdon Moria Crozier respectively. In total there were 128 Royal Navy officers and men, all under the primary command of Franklin. The mission was given supplies and provisions expected to last for 3 years and included both non-perishables – both conventionally preserved and tinned - and livestock, which were boarded at what is Godhaven in Greenland

today. Further the ships were furnished with the comforts of home, including large libraries with over 2000 books.

Unlike the previous two missions - where the survey expedition was made overland and the ships were simply a means of transportation to the base location - this final exploration aimed to sail the final few hundred untracked miles of the passage. Franklin's expedition set sail on 19 May 1845 from England and was last seen by British Whalers on 28 July 1845 north of Baffin Island at the entrance to Lancaster Sound.

Both ships wintered at Beechey Island between 1845-6, after which they returned southwards. In September 1846 they become trapped in ice in Victoria Strait, off King William Island and stayed there for 1.5 years. It appears that the weather was unusually harsh resulting in the prolonged frozen conditions. Under more normal conditions, the ships might have expected to have been set free when the ice melted. Franklin and 23 others died between September 1846 and April 1848. On 22 April 1848, the remaining 105 crew abandoned the ships to head south across the North American mainland. There are reports that the men attempted to unload the ships furniture and appeared disoriented. Other reports indicate that men fell and died as they walked. There are suggestions that some resorted to cannibalism. The post-mortems of several preserved bodies of crew suggest that lead poisoning was prevalent and may have contributed to the mental and physical decline of the men. The lead poisoning is attributed to faulty food tins, where beads of solder present on the interior edges were able to interact with the contents and are believed to have occurred because a new, cheap supplier was selected and given a short lead time to produce supplies for the mission. It appears that while his patent was sound, his manufacturing quality control was not.

3.5.6 Dissolution

After no news had been heard of the exploration for 2 years, a search was launched in 1847 funded initially by Franklin's wife and from 1848 by the British Admiralty which also offered a £20000 reward. For 12 years the search continued without generating any information about the fate of Franklin's expedition. The search missions are reputed to have been the largest push into the Arctic and involved several dozen ships, largely British but also some from the United States. Five ships were lost. The Admiralty continued to fund searches until 31 March 1854 when they declared the crew deceased in service.

It was not until 1859 when a final search mission, sent in 1857 and funded by Franklin's wife, Lady Jane Franklin, and led by Captain Francis Leopold McClintock, found written expedition records and crew skeletons on King William Island, south and west of Lancaster Sound, approximately mid-way between the Atlantic and Pacific Oceans. Analysis of these records and postmortems of the skeletons, together with data collected from testimonies of local Inuit, help piece together the final stage of Franklin's exploration.

3.5.7 Key Statistics

Table 3.4 shows key statistics for Franklin.

Table 3.4 – Key Statistics for Franklin Missions

Exploration	*Ships*	*Crew*	*Ships Lost*	*People Lost*
1819-22	1	29	0	20
1824-27	4	-	0	-
1845	5	129	5	129

3.5.8 Risk Lessons Learned

Despite improved technology, highly trained crew, greater resources and the opportunity to learn from previous explorations, the last mission led to catastrophic loss of life and prestige for the British Empire. This section examines why. Figure 3.5 shows the Venn diagram representing the key risks arising in this case.

Franklin was the exploration leader, although it is not clear how far he influenced the decision to conduct the final survey by sea rather than overland. Other actors include the crew, while the main stakeholders were the British Admiralty, spending monies on behalf of the nation's taxpayers, and his wife, Lady Franklin who made a personal investment. The search for the Northwest Passage involved many expeditions beyond those involving Franklin. These are not discussed here as they are deemed independent of the events that influenced the risks of this mission.

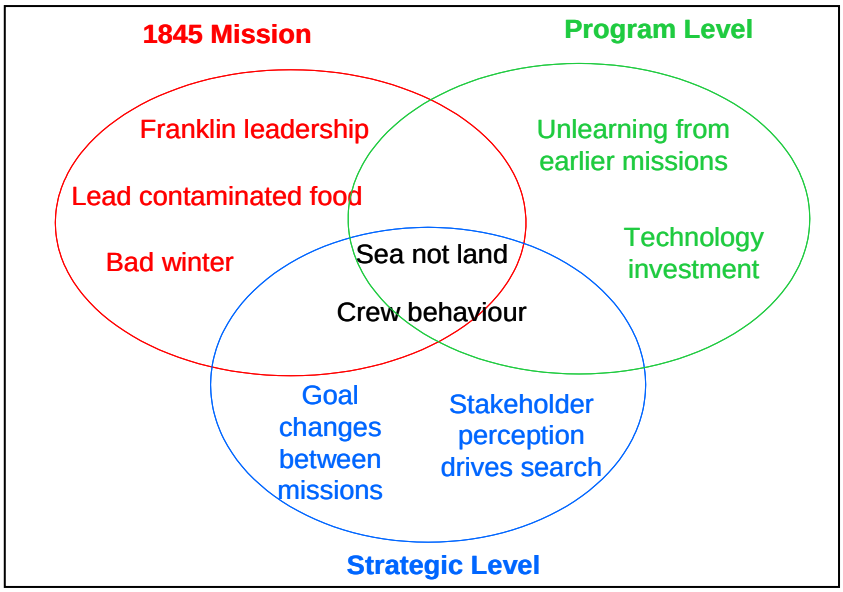

Figure 3.5 – Venn Diagram of 1845 Franklin Mission Depicting Key Risk Classes

Franklin, as supreme commander, was responsible for decisions made during the mission. As a military man he has been criticized because he adhered to official regulation in circumstances which put his crew at risk. This contrast between the two early missions and the last is interesting because it illustrates a

change in the model assumed by the explorers. The early missions were driven by the goal to generate trade, while the 1845 mission was driven by the communicated goal of scientific discovery, which might arguably have been masking an intended political goal. This shift in goals between the decades is accompanied by a divergence in the set of assumptions made and the reality of the mission. For example, the early missions were conducted in collaboration with people and methods familiar with the region, while the latter was very much a military affair with an apparent over-provision of the supporting comforts and reliance on new technology relative to the investment in understanding of the environment in which the mission would take place. The lack of priority given to the latter is evidence that they not only did not learn but that they actually "unlearned" good practice from the past.

The 1845 mission was beset by operational difficulties, including poorer environmental conditions than the norm for the region and contaminated provisions. The former contributed to the failure to progress the mission and the latter appears to have had direct and indirect effects on the ability to abort the mission successfully. Considerable investment was made in the novel technology for this mission but less attention given to the routine quality control of basic provisions. The solution to loss of the mission was to allocate considerable resources to act, and to be seen to act, in recovery of the crew.

The 1845 mission could be classed as successful against the stated goal of trying to track the Northwest Passage – largely because it was traced by John Rae while involved in the search for Franklin. However the consequences were high in terms of loss if life, financial investment and damaged reputation at the height of Britain's so-called imperial century.

3.5.10 Key References

Delgado J P (1999) Across the Top of the World: The Quest for the Northwest Passage, British Museum Press

3.6 Antarctic Voyages of Sir Ernest Shackleton (1901-1916)

3.6.1 Summary

Sir Ernest Shackleton was one of the last great individual explorers. At a time when most of the earth had been discovered and charted, Shackleton attempted to explore Antarctica. Whilst his exploration was ultimately a failure, his battle against adversity and the triumphant safe return of his twenty seven-man crew was seen as a huge success. In comparison, the story of his partner voyager, who successfully laid food depots for Shackleton's land trek but lost three men in the process, is largely untold.

3.6.2 Mission Goals

The aim of the Imperial-Trans Antarctic Expedition was twofold. First, to carry the British flag across the continent from the Atlantic Ocean to the Pacific Ocean

via the South Pole and second, to conduct a number of scientific experiments, which could be carried out during the voyage.

3.6.3 Context

At the turn of the 20th century, very few parts of the earth lay unexplored. One such place was the South Pole. Britain, Japan, Germany, Sweden, Norway, France and Belgium all took an interest in the continent and began a race to see who would be first to plant their flag on the South Pole.

3.6.4 Concept

Prior to the Imperial Trans-Antarctic Expedition, Shackleton had been on one expedition led by Robert Scott and led another of his own. The British National Antarctic Expedition, led by Scott, lasted for Shackleton from 31 July 1901 till 28 February 1902. The primary aim of this mission was to carry out scientific research along the coast of the Ross Sea – however Scott harbored hopes of reaching the South Pole. For Shackleton, however, the mission was not a success. The relationship between Shackleton and Scott was strained from the beginning of the expedition. Where Scott was trained in the Royal Navy and expected high levels of discipline, Shackleton preferred to use camaraderie to motivate the men. Scott, Shackleton and Edward Wilson attempted to reach the pole, ending up within 533 miles of the pole before giving up, partially due to Shackleton's ill health. On 28 February 1902, Scott sent Shackleton home on the grounds of ill health despite the fact that by this point, he had almost fully recovered.

On returning, Shackleton began to put in place steps to lead his own expedition. On 1 January 1908, the British Imperial Antarctic Expedition began, led by Shackleton on the *Nimrod*. As before, the aim was to lead a small party of men to the South Pole. Again, the mission was unsuccessful, however Shackleton was to reach closer to the South Pole than anyone else until in 1911, the Norwegian, Amundsen, and then 33 days later, Scott and his British party reached the South Pole.

Despite the fact that the South Pole had been reached by Amundsen and Scott, there was still much interest in supporting expeditions to the South Pole. Shackleton managed to raise funding for the expedition through the British Government, the Royal Geographical Society, a number of private smaller sources and in particular, James Key Caird; who was the largest single donator. Shackleton acquired two ships for the voyage – *Endurance* and *Aurora*. In addition, he had no trouble in gaining interest in the expedition - receiving over 5000 applicants for a total of 56 positions.

3.6.5 Exploration

On 8th August 1914, *Endurance,* set sail with 28 men onboard. The plan was for *Endurance* to reach the Atlantic coast of Antarctica and to begin to move across land, via the South Pole to the Pacific coast. The supporting party in the *Aurora* would land on the Pacific Coast of Antarctica and leave depots to provide support for the last portion of the on-land trek. *Endurance* arrived on South

Georgia, took on the last of their supplies and began to move south towards the Antarctic.

For the first couple of months, the *Endurance* made fair speed, however, the ice conditions gradually worsened. The *Endurance* sporadically became caught in ice, unable to move. Initially, however, Shackleton was unconcerned about the ship being stuck. He was aware that it was normal for ships to be caught in ice, only to be released at a later time. Shackleton later regretted not making an early spring landing – however, in hindsight, he may have made the correct decision.

On 17th January 1915, the ship became surrounded in ice. The ship began to be carried first South-West and then North-West by currents. On January 24th, the ship was 60 miles from Vashel Bay – the projected point of landing. As before, Shackleton was initially unfazed by the development. It was not till 14th February that Shackleton began to take measures to cut the ship free from the ice. On 24th February, the crew of the *Endurance* buckled down for the winter. Knowing they were unlikely to be freed the scientists continued to work, but life became uneventful for most of the crew.

By 31st March, the ship had moved 95 miles North-West; however, it was not until July that the ice began to put pressure on the ship and on the 24th July, the crew made plans for an emergency abandonment of the ship. On October 24th, the ship began to buckle, on the 27th the order was given to abandon the ship and on 21st November, *Endurance* finally sank. The crew was able to scavenge three lifeboats, sledges and a large amount of provisions prior to the ship sinking. At this point, achieving the goal of reaching the South Pole and beyond was unrealistic and the goal became one of survival and returning home. Shackleton began to move the crew across the ice floe and onto land; however, his first two attempts were unsuccessful.

On 9th April, the floe broke up and the party began to move again by sea. This gave them increased maneuverability, but ultimately forced Shackleton to make a decision regarding their future direction. He chose to head towards Deception Island; however, after only a few days at sea, the conditions were clearly too much for the lifeboats and they made their way to Elephant Island. Upon landing, the crew settled down and Shackleton again began to plan for the future. Elephant Island was not located anywhere near where the crew was expected to be and was not on common shipping routes. Rescue from here was unlikely. The island was barren other than for some seals and penguins which offered food and blubber to the men.

Shackleton decided that moving all the men at once on three lifeboats was unlikely to be successful. Instead, he picked six men to sail from Elephant Island to South Georgia – a distance of 800 miles known as Drake Passage. The Falkland Islands were closer; however, the winds made this a more difficult journey. Drake Passage is considered amongst the most dangerous in the world and winds of up to 40 miles per hour are experienced on average of 200 days per year. He knew the dangers of Drake Passage and only packed for four weeks of rations – knowing that if the journey lasted longer than four weeks; the lifeboat was unlikely to be intact. He was constantly worried about the morale of his men and chose to take along Harry McNish, who Shackleton considered

disruptive. McNish and other members of the crew began to strengthen the *James Caird* lifeboat; preparing it for the journey ahead.

Aboard the *James Caird,* named after the largest donator, the six men set sail for South Georgia. After fourteen nights at sea, the crew spotted land – however in order to avoid a night time landing, they waited at sea. That night, the boat was subjected to hurricane-force winds and the crew barely survived. Frank Worsley later wrote that a 500-ton steamer had been lost in the same storm. The next day, the *James Caird* landed on South Georgia.

However, they were on the southern unpopulated side of the island and needed to cross 20 miles of uncharted territory. Due to poor weather conditions, the crew was given an enforced rest for 9 days. Two of the crew where unfit to travel across such inhospitable terrain and a third crew member was left to care for them. On the 19th May at 2am, Shackleton, Worsley and Tom Crean set off to reach one of the whaling stations on the north side of the island. The journey took 36 hours – an impressive time that is difficult to match even today. Once they reached the whaling station, the three-man party on the south side of the island were picked up the next day.

Unknown to Shackleton, his marooned men on Elephant Island had found sufficient food to last them several more weeks. Therefore, he immediately began to put in place measures to rescue them. The danger of the journey they had just taken is highlighted by the fact that it took 4 attempts to reach the party. World War I had broken out in and Britain was unable to send any support for six months. Shackleton was eventually successful reaching the party using a Chilean steamer for transport. After 4 ½ months away from his crew, Shackleton was finally able to rescue all 22 men in late August.

3.6.6 Dissolution

At the same time, the *Aurora* ship was continuing its way to the Pacific coast of Antarctica in order to lay supply depots for Shackleton's land trek. Despite the fact that the *Aurora*, after landing the ten man supply party, was blown off course, stuck in ice and drifted for a total of 283 days, the mission was successful and depots were left for Shackleton. Once it was freed, the ship sailed to New Zealand to be repaired.

3.6.7 Key Statistics

Table 3.5 shows key statistics for Shackleton and the Ross Sea Party. The implications of these statistics will be examined in the following section.

Table 3.5 – Key Statistics for Shackleton and Ross Sea Party

	Number of Outgoing Ships	*Number of People*	*Number of Ships returned*	*Number of Men Returned*	*Mission Success*
Shackleton Party	1	28	0	28	Failure
Ross Sea Party	1	28	1	25	Success

3.6.8 Risk Lessons Learned

There were a number of risks encountered and overcome during the mission. Due to the previous successful exploration of the waters around Antarctica, the types of waters that they would encounter were well known. Shackleton had been in the area in two previous voyages and potentially underestimated the threat posed by the ice. He was largely unconcerned when they were initially caught in the ice and may have lost opportunities to identify a suitable landing spot.

Due to the popularity of the mission and the fact that Shackleton was able to hand pick the crew; he was able to select a mixture of very qualified and experienced crewmen. When they encountered problems, it is likely that being surrounded by a qualified crew helped to overcome issues that other crews may have suffered with. For example, the lifeboat had to be modified in preparation for the voyage to South Georgia. Without the experience of his crew to be flexible and adapt to new goals, it is possible that they would have been unable to meet those goals.

Other risks were the lack of communication between the two parties. At this time, radio communication could only be conducted over a relatively short distance. The distance between the ships was such that there was no communication between both parties. Due to this lack of communication, the Ross Sea party continued with their mission despite the fact that Shackleton's party had failed.

We can apply the DSRM, Figure 3.2 to the Shackleton case study. Shackleton had already been on two Antarctic missions and so was aware of what could be achieved. From this, he was able to provide incentives to his crew to align the goals. These incentives were neither money nor a chance for a new start in life, as in previous cases, but instead the incentive of adventure. He was able to hand pick highly competent men to join him due to the vast response he received. In this case, the unwanted event was losing the ship – which forced the goals of the mission to change from exploration to survival. This created highly motivated crew all working towards a common goal which, combined with their high skill level, ultimately led to the survival of the entire crew.

3.6.9 Key Reading

Hayes J.G. (1932) The Conquest of the South Pole, Thornton Butterworth, London.

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3.7 Project Apollo (1961-1972)

3.7.1 Summary

From the famous speech of President Kennedy in May of 1961 to the final landing on the moon in 1972, Project Apollo was a rapidly expedited and highly successful exploration mission. We shall sketch the main events, but since these are well known and comprehensively documented[5] our purpose is not primarily to go over known facts, but to organize them in a way that fits into and illustrates aspects of the comparative framework used for other cases. In particular we shall make a broad-brush comparison of the US and Soviet manned lunar efforts, consider in what ways strategic risks were mitigated by looking at the wider political decision making context, and finally illustrate that even the most familiar and recent historical events have been shaped by chance events.

3.7.2 Mission Goal

On 25th May 1961, President Kennedy made a speech before a Joint Session of Congress defining the overall Mission Goal:

I believe that this Nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safety to earth.

This objective, defined in the context of a Soviet lead in space, was the signal for a huge investment in the newly formed NASA. However, it was also a clearly defined and limited goal.

3.7.3 Context

A large part of the scene-setting is at a social and political level. The decision to go to the moon cannot be divorced from the political tensions of the time, from the Cold War, and from superpower rivalry. The survival of the Soviet Union in the war, the rapid progress it was making in industrialization and education, and the technological progress that it was making (as illustrated by its rapid development of nuclear weaponry, the first test explosion taking place in 1949) gave confidence to the Soviet leadership that history was, as Khrushchev was reported to have said, “on their side”.

At the end of WW II, the arms race between East and West began in earnest. The strategic importance of rocketry was clear as illustrated by the move of most German rocket scientists to the US, where they worked largely for the Army. Each of the US military services had R&D programs in missile development: the USAF was given primary responsibility for the development of ICBMs; the Army was involved in the development of shorter range missiles (but with the technical capability through its German rocket scientists to do more); and the Navy with its interest in the benefits of satellite communication and navigation was interested in developing the capability of launching satellites. The extensive rivalry between the services has been well documented – each vying for primary or shared responsibility for space research and development.

[5] For example, the NASA website and the work of Stephen Dick, the NASA Chief Historian, gives a comprehensive coverage of the Apollo events

This rivalry came to a head during the preparations for the US contribution to the International Geophysical Year (IGY; was in fact 18 months, from 1 July 1957 to 31 December 1958). The IGY, organized by the International Council of Scientific Unions (ICSU), is a good illustration of the way the scientific community can take initiatives to force the pace of international scientific and technological progress. Both the US and the USSR were interested in launching a satellite as part of the IGY. In the US, the National Security Council ordered the DoD to start a program for such a satellite with support from the National Science Foundation (NSF). All three services came forward with proposals for a launcher: the Naval Research Laboratory had developed its Viking rocket; the Army Ballistic Missile Agency (ABMA) proposed using its Redstone launcher (developed by Von Braun and his team from the V2 missile) in what they called "Project Orbiter"; and the Air Force proposed using an Atlas ICBM launcher. Based on reasonable criteria, but on an assessment of those criteria that in hindsight looks to have been incorrect, the Navy was selected. Unfortunately the Navy's "Project Vanguard" was beset with technical and funding problems. Only after the second Sputnik launch was the ABMA launcher brought in as an alternative, leading to the first successful launch of a US satellite in January 1958, nearly 4 months after the first Sputnik.

Sputnik I and II had a large impact on the American public and their politicians, but the line taken by the Eisenhower administration was that there was no particular significance. In strictly rational terms this was correct – the Russian's ICBM capability was not new, there was no short term military significance of launching the satellite, and the US had almost the same capability (the minor difference being that it was not a proven capability). However, in what could now be considered a case study in social risk amplification, the media, politicians in the Senate and Congress, and the public themselves created a real political storm in which action was unavoidable. Senate majority leader Johnson was perhaps the key person to understand that the rules of the political game had changed. While Eisenhower was satisfied that there were no significant military implications and saw a satellite launch as a purely scientific mission to be justified on purely scientific grounds, Johnson saw Sputnik significance as a highly visible symbol of USSR power (or rather, lack of US power) in the domain of science and technology. It was also a very clear statement of capability – with implications for military capability - that had previously not been widely known. Now many ordinary Americans knew what Sputnik was, and this affected their perceptions about the position of the US.

NASA came into being in October 1958 after a difficult debate within the government about the primacy between civilian and military space programs. The decision to place space under a civilian agency became important later because it meant that the moon race was not a military competition.

The political situation changed rapidly after the election of Kennedy, with the embarrassment of the Bay of Pigs and the first human space flight by Gagarin. The time was ripe for the new President to take a bold step that would demonstrate his ability to control events and the US' ability to provide a technological lead.

3.7.4 Concept

The *desire* to reach the moon has been around for a long time, probably for as long as mankind has had an awareness of the moon's existence. Long before space flight was possible, space travel was being popularized in literature and on film. However, the fact that space travel had captured the popular imagination did not mean that it was technically, or politically feasible. Prior to Kennedy's speech however, the scientific community had put space flight firmly onto the political agenda through the IGY initiative. The German rocket scientists led by von Braun had apparently chosen to go the US at least partly because of a sense that they would have greater scope for manned space flight. Finally, manned space flight, leading to a mission to the moon was on the agenda proposed by the newly formed NASA.

After its formation, NASA had been given responsibility for the Mercury program, and the development was proceeding relatively quickly. The launcher was the Redstone developed by ABMA which had been through a number of successful launch tests, but which was now to be used for the first manned US space flight. The Redstone was eventually further developed into the J2, and the technology developed ultimately used in the development of the Saturn V launcher. At this point, prior to the Gagarin launch, there was still a lot of uncertainty about the human body's physical endurance to launch and reentry. A number of animal tests, together with the known animal flights carried out by the Russians and tests performed on the pilots, gave sufficient assurance that an astronaut could survive the journey. The first manned mission was planned for March 1961, which was prior to Gagarin's mission. However, the von Braun team was still cautious about the launcher and insisted on an additional test firing. This was successful, but the Russians were able to claim the first manned flight.

The successful manned flight underlined Russian leadership in space and was seen by Kennedy as a political challenge. Although Kennedy had little knowledge of space issues, his Vice President Johnson had already spent a considerable time devoted to the subject and knew many of the key players. On 20 April 1961, Kennedy appointed Johnson as Chair of the Space Council and sent him a memo asking for an inquiry into a number of questions, of which the first was:

1. Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the moon, or by a rocket to land on the moon, or by a rocket to go to the moon and back with a man. Is there any other space program which promises dramatic results in which we could win?[6]

It is clear that for Kennedy the question was simply one of national prestige. His scientific advisor, Wiesner, described later what Kennedy had told him about the decision to go to the moon:

[6] Quote in Logsdon (1970)

Well it's your fault. If you had a scientific spectacular on this earth that would be more useful – say desalting the ocean – or something that is just as dramatic and convincing as space, then we would do it.[7]

It is clear that Kennedy's interest in the space program was as a vehicle for regaining national prestige. The choice had to be for a goal that was dramatic, that was feasible and that the US would achieve before the Soviets. Johnson took soundings from a number of different experts, but a particularly important and influential one was von Braun, at the time Director of the Marshall Space Center, but writing in a personal capacity:

we have a sporting chance of sending a 3-man crew around the moon ahead of the Soviets...an excellent chance of beating the Soviets to the first landing of a crew on the moon (including return capability).....because a performance jump by a factor of 10 over their present rockets is necessary to accomplish this feat

One of the principal reasons for the "excellent chance" was the development, headed by von Braun, of a heavy lift capability. This development, which went on to contribute to Saturn V, was already far advanced before the Apollo program was agreed. Indeed, von Braun's group seems to have gone so far that that there was no immediate military need for the Saturn class, and the DoD had agreed to transfer the team to the newly formed NASA.

From the perspective of Kennedy then, the goal to land on the moon was one that met all of his desiderata: The US could and would get there first, and this would be a striking demonstration of US technological superiority. The perceived technological feasibility and indeed the potential advantage were both key to the setting of the goal by Kennedy. Without the cold war context providing the need, and the technological advantage providing the strong probability of a win, it is not clear that Kennedy would have set the goal and Lunar exploration might have been placed in the slow lane.

3.7.5 Exploration

The Apollo program consisted of a large number of unmanned test flights together with 11 manned missions: There were two manned missions in Earth orbit, two in lunar orbit, six missions which landed on the moon, and a further mission (Apollo 13) which was unable to carry out its planned landing but which returned after a lunar swing-by.

The preparatory manned missions were intended to demonstrate various subsystems: Apollo 7 demonstrated the Command Module function and Command/Service Module rendezvous capability. Apollo 8 was the first manned launch using the Saturn V rocket, and the first to orbit the moon, thus providing experience of manned flight over that distance and providing detailed images of the lunar surface. Apollo 9 was used to qualify the Lunar Module and test docking with the Command Module. An almost full "dry run" of the landing mission was carried out with Apollo 10. All functions, including orbits of the lunar module, except the actual landing were carried out.

[7] Quote in Logsdon (1970)

On January 27, 1967 during a launch pad test for the AS-204 mission, a flash fire occurred in the command module, killing the three astronauts, Grissom, White and Chaffee. Besides the tragic loss of life, the fire caused a delay to the whole program while the Board of Inquiry carried out its work. That report revealed many design, planning and manufacturing problems and gave many recommendations that vastly improved the safety of the systems. As such it was an unwanted, but vital opportunity for the whole NASA organization to learn and raise its game. In addition to these direct benefits however, the delay also gave the other parts of the Apollo project some extra breathing space. The overall objective had been set to a very tight schedule.

The other very public failure during the Apollo program was the Apollo 13 flight. Through the ingenuity of its staff, NASA was able to turn this potential disaster into its “finest hour”. Lessons again were learnt, in this case related to quality management.

Alongside the American space effort, the Russians were still active. Von Braun’s claim that the US had an excellent chance of beating the Russians to a moon landing was of course vindicated, but there were strong efforts made by the Russians to compete – though little was known about this at the time.

A heavy lift launcher, the N1 was proposed in 1960 by Korolev, who later also sought and was given permission to attempt a manned lunar landing. Chelomey, one of his rivals, was given permission to attempt a circumlunar mission, using an alternative launcher (later known as the Proton). The Soviet space effort, however, was military, and this restricted funds for what was seen as a purely political objective. Korolev’s program was hampered by problems arising from lack of clear political prioritization and funding. Arguments over propellant choice led to the loss of the most experienced rocket engine designer Glushko: Korolev wanted a LOX/kerosene engine while Glushko wanted to use storable propellants (UDMH/N2O4) which would have direct military applications. Glushko’s replacement was Kuznetsov, an able aircraft engine designer, but inexperienced as rocket engine designer.

The program, hampered already by lack of funds and disagreement about goals, was further set back by the death of Korolev in 1966. He was succeeded by his deputy Mishin, who planned a manned circumlunar mission to take place just prior to Apollo 8. The whole program was struck by a series of launch failures, including the second N1 test in which much of the launch facilities were destroyed. The program was later cancelled after the US had won the moon race, and without the N1 ever having been successfully launched.

3.7.6 Dissolution

The rapid promotion of manned space flight to a national strategic priority was matched by its fall in political priority after the achievement of Kennedy’s goal. Budget cuts led to the cancellation of three planned flights (Apollo 18-21). Fifteen Saturn V rockets had been constructed – one was used for Skylab, and another two became exhibits.

Kennedy’s goal had been achieved, and to many outside the space sector, there seemed little point in making expensive journeys to a place that did not deliver

palpable benefits. The main motivation was now science, and this could be done more cheaply in different ways. Instead, there was more to be gained by developing the use of space closer to Earth.

3.7.7 Risk Lessons Learned

So much has already been written about Apollo from a technical and project management point of view that we do not feel it useful to go over those aspects in detail. Instead we shall concentrate on the more strategic aspects.

The most important aspect is how the goal came to be set. Kennedy needed a way to demonstrate national prowess, but this need not have been in space if some other goal had been available, and would not have been a manned lunar landing unless he had been fairly sure that the US could get there first. A simplified reading of the situation would suggest that the scientific and technological communities simply "hitched a ride" by providing Kennedy with the goal he was looking for. To some extent this is true, but it also ignores the role of those communities in two other ways:

- The development of space as an area for superpower competition, stimulated by the scientific community's promotion of the IGY;
- The provision of key enabling technology that assured *a-priori* a high chance of success, and a relative competitor disadvantage.

Hence, while the scientific and technological communities do not set the agenda, they can quite effectively determine what is on it.

A second key aspect is the role of competition. Human institutions are driven largely by competition – whether this is competition for basic resources or for more abstract aspects such as prestige. While geopolitical superpower competition was the main driver for the political prioritization of the Apollo project, competition between emerging institutions played a key role elsewhere. One example is the way that competition between the US Military Services led to different launch systems and technologies, despite the efforts of the DoD to coordinate and spend money efficiently. The relative freedom available was used in particular by von Braun's group with the development of cryogenic launcher technology. That this - from a purely military point of view – could be seen as dubious use of resources is illustrated by the problems that Korolev had in the Soviet Union.

Human competition takes places within an (emerging) framework. An important element in the moon race was civilian control of NASA. Besides allowing the prioritization of civilian goals above military ones, it enabled Kennedy to "safely" use space as an area for superpower competition. Had the US space effort been led by a military organization it is quite likely that the Soviet military would have more heavily prioritized its own efforts, because they would have seen the moon race as a military competition. In this particular case civilian control in the US and military control in the Soviet Union gave a competitive advantage to the US.

These strategic issues can be represented within a Strategic and Program level Dynamic Systemic Risk model. This is shown in Figure 3.6.

Starting prior to Kennedy's goal setting speech, key stakeholders were aware of the competitors activity and were assessing this in different ways: political stakeholders were sensitive to the loss of leadership of the US, while technical stakeholders were assessing the US position as close and in some areas ahead of the USSR. These key stakeholder perceptions were formative for the strategic goal setting. However, the main strategic goals were political, rather exploration goals. Therefore the prospect of program success (as held out by von Braun) was a major factor in selecting the goal. This was Kennedy's strategic level risk mitigation.

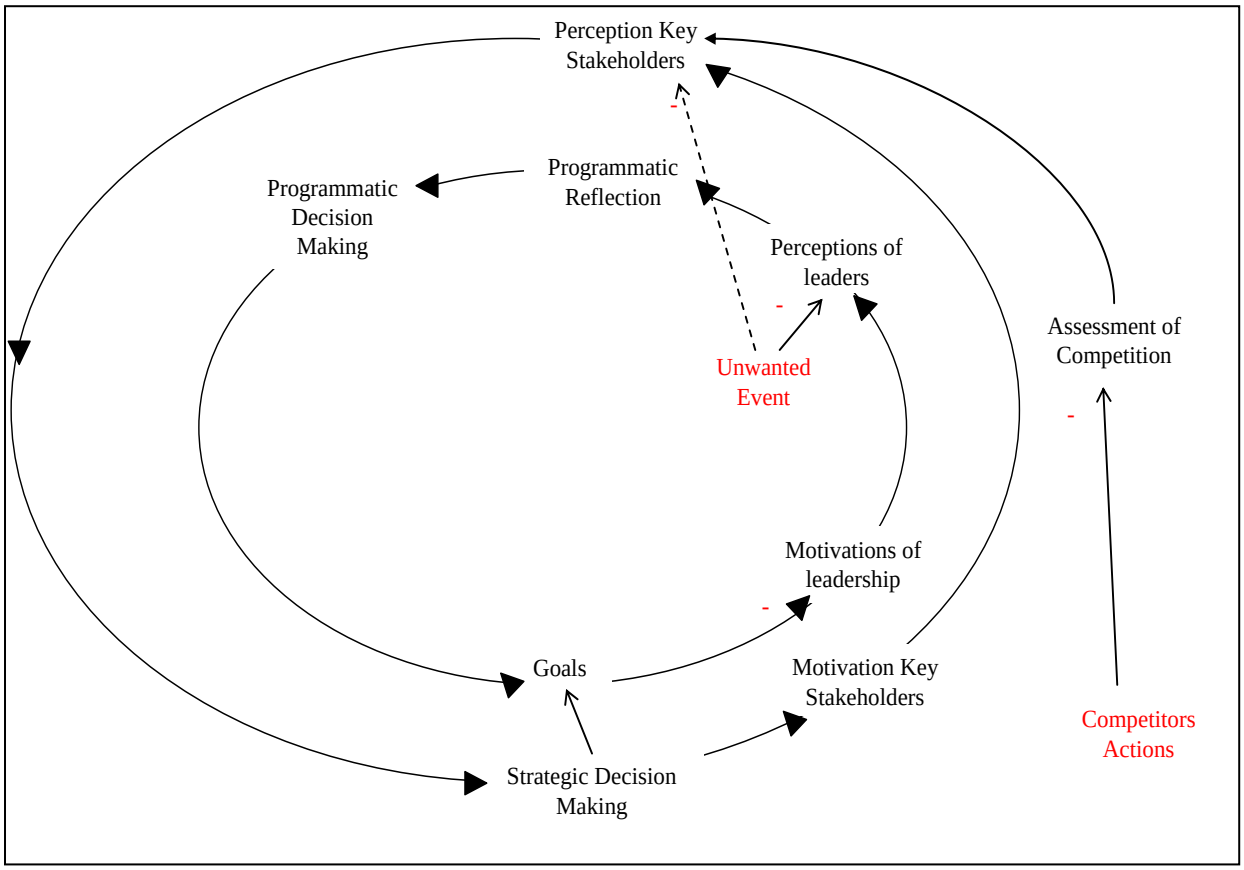

Figure 3.6 – Program and Strategic Level Dynamic Systemic-Risk Model

The setting of tight program goals gave rise to a highly motivated and directed program leadership, who became emboldened through early successes. The Apollo 1 fire was a significant unwanted event that led to severe reassessment of project organization. Through the relatively open and transparent US political system, key stakeholders were quickly aware of the problems, but in this case the tightness of the overall goal meant that no strategic changes were made. Success of the Apollo program meant that the program leadership was looking to increase the overall scope, and indeed had always wanted to carry out further lunar exploration. However, the strategic level goals were simple and motivated

primarily by political rather than exploration objectives. By successfully landing a man on the moon and returning him safely to earth, before the Soviets had managed to do this, the strategic goals were met, and the support of key stakeholders for wider strategic exploration objectives was not forthcoming. Hence, viewed from the point of view of exploration, Apollo was a strategic failure because it did not place the US in a position from which it could easily move to the next stage of exploration. Indeed, it represented from this perspective – perhaps inevitably – a dead end.

Finally it is clear that Kennedy's goal setting came at a time in which political and technical agendas were uniquely aligned. Historical events, which helped align those agendas were therefore key to making Kennedy's decision happen. Two such events are, paradoxically, early failures of the US space effort – allowing the Soviets to be first with a satellite and with manned flight. Both these failures were narrow – the US Army claimed that it could have launched before Sputnik, and it was von Braun's extra Redstone test flight that postponed the first US manned flight until after Gagarin (admittedly, the US flight would have not been orbital, but this distinction may well have been lost on the general public and on most politicians). Therefore one could plausibly argue – though it must remain speculation – that the US narrowly missed the Soviets on two occasions, and that US successes there might have reduced the political imperative for action so much that the Apollo program would not have been give as high a priority. After the US decision to go to the moon, we have seen that the Soviet leadership made half hearted efforts to compete. We also noted that, had NASA been a military organization, the Soviet armed forces may well have had a very different view of their strategic priorities. Under these circumstances there might have been a very competitive race to get to the moon, notwithstanding von Braun's assessment of Soviet chances.

3.7.8 Key Reading

Apollo Program Summary Report (1975) NASA, Johnson Space Center. JSC-09423, Houston, TX

Lakoff, S. A. (1966) Knowledge and Power: Essays on Science and Government, Collier-Macmillan Limited, London

Logsdon J. (1970) The Decision to Go to the Moon: Project Apollo and the National Interest, The MIT Press, Cambridge, MA

Siddiqi, A.A. (2003) The Soviet Space Race with Apollo, University Press of Florida, Gainesville, FL.

Siddiqi A.A. (2003) Sputnik and the Soviet Space Challenge, University Press of Florida, Gainesville, FL.

4 Overarching Discussion of Risk Themes

The cases discussed above provide a range of different exploration and colonization projects dating from the 15th to the 20th Century. The purpose of this chapter is to draw together the common elements into a framework that can then be used to consider where modern risk management techniques can help us for future projects, and where there are gaps.

4.1 Motivation for Exploration

The first issue is to consider the motivations for exploration throughout these cases. The costs of exploration have always been relatively high, and have meant that explorations are carried out by or on behalf of institutions (usually nation states). The motivations of the sponsors differ markedly from those of the actual explorers. In general the explorers have a personal drive to go into the unknown, even when the odds of personal survival are not great. The sponsors on the other hand are looking for tangible benefits in the form of prosperity, security, or political advantage. However, many of these benefits are constrained – there are only limited numbers of locations with oil, gold etc, There is competition to acquire these assets, and either a desire to gain if you are first or a fear to lose out if you are following. Scientific expeditions are slightly different because the desire for new knowledge leads to benefits in terms of increased scientific understanding. However, it is difficult (as many Universities today know) to commercialize and gain more tangible benefits from such knowledge because it is available to all. In fact there is a free rider problem – those who do not pay still get access to the scientific knowledge.

It is worth reflecting further on the differences between those expeditions which are really leading (desire to gain) and those which follow on (fear to lose). Those who are following know that certain things are now possible, and can benefit from that knowledge. In technical terms, “unknown unknowns” are converted into “known unknowns”. An example of this is the flight of Alan Shepard coming after the flight of Gagarin which confirmed that humans could really survive launch and reentry. A historical example is that Cabot felt able to make the journey to America with just one ship – based on Columbus, he knew there was land, and he knew roughly how long he would have to travel. On the other hand, those being driven by the fear to lose are often in a state of crisis, and may therefore exhibit poorer decision-making, as in the case of Darien, or even with Apollo (until after the Apollo 1 accident).

4.2 Comparative Findings

Table 4.1 gives a summary, for each of the cases we have studies, of motivations, costs, and outcomes at program and strategic levels. See Section 2.2.5 for an explanation of how the present day costs were calculated using a GDP deflator. See Appendix 3 for further information on how these costs were calculated.

The table shows that political or economic benefits have been sought, even on those expeditions with a scientific character. As one might expect, given that we have covered a range of different mission types on a range of different scales,

there is no particular pattern in the number of ships involved and the numbers lost.

Table 4.1 – Summary of Motivations, Costs and Success of Cases

	Driver	Benefits	No. of Ships Outward	No. of Ships Lost	No. of People	No. of People Lost	Estimated Present Day Cost using GDP Deflator	Program Outcome	Strategic Outcome
Columbus	Desire for gain	Prosperity	13	5	~400	39	£320,000 Exploitation rights	Failure	Success
Cabot	Fear to Lose	Prosperity	6	4	?	?	£408,000 Exploitation rights	Failure	Failure
Raleigh	Fear to lose	Prosperity Political	10	1	226	Min. 109	~£6.8M Exploitation rights	Failure	Failure
Darien	Fear to lose	Prosperity	17	16	~2500	~2470	~£63M	Failure	Failure
Franklin (1845)	Desire for gain	Political Scientific	5	5	134	134	~£2M	Failure	Success
Shackleton	Desire for gain	Scientific	1	1	28	0	~£600K	Failure	Failure
Apollo (1-17 without 2 - 6)	Fear to lose	Political Scientific	12	1	36	3	~£70 B	Success	Failure

In terms of costs, it is noteworthy that Cabot's expedition was privately funded. Cabot had to gain the support of the King only so that he could obtain a guarantee of future exploitation rights. Without such a guarantee anyone could have stepped in to benefit from his investment. Of course, there was no international law and no jurisdiction over the new lands except that asserted by European sovereigns and the Pope. They had to be careful about exercising that jurisdiction as conflicts could only be resolved, ultimately, by war. Hence King William's politically motivated resolve not to support the Darien colony, despite its establishment by his own subjects.

The table shows that only Apollo was successful at a programmatic level in achieving its initial goal. Columbus was a strategic success because, although he did not find a route to Asia, he did, in a more general sense, achieve his strategic goals of finding new lands and creating new trading possibilities for his sponsors. Franklin was a strategic success because his mission led to the

successful discovery of the North West Passage. We have classified Apollo as a strategic failure from the point of view of exploration, as it closed off an avenue of exploration rather than opening up new exploration ventures. However it should be said that from a political point of view Apollo was a strategic success, as it helped to reestablish the perception of US technological pre-eminence.

We have not considered public opinion in assessing whether exploration ventures are considered successes or failures. Public perception is of course notoriously fickle, and driven by many factors. In particular the successful struggle against adversity, when the mission is a failure, but human survival is (partially) achieved has been important in forming public perception of some missions – most notably Shackleton, and Apollo 13. This contributes positively to overall perception of the program (as with Apollo 13) despite the failure at mission level.

4.3 A Common Risk Framework

With such a range of different exploration ventures over widely different time periods, any attempt to provide a common risk framework is necessarily broad brush. Nevertheless, we can still gain useful insights. As discussed above, and shown in Figure 2.4 we generated a set of generic risk categories at mission, program and strategic level. Definitions for these risks are given in Table 2.2.

In some sense the False Model and Self-interest of Actors risks are quite fundamental, relating as they do to how we make sense of the information we receive, and how we deal with the fact that our organizations are built from individuals who are able to make their own decisions. False model and Self interest of Actors also affect some of the other risks shown in Figure 2.4, for example by affecting the organizations ability to learn from data it obtains. The influences between different risks, and their impact on mission, program and strategic level success are shown in Figure 2.5.

In order to assess how the different risks impacted on each case, we first took the most significant events relating to the venture and decisions of crew, leadership and stakeholders, and produced a Risk Experience Diagram. The diagrams for each case are included as appendices. We have consciously attempted to ensure a similar level of detail was used for different ventures. The diagrams represent the major events described in the narrative, and do not go into a detailed technical level. By counting the different types of risks that occurred in each diagram we were able to assess the relative impact of different types of risk on the exploration ventures. The overall risk count is summarized in Table 4.2

Table 4.2 – Summary of Risk Count

	Mission Failure			Program Failure		Strategic Failure			
	Internal Events	Leadership decisions	External Events	Lack of Learning	Resourcing	Stake-holder perception	Goal change	Self interest of actors	False model
Columbus	0	2	1	2	0	3	1	8	1
Raleigh	0	3	1	0	2	0	3	6	2
Darien	0	0	6	0	0	6	2	1	4
Franklin	2	1	1	1	0	1	1	3	1
Shackleton	0	0	1	0	0	3	2	1	2
Apollo	0	2	1	0	0	7	2	0	0
Total	2	8	11	3	2	20	11	18	10

Table 4.2 shows that, across the cases considered, strategic risks are numerically more significant than program or mission risks. Furthermore, self-interest of actors and false model have been significant, though not on Apollo.

We suggest that self-interest of actors was insignificant in Apollo because of the very tightly defined goals and timescale, which did not allow for significant divergence within the organization. We suggest that false model was not a significant problem partly because of the high investment in science and technology and because (again) of the limited goals and the short time span. One can only speculate that these issues might be significant in longer lasting programs with international consortia.

Of course, one of the clear differences between modern and historical exploration ventures is that we now have a host of modern management tools available to assess and (should we so choose) mitigate risks. Hence we can legitimately ask whether the historical stories would have been different – in terms of the risk count given above – if they had had the benefit of modern management techniques. This question is of course impossible to answer with any certainty. However, it is certainly the case that the individuals involved in all of these ventures were extremely professional, and therefore presumably carried out informal risk assessments even if these were not carried out with the rigor and completeness that modern techniques would imply. If, furthermore, we consider the scope of modern analysis techniques then we see that mission level risks are typically analyzed with Technical Risk Analysis methods. At the program level, risk mitigation is informed using techniques belonging to Programmatic Risk Management. At strategic level we do not yet have a well defined body of techniques designed to analyze this level of risk.

Given that the predominant risks observed in the Risk Experience Diagrams are at the strategic rather than mission or program levels, our conclusion must be

that modern risk management techniques would *not* have addressed the dominant risks appearing in the cases we have studied.

Clearly we must also conclude that future exploration ventures are also susceptible to strategic risks, however well the mission and program level risk analysis and mitigation functions are carried out.

4.4 Overall Dynamic Systemic Risk Model

We have observed that human decision making dynamics are significant at mission, program and strategic level, though the most important dynamics may be at one level or another, depending on the case. We can combine the different levels together in an overall model as shown in Figure 4.1

The inner loop describes the motivations experience and activities of the crew, that is, it describes mission level dynamics. The middle loop describes program level decisions and motivations, including ways in which the program leadership can intervene to influence those operating at mission level. Finally, the outer loop represents the strategic level, which influences the program level through goal setting, and is influenced by competitor actions in its own choices.

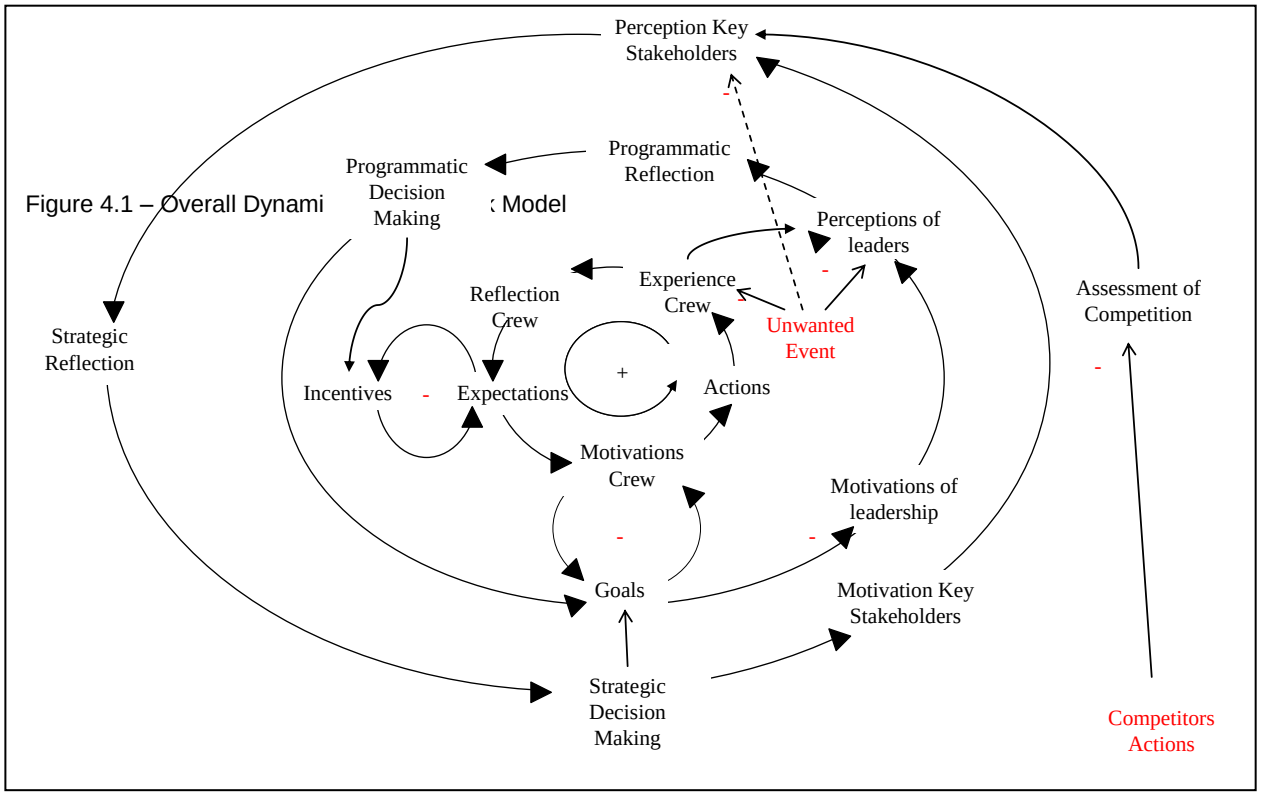

Figure 4.1 – General Dynamic Systemic Risk Model

As described so far, this model is a system dynamics model, albeit one operating at different speeds in the different levels depending on the phase of decision making. The system dynamics model reflects how the individuals involved at different levels interact and drive each other's motivations and decision making. However, what makes this model different from a classic systems dynamics model is the appearance of unwanted events and competitor actions. These are random events, or competitor-driven events respectively, and influence the actions of actors at each level. Competitor action is usually most significant at the strategic level, influencing the perceptions of stakeholders through competitive actions which demand a strategic response. Unwanted events which we nowadays try to analyze and anticipate through risk tools. Historically these were a direct influence at a mission level, and only slowly filtered through to program level (or not at all, in the case of Darien) and higher. Nowadays, through modern communication and the transparency in many parts of the world, such events quickly become known at a higher level and are sources of immediate concern at both program and strategic level. Indeed, one of the main drivers of program risk management is the management of the way mission level events are interpreted by stakeholders, as they become known.

4.5 Specific Lessons Learnt for Future Exploration

This part of the document summarizes some of the individual lessons drawn from the cases. We explain each point briefly, with reference to the individual cases from which the point is drawn. All is used to denote when the lesson is applicable to all cases.

- "Unknown unknowns" can be converted to "known unknowns" by experience, but we can use information gathering to buy down uncertainty on known unknowns (All)
    - This arises in all the cases. For example Columbus studied the currents around different Atlantic islands in order to reduce uncertainty about departure and return directions. He had to encounter land before he found out that the Americas existed.
- Some unknown unknowns remain and can be mitigated by goal change (All)
    - Columbus remained publicly convinced that he had found a route to Asia, but mitigated this uncertainty by concentrating on exploiting the lands he had discovered.
- Goal changes are natural and can be opportunistic (Columbus, Raleigh, Shackleton).
    - For Columbus, the Spanish monarch shifted their goals from identifying a trade route to the Far East to exploitation of America. Raleigh shifted his goals between privateering and colonization. However in both cases, the strategic goal of prosperity and increased security remained – it was only the program goals that changed. In the case of Shackleton, the strategic goal was abandoned and the program goal became survival.
- History judges by hindsight (Columbus, Shackleton, Apollo 13)

    - With hindsight many judge the successful return of Apollo 13 to be as great an achievement as the landing on the moon – certainly, it has remained as high in public consciousness. In the case of Shackleton, history remembers the name of the Shackleton party but the successful Ross Sea party is largely unknown. Columbus is considered a visionary and very successful explorer when in actual fact he was an excellent mariner but not necessarily an excellent explorer.

- Need to be wary of decisions that restrict future goal changes (Raleigh, Darien)
    - Both Raleigh and Darien made initial choices of location that greatly restricted their ability to continue the missions. Raleigh attempted to move location at great cost and was ultimately unsuccessful.
- Technology heavily influences goal setting and political agenda (Franklin, Apollo)
    - Franklin's goals were set because the organizers believed that technology had increased to the point where they could overcome the environmental conditions previously encountered. The Apollo goals were set based on the political and technical assessment of US capability relative to the USSR. The International Geophysical Year pushed the US and USSR governments into competition in space.
- Historically, internal risks are not causes of strategic failure (All)
    - Internal risks are problems at mission and sometimes at program level, but not at strategic level.
- Competition is a principal driver for exploration (All)
- Exploration success can be accelerated by competition (Columbus, Apollo)
    - Columbus was forced to identify a trade route to the Far East by sea due to the collapse of the Silk Road. In addition he had to choose a route that avoided the Horn of Africa because of posts set-up by the Portuguese. For Apollo, because the Soviet Union was able to achieve significant advances in the space race prior to the US, the US focused substantial resources on their strategic goal.
- Lack of alignment in stakeholder and actor priorities is a contributor to strategic failure in colonization (Columbus, Raleigh, Darien)
    - In all three cases, what the crew had expected to be accomplished during the mission was not met. This was because the goals of the leaders and the crew were not aligned with one another. Actors, both leaders and crews, were acting in their own self interest and not meeting the strategic or program goal.
- A potential downside of any form of collaboration is the self interest of actors
    - More opportunities for problems during colonization than exploration. However incentives provide means of aligning priorities but must be robust to future events (Columbus, Raleigh)

- Natural and generated in situ resources can provide substantial competitive advantage, e.g. choice of point of departure (Columbus, Apollo)
    - Columbus was able to leave from the Canary Isles due to the fact that the Spanish monarch had previously acquired the island.. The US had an advantage over the Soviet Union as they were able to depart from a site much close to the equator.
- Failures can open up new opportunities and chances to learn (Columbus, Apollo)
    - In the case of Columbus, the loss of a ship on his first sortie meant that he had to accelerate plans for colonization. The fire of Apollo I meant that stricter procedures were put in place for future missions.
- Safe havens and alternative modes offer the chance to mitigate against program failure when mission failure occurs (Columbus, Shackleton, Apollo 13 as opposed to Darien)
    - Columbus was fortunate that there were abundant natural resources and good weather at his destination. Similarly, whilst the environmental conditions were difficult, Shackleton was able to find safe havens so he could break up his party and have greater chance of success. For Apollo 13, the Lunar Module acted as a safe haven for the crew when their primary ship, the Command and Service Module could no longer support them. If this failure had occurred, during the Apollo 8 mission where the Lunar Module was unavailable, the crew would not have been able to return to Earth.
- Tangible outputs keep stakeholders happy and give credibility (Columbus as opposed to Cabot, Raleigh)
- Skill of the crew to be flexible to failures and opportunities is important for crew survival and mission success (Shackleton, Apollo as opposed to Raleigh, Franklin)
    - The crew, in the case of both Shackleton and Apollo, were able to adapt to the difficulties they were facing

5 Conclusions

This study has developed a systematic methodology for the comparison of risks in historical exploration campaigns ranging from Columbus to Apollo. Perhaps the most remarkable observation is that the only one of the cases studied that met its original goals was that of Apollo. However, several cases – most significantly Columbus - were strategic successes in spite of this. Strategic success entails that the campaign not only achieve its set targets, but also puts us in a position from which we can move further by setting and achieving future goals. Many early explorers were entrepreneurial and indeed opportunistic in a way which is difficult for modern large-scale organizations to emulate, but achieved success because of this.

There are three key conclusions to this study:

1. *Analyses of historical cases have shown that there exists a set of generic risk classes*.

This set of risk classes cover mission, program and strategic levels, and include all the risks encountered in the cases studied.

2. *There is no reason to believe that they will not be applicable to future exploration and colonization campaigns.*

We have deliberately selected a range of different exploration and colonization campaigns, taking place between the 15th Century and the 20th Century. The generic risk framework is able to describe the significant types of risk for these missions. Furthermore, many of these risks relate to how human beings interact and learn lessons to guide their future behavior. Although we are better schooled than our forebears and are technically far advanced, there is no reason to think we are fundamentally better on these issues.

3. *Modern risk modeling techniques are capable of addressing mission and program risk but are not as well suited to strategic risk.*

We have observed that strategic risks are prevalent throughout historic exploration and colonization campaigns. However, systematic approaches do not exist at the moment to analyze such risks.

6 Proposal for Forward Work

The purpose of this proposal for forward work is to begin the creation of a set of tools for identifying and assessing strategic and programmatic risk through a staged process of applied development. We propose initially to apply the results of the study to the current NASA exploration approach in order to qualitatively identify risks and possible mitigating actions. This will provide an opportunity to further scope future requirements on a more sophisticated tool, which could ultimately include simulation type methodologies, but for which would only be developed in a straightforward illustrative way in the first study.

6.1 Examination of Scenarios to Identify NASA Exploration Risks

In this section we describe the proposal for the short term future work, providing insight into the extension of the methodology used for the historical cases to examine live and prospective projects.

6.1.1 Objectives, Deliverable and Project Phases

The objectives of immediate forward work would be as follows:

1. To apply the risk classification template to NASA's planned exploration campaigns to identify risks at program and strategic level.
2. To review previous work (raised by Deborah Neubek at the final JSC presentation) carried out within NASA with regard to strategic risks for interplanetary exploration, and integrate those results into the risk model.
3. To identify potential control mechanisms operating at program and strategic level in order to gain an understanding of how these might qualitatively affect the future course of the campaign. This requires an assessment of stakeholders and competitors and also of their motivations and objectives.
4. To integrate the potential unwanted events and control mechanisms into a qualitative model and create qualitative scenarios for the future course of the campaign.
5. Provide illustrative examples of how these scenarios can be used to inform decision making now and in the future.
6. To provide reflection and discussion on how such analyses can be further developed.

The deliverables would be:

1. A report containing
    i. A more detailed methodology for classifying risks, unwanted events, and control mechanisms.
    ii. A case study based on NASA's current (planned) exploration program which qualitatively discusses how these aspects interact to form potential scenarios against which NASA management can consider how they can influence strategic decision making.
    iii. A proposal for building on the work carried out to provide the basis of a strategic risk assessment approach.
2. A set of PowerPoint slides and final presentations to be made at NASA HQ and JSC.

The project would be carried out in five phases:

1. Initial review and structuring, using existing public domain materials, such as the ESAS report. Identification of key NASA personnel. Comparison with previous NASA work on strategic risks and scenario planning.
2. Semi-structured interviews with a number of key personnel to assess risks, control mechanisms and so forth.
3. Structuring of data and creation of exploration scenarios.
4. Workshop on scenarios to create potential response strategies.
5. Writing final report and presentation of results.

6.1.2 Methodology and Data Requirements

The methodology used would be an extension of the approach used for the historical cases, but adapted to deal with prospective, rather than retrospective, projects. Hence the innovation in the methodology would be the development of scenario structuring approaches that build on the retrospective analysis but adapt scenario planning methods to scope potential futures for the exploration project.

Scenario planning assumes there is no single criterion against which decision alternatives can be assessed. Alternatives have strengths and weaknesses which vary against different possible futures. The premise of this methodology is that the future is fundamentally uncertain and that alternatives should be discussed in the context of several possible futures. The process of conducting scenario planning involves eliciting uncertainties as well as project constraints from relevant personnel and creating sensible sets of realizations to construct a few plausible futures against which alternatives can be discussed. For example, Table 6.1 illustrates a simple set of scenarios for the Darien project.

Our study has provided the outline of a systematic approach to assess and classify risks at a strategic level, of which the most important factors are the unwanted events (which may be technical, program, competitor driven, even stakeholder driven) and control mechanisms. The process of considering the scoped futures will provoke strategic discussion, raise awareness of hazards and threats as well as facilitate communication over time. This in turn increases the ability to learn and reduces the hazards associated with false models.

The outline approach will be further developed to provide a more detailed systematic classification. The elicited data will be used to construct scenarios to provoke strategic discussion.

Table 6.1 Example Scenarios for Darien

	England Supportive of Darien	England Destructive Towards Darien
Darien has a supportive natural environment	Assume good agriculture Assume Spain feels threatened Assume England is supportive through colonies	Assume good agriculture Assume Spain feels threatened Assume England feels threatened
Darien has a destructive natural environment	Assume climate is poor for vegetation Assume English colonies are supportive Assume Spain feels threatened	Assume climate is poor for vegetation Assume Spain feels threatened Assume England feels threatened

The project would require inputs from a number of NASA personnel at program and strategic levels, as key sources of data would be from "expert judgment" within the program.

6.2 Development of Simulation Tool to Analyze Strategic Exploration Risks

Although this is not part of the immediate program for further work, we see the above proposals as linking in to a longer term vision of being able to model risks, control mechanisms and stakeholder/competitor responses through a simulation tool which would combine the control aspects common in System Dynamics modeling with the random unwanted events common in Fault tree/Event tree modeling. This modeling approach is called a Dynamic-Systemic risk model in this report. The outputs of such a model would be future sets of events and can be represented as risk experience diagrams. Hence a range of risk experience diagrams would be generated from a given model, representing possible future histories. As with other Monte Carlo based models, we can then calculate output measures such as time to program success.

Such models, while not standard modeling tools, are not technically difficult to construct. However, what is not at all well understood is how a real-world problem can be best structured in order to inform the construction of such a tool for a specific case. Hence the real initial difficulties are in the creation of an appropriate qualitative structure, which is going to be addressed in the first stage of work proposed above. Follow on work could then be focused (or re-focused, depending on the insights gained from the first stage) to generate other parts of the model and tool.

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Appendix 1: System Dynamics Modeling Example

A simple example is provided to illustrate the concept of a qualitative systems dynamics model for the "chicken and egg problem" (Sterman, 2000). Figure A1.1 shows that as more eggs are laid, more chickens are born. As more chickens are born, more eggs are laid. This cycle continues, reinforcing itself with the populations of chickens and eggs increasing. Alternatively, if too few eggs are laid, then fewer chickens are born, which reinforces itself with even fewer eggs and chickens. Such cycles are denoted with a "+" and referred to as virtuous or vicious if the results are desirable or not. In order to manage either the perpetually increasing or decreasing populations, a control loop can be introduced. In this example, building a road crossing can provide a suitable control mechanism. For example, not all chickens will survive crossing the road and hence the population of chickens will be constrained and so reach a steady state. In order to change the size of population of chickens, we need to introduce or remove roads. Control loops are denoted with a "-".

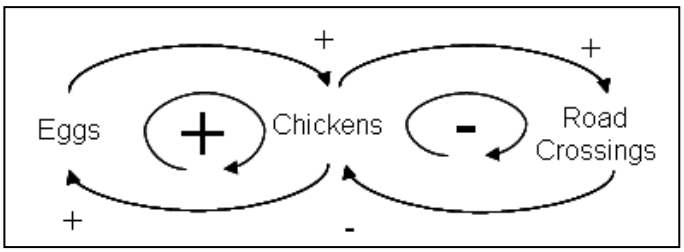

Figure A1.1 – Example System Dynamics Qualitative Model

Reference

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Appendix 2: Risk Experience Diagrams

The key for the Risk Experience Diagram is as follows.

Risk	*Key*
Leadership Decisions	LD
Internal Events	In
External Events	Ex
Lack of Learning	L
Resources	R
Goal Change	GC.
Stakeholder Perception	SP
Self Interest of Actors	SIA
False Model	FM

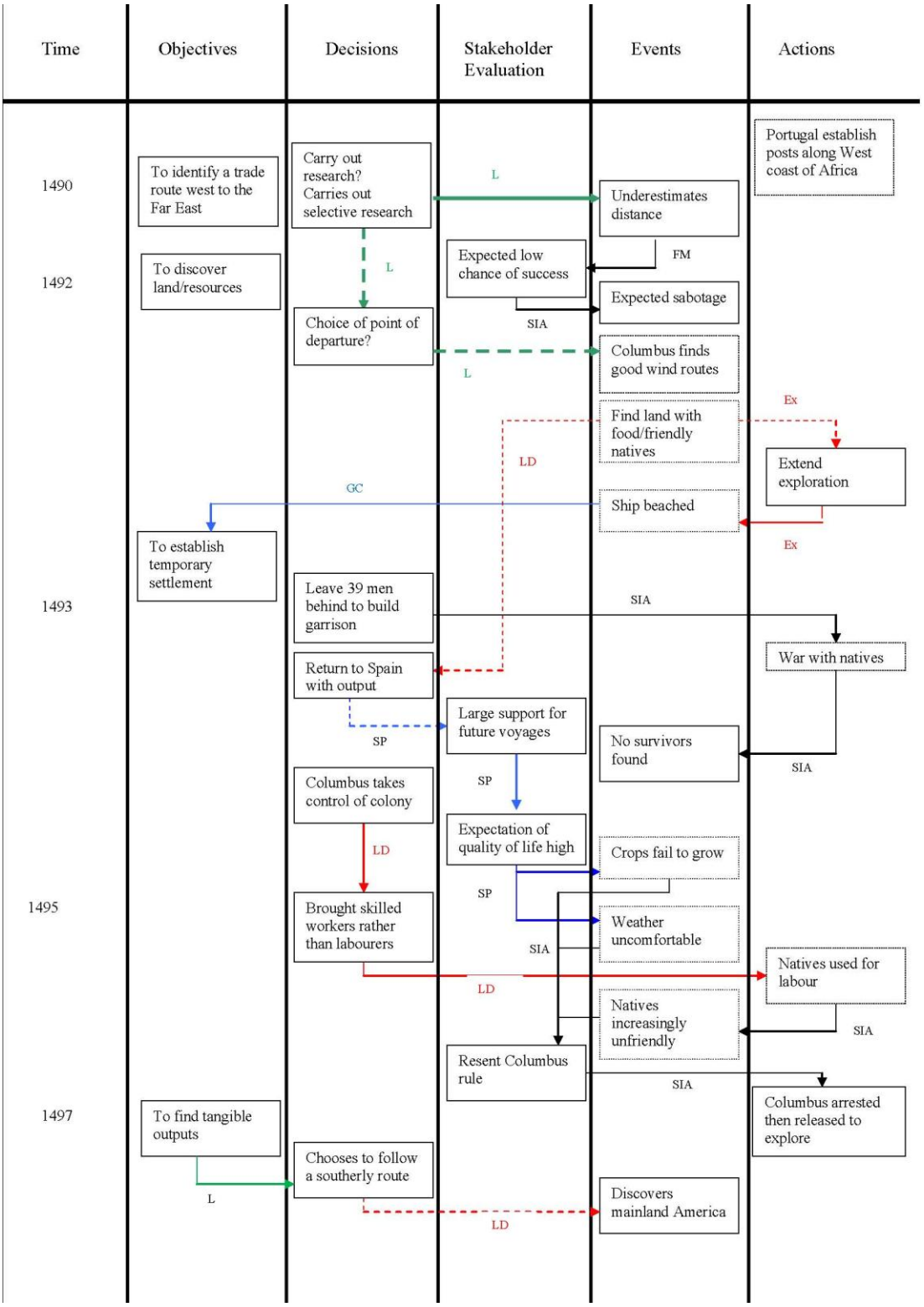

Figure A2.1 Risk Experience Diagram for Columbus Case Study

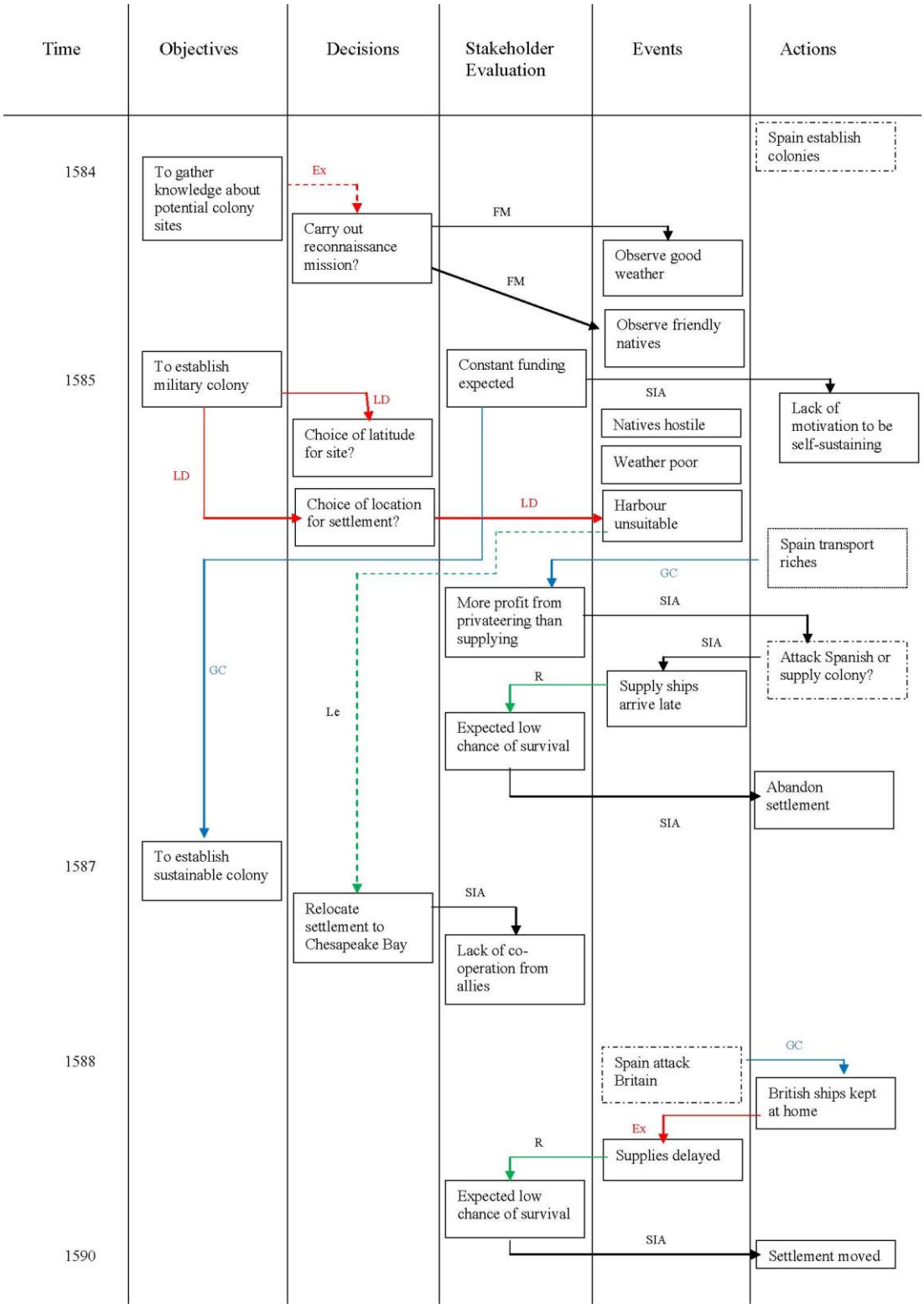

Figure A2.2 Risk Experience Diagram for Raleigh Case Study

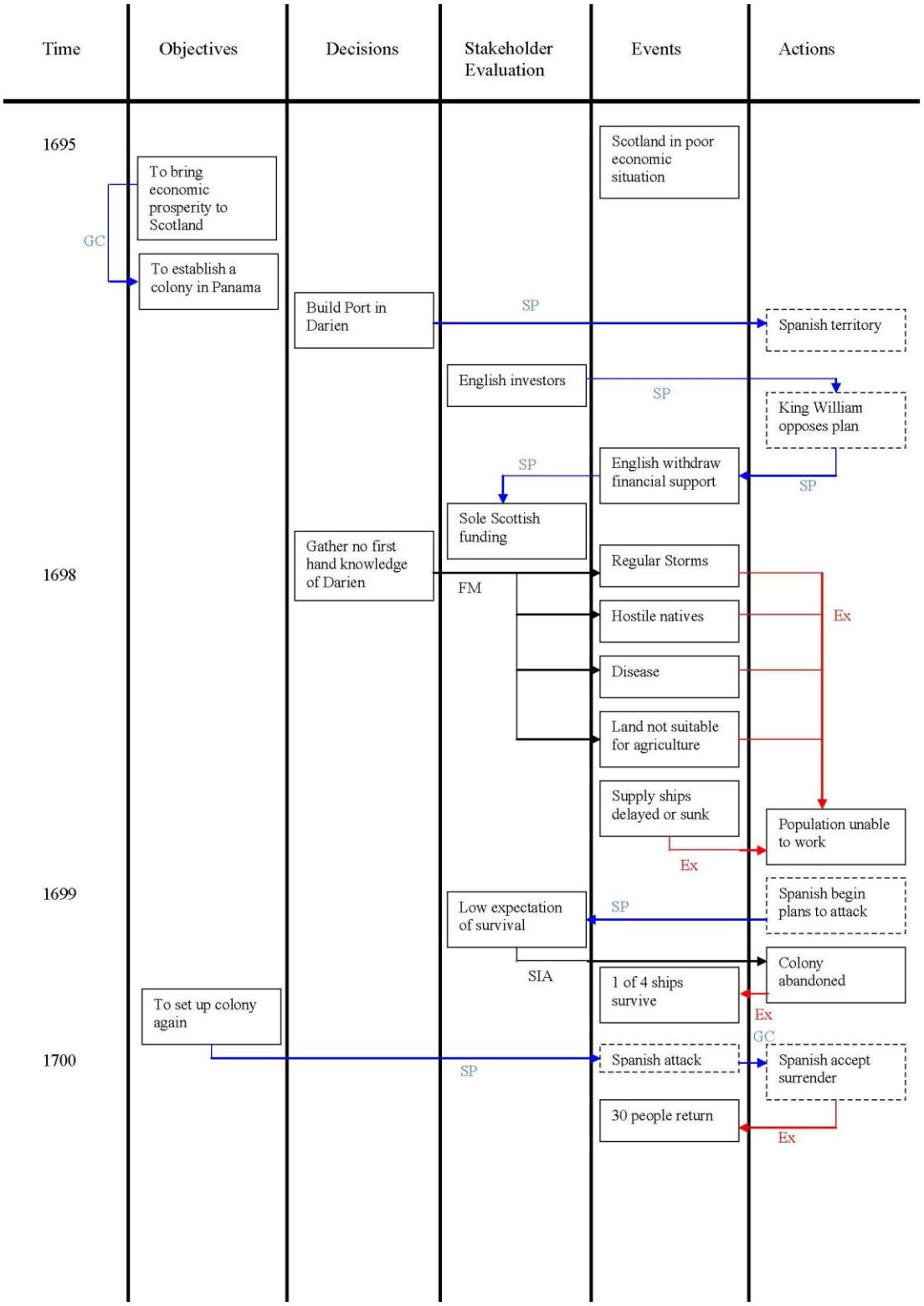

Figure A2.3 Risk Experience Diagram for Darien Case Study

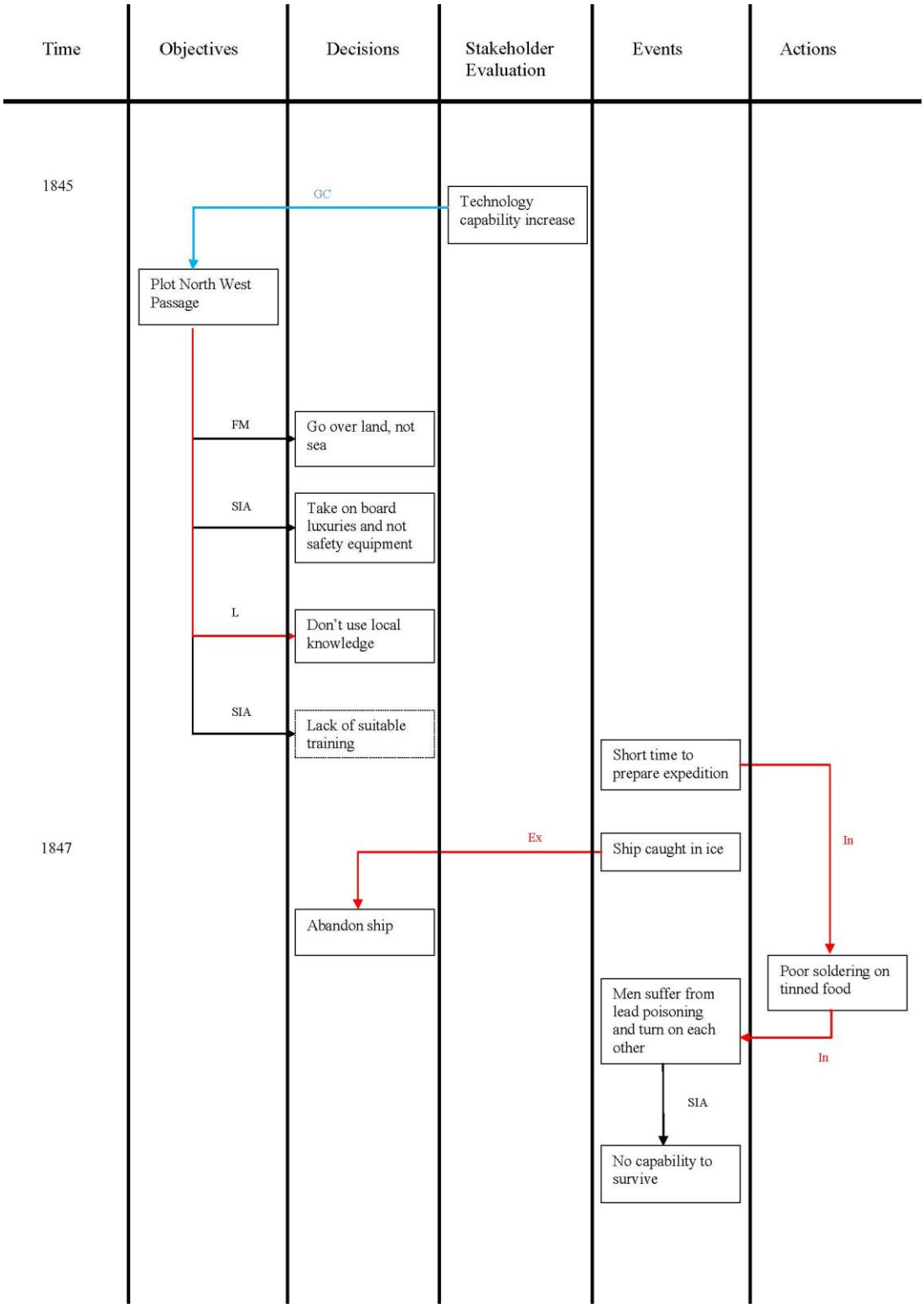

Figure A2.4 Risk Experience Diagram for Franklin Case Study

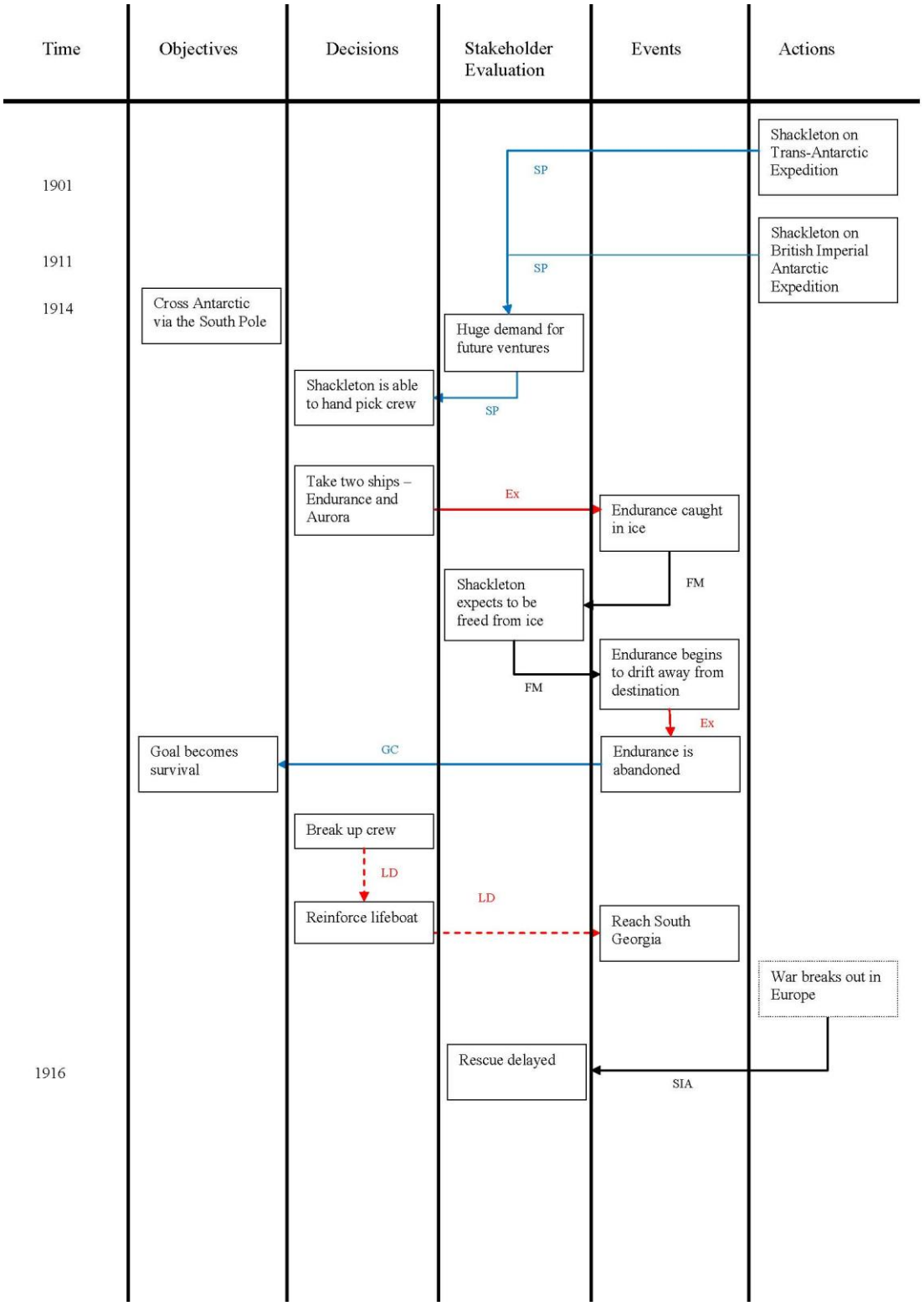

Figure A2.5 Risk Experience Diagram for Shackleton Case Study

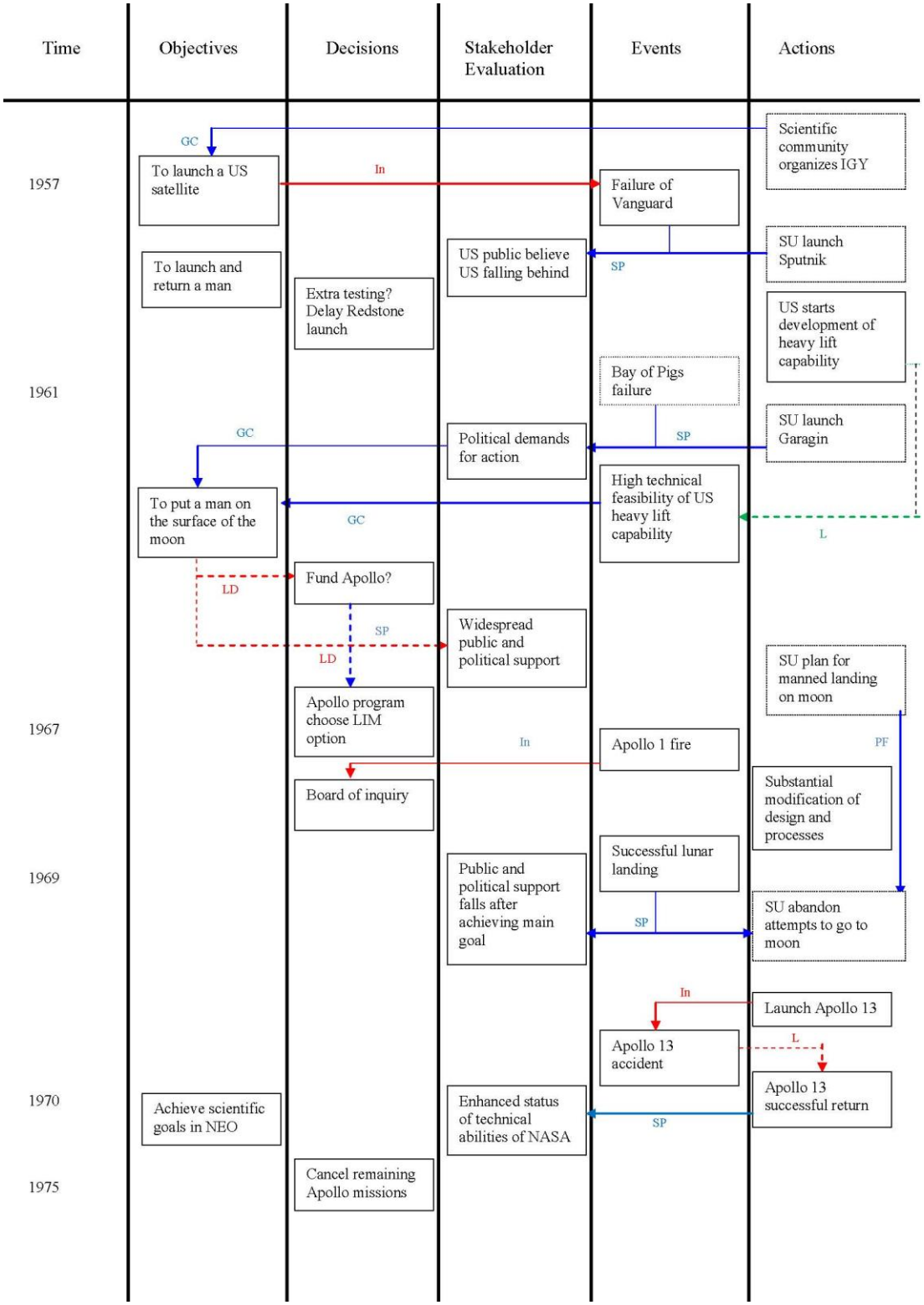

Figure A2.6 Risk Experience Diagram for Apollo Case Study

Appendix 3: Cost Analysis

In order to provide order-of-magnitude costs we have looked for estimates of the costs of the lost ships – on the grounds that those ships that were not lost could be reused.

For Columbus, Morison () tells us that the cost of the ships for the first mission was 2,000,000 maravedis, and that 375 maravedis were equal to 1 gold ducat, or about 3.48 grams of pure gold. Since 31.11 grams is equal to one Troy ounce, this implies that 1 gold ducat had 0.11 fine ounces (that is pure gold Troy ounces). According to Measuringworth.com, the official British currency was 2.01 pounds per fine ounce at that time. Hence, converted into British pounds of the time, the cost of the ships would have been around £1200, or £400 each. This relates to the cost of the ships only and not the payroll, which is the same order of magnitude again. Assuming that we only require the cost of the lost ships, we have total cost of £2000 (5 ships) over all the expeditions. Using the GDP deflator as an appropriate measure of inflation, and using the figures provided by Measuringworth.com, we find that the 2006 equivalent value would have been approximately £511,000.

For Cabot, based on the same ship costs we obtain a figure of £408,000

For Raleigh, Morison (1971) estimates that the cost of the colonization attempt was approximately £35,000. However, this does not take into account any money recouped through privateering. Using the GDP deflator, this is equivalent to £6.8M at current prices.

For Darien we have used the costs of £400 000 (1700 prices) that are widely quoted, although it is not entirely clear what is covered by these costs. Using the GDP deflator this is equivalent to £63M at current prices.

The costs for Franklin and Shackleton comprise the loss of ships only, i.e. two ships for Franklin (Erebus and Terror) and one ship for Shackleton (Endurance). The tonnage for Erebus was 372, Terror was 325, and Endurance was 350. The cost of a ship in 1850 was approximately £25 per ton, which results in a nominal cost of £17,425. The cost of a ship in 1915 was £21.9 per ton, which results in a nominal cost of £7,665. Using the GDP deflator, we get approximate costs of £2M and £600,000 for Franklin and Shackleton respectively.

In the case of Apollo we have taken total project costs.

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