The European Satellite Navigation Program:
Policy Analysis and Recommendations for the Future

by

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Abstract

The European Satellite Navigation Program is a case study that combines Technical / Public / Private aspects in an integrative way. Therefore, it is a sound case for a TPP thesis candidate. This thesis analyzes the European Union policies for the Galileo program, Europe's bid to have its own Global Navigation Satellite System (GNSS).

Galileo is the Europe's first major attempt to develop a complex, Pan-European infrastructure project, to be owned by the European Union. It challenges its capability to gather strength and achieve the political capability to deal with major technology policy projects to lead in world affairs. It is a unique case that serves as a precedent for further infrastructure/technical projects to be managed by European Union institutions in the future. Such a major technology policy project involves the interrelation of a complex structure of multinational political and industrial organizations, and the interrelation of leading edge technical, economic, commercial and social concerns in the heart of the European Communities.

During the last two decades Europe has committed to maintain a remarkable long-term vision and a strong political determination to developing Galileo. On the downside, the EU has had difficulties in establishing a coherent financing program and a punctual manufacturer deployment. On the basis of the Galileo endeavor, this thesis assesses the use of Public Private Partnerships in large pan-European infrastructure projects in the complex political framework of the European Union. This analysis is performed upon the perspective of a theory of how to devise a strategy, a tactical plan, and a way to implement a technology policy effectively, developed by the guidelines set forth by the MIT Technology and Policy Program. It reviews the history of the European Union's policies attempting to develop Galileo, evaluates the strengths and weaknesses of such policies, and delivers a plan and a guide to help implement future projects more effectively.

Finally, it aims to provide a set of recommendations for the future policymaking the European Union will face in the next decades with regard to the operation and exploitation of the system.

Thesis Supervisor: Richard de Neufville.
Professor of Engineering Systems

It has been stated to an excess that Spain's main problem is an education problem. It has been urged, in practice, that if we want to be incorporated into the civilized world, we must nurture intensely our uncultivated lands and brains, saving for the prosperity and praise of our homeland, all the rivers that flow in the sea for lost, and all the talents that are neglected in ignorance.

Santiago Ramón y Cajal,
Nobel Prize in Medicine 1906.

I want to dedicate this thesis to my beloved grandfather, Pacho, for having instilled in me the value of education as a means of achieving progress and liberty. I learned from him that no army can forbid one's beliefs, nor impede an intelligent man from thinking for himself. Additionally, I want to thank him for providing me with a taste of involving myself in world affairs and introducing me to the importance of public policy to better world, on the basis of equity, freedom and tolerance, and above any kind of violence to men, animals or Mother Nature. I learned from him that it is within our life's duties not to remain quiet to injustice and do our modest bit for the sake of humankind. Abuelo, oblivion is full of memory and your attempts were not in vain. I hope that, wherever you are, you can see this academic accomplishment of your granddaughter, and feel it as a triumph of those eternal ideals of progress and democracy you dreamed of. You will never vanish while I ever love you, because your essence lives in me.

Next, I want to thank my parents, Gabriel and Consuelo, for giving me always their unconditional love, support and care, most especially during the last three years. Thanks for your sacrifices that enabled me the best education you could, believing it is the best legacy you will leave me. Thank you to my sister Elena; always positive, loving and upright. I owe you all that I am, and I love you.

There are no words, no foreign language, to express my gratitude to my thesis advisor, Richard de Neufville, a man I truly admire and have so much to thank for. Thank you for mentoring me, for your support, your help, your patience, your brilliant insights and your humanity. Thank you for believing in me and advocating, without judgments, my competence. It has been a honor to meet you and work with you.

I also want to thank my friends, especially those I made at MIT, for being always there when needed, and for the moments we shared. You made this experience entirely worthwhile, and I consider you to be part of the best that I will bring from this place.

I am also thankful to this institution for letting me discover so many new things to learn about. In particular, I have so much to thank the MIT Technology and Policy Program for, allowing me study public policy on top of engineering. Shaping technology policy is somehow a way of turning technology into poetry for me; insofar as it endows it with a human dimension. Thanks for allowing me cultivate my interests in humanities, yet embracing the pure mathematical side of me; enabling me to express both facets of myself at once, finally.

I would like to thank Sydney Miller and all the MIT staff for making all this possible, making my life easier in times of despair, and helping me reemerge a new woman in my early thirties. You make this institute of technology truly human.

My gratitude also goes to the Fundación Caja Madrid for awarding me a scholarship that gave me the opportunity to embark on this venture. I hope I can return to society – and potentially to my country – the great investment made in me.

Finally, I would like to express my feelings of appreciation for the people of the United States of America, who have welcomed me so well during this time in Cambridge, making my time in this country one of the most rewarding personal experiences in my life trip.

Thank you all.

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Chapter 1

Introduction

Satellite navigation is one of the most promising technical revolutions of the years to come, having a wide range of potential profitable applications, and leading to a growing satellite navigation market of products and services. Studies and forecasts performed at European level estimate that it is becoming the next big technology wave.

Galileo is Europe's bid to have its own global satellite navigation system in orbit. This ambitious program was set out by the European Commission (EC) and the European Space Agency (ESA) and has the scope to provide real improvements in the world of satellite navigation. It gathers technical, political and economical aspects in a unique way. Galileo is a multinational project that involves a complex structure of political and industrial organizations from different European nations.

Comparable to the U.S. NAVSTAR Global Positioning System (GPS), Galileo is a large industrial project that has an important strategic and political value, and involves the design, development and operation of ground and space infrastructure. Once deployed, the Galileo infrastructure will also remain in public ownership consistent with the strategic and political value that a satellite navigation system represents.

In fact, Galileo is considered the largest industrial project that has ever been organized in Europe, and the first public infrastructure that will be fully owned by the European Union (EU) as public authority, above the national authorities of its Member States.

Galileo is one of the two pillars of the European Space Policy. The system was designed under public procurement procedures *via* the European Space Agency (ESA). Considering the commercial nature of this project, the European Union initially envisioned financing its deployment and operation phases in partnership with a Concessionaire of the main European aerospace companies under a public-private financial agreement. This public-private agreement allowing private sector financing to procure and maintain large public-sector infrastructure is known by the generic term "Public-Private Partnership[1]" (PPP).

The use of PPPs has been increasing at national level within the European Union in several areas; in particular, in transport, public health, public safety, waste management and water distribution [COM(2003) 283.] However, structuring PPPs is complex because of the need to balance the aims of the diverse number of public and private parties involved, and the European Institutions lack the experience in the use of PPPs

[1] For the purpose of this thesis the term PPP refers to any kind of financial model that has private sector financing, at any level.

at EU level. Therefore, being the first, the largest and unique, the success of a PPP for the Galileo Project tests the European capability to deal with this kind of challenge. It sets a precedent for future pan-European infrastructure projects to be financed as PPP. In other words, it provides a real case for analysis that addresses the strengths and weaknesses of the use of PPPs in large infrastructure projects in the complex political framework of the European Union.

1.1. Motivation

The motivation for this thesis comes from the fact that the use of any scheme of PPP for the Galileo project has long been questioned. In particular, the terms of the initial PPP model, first envisaged for Galileo in 1994, came to be inappropriate a decade later when the public and private sectors intended to negotiate this agreement. As a result, this first attempt to finance the deployment and operation phases of the Galileo project *via* a PPP scheme failed, revealing that the rationale of this model was based on an unrealistic analysis. Consequently, the European Union abandoned the idea to impose a PPP scheme for the deployment phase and took over the project, ensuring its continuity. The financial and governance structures of Galileo were reframed and the European Union fully funded the deployment phase. Several alternatives of private participation in the financial structure of Galileo for the operation phase remain under study in the European Commission, which is working on a concept for the operation and exploitation of the system, after deployment.

1.2. Objectives

Taking into consideration the previous experience with the first attempt to create a Galileo Concession, the public sector is highly reluctant to consider any scheme that involves private participation in the operations and exploitation of the system. The main purpose of this thesis is to demonstrate whether such private involvement would still help increase the effectiveness of the project after deployment and, if so, under which circumstances. It should be assessed why the early decision of using a PPP financing scheme was taken, from whom, and under which circumstances, so that this question is tackled.

Thus, this thesis will attempt to answer the following question: *Is it still recommendable or feasible to have a private involvement in the exploitation and operation phase of Galileo at any level? Or should it be undertaken under public procurement only?*

At the same time, by analyzing the feasibility of a PPP scheme for Galileo, this Thesis helps identify the particular hurdles that may emerge when adopting public-private financing models for large public infrastructure projects at a European Union level.

1.3. Methodology

Policy and finance are inextricably entangled in PPPs. This thesis addresses the general policy issues that arise for the European Union in considering whether to adopt a PPP procurement route for Galileo. Thus, it requires the evaluation of the PPP decision within the framework of the European Union decision-making process. We will assess this following the methodology of the policy-making process articulated by the MIT Technology and Policy Program (TPP) for technology policy projects.

The public sector must develop PPP policies taking into consideration not only financial constraints, but also the different interests and needs of both public and private actors, the political environment, the market dynamics, and the uncertainty that surrounds long-term projects. It must and be careful to avoid entering into PPP arrangements whose implications are misunderstood, thus undermining the benefit of the use of these financial schemes.

On the basis of this methodology, a multidisciplinary assessment is developed, considering the political, economical, commercial and social dimensions of this technological project; so that a comprehensive assessment is performed.

1.4. Thesis Roadmap

Chapter 2 provides an introduction to the satellite navigation topic, introducing the Galileo project from a technical, market, programmatic, and political point of view. Next, Chapter 3 describes the policy-making process, as articulated by the MIT Technology and Policy Program (TPP), under which the policies of Galileo will be assessed. Besides, the Galileo program has multiple objectives that result in a wide range of stakeholders' expectations. Chapter 4 introduces the public and private actors that are involved in the project, their role, aims and interests. Chapter 5 introduces the concept of "Public Private Partnerships" as generic kind of financial agreement between public and private sector that incorporate private financing to procure and maintain large public infrastructure projects.

The following chapters attempt to analyze the evolution of the Galileo Program, since its early times to its current status, according to the policy-making methodology previously introduced in Chapter 3. We analyze the policy-making processes concerning these four main periods: Chapter 6 is about the policy-making process of the European Union in the 1990s that analyzed the European role on satellite navigation and formulated the strategy to "do" Galileo. Chapter 7 is about the policy-making process aimed for deciding "how" the Galileo Program should be developed and implemented, that came up with a strategy in 2001. Chapter 8 tackles the procurement process for the development, deployment and operation phases, according to the original plans. However, the strategy defined in 2001 was proved to be unfeasible in 2007, when the Concession negotiations failed. The program entered in crisis. Europe needed to redesign its strategy for Galileo. This new loop in the policy-making process is tackled in Chapter 9, which addresses the new analysis performed according to the new conditions and the evaluation of different options to redirect (including to abort) the project. The new strategy defined the way in which the fully deployment phase was going to be implemented, and postponed the decision on how to operate it for the future. This later is addressed in Chapter 10, together with a set of recommendations to undertake the future challenges.

For the purpose of this thesis, the author will go along the tendency of politicians and media to use "Europe" as shorthand for the European Union member states as a whole. Besides, one important remark the author emphasizes is that this policy analysis of the European/Galileo strategies was mainly done "in retrospect", as is commonly the case with strategic choices in general.

PART A

Chapter 2

Introduction to satellite navigation

A true understanding of the intricacies of a particular infrastructure projects from a technical, political and programmatic point of view is a prerequisite for the analysis of the best policies under consideration. This chapter introduces the technology, applications, market and international context of satellite navigation, followed by an introduction to the Galileo project, as the pivot of the European satellite navigation program.

2.1. Satellite navigation technology and its applications

"Since time immemorial, people have looked to the heavens to find their way. Today, satellite navigation is continuing this tradition, while offering, thanks to leading-edge technology, an accuracy far beyond that possible from simply observing the sun and the stars" (© European Communities, 2003.)

This section covers an introduction to the fundamentals of this technology, its applications and a review of the current worldwide context of satellite navigation systems and related markets, in which the Galileo project is framed.

Satellite navigation enables anyone with a receiver capable of picking up signals emitted by a constellation of satellites to instantly determine its position in time and space very accurately. This technology is possible thanks of the operation of a complex space and ground infrastructure.

Global Navigation Satellite System (GNSS) is the standard term for satellite navigation systems, like GPS or Galileo, which provide autonomous services with global coverage. Most recently, the generic acronym "GNSS" is being used to encompass all satellite navigation systems, at global or regional level, and the so-called Satellite-Based Augmentation Systems (SBAS), that augment the performance obtained from the global systems when used as a complement, allowing the use of satellite navigation for critical safety-of-life applications such as aviation.

Furthermore, satellite navigation technology can be hybridized with other positioning technologies that increment the combined use performance, such as inertial navigation systems or cell telephony, which in addition enable a broad range of services above and beyond timing and positioning provision.

Satellite navigation applications

Looking beyond the transport sector, where it will enhance safety, efficiency and comfort, satellite navigation's advanced technological features and its commercially oriented services makes this technology a valuable tool for nearly all economic sectors. Integration with other technologies such as mobile communication or traditional navigation aids furthers increases its potential.

Useful applications benefit both industrialized countries and the developing world. These include social services to disabled or elderly people, tailored information to people on the move, improved management of all modes of transport, infrastructure and public works management, agricultural and livestock management and tracking, coordination of external staff and even e-banking and e-commerce authentication.

But the value of satellite navigation is not limited to the economy and companies. Satellite navigation can also be a key asset for the provision of public services (rescue operations, crisis management, law enforcement and border control). It can also be used to help guide the blind and people suffering from reduced mobility, monitor children or Alzheimer's sufferers with memory loss, help protect the environment, generalize precision agriculture, guide and rescue explorers, hikers, fishermen or sailing enthusiasts, and provide real-time information on local public transport.

2.2. A world of Satellite Navigation

Both local and global GNSS systems are developing fast across the world and improving their performance, leading to the growth of an entire downstream industry. In a near future, there will be at least four global systems (U.S., Europe, China and Russia), and at least a dozen of regional systems worldwide.

Current and planned satellite navigation systems are increasing the number of constellations available for users worldwide; complemented by several SBAS at regional level. As of 2009, GPS is the only satellite navigation system fully operational at a global level, but this situation is certainly changing in the short term, as soon as more satellite navigation systems become operational; the Russian global satellite system, GLONASS[2], is in process of being restored to full operation, and Europe's global satellite system, Galileo, it to be operational in 2013. At regional level, the U.S. has developed its regional SBAS, the Wide Area Augmentation System (WAAS), Russia has its Wide-area System of Differential Corrections and Monitoring (SDCM), Europe has its "European Geostationary Navigation Overlay Service" (EGNOS), and the People's Republic of China has Beidou, to be expanded into the Chinese global navigation system Compass by 2015. India contributes to the GNSS world with GAGAN and IRNSS, SBAS and Regional satellite navigation systems respectively, as does Japan with the Quasi-Zenith Satellite System and MSAS MTSAT.

Several working groups are gathering efforts towards the compatibility and interoperability[3] of these systems, which are in constant evolution, so that they do not interfere with one to each other and can be used independently or combined. In the future, it is expected that most users will benefit from a combined use of all GNSS available at the same time and get better capabilities at the receiver level than would be achieved by relying solely on one system only. This means that most users will probably have combined GPS/Galileo/… receivers, which will be able to use the basic signals of satellites from all available constellations, increasing drastically the performance in terms of accuracy[4], availability and robustness. In other words, the receivers will be able to combine the signals from the satellites of all systems and compute better results in comparison with the use of just one system. Beyond better performance, interoperability also provides benefits in terms of receiver cost; the marginal costs of incorporating both/all systems into a chip would be negligible in comparison with the added benefits. Regarding the marketplace, integrated receivers are expected to become the "*de facto*" GNSS standards for user equipment.

In the early years of Galileo, Europe found the strong opposition of the U.S. Government, who were concerned about Galileo as direct competitor of GPS and a major threat to GPS, especially in terms of security. However, in 2004, U.S. Secretary of State signed a deal with E.U. Transport Commissioner that paved the way for future co-operation over satellite navigation between both sides of the Atlantic. The Galileo case is not about competition with GPS, but about competition within GNSS; Galileo is the European's bid to have a GNSS of one's own.

2.3. GNSS market

The market associated to satellite navigation will become a substantial driver in the global economy in the very next future, which makes the completion of Galileo an indispensable infrastructure investment for the EU. The current market size is estimated to be in the range of €140 billion annual, from which around €60 billion belong to the European market for GNSS services, in terms of revenues generated from sales of GNSS-enabled devices. The expected compound annual growth rate was expected to be around 24% in the period 2009-2013, and to accelerate as new satellite systems with superior performance become operational. Several studies predicted a €450 billion annual GNSS product and services downstream market worldwide by 2025 from 3.1 billion receivers [ESSYS Consulting, 2006], from which Galileo is expected to capture its market share.

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2 GLObal'naya NAvigatsionnaya Sputnikovaya Sistem.

3 Interoperability refers to the ability of global and regional satellite navigation systems and augmentations to be used together to provide better capabilities at the user level than would be achieved by relying solely on the one system.

4 The degree of conformance of an estimated or measured position at a given time, to the *truth*.

The personal navigation market has become a mass market since 2005 thanks to the exponential growth of Personal Navigation Devices (PNDs) sales[5], including the integration of navigation and cell phones. The number of subscribers to handset-hosted location based services (LBS) increased in 2008 to more than 18 million [ESSYS Consulting, 2006.] PND mass market is followed by mass market for vehicles and commercial services.

2.4. The European Global Satellite Navigation System, Galileo

"Measure what is measurable, and make measurable what is not so" - Galileo Galilei

The contribution of Europe to the GNSS began late in 1994, when the European Commission first proposed the creation of a European GNSS under civil control, to be developed together with the European Space Agency (ESA). This was designed in a two-step approach, as follows:

- GNSS-1, a Satellite-Based Augmentation System (SBAS), EGNOS[6], which was designed to complement at regional level the existing American and Russian satellite navigation systems (GPS and GLONASS, respectively), leading to,
- GNSS-2, the creation of its own independent system, Galileo, to provide a highly accurate and guaranteed global positioning service under European civilian control, independent but still interoperable and compatible with GPS and GLONASS.

Both systems constitute the European GNSS Program. Most probably the Galileo system, when operational, will be integrated with EGNOS. Both systems are framed in a common EU budget, though their policy-making, even if complementary, is separate. For the purpose of this thesis, we will focus on the policy-making process of the Galileo project, although at every stage of the process the parallel evolution of EGNOS was present. In the latest stages of the process, one of the main decision points concerns the integration of both systems.

Galileo and EGNOS (Europe's first venture into satellite navigation) are regarded as a key investment that will lead Europe to emerge in the satellite navigation area and retain a large share of this market, breaking the current monopoly mainly held by the American GPS. Galileo has become a pillar of the European Space Policy and signifies Europe's ambitions in space, technology, and innovation. Technically speaking, at its conception, Galileo promised real-time positioning down to less than one meter, compared to the five

[5] The market of chip industry met a significant growth (~ + 45% /year) to reach a turnover of €200M in 2005. Besides, the personal navigation equipment and software market met a significant growth of +45 % in 2004 and + 58% in 2005, 6 millions equipments were sold in Europe in 2005 (versus 700,000 in 2003).

[6] EGNOS broadcasts signals to the European region sending complementary correction data of the GPS and GLONASS signals so that its accuracy is improved from about 20m to better than 5m. EGNOS messages also include warning messages in case of failure or low performance of those systems, which is especially useful for aviation applications. EGNOS is comparable to similar systems that are being developed in the USA (WAAS), Japan (MSAS) and India (GAGAN) for their corresponding regions.

to ten meters of accuracy offered by the GPS service publicly available. In contrast to GPS, which depends on the U.S. Department of Defense, Galileo will be controlled and administered by civilian authorities, and will offer a guarantee[7] of quality and continuity of the service under all but most extreme circumstances. In a nutshell, Galileo guarantees that in case of a degradation of the signal or system failure, the users will receive an alert message in less than six seconds. This feature, called "integrity[8]" is critical for many applications in which human life is involved, as with air or rail traffic control, and was one of the initial main expectations of Galileo with respect to GPS.

2.4.1. Galileo services

With a range of five different services (Open Service, Safety of Life Service, Search and Rescue, Commercial Service and Public Regulated Service), Galileo will meet the needs of all potential different users worldwide, as follows:

- The "Open Service" (OS) is a global free of charge open-access service, which provides simple timing and positioning down to one meter and targets mass-market users. These basic Galileo navigation signals will operate on two frequency bands that will provide significantly higher accuracy. It is expected to match the performances of GPS III and be used in a combined mode with the GPS open service, leading to an improved availability and accuracy.
- The "Safety of Life" (SoL) service provides a high quality and integrity ("error warning") signal based on a multiple frequency capability, which overcomes the degradation of the transmission caused by the ionosphere. The signal is authenticated and the service is guaranteed. It targets users of the professional transport market in which human life is involved, such as aviation, railways and maritime operators.
- The "Commercial Service" (CS) provides a high accuracy at the centimeter scale. It is a guaranteed service for which service providers will charge fees and it is provided by means of an encrypted signal.
- The "Public Regulated Service" (PRS) provides two-wideband encrypted signals that will be used exclusively by authorized governmental agencies. It will require very stringent access control mechanisms and will be available even in time of crisis. The main objective of the PRS is to ensure – in times of crisis, when the open service is jammed – the continuity of service to specific types of users (police, ambulances, firefighters, other emergency services, civil security and, potentially, military), whose reliance on GNSS is considered critical. It is as accurate as the Open Service, albeit has far higher robustness and provides integrity. The PRS signal is required to be

[7] Legally speaking, this guarantee can even be laid down in a contract and implies that Europe assumes some liability in case a system failure occurs and is not notified within that time, and this incurs in an accident of, for instance, a plane that crashes.
[8] Integrity is the ability to determine whether the system is providing reliable navigation information.

operational at all times, including times where other signals may be jammed. The signal is also separated from other Galileo signals so they can be jammed deliberately without affecting PRS, which will also have a more robust signal. States that wish to use the PRS will need to pay for access to the signal. The PRS will be available only to authorized Government-sponsored users who can be trusted with its special encryption codes and receivers.

- Finally, a “Search and Rescue” (SAR) service allows the provision of near real-time aid to people who are in distress or imminent danger, and is Europe’s major contribution to the Cospar-Sarsat MEOSAT program, which offers this service for free. Galileo satellites will be able to pick up distress beacon locations and, in addition to the current Cospar-Sarsat service, to send feedback to the users, confirming help is on its way via the so-called SAR/Galileo Return Link Service.

2.4.2. Galileo as a public infrastructure

A public infrastructure is defined as facilities that are not ends in themselves, but necessary for the functioning of the economy and society [Yescombe, 2007.] They can be divided into:

- “Economic” infrastructure: those supporting a nation’s economic activity, such as transportation facilities and utility networks.
- “Social” infrastructure: those supporting a nation’s structure of society, such as schools, hospitals and libraries.
- “Hard” and “soft” infrastructures, depending on whether they primarily involve the provision of buildings or other physical facilities, or of services.

Galileo is a complex public infrastructure that is classified as both economic and social, both hard and soft. As a public infrastructure, it is not an end in itself, but a means of supporting Europe’s economic and social activity, providing general economic and social benefits. Besides, it involves the provision of space and ground infrastructure designed to provide a range of services.

Beyond the technical aspects, Galileo is considered a strategic program that is crucial for Europe in political, economical, social and strategic terms, as depicted in Figure 1.

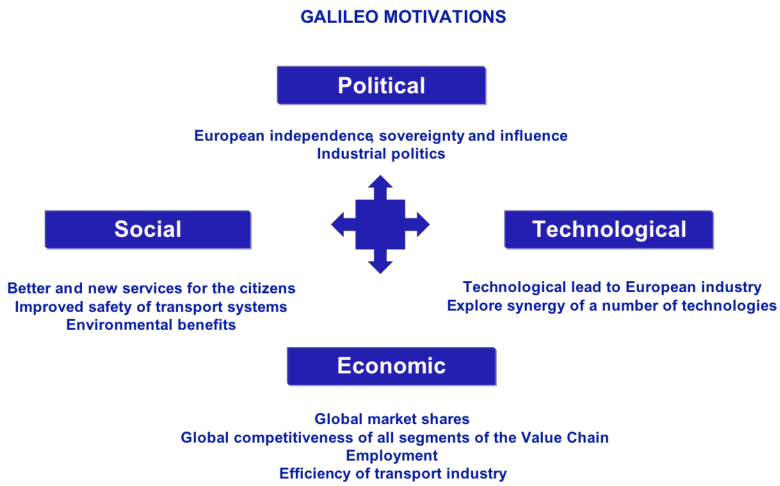

Figure 1: Galileo's unique nature and motivations

The European Parliament, the Council and the European Economic and Social Committee have consistently supported Galileo, indicating that Europe's engagement in Galileo is critical to taking a worldwide leading role in this technology. Europe needs Galileo for its independence, sovereignty and influence; it is critical for Europe that its air, rail and maritime traffic systems do not dependent on a navigation system controlled by someone else, neither its financial transactions nor communications systems. Therefore, it is needed for the European safety, economy and industrial politics.

Galileo represents the technological independence of Europe. It helps increase the technical competency of Europe in the satellite navigation market, and get a share of this market currently mainly captured by GPS.

Chapter 3

The Policy-Making Process

3.1. Perspective overview

Public policy issues typically are complex, involve conflicts of interests among different actors and occur in changing environments that are characterized by uncertainty. Furthermore, the rational development and successful implementation of major technological projects is a highly complex task that requires the utmost of our capabilities in engineering on the one hand, and in management and policy on the other [de Neufville, 2003a.]

The efficient development, deployment and operation of a satellite navigation system, such as Galileo, requires a mastery of high-tech engineering, of the pricing and marketing of the GNSS services and of the regulatory process in which the system must operate internationally. Likewise, the commercialization of new products, such as GNSS receivers, requires the ability to design and manufacture these devices, according to the specific desires of the customers. In short, the definition of technology policy requires the integration of engineering and of the applied social sciences [de Neufville, 2003a.]

Policy-making goes beyond making formal decisions or proposals. It entails the gathering and interchange of information, the elaboration of different options and their expected consequences, and experiential learning [Koundouraki, 2007.] In larger and complex endeavors such as the Galileo project, policy-makers act in an extremely information-rich environment, however, the amount of information that can be handled by a decision-maker in every stage is limited by the mind's cognitive and computational capabilities, and the information that is finally used has passed along a bottleneck of attention. This means that policy-makers base their choices on simplified models of the issue and only some facets of a complex matter are considered before a decision is made [Egeberg, 2002.]

3.2. Introduction to MIT TPP Policy-making process.

There are three stages to the Policy Making Process, as articulated by the MIT Technology and Policy Program (PPP). These concern its three stages: issue analysis, policy formulation and policy implementation, as depicted in Figure 2. The process begins with an issue analysis, where the problem is defined, the policies and methods of analysis are examined, and the stakeholders and politics are considered.

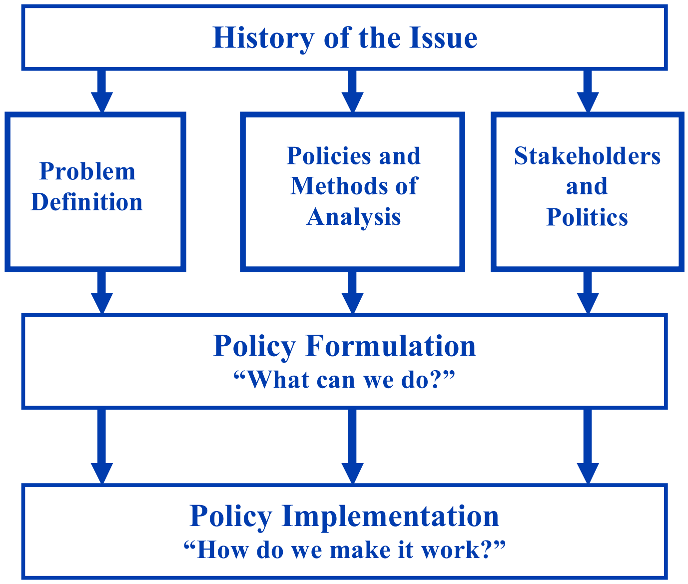

Figure 2: Overview of the Policy Making Process

Before any decision is taken, a careful analysis is required, in which the background, policy alternatives, means and cast of characters are assessed as a whole.

- During the problem definition stage, the issue is identified, historical context is considered (specifically why and how the issue arose) and its current condition of the issue is examined. From this analysis, a definition of needed change arises, which details the necessary actions to be taken to address the issue.
- This definition of needed change is the first component of the policy formulation; however, more analysis needs to be done. In addition to defining the problem, issue analysis also involves looking at the policy options and instruments, which includes defining the analyst's frame (i.e. the perspective by which the issue is seen), specifying the various analytic methods available, and identifying the alternatives. The procedures for evaluating efficiently for the different alternatives must consider the vast number of possible different results for each of them (given the inherent uncertainty of markets and competition). In other words, it must recognize the risks and uncertainties associated with each possible choice in the design, management and operation of the system. This dynamic approach is particularly valuable in large-scale infrastructure projects operating under uncertainty over a long timeframe [de Neufville, 2003a.]
- This analysis of the policy options and instruments generates the definition of options and means. This is a list of the various means by which the policy can be realized; including technical, administrative, legislative, political and financial means. A complete analysis takes enormous effort. It is intended to elucidate the risk, uncertainty, and the relative advantages and

disadvantages of the alternatives being considered; show the sensitivity of each alternative to possible changes in key assumptions; and aid decision-makers in judging whether or not any of the proposed alternatives offer sufficient benefits to be worth the costs. Effective decision-making requires the combination of different policy instruments (various forms of legislation, programs, guidelines, use of structural funding, etc.)

- Considering the range of possible options, associated with their corresponding many different results, in several stages of the project, involve a huge number of possibilities [de Neufville, 2003a.]
- Finally, the issue analysis includes specifying the cast of characters involved in the policy-making process. This includes careful thinking about which stakeholders are affected directly (or indirectly) by the issue, and what are their interest ands views over the issue. Consequently, we identify the decision makers who have the power to create or alter policy, along with their opportunities and limitations, and the influence brokers who can sway the decision makers one way or another. From the analysis of the cast of characters, the relevant players in the policy-making process are defined in the definition of constituency, which is another important component of the policy formulation.

Then, by considering the formulations of needed change, operations and means, and constituency, the definition of a strategy can be addressed. At this point of the decision-making process the impediments to the realization of the policy should be identified and evaluated in order to come up with a broad definition of strategy in which prudent objectives are set and an initial plan for realizing the policy is specified.

Once this broad strategy is developed, having taken into account the impediments that may arise, a more detailed tactical plan is developed, which specifically details the steps that need to be taken in order to meet the strategic objectives.

With a tactical plan, the policy-making process enters the final implementation stage. The first step of implementation is negotiations, where positions acceptable to the different actors involved in the process are argued. Then, from the negotiations, changes in both legislation (laws) and regulation (rules) need to be written. Of course, these regulations and legislations must be enforced to be effective, which is the final step in policy implementation stage and the TPP Policy-Making Process as a whole.

Figure 3 depicts the Policy Making Process along its different stages more in detail.

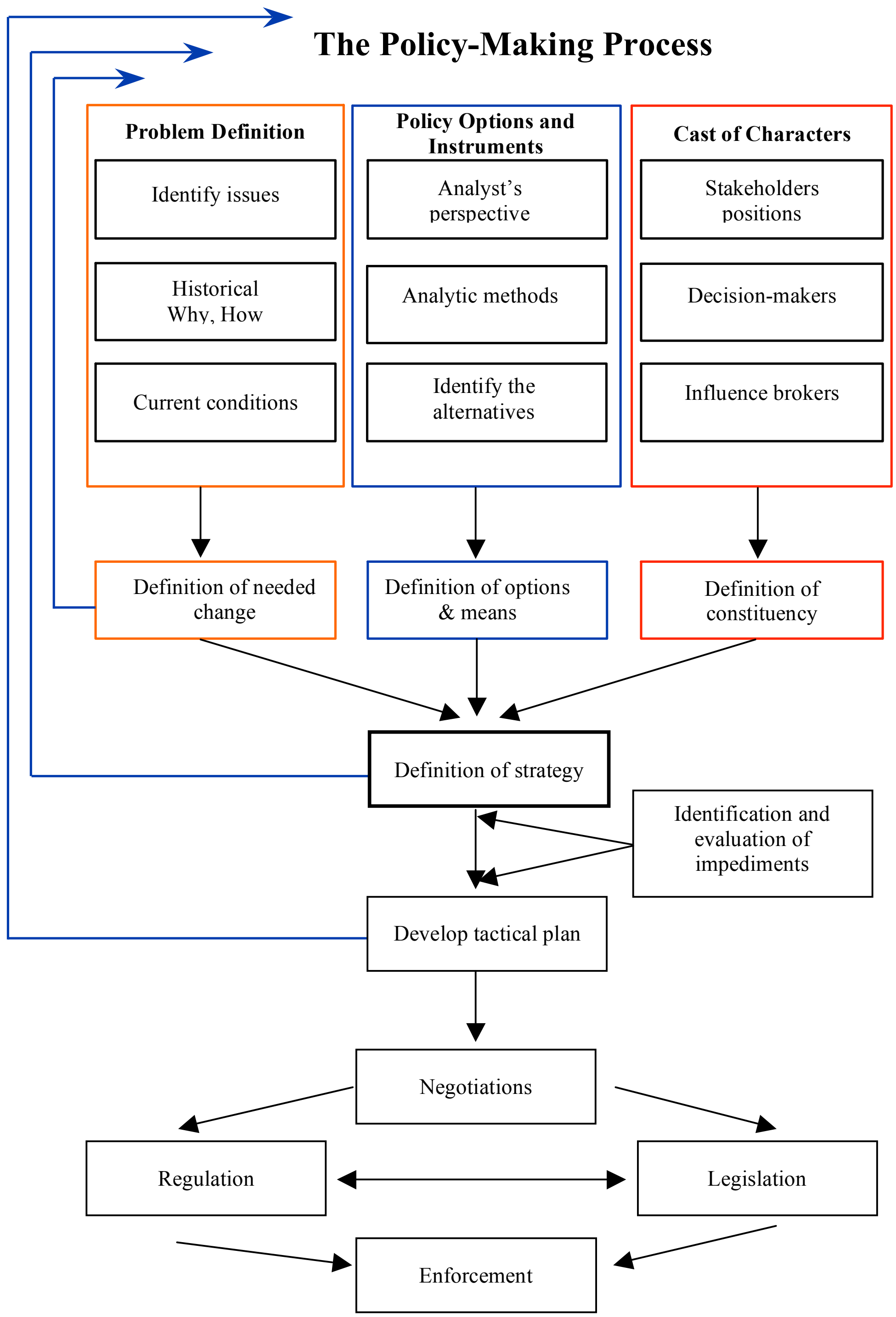

Figure 3: Detailed diagram of the Policy Making Process

3.3. The need of flexibility in the decision-making process

Although the TPP Policy Making Process was described above in a linear manner, the actual process itself is often iterative and may involve several feedback or adaptive loops. For instance, at any point in the policy formulation, such as during the definition of needed change or the definition of strategy, new insights may arise which may require a re-analysis of the problem definition, policy options and instruments, or the cast of characters. Hence, this may lead to new definitions, which will lead to new insights, and so on.

Also, in the policy implementation stage, regulation and legislation occur after negotiations have taken place, but legislation may follow regulation, or regulation may follow legislation or the two may occur concurrently. Finally, the regulations or legislations themselves may create new problems or issues that require further analysis, which then may require new policy formulation, which ergo requires new policy implementation, closing the iterative loop process.

Long-term projects might be jeopardized by the inertia of the public institutions, which might be reluctant to adopt changes in a quick manner, and may do nothing and let the process go forward on its own momentum, without supervising and revising the policy making process.

A good policy-making process will allow revising, rethinking and reevaluating the strategic views over time, in a way that quickly overcomes obstacles and adapts to the new circumstances. This is particularly valuable in case of long-term projects, for which long-term strategic views are difficult to foresee.

Flexibility in the decision-making process allows the policy-makers to defer certain decisions to a later stage when they can be better addressed [de Neufville, 2003a.] Consequently, flexibility helps handle uncertainty and reduces overall risks.

Doing dynamic policy-making is comparable to playing chess [de Neufville, 2003a]: the policy maker evaluates many moves ahead, but only commits to one at a time, preserving the flexibility to adapt to the game plan according to the events as they occur.

Decision analysis must come up with and optimal strategy given an uncertain future, rather than a fixed plan. Technology ventures are complex socio-technical systems offering many sources of flexibility, in technology, product, operations and organization design [Mikati, 2009.] The analysis over two or more stages acknowledges the value of flexibility, which –together with the options to defer- have become essential tools to handle and exploit the value of uncertainty [Pettit and Stewart, 1999.]

Chapter 4

Stakeholders description

The crux of the policy model concerns how to create a sustainable coalition of stakeholders to define and implement a policy. This means that it is really important to identify them and define their motivations and concerns. The decision-making process for the Galileo program should be addressed in the context of the European political and industrial framework, and as a part of the international Global Navigation Satellite Systems (GNSS) scope. This includes an insight into the public and private actors involved in this project at a high level, its respective objectives, capabilities and interests, and the relative position of Galileo within the world of satellite navigation.

4.1. Institutional Framework (public sector)

The public sector involved in the Galileo project is mainly composed by the EU, ESA and the Member States, among other public authorities related to this project at national and international level.

4.1.1. The European Union

The three main institutions involved in the European Union policy-making process are the European Commission, the European Council and the European Parliament. This section also provides a review of the EU policy-making structures and procedures[9], covering how the policy-making process works in the EU and introducing the different legal instruments that are used to take decisions.

The European Commission

The "Commission" is the executive organ of the Community, representing the general European interest. It is composed by and administrative body and a team of Commissioners – politicians – who lead it. It currently consists of 27 Commissioners, one from each Member State, supported by an administrative body of European civil servants divided into departments called Directorates General (DGs).

The EC has four main roles: propose regulation, administer and implement Community policies, enforce Community law, and negotiate international agreements. More in detail, the Commission;

- Has the exclusive power to initiate a proposal, though once it has initiated a proposal the Council and the European Parliament have the opportunity to amend the proposal and change it.

[9] A detailed description of the EU decision-making process can be found in the European Commission website. A simplified version is presented here, as for the purpose of this thesis.

- Is in charge of the implementation of the policies decided by the legislature (composed by the European Parliament and the European Council) and ensures the implementation of the legislation by the Member States.

- Acts of "guardian of the treaties" which provides the legal basis for the EU.

<u>The Council of the European Union</u>

The Council of Ministers (as it is informally referred to) forms, along with the European Parliament, the legislative arm of the EU. The Council is the most powerful of the Community's organs; it is made up of ministers of the governments of the Member States, and its position gathers their respective own interests. It is the institution in which the particular interests of each Member State are brought to bear. Each member state holds the Presidency of the council for six months on a rotational basis.

<u>The Parliament</u>

The parliamentary body of the EU is directly elected by European citizens once every five years. It comprises, together with the Council, the legislative branch of the European Union. Its influence on legislation varies according to the decision-making procedure used. It cannot initiate legislation, but can veto or amend the proposals received by the Commission. It also has the right to control the EU budget.

European Union annual budgets are established within a seven-year financial framework settlement, namely the 'Financial Perspective'[10], that is agreed jointly by the European Parliament and the Member States, which must come into terms by unanimity. The Galileo program is part of the budget heading 'Competitiveness, Growth and Employment', which has a high priority in the EU's current objectives, corresponding to the so-called 'Lisbon priorities'.

The Parliament cannot initiate legislation, but since the Treaty of Maastrich[11] (implemented in 1993) can veto or amend decisions in many policy areas. It has a negative voice in the policy-making process but it cannot on its own pass a decision without the assent of the Council of Ministers.

<u>The legislative process (EU Policy-making process)</u>

The EU Policy Process has four stages:

- **Initial consultation: Demands for policy are made and articulated.**

  The process originates when the European institutions decide whether EU action is required in a particular area. Like national executives the Commission is expected to initiate and formulate

[10] For each programming period, the "financial perspective" determines budgetary "ceilings" per "heading" (categories of expenditure) for each year.

policies, e.g. in the form of legislative, budgetary and program proposals. These policy documents are prepared for the legislative bodies (the Parliament and the Council).

Before producing a proposal, the Commission may launch an "open consultation" and call on relevant interested bodies. Sometimes the Commission generates Green Papers (intended to motivate discussions, brainstorm ideas and options) and White Papers (providing a tangible policy proposal in an particular field) as a part of the policy-making process. In practice, policy initiatives often originate from outside the Commission itself – other actors like the Council, the Parliament, member governments or interest groups may advance policy proposals. In other words, policy demands can come from other stakeholders; within the institutions of the EU themselves, non-governmental (lobbying groups of any sort, NGOs, business lobbies, industrial groups, etc). Besides, the Member States could also advocate for specific policy goals via the EU. However, the Commission decides whether such contributions will be addressed and subsequently sent to the legislature.

- **Drafting the proposal: Translation of demands into policy proposals.**

  Draft proposals are generated by officials in the relevant Commission DGs. Therefore, they must be approved by the lead Commissioner, and then by all the Commissioners (who meet on a weekly basis). Hence, Commission proposals are published as COM[12] documents.

- **Policy proposals must be agreed to by the appropriate elements of the government.**

  The Commission's proposals are sent to the Council, which refers them to the Parliament for its opinion. A committee will be appointed as lead committee. A draft resolution is produced in which the Parliament approves, rejects or proposes amendments to the proposal. The final report is put before the entire Parliament for a vote. The amended proposal and Parliament's opinion at this first reading are sent back to the Council. A working group in the Council will then examine the Commission proposal and Parliament opinion. These working groups gather national officials and experts, undertaking the technical groundwork needed before a decision is taken. They may or may not incorporate any changes that have been made. The Council communicates its common position back to the Parliament for review.

  Since the Treaty of the European Union (also known as the Treaty of Maastricht, signed in December 1991 and implemented in 1993) they are "co-legislators" under the "co-decision" procedure. The "co-decision" procedure is based on the principle of parity, which means that

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[11] The major Treaties and Treaty Reforms of the EU are (year implemented): The Maastricht Treaty (creates the EU, 1993), the Amsterdam Treaty (1999), the Nice Treaty (2002) and the Lisbon Treaty (2010).

[12] European Commission documents are referenced as: COM(year) ID number.

neither institution (European Parliament or Council) may adopt legislation without the other's assent. Nothing can pass unless both agree. This procedure is the main legislative process in the EU and the one that gives the Parliament the most influence, since it can veto or amend proposals. This process can take months. According to the Treaty of Amsterdam (implemented in 1999), the “co-decision” procedure applies to a range of the policy areas[13] relevant to the Galileo Program; Transport (Article 71), Trans-European networks (Article 156), Framework Program for research and technological development (Article 166) and Research (Article 172).

Decisions at the Council are taken by simple majority, qualified majority or unanimity. Most co-decision legislation requires the Council to take decisions by qualified majority voting (QMV). Those taken at the Parliament must reach an absolute majority of its members.

- **Implementation: Policy Proposals must be implemented by the Commission**

  The Commission is in charge of implementation, which is the longest and most arduous part of the policy-making process. This is especially true in the EU because of its federal character.

In conclusion, even though only the Commission has the power to initiate a proposal, the impetus or demonstration of the need for policy can come from almost anywhere in the EU. Still, the Council and the Parliament have the power to change the EC proposals. Both the Council and the Parliament, under a co-decision procedure, adopt any policy proposal. They both have the joint responsibility to adopt the Community budget. Nevertheless, the Commission is in charge of implementation, which is done through secondary implementing legislation. The EC also negotiates international agreements on behalf of the Community, though the Council can only conclude these. Unlike in a nation state, where the Parliament is responsible for enacting legislation, the Council performs the legislative role.

As described in the following chapters, the European Union, through its institutions has repeatedly re-affirmed the value of Galileo as a key project of the European Union. In 1988, the Commission’s first communication on space first established the principle of EU involvement in Europe’s space endeavor to this respect.

Whereas the earlier phases of Europe’s involvement in space activities was mainly led by the space agencies whose main objective was to contribute to the technological and industrial capability (“technology-push” approach), the EU is moving progressively towards a “demand-pull” *modus operandi* in order to integrate space activities into the broader socio-economic sphere. In other words, the interest of

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[13] A list of areas to which the co-decision procedure applies can be obtained at the Scottish Parliament Guide to EU Policy Making Processes, July 2002.

the EU is to orient space programs according to the implementation of community objectives [COM(92) 360.]

It is within the Communities' powers and interests to help establish the appropriate conditions for the development of space application markets and a competitive European space industry. Because of its competencies in a number of pertinent policy areas, it represents a critical actor in this policy-making process. Europe needs space activities for the implementation of Community policies in key areas. Besides, it will become an important customer of the space-derived services, which furthermore reinforces the "demand-pull" approach.

4.1.2. The European Space Agency

The European Space Agency (ESA) is an intergovernmental organization established in 1975 with the purpose to "*provide for and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space application systems*"[14].

ESA's Council of Ministers serves as its government body, and gathers representatives of the national bodies responsible for space in its Member States. Even if ESA and the EU share a common aim and have a cooperation relationship, ESA is independent from the European Union. Consequently, it is not bound by EU regulations and is governed by different rules and procedures. Indeed ESA and EC have different Member States. Even if most of ESA Member States also belong to the EU, there are some ESA Member States, such as Canada, Switzerland or Norway, which do not belong to the EU. The other way around, there are some EU Member States that do not belong to the ESA. Some ESA Member States joined after the Galileo Program was launched: Portugal became an ESA Member in 2000, Greece and Luxembourg in 2005, and the Czech Republic late in 2008.

ESA's Industrial Policy sets rules relating to the geographical distribution or contracts (commonly referred as the principle of "fair return" or "*juste retour*".) With this respect, the ratio between the share of a country in the weighted value of contracts, and its share in the contribution paid to the Agency, must be of X per cent (e.g 0,98%) by the end of a given period[15]. That ratio is called the industrial return coefficient. This constraint limits in practice a free competitive bidding. Typically a country will receive at least 90% of the share it paid for a program (after ESA's operations costs are subtracted) in industrial contracts to perform the required work. The European Space Agency has "mandatory" and "optional" programs. Mandatory

[14] Article II, Purpose, Convention of establishment of a European Space Agency and ESA Council, Ref. CSE/CS(73)19, rev. 7, 1975.
[15] ESA Council at Ministerial level in March 1997.

programs must be funded by member nations according to a percentage of GNP; optional programs need participation by two or more countries on a voluntary basis to get started.

The European Space Agency, through its Navigation Department, has been one of the main and first advocators of Europe's involvement in satellite navigation, under the framework of the ARTES-8 and ARTES-9 optional programs. Together with the EC and Eurocontrol, ESA is part of the European Tripartite Group (ETG) that is developing EGNOS and performing the studies aimed at the development of a full civil system (GNSS-2). Even if Galileo "dual-use" for both civil and military purposes could be explored, no military purposes could be expressed because ESA is inhibited from engaging in military activities. ESA Member States decide at the PB-NAV (Programe Board on Satellite Navigation) their strategy concering the Galileo program.

4.1.3. Member States

Member States have a disparity of interests and high powers in the EU decision-making process, by means of the seat they have in the Council and the Parliament. They defend their industries, mostly ahead the general Community interest. Concerning the Galileo program, they have different levels of commitment. As detailed in the following chapters, France was highly supportive since the early beginning of the project, whereas UK would most probably have not joined a project with a security dimension not welcomed by the US Pentagon. Figure 4 shows ESA and UE Member States, identifying which ones both institutions have in common.

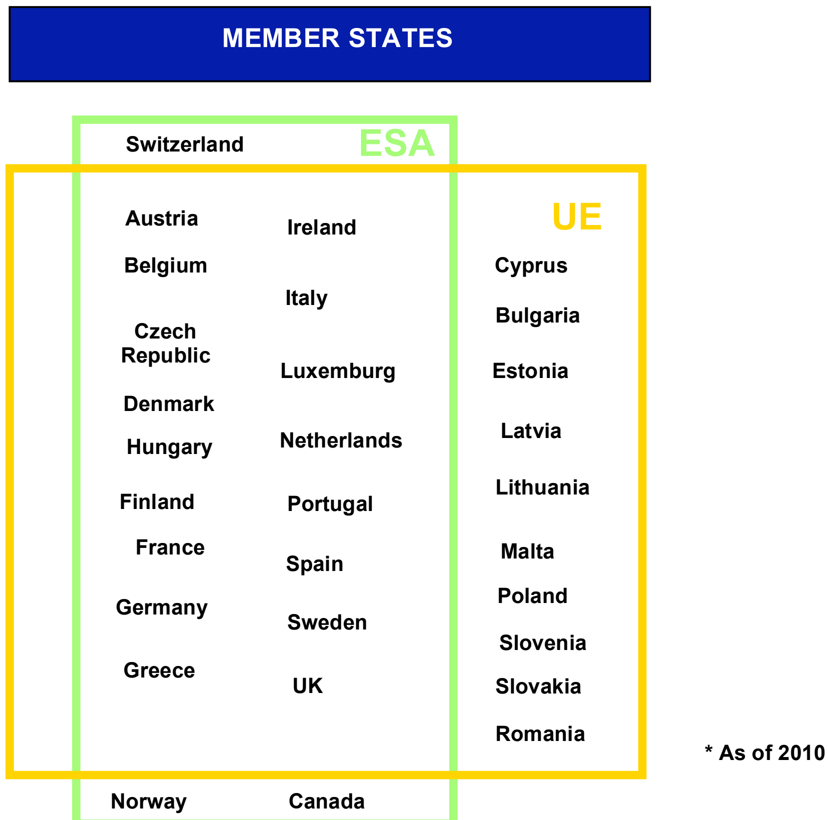

Figure 4: Detailed diagram of the Policy Making Process

4.1.4. Regulatory international agencies

The International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), both United Nations specialized agencies, are the main international organizations that fix the "standards and recommended practices" (SARPs) for aviation and maritime transport, two of the main applications of satellite navigation. The SARPs become mandatory when transferred to the corresponding national organizations of their Member States.

Besides, the International Telecommunication Union (ITU) establishes multilateral regulations and procedures applicable to the operation of global radio-navigation systems, as well as to other radio communication systems. Decisions on frequency allocation for the signal broadcast by the satellites are taken at global level at the World Radiocommunication Conferences (WRC), under the auspices of the International Telecommunication Union (ITU).

The position of IMO and ICAO with respect to GNSS.

Minimum operating standards and recommendations have already been tackled concerning GNSS as means of navigation in ICAO and IMO. ICAO has recognized the benefits of satellite navigation and is considering the introduction of GNSS for its CNS/ATM[16] concept as sole means of navigation for certain operations ("*en route*", approach and landing phases of flight), in place of ground-based navigation infrastructure. A worldwide evolution to GNSS-based air navigation represents a significant saving in terms of installation, maintenance and operation costs of ground-based navigation equipment.

An agreement between ICAO and the US and Russia over this matter dates since 1991. An ICAO GNSS Panel was established in 1993 to develop SARPs for the aeronautical applications of GNSS. In 1994 and 1996 respectively, US and Russia offered to provide the services of their GNSS free of direct user fees and on a continuous worldwide basis (with at least 6 and 15 years notice prior to termination respectively). In 1994 a statement of ICAO policy considered the feasibility of an evolutionary progression of existing GNSS towards an international civil GNSS that meets the civil aviation safety requirements, and over which its Member States have a sufficient level of control.

In 1998 two resolutions on the "Rights and Obligations of States Relating to GNSS Services" and the "Development and elaboration of an appropriate long-term legal framework to govern the implementation of GNSS" were published. GNSS SARPs were finished in 1999 (to be applicable in 2001 and enhanced from then on).

ICAO acknowledged the advantages of having two redundant GNSS (GPS and GLONASS) and would welcome the concept of Galileo as a third base system. The other way around, Galileo enables Europe to fully participate in the definition of international standards concerning civil aviation.

Comparably, IMO has expressed the need to use at least two different and independent positioning systems for safety purposes. GPS and GLONASS were recognized as appropriate systems in 1996, though their lack of integrity warning of system malfunctions was remarked.

4.2. Industrial Framework (private sector)

Since 1990, the civil sector has become progressively more important to the EU aerospace industry revenue than military aerospace, therefore these companies are less dependent on government contracts than 15-20 years ago [Lungu, 2004.]

GNSS is a significant opportunity for the EU space and high technology industries. The private sector supports an independent European GNSS and regards Galileo as providing equity with the US in global competition in the GNSS market.

GNSS means a new infrastructure with upstream and downstream value chains. The upstream corresponds to the infrastructure deployment and signal provision. The downstream value chain is associated with the

[16] CNS/ATM stands for Communications, Navigation, Surveillance / Air Traffic Management

services and products for users; going from the component segment (chipsets, antennae, receivers), to system integrators (product equipment, hardware) to value-added service (content providers). Both streams constitute the industrial stakeholders of GNSS, and consequently, of the Galileo project.

4.2.1. *Upstream industry*

The upstream value chain corresponds to the system manufacturers developing the space and ground network for Galileo, and the system operator that will act as signal provider. Hence, the European aerospace industry is to be involved in the design, deployment and operations (and maintenance) of the Galileo system.

Europe has developed a competitive aerospace industry, which is relatively stable and centralized, with mainly big companies. The successful experience of Ariane launcher, which has developed a commercially successful project that supplies just under 50% of the market in launchers, and other space programs have raised the European confidence in its space technological capabilities. So happened with their early involvement in the EGNOS Program.

However, the competitiveness of the European space industry has been inadequate in the areas of satellite and ground equipment due to the small size of the European market, and the absence of multilateral trade discipline [COM(92) 360.]

4.2.2. *Downstream industry*

The downstream industry is composed of the product manufacturers and service providers. Their turnovers will account as indirect benefits for the undertaking of Galileo. In Europe, this industry is dynamic and fragmented, very competitive and innovative, with niche companies competing with global giants. Some European companies are already involved in the GPS downstream market, even if the European components industry is still weak in comparison.

Europe's involvement in the Galileo project would give them access to a market that remains monopolized by their American competitors. The European downstream industry starts from an unfavorable position, holding around a 15% of the European market of navigation equipment and a 5% of the global market. Finally, their drivers are cost efficiency, pulled off through economies of scale.

The involvement of the downstream industry in the decision-making process is required to achieve the integration of Galileo in the user terminals and generation of innovative applications and services leading to commercial revenues. It is also important in order to create synergy with other functionalities, such as communications, commercialized by service providers.

The GNSS manufacturers have the best and most updated information concerning the user needs and demands, and the trends of the market, applications and R&D activities.

4.3. Users (demand side)

For any initiative to succeed, the needs of the potential users/customers must match the service design and architecture, and drive the business plan. As the ultimate goal of the Galileo project is to create services that meet the perceived needs of users, one its major concerns should be to focus on the requirements of the ultimate users during research and development. We can differentiate three main user groups: mass market, governmental and professional users. Each of them has different needs.

European Commission prospects [COM(94) 248] envisaged 3 million units of user equipment sales, of which 74% were associated to the mass market, 16% to the maritime market and only 2% to the aviation market. On the face of it, we can conclude that the mass-market users have the strongest impact on the success of Galileo. The mass market is not very sensitive to significant improvements in navigation performance, but to cost and development of new services and applications. Governments require integrity and robustness. Civil aviation users require an integrity and availability.

Users will benefit from the new services enabled from Galileo, and those enabled through the complementary use of Galileo with GPS. Several European user communities already relied and had interests on GPS, and potential users of Galileo argued that they would not use it unless it were interoperable with GPS.

The GPS signal for civilian users is provided openly and free of charges. However, there is no guarantee this is going to happen in the future. Besides, both GPS and GLONASS lack guarantees of availability and integrity of their signal. On the other side, the use of satellite navigation by the civilian users in increasing and it is becoming a critical technology in many economical and safety of life aspects. With this respect neither the GPS nor GLONASS fulfill the requirements of a wide range of civilian users, which are concerned of the dangers it poses, as it will be detailed further in Chapter 6.

In addition, users' interest is to benefit from as much satellite navigation systems as possible, since this increases the performance that can be obtained[17], leading to the creation of better products and services. Studies revealed that the effect to adding Galileo to GPS is that it would increase the coverage of the system from 55% to 95%, notably in urban areas[18] where most mass-market applications are developed.

[17] Technically speaking, the more satellites a receiver can "see" from different but interoperable constellations, the better its performance in terms of accuracy, availability, robustness and integrity, can be – concepts defined in the appendix

[18] Technically speaking, users in urban areas usually obtain worse positional accuracy. This is due to the fact that, because of high buildings, the number of satellites the receiver "sees" (has in its line of sight) decreases. The fewer the

Users around the world will also benefit from the additional GNSS resource that Galileo represents; more and better signals in space lead to more robust products, services, and applications. Furthermore, as addressed in the following chapters, the world needs the redundancy Galileo provides to global satellite navigation from a safety and security perspective. The world needs redundant back-up systems in the event of catastrophic systems failure. Terrorists' attacks, such as the occurred 9/11, revealed the global vulnerability of critical infrastructures, such as transport and communications, which are more and more GPS-dependent.

4.4. Competitors

The competitors for Galileo are stakeholders in this decision-making process since they affect its profitability.

In 1990, the US Government adopted a national space policy aimed at maintaining its pre-eminence as the only space superpower. The United States has led the development of satellite navigation for decades. The NAVSTAR GPS program was initiated by the U.S Department of Defense in 1973. An Initial Operational Capability (IOC) was declared at the end of 1993, and the U.S. Air Force Space Command (AFSC) formally declared the GPS satellite constellation as having met the requirement for Full Operational Capability (FOC) in 1995. Beyond its original military purpose, GPS brought a diverse range of civil, scientific and professional applications and generated a market revolution as far-reaching as the telecommunications advances, leading to many domestic and industrial applications. Nevertheless, according to its paramount military purpose, GPS has always been funded under military budget. It was undertaken as a public project and owned by the US. GPS funding was never addressed from a business case perspective, despite the market revenues it generates for civilian applications.

In 1996, the US published a Presidential Policy on GPS [White House OSTP, 1996]. Since then, an Interagency GPS Executive Board gathering military and civilian agencies manages and controls GPS, though the ultimate decision authority over GPS policy belongs to the US President. A Joint Program Office of the US Department of Defense and the Air Force Space Command operates the military use of GPS. The responsibility for the civilian applications falls on the US Department of Transport and the US Department for Homeland Security. The US controls the GPS infrastructure and operations, including the performance of GPS and the timing of changes to this performance. It also controls the users who can have access to GPS; that specific authorization to use GPS remains with the Deputy Under Secretary of Defense for Space of DOD.

The GPS is the main direct competitor to Galileo, though many others will arrive. The US enjoys a great

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signals acquired and tracked, the worse receivers can process their position (a minimum of four is required in order to calculate the position and time by means of a triangulation algorithm.

advantage in the field of satellite navigation and has an interest in supporting advantages and technologies of GPS as public goods in order to perpetuate its technological leadership internationally. Consequently, Europe's will to get involved in GNSS is expected to cause reactions with respect to the GPS policy.

In Russia, the GLONASS initiative began in the early 1980s and achieved a full constellation capability in 1996. Nevertheless, only seven operating satellites were left in orbit by 2001, as a consequence of the financial shortage prompted by the fall of the Russian economy after the collapse of the Soviet Union in the 1990s. Russia and other republics of the former Soviet Union have much to offer in the space domain, and they actively seek both to commercialize their know-how and develop co-operation with international partners [COM(92) 360.] This creates new opportunities that would allow Europe to do more by sharing tasks internationally.

The position of the competitors has a direct impact in the Galileo policy-making as for international politics, security matters and international trading policies. Until now, Europe has developed privileged relations with the US in the field of space, however cooperation with the former Soviet Union has been limited for political and military considerations. A cooperation relationship with Russia could allow Europe to counterbalance its relations with the US in the space activities, thanks of its advanced technological capabilities.

Besides, substitute technologies, like the new generation of mobile phones technology can be combined with Galileo in some functions, but can also displace it in others, and therefore act as competitors. Competing technologies like UMTS or EDGE may be chosen for providing position based services.

Chapter 5

Introduction to public-private partnerships (PPPs)

This chapter provides an introduction to the concept of PPP, their benefits and typical drawbacks, a description of the typical financial structures of the PPPs and some legal and regulatory concerns regarding the use of PPPs in the European Union. Along these sections, it provides a review of the general policy issues that arise for the public sector in considering whether to adopt a PPP or a merely public procurement route.

5.1. What is a PPP

The term "PPP" covers a range of different structures where the private sector delivers a public infrastructure or service. Concession-based transport and utilities projects have existed in EU member countries for many years, particularly in France, Italy and Spain [PWC, 2005.] Recently, the use of PPPs has spread to most EU member countries. However, depending on the country and the politics of the time, the term can cover a spectrum of models. There is no unambiguous definition[19] of what constitutes a PPP [COM(2003) 283.] In particular, the EU does not have an official definition of a PPP. The European Commission's 2004 Green Paper on Public-Private Partnerships referred to PPPs as "forms of cooperation between the public and private sectors for the funding, construction, renovation, management or maintenance of an infrastructure or the provision of a service."

PPPs are aimed at increasing the efficiency of infrastructure projects by means of a long-term collaboration between the public sector and private business. Broadly speaking, PPPs are contractual agreements between a public entity and a private sector supplier that transfer to the private sector investment projects that have been traditionally executed or financed by the public authorities. Structuring PPPs is complex because it requires reconciling the aims of the large number of parties. These actors need to understand how their part of the project is linked to and affected by policy and financial issues.

- The private actors are investors, lenders and companies deploying and operating the infrastructure and/or services.
- The public actors are public authorities and the general public creating and implementing PPP policies and using the facilities it provides.

[19] The author acknowledges a high degree of inconsistency found within the literature reviewed, not only concerning the definition of PPPs but also in relation to the classifications of different schemes, nomenclature standards, and rules that apply. Having this said, the author attempted to summarize all the literature reviewed trying to focus on the EU

The following elements seem required to qualify PPPs [COM(2003) 283]:

- The project should concern the construction or the operation of public infrastructure, and involve the public sector as the principal purchaser, which normally pays for the services to be supplied or has an influence in their specification;

- A private corporation, which is usually a special-purpose company (SPC) created by private-sector investors specifically to undertake the PPP contract, serves as the principal operator;

- The public sector is mainly in charge of defining the objectives to be attained in terms of public interest, quality of services and pricing policies. These objectives are translated into system requirements whose compliance is monitored by the public sector;

- The private sector party provides significant inputs at different stages of the project (design, deployment, financing and operation), and bears a relevant amount of risk;

- The principal financing should not come from public debt but from other sources, such as private bonds.

Besides, the following elements normally characterize PPPs:

- Relatively long-term nature of the relationship, often around 30 years, due to the fact that the revenues for the private sector must be distributed over sufficiently long time horizons to cover up-front costs.

- Risk sharing between the public sector and private sector should be based on the principle that risks should be managed by the party best able to identify, control and cope with them. Appropriate risk allocation should minimize the cost of risks. As much as risks are shared, so the rewards should be.

- The facility often remains in public sector ownership or reverts to public ownership at the end of the contract.

The main characteristic of a PPP, compared with the traditional approach to the provision of infrastructure, is that it bundles investment and service provision in a single long-term contract [Engel et al, 2008.] The private sector is responsible not just for asset delivery, but also for overall project management and implementation, and/or successful operation for several years thereafter. The private sector returns are linked to service outcomes and performance of the asset over the contract life [PWC, 2005.]

framework, whatever it concerns or has concerned the Galileo project procurement, and the evolution of the PPP concept and rules along the timeline in which it has been framed.

The duration of the partnership must be set so that it does not limit open competition beyond what is required to ensure that the initial investment is paid off and there is a reasonable return on invested capital. It is inherent of the relationship between the size of capital invested, the degree of private sector involvement, and the length of time required to ensure investment and profit recovery.

In a PPP, the public sector specifies its requirements in terms of "outputs", as regards to the public services the infrastructure is expected to provide in the long run. The private sector receives payments back, on a pre-agreed basis, that are subject to deductions in case of failure to meet the "output" specifications. For the duration of the contract, the concessionaire manages and controls the assets, usually in exchange for user fees and capacity availability payments[20], which are its compensation for the investment and other costs. Charge may vary according to volume of service provided or consumed. Compensations may also include up front subsidies or "shadow tolls"; fees paid by the public sector as a customer of the project. This way, users do not actually pay directly through real tolls; the taxpayers finance the costs. Shadow tolls regimes are a way for the public sector to mitigate market risks. [Beltran and Vidal, 2005.] The design of an appropriate revenue mechanism is critical, as it provides for the financial effect of the risk allocation. There are two typical payment mechanisms designed for PPPs: availability payments and volume payments

5.2. Benefits and disadvantages of the use of PPPs

The debate on the benefits and disadvantages of PPPs is rather complex. This section outlines the key arguments for PPPs and then considers some of their drawbacks associated, all from the point of view of the public sector.

5.2.1. Benefits

A main benefit for public sector – maybe top most – is that private sector provides funding; in effect, a loan to government. Other benefits are:

- Delivery of better "value for money" (VfM). With PPPs, risks are allocated to the party best able to manage or absorb each particular risk, specifically some are transferred to the private sector. This decreases the overall costs and improves the VfM.

- PPPs allow early capital cost of a public infrastructure to be spread out over its life and avoid limitations on public-sector budgets. Instead, this cost is balanced with long-term operational expenditure via value-based deals across the supply chain, making projects affordable. Capital expenditure can be paid by users instead of paying taxes and/or by the public sector through the payment of "service fees". This "additionality" is often behind the political argument in favor of

[20] Once again, there are so many forums that the classification of these payments is not consistent.

PPPs that are seen as ways to allow the public sector to invest more quickly in public services.

- PPPs maximize the use of private sector skills. Private-sector is said to have better project management skills and higher efficiency than the public sector. Therefore, the public sector benefits from the know-how and working methods of the private sector. Besides, PPPs encourage the development of specialist skills, such as life cycle costing. The involvement of the private sector can also improve the alignment of the interests of providers of capital with the needs of the users.

- The public sector benefits from a better transparency and accountability for the project, and from the use of private financing methodologies, such as the use of Net Present Value (NPV) rather than cost as a way to evaluate an investment. It also benefits from the lenders checking the project's viability.

5.2.2. Disadvantages

- There are higher financing costs inherent to the use of PPPs. The cost of capital for a PPP scheme is typically around 2-3% p.a. higher than a public procurement one, although risk transfer and value for money for PPPs may counteract this fact.
- Complexity. PPP adds another layer of complexity to the already complex task of procuring a major project, and therefore may make the project miscarry due to its own complications.
- Flexibility: Private sector may be more flexible in some ways, though contract rules can lead to inflexibility.
- Longer time and greater skills required to work out a contract, specially as for the best allocation of all kind of risks.

5.3. Types of PPPs

PPPs lie on the spectrum from wholly public-sector projects (and risk) to wholly private sector ones. There are a number of different approaches to the involvement of private financing into provision of public services and a number of alternative names for PPPs that are not really used consistently[21], since there is a lack of consensus regarding the different typologies of PPPs.

This thesis will focus on the classification of the European Communities (2004), although it has been changing as long as the concept of PPPs has evolved in the last decade, making it difficult to present a sound classification integrating many sources of information. It also refers to Private Finance Initiatives

[21] Different approaches and classification methodologies for PPP varies from country to country, from year after year, and from author to author.

(PFI), which is a term originating in the United Kingdom. Besides the terms "concession" and "franchise" have a long history in European Union terminology. The Concession is a "user pays" PPP model in which a private sector (known as the Concessionaire) is allowed to charge the general public "service fees" for using the facility [Yescombe, 2007.] These fees reimburse the private sector for the deployment and operation costs of the facility, which usually reverts to public-sector control at the end of the Concession period.

In a concession model, the market risks are usually transferred to the Concessionaire, though they may be underpinned by the public sector, while in PFI model projects there is a general trend for this risk to be retained by the public authority [Yescombe, 2007.]

A franchise (also know after their French term, *affermage*) is the right to exploit an already constructed infrastructure. In the European Union it is known as "service concession", while a Concession is known as "works concession". Service concessions have been characterized by the European Commission as a form of PPP, and concern the exploitation by a private sector supplier of a right to provide a service where payments are made directly by the public sector as customer, and sometimes partly subsidized [COM(2004) 327.] However, some authors state that it should not be considered a PPP scheme since it does not involve the provision or upgrade of the infrastructure.

PPPs can also be classified by the legal nature of private-sector involvement in the infrastructure. The terms BOO-BOT-BTO-DBFO[22] mainly reflect the point at which legal ownership is transferred to the public sector. They describe which sector designs, builds, finances, owns, and operates the infrastructure. In case the private sector never owns the facility, they reflect the nature of its legal interest.

Finally, PPPs can be split into two main categories on the basis of the service and risk transfer inherent in the PPP contract: usage-based and availability-based[23] [Yescombe, 2007.]

Besides, the European Commission makes a distinction between [COM(2004) 327] purely contractual PPPs, in which the partnership between the public and the private sector is based solely on contractual links; and institutional PPPs (or IPPPs), involving the establishment of an entity held jointly by the public and the private partners.

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[22] BOO stands for Build-Own-Operate; BOT for Build-Operate-Transfer; BTO for Build-Transfer-Operate; and DBFO for Design-Build-Finance-Operate [Yescombe, 2007.]

[23] The Power Purchase Agreements (PPAs), which provided the modern contractual and financial framework for PPPs, were developed in the United States in the 1980s and arrived in Europe (United Kingdom mainly) in the 1990s with the privatization of the power utilities. Under a PPA investors were paid a "tariff" split between "availability payments" that covered the capital expenditure of building and operating the power station, making it available to provide power to the utility, and "usage charges" that mainly cover the marginal cost of generating such power as and when required by the utility.

- **Contractual PPPs**, in which the relation between the public and the private sector is based exclusively on contractual links. The public sector delegates one or more tasks to private organizations; these tasks can include the design, funding, execution, renovation or exploitation of a work or service. Concessions are one of the best-known models for contractual PPPs, in which the public sector signs a contract with one or more private organizations to develop and manage a project. Contractual PPPs are broadly used in infrastructure development in order to share out the economic costs that they entail [COM (2004) 327.]
- **Institutional PPPs (IPPPs)**, in which public and private organizations cooperate by creating a new organization to be governed by all parties in the alliance. The main example is the joint venture, in which one or more public and private organizations engage in a project by creating a new organization (mixed capital entity) where all the parties share the authority to decide [COM (2004) 327.] The public sector may choose such a form of cooperation for the purpose of: retaining a relatively high degree of control over the project. It has a stronger say in the operation of the jointly held company as compared to a contractual PPP.

5.4. Phases of a PPP project

The life of a PPP project can be divided in four phases [Yescombe, 2007.]

1. Initial feasibility: This is the stage during which the public sector decides to follow the PPP route *versus* the public sector procurement one. The presentation of the project for political approval within the public authority is known as the "business case". During this stage, the project-management structure must be set up. This period will be addressed in the Chapter 6 and Chapter 7.

2. Procurement phase: This is the period in which:

    a. Bids are requested, received and evaluated. Consequently, a bidder is chosen.

    b. The "special purpose company" (SPC) is created, in whose name the PPP contract and subcontracts are negotiated.

    c. The public authority's "due diligence"[24] process is completed.

    d. The private sector (investor's) equity investment and their lenders' funding are put in place.

[24] Reasonable steps taken by an entity in order to satisfy a legal requirement, especially in buying or selling something.

3. The end of this phase is known as the "financial close", after which the construction (or operation) of the infrastructure can begin. This period will be addressed in the Chapter 8.

4. Construction phase: Once the "financial close" is achieved, the public authority's relationship with the Project Company is one of contract management. The end of this phase, when the infrastructure is formally accepted as being available for the purposes formerly agreed, is known as the "service availability date".

5. Operation phase: This is the period during which the infrastructure provides the services required by the PPP contract and generates cash flow to pay the lenders' debt and the investor's equity return. The public authority remains as the contract manager.

5.5. Legal and regulatory framework of the PPPs in the European Union

PPP are complex transactions that need a lengthy selection process. It is important to know when they are the right solution to make the right operational and commercial decisions when implementing them, and to have the legal certainty necessary to attract competition for the private sector. The success of a PPP depends to a large extent on a comprehensive contractual framework for the project; a conductive legal, regulatory and financial framework supporting the development and implementation of PPPs. Successful PPPs require an effective legislative and control framework, which ensures that each partner recognizes the objectives and needs of the others.

The public sector establishes this legal framework under which the Concessionaire is chosen and operates. The Concession Agreement signed by both parties regulates the detailed requirements for the deployment and operation of the infrastructure. It must be able to evolve over its duration period in line with general interest requirements and macroeconomic or technological changes. Therefore it should cover automatic adjustment or review clauses.

Fair competition among the private candidates is the basis for the achievement of value for money in the context of PPPs. Uncertainty as to what set of rules apply to the award of a given PPP can clearly become an obstacle to effective competition in the area of concessions.

In some European countries, as UK, the PPP models are treated as a variety of government procurement. In civil law countries specific PPP laws are needed to provide a framework for this type of contract. A lack of clarity also concerns the use of IPPPs. At Community level there are no specific rules governing the founding of IPPP [COM(2007) 6661.]

As we will assess in the next chapters, there has been much uncertainty as to what set of rules at EU level applied for the first pan-European PPP envisaged for Galileo.

PART B

Chapter 6

European overall strategy on satellite navigation

As early as 1992, policy-makers in Europe foresaw the potential of satellite navigation and the problems associated with future dependence of Europe on the American GPS and other systems. The European Commission declared the importance of space for Europe and the need for Community action, and announced its intention to ensure reliable and efficient position fixing services for European users [COM(92) 360.] The European institutions decided EU action was required at the end of 1992 and funded the SatNav study, addressing the satellite navigation options for Europe. Consequently, the EC published a "White Paper on Growth, Competitiveness and Employment" [COM(93) 700] that envisaged the need for European action in the field of satellite navigation.

In May 1994, the European Parliament adopted a Resolution on Space Policy that called for an urgent European action in this field and asked the Commission to determine a strategy in order to enable the European industry to participate in the implementation of global satellite navigation systems. One year later, the European Commission submitted a formal Communication to the European Council on the European approach to the satellite navigation services [COM(94) 248], in accordance with Article 130f of the EU Treaty on research and technological development policies. The Commission suggested a general implementation plan following a two-step approach:

- Deploy and operate an initial European component of the first generation GNSS (GNSS-1), as a complement to GPS/GLONASS. This meant relying on the basic US and Russian signals (GPS and GLONASS respectively), but augmenting these signals over Europe by means of a European SBAS called EGNOS. This monitoring system is aimed to warn the European users in a very short space of time of any malfunction that could affect the quality of the signals broadcast by the existing global systems. The augmentation of their signals allows a safe use of GPS/GLONASS for safety-critical applications.

- The next step, to be taken in parallel, was proposed in order to avoid keeping the EU dependant on GPS through EGNOS. It was aimed at involving Europe in the development of a internationally controlled second generation global satellite-based system (GNSS-2) meeting the needs of the civilian community.

The European Council adopted the GNSS-1 concept and the European Commission launched the EGNOS Program in co-ordination with its Europe Tripartite partners the European Space Agency and Eurocontrol in 1998. EGNOS was initially intended to be fully operational by 2004.

With respect to GNSS-2, the Council invited the Commission to explore different alternatives, such as getting involved in the joint development of a civil GNSS-2 in co-operation with other international players, such as GPS or GLONASS or developing Europe's own independent GNSS-2 for civil use. Consequently, the European Commission decided to investigate the development of a European GNSS, later named as Galileo, in coordination with the European Space Agency (ESA).

The Council also invited the Commission to initiate the preparatory work needed to clarify what a European system would look like, and how much it would cost. Besides, the Council also invited the Commission to examine the potential for private sector financing for this potential system. The involvement of the private sector would not only bring new sources of funding, but also fresh ideas and methodologies.

In 1998 a GNSS High-Level Group was established to consider the European involvement in this area; whereas to develop a civilian based enhancement to supplement the existing global systems only (EGNOS), or compete with them.

Europe needed to take a decision, better sooner than later, on the strategic issue of how best to ensure an effective role in long-term development of GNSS. The first quarter or 1999 was set as the target date for such decision. Together with the decision on "what to do" with this respect, another analysis was required in order to decide "how to best do it", as covered in Chapter 7.

6.1. Policy analysis

6.1.1. Problem definition and current conditions

Internationally, two global satellite systems were present: The American GPS and the Russian GLONASS. They serve as a technical guarantee that satellite navigation is a feasible reality and the source for multiple business opportunities in a growing market. GPS and GLONASS remain under the military control of the US and the Russian Federation respectively and are not able to fulfill the requirements of a wide range of civilian users.

The reliance of transport infrastructure and critical sectors on GNSS is increasing in Europe, as in the US. GPS is increasingly moving forward as the main navigation system in all traffic modes. Users increasingly rely on GPS as a source of accurate vehicle positioning. Furthermore, GPS has started providing timing reference for banking systems, energy distribution networks and telecommunication networks. This dependence poses strategic, economic and safety dangers for the EU.

GPS signal for civilian users is provided open and free of charges so far. However, in order to preserve the national defense needs and prevent the GPS signal from being used for military or other security-related purposes, the GPS signal could be jammed or degraded whenever the US Government judged this necessary; by default, the US Government unilaterally introduced an artificial error called "selective availability"[25] that deliberately degraded the open access civilian signal, providing a minimum accuracy of 100 m. Furthermore, the US could unilaterally suspended or deny the GPS service. Therefore, GPS does not guarantee continuity of service on an international acceptable basis. Consequently, the European economy would be impacted to a certain extent in the event of GPS interruptions. Finally, GPS and GLONASS lack guarantees of availability and integrity. System operators take no responsibility on the use of their signals by non-military users "at their own risk".

Additionally, several cases of GPS service disruption have been reported over the past years, which had many different origins, including unintentional interference or satellite failure. Consequently, one major concern for GPS users has been the vulnerability of the navigation signal. Furthermore, GPS coverage was not uniformly good world wide, and was particularly limited in urban areas where high-rise buildings obscure satellite reception. Not only GPS can fail, it also provides no guarantee of reliability. This means it cannot provide a service that is reliable enough for safety of life applications, such as navigation aids for civil aviation.

In fact, the degree to which GPS had been taken up by the civil community in the USA raised several safety concerns over the vulnerability of GPS to unintentional and intentional interference, as expressed in a US Presidential Decision Directive issued by the White House on 22 May 1998. Consequently, the US Department of Transport evaluated the vulnerability of the national transportation infrastructure that relied on GPS. Its Volpe Report confirmed the need for improved robustness in safety of life and regulated applications since GPS is inherently vulnerable [Volpe, 2001.]

Market estimations are promising: There is a business out there

GPS is an example of the argument that defense R&D generates externalities in the form of innovations for the benefit of the civilian side of the economy (the "spin-off" effect). In the mid-1990s, the decision of the U.S. Government to make GPS data available to civilian users anticipated the advent of very promising markets related to new commercial space applications, including satellite navigation. GPS dominates the marketplace and holds a majority share of a profitable global satellite navigation market. In 1995 the U.S. GPS Council estimated the commercial spin-off from the GPS at $8.5 billion for the year 2000.

In 1998, the European Commission handled estimations suggesting that the world market could be worth $ 50 billion by 2005 [IP/98/59.] Accordingly, first market analysis for Galileo was reported by the Commission in 1999, indicating a potential global market valued at €40 thousand million between then and

[25] As stated in Chapter 7, the "selective availability" was deactivated in May 2000.

2005, from which Galileo was challenged to capture a fair share of the market [COM(1999) 54.] The same year, market analysis indicated that the European sale of satellite navigation equipment and services reached €l billion [Flament, 2004.] In 2001 there were more than six million users in Europe and studies estimated a market growth of 250 million in Europe by 2020, expected to reach 800 million worldwide.

With respect to the deployment and maintenance of the space and ground segments of these systems, it represents a significant potential market for the European aerospace industry if it acquires the expertise and market conditions allow it.

EU current political framework

1992 was a decisive year in the development of the EU, as the target date of its efforts to complete the single market. The Treaty on European Union acknowledged the growing international role of the Community and also reinforced the role of the Community in R&D; both aspects are likely to have an impact on European space activities. It mandated the Commission to prepare guidelines for the implementation of Trans-European Networks and since 1996, the Parliament and the Council included satellite navigation in the Community Guidelines as an integral part for their development.

European space industry status and the European technological gap with respect to the US

Industrial restructuring in the space-related industries in Europe was accomplished as part of the single market objectives [COM(92) 360.] Europe has developed technological competence in space activities, thanks to the European Space Agency and complementary national programs.

The Ariane program of launchers, which begun in the 1970s, strengthened Europe's position in the international market for space launches and gave Europe autonomy in this area. Ariane had a period of notable commercial success though it was challenged by US policies aimed to protect its markets, and by the entry of Russia and China in this market [COM(92) 360.]

The commercial success of Airbus Industry highlights that EC, the Member States, and industrial interests are able to successfully engage in sustained collaboration and create an effective instrument of commercial strategy in a particular high technology sector. Cross-border cooperation at both the industrial level and inter-governmental level has been critical to Airbus's success [Lungu, 2004] and can be regarded as a model for European industrial cooperation. The European competitiveness is fragile in the fields of satellites and ground equipment, as a consequence of the weakness of the component industry and the small size of the European market.

The differences between the European and US space industry turnovers are notable. This is caused by the tremendous difference of their respective government markets (14 times greater in the US), which are not open to international competition. The US space industry has access to a large military market that accounts for about 53% of it total revenues, in comparison with a 10% representation in Europe. Civilian public-sector markets are also contrasting. However, this gap is smaller as for the size of their commercial markets.

In the 1990s, the consolidation of the American defense industry can be attributed to a certain extent to deliberate policy decisions taken by the US DoD since 1993. Federal funds were used to boost the rationalization of the industry through a series of mergers leading to giant corporations. [Lungu, 2004]

The debate over the alarming technologic56al gap between the European industries and their American competitors goes back at least as far as the World War II, when transatlantic gaps in the military and aerospace technology fields were already identified. The European concerns about lagging competitiveness in the area of high technology had become a topic of discussion among the European policy-makers for decades [Peterson and Sharp, 1998.]

Despite the gap between the European an the US industry, Europe has the human, technical and industrial potential to face the satellite navigation challenge and develop both a system infrastructure and the products and services of its downstream market.

Correlation between technological competitiveness and political international influence

In the late 1980s the European perceived “the interrelated issues of increasing technological dependency and declining international competitiveness" as the primary areas of insecurity for their economies [Lawton, 1998.] To the extent that European technological and industrial sovereignty is threatened, European political sovereignty – the most fundamental of interests – is threatened [Pfaff, 1998.]

In the US the establishment of the National Economic Council (NEC) and the position of Assistant Secretary of Defense for Economic Security (in 1993 and 1994 respectively) evidenced Clinton Administration’s will to link the preservation of American military and technological power and the pursuit of its own economic interests in global markets.

A report on "The Management of European Technology: Defense and Competitiveness Issues” prepared for the EU Commission between 1998 and 2000 drew attention to the perception of an “American threat”[26] to the European military-industrial survival and advanced technology competitiveness, which had emerged in Europe during the second half of the 1990s.

[26] This perception was a consequence of the European evaluation of the technology policy promoted by the Clinton Administration, seen as promoting an enhanced role of economic and technological issues in determining US’s national security policies.

6.1.2. Definition of needed change

Finally, this problem definition resulted in the formulation of a desired change mainly due to the political and strategic threats of reliance on military systems controlled by one or more third countries. Ultimately, these systems are meant to support the interests of their own countries, regardless of the European interest.

Dissatisfaction with the *status quo* and leadership's aspirations and are conventionally accepted as circumstances that might drive a nation (or a group of nations, as the EU) to develop policies in order to challenge the prevailing configurations of power in the international sphere [Szayna et al, 2001.]

Consequently, the pursuit for strategic independence in order to increase influence in international affairs and enhance the international economic competitiveness were main driving forces behind the need of a European decision on GNSS [Lungu, 2004.]

The EC White Paper on European Transport policy for 2010 identified GNSS as a critical technology that could revolutionize European transport infrastructure [COM (2001) 370]. No action taken from Europe in these matters would leave Europe completely dependent on the US controlled GPS. A need of action also arises from the fact that Europe will depend on GNSS for certain safety of life applications and the current GPS and GLONASS do not comply with such safety requirements. Furthermore, EU Directives for safe transport of People and Goods require “guarantees of service” and carry “liability” commitments that GPS currently does not provide, and that require EU having a certain control over one GNSS system.

Beyond a need in terms of sovereignty and security issues, satellite navigation represents an opportunity for European space industry. From an economic perspective, the European Union needed to ensure that the European investments across many different market sectors that are increasingly relying in GNSS are not solely dependent on GPS. Even if the US provided the GPS open service for free, there was a need to ensure that European users were not subject to the possibility of US imposition of charges in the future. The introduction of regulation or charging mechanisms based on a monopolistic GPS not under EU control would leave Europe vulnerable to unreasonable charges or fees.

On the basis of these needs and opportunities, in January 1998 the EC proposed that the EU and its Member States unequivocally confirmed their commitment to a full European contribution to GNSS [COM (1998) 29.] As a result, the Council of Transport Ministers asked the EC to propose Europe’s strategy in terms of global satellite navigation, contingent upon these conditions:

- It guarantees European independence in this area in view of its growing economic dependence on GPS.
- It guarantees safety in the service as required by certain vital and GNSS safety-related applications.

- It empowers the European industry and services to compete in all segments of this profitable market.

6.1.3. *Policy options and instruments*

Analyst's perspective

There are major strategic, geopolitical and commercial interests at stake in relation to Europe's capacity to control the positioning and navigation services for its own territory and to the access of European industry to this technology. GNSS raises a whole range of complex technical, financial, legal, organizational and industrial issues. Policies must be grounded in interests and values supportive of both economical and strategic benefits. Therefore, from the standpoint of the analysts, multiple perspectives needed to be considered, combined and balanced, in this policy-making process:

- National strategy, sovereignty and safety issues – The increasing European reliance on a system provided by a third party results in the need for attaining European independence and a degree of control over this technology. International relations and diplomacy issues at a global sphere must be also taken into consideration.
- Security issues – Such GNSS systems also involves security and defense concerns, considering the military applications associated.
- Technical perspective – Galileo is a space project, and therefore, it is subject to the intrinsic technical nature of such projects.
- Commercial perspective – The potential direct revenues from the exploitation of a satellite navigation system should also be considered. Analysts should investigate the issue from a business case perspective.
- Economic perspective – European involvement in satellite navigation technologies would raise the European industry to a level of international competitiveness by enabling it to participate in the deployment of a satellite navigation system and to ensure that Europe can take a fair share of the associated global GNSS downstream market. This involves an analysis addressing the GNSS market value chain – upstream and downstream – components.
- Social and macroeconomic perspective – Satellite navigation systems are "public goods" that benefit everyone as members in society, leading to significant macroeconomic and social benefits. In particular, it should also be regarded as a public infrastructure project that can make an important contribution towards achieving the Community objective of a transport policy sustainable for the environment and industry. In addition to the EU Common Transport Policy, Galileo also supports other policies such as employment, environment, industry and cohesion.

Satellite navigation instigates better efficiency and enables numerous applications in a diverse range of sectors.

It is crucial that the needs and challenges involved in this policy-making process are clearly identified and prioritized. Policy-makers need to know to what extent sovereignty and strategic matters prevail over market revenues, before they come up with a strategy, and most specifically, over the private participation in the financial aspects. In this respect, analysts must differentiate the direct from the indirect revenues and the proportional weight in which they have an impact in the decision-making process.

Analytic methodologies

Considering the multiple dimensions at stake in this policy-making process, multi-disciplinary methodologies must be also used according to the multi-domain perspectives introduced above.

ESA is already conducting the feasibility and design studies of a GNSS-2, as required by the Council, and is evaluating alternative technical proposals of the system architecture of the system, in compliance with the user needs. Furthermore, these studies include an assessment on the estimated costs for the development, deployment and operation of the system.

The cost-benefit framework is an appealing way to frame the policy questions at stake. Realistic Cost Benefit Analyses (CBA) should be executed in order to evaluate the benefits of the European strategy with respect to the investment required.

Initially, analyses must quantify the impact to the European economy in the event of GPS interruptions in comparison to the cost of getting involved at any level in the development and operation of a civil GNSS-2. Hence, some studies reported damages to the European economy estimated at €1 billion in case of a 48-hour close down of GPS in 2015.

With relation to the development of a European independent GNSS-2, these methodologies will be addressed in the Chapter 7, that covers the policy-making related to the definition of a strategy for Europe's own GNSS-2, Galileo.

Identify the alternatives

Europe had three broad options to get involved in the satellite navigation technologies:

1. Not to get involved at any level in the development and operation of a civil GNSS-2. No European involvement in a civil global system would make Europe rely on GPS and GLONASS signals, even if augmented with EGNOS over its territory.

2. To co-operate with the international partners, such as the US or Russia, towards the development of a jointly owned GNSS-2 by all the major international players. The joint development of an international GNSS-2 was regarded as the most cost-effective option on paper. It would avoid duplication of the existing infrastructure and allow the sharing of the costs among players. This alternative seemed to be the most attractive to pursue for Europe, but only under some conditions that would preserve the European interests in terms of security and freedom of action in this area [COM(1998) 29], as described before.

3. To go for it alone, as proposed by the Commission, and get engaged in the generation of Europe's own independent global system.

6.1.4. Definition of options and means

Considering the wide range of sensitive political, international, industrial, economic and security issues at stake, only Community level action could make possible to undertake any of the alternatives.

ESA can provide technical and management expertise in space programs, as well as the procurement framework to manage the industrial prime contract for the development of the system. However, the convenience of ESA's procurement framework in comparison with EU procurement rules should be assessed.

Together with ESA, some organizations like Eurocontrol have developed a comprehensive understanding of the future technical and industrial implications of satellite navigation, and of the institutional, political and financial aspects related to the service provision and the use of receiver equipment.

Concerning the funding, the European Parliament and the Council were to raise the community participation to the satellite navigation projects to a 20% in the Regulation for the trans-European transport network [1999/C 221/01] and substantial funding can be obtained through the EU Budget (mainly transport and the R&D 5th Framework Programs budget) and ESA.

The European Council at its 1994 Corfu meeting stated, "it is primarily up to the private sector to respond to the challenges in the field of information technology and to take the necessary initiatives, in particular as regards financing" [94/C 379/02.] This can be regarded as an implicit recommendation for funding to be obtained by other means beyond public investment. This includes diverse revenue mechanisms (fee on receivers and access service charges associated to different level of services) and the development of a public private partnership. Besides, as part of the Growth initiative, the Council approved measures designed to increase investment in the infrastructure of TEN and in the fields of innovation, R&D, mainly through forms of PPPs" [COM(1997) 453.]

We must emphasize that economics is not the right language for addressing the decision at stake; at least it is neither the only nor the most relevant. The European debate over what to do about satellite navigation should not exclusively be formulated in terms of economics. Notwithstanding the prominent role of economic analysis in this important decision, it cannot become the ruling principle in this important decision process in which other fundamental values are at stake. A purely economic perspective cannot become the leading justification for one or another strategy.

6.1.5. Cast of characters

The European Parliament recognized that the European industry had previously suffered from a lack of political guidance and commitment in the space sector by the European Institutions and welcomed the EC proposals in this field. It stressed that GNSS should, as far as possible be financed through PPP models.

Some Member States were more supportive than others.

Developing high technology has been a key priority for both French industry and government since the 1960s. French government integrates defense industrial policy with other industrial, economic, and social policies in a systematic way to develop a broader strategic-industrial perspective [Lungu, 2004.] France argued that not having control over such critical infrastructure would compromise European sovereignty, security and autonomy in the future. French defense analysts suggested that [Boyer, 1994] "since the late 1980s the US had begun to promote a new international order, in which advances in technology functioned as instruments to achieving economic and military dominance. Without any doubt, the French were the main promoters of the Galileo initiative within the EU."

On the other side, the United Kingdom was rather skeptical about the need of Europe to engage in an independent GNSS initiative. Still, the Chairman of the British Aerospace Defense Ltd. stated in 1996 that consolidation measures needed to be pursued in Europe in order to increase effective competition against the American in these domains.

As for the competitors, the prospect of Galileo generated significant reactions, as follows;

The United States GPS

The US regarded Galileo as a threat to its hegemony in satellite navigation and adopted a competitive strategy. Therefore, this European attempt precipitated the first exhaustive Presidential Policy on GPS in 1996 and led to the deactivation of the selective availability (SA) that degraded the accuracy for mass-market users. This strategic movement, together with the reaffirmation to provide the open service free of charge, favored the interests of the worldwide civilian GPS users and enhanced the US reliability of satellite navigation data provision. The new level of accuracy – 10 meters instead of 100 m – stimulated the development of new products and applications. Still, the capability of reactivating SA was maintained for the future.

Furthermore, Europe's initiative provided with an incentive for the modernization of the GPS satellites (GPS II), with the purpose to enhance its capability by 2008, and the planning of a future next generation of the GPS system (GPS III[27]) that will improve its service to the civil community. Still, the system's evolution continued being governed primarily by US defense requirements.

Above all, the concept of Galileo raised several concerns for the United States as a challenge to its security strategy. Broadly speaking, "enemies [of America] may still be able to rely on Galileo, operational if Europe considers so, regardless of US interests". Consequently, the US initially opposed to Galileo and persuaded Europe not to get engaged in the development of its own GNSS.

With regard to transatlantic co-operation with Europe in matter of a joint development of a civil GNSS, bilateral negotiations on GNSS were included as a priority in the New Transatlantic Agenda. Europe claimed for full participation in the decision-making structure for GPS, equal access to the basic technologies for the European industry, and firm guarantees that the service will not be withdrawn or disrupted, with, ultimately, a full EU role.

However, the US position reflected their strategy of ensuring dominance of GPS and was not in a position to adopt the European conditions and transfer any control over such key national infrastructure. In fact, according to the "Interpretation of the 1998 (HR1119) National Defense Authorization Act Section 2281", US "cannot share ownership of GPS with a foreign power". Nevertheless, the US expressed its willingness to consider making a statement of intent to provide continued access to the GPS signal, free of direct user charges. In any case, considering that the commercial applications of GPS are increasing, also for the European investors, the US tax payers are expected to claim at some point a European compensation by some means.

On the other side, the US also recognized the benefits of having two complementary systems (GPS + Galileo) in terms of overall robustness and better accuracy; adding Galileo to GPS would increase the coverage of the service from 55% to 95%, notably in urban areas where it is most needed for the mass-market applications.

GLONASS

Russia offered the joint use of GLONASS frequency bands to Europe in case a reasonable cooperation in GNSS-2 could be initiated, under the framework of the EU Partnership and Co-operation agreement with Russia. However, the Europeans questioned Russian involvement in an international program in view of

[27] GPS III program was finally launched in 2004, New Presidential GPS Policy.

the economic difficulties in Russia. They were concerned this could cause failures to deliver on time that would impact the overall integrity of the program objectives. Russia did not get as involved in the European plans as they hoped to get.

Consequently, a 1999 presidential decree formally established GLONASS as a dual-use (civil and military) system, as is GPS. An Interagency Coordination Board was also established in order to provide inputs from user communities. GLONASS remained controlled by the Russian Ministry of Defense, although Roscosmos (the Russian Space Agency) acts as the program coordinator. Later on, in 2001, in view of the GNSS programs launched worldwide, the Russian Government[28] made a new commitment to a 2002-2011 program to rebuild and modernize the system and compete at the international sphere.

6.2. Policy formulation

6.2.1. Definition of strategy

Considering that the initial discussions between the EU and third countries on this matter did not progress, in February 1999 the Commission recommended [COM(1999) 54] the development as soon as possible of an independent European GNSS as the most cost-effective strategy to satisfy Europe's needs. This GNSS was provisionally named for the very first time Galileo and was aimed to provide a minimum accuracy of 10 meters horizontally and at least two levels of service; there should be a basic open service, free of charges, and a service designed for users that require a high level of service guarantees. In addition, it was decided to be open to complementary contributions from third countries and organizations. With this respect, a significant role for the Russian Federation was recommended.

The ESA Ministerial Council approved the Galileo program in May 1999, and the EU Transport Council endorsed a first resolution on Galileo in July 1999 [1999/C 221/01], asking the Commission to develop "without delay" a global system under civil control, to serve civil purposes, including public safety and security, and providing an added value with respect to the existing systems while being compatible with them.

The development of a PPP approach was regarded as a priority in this strategy, ideally from the beginning of the development phase, and in any case before the deployment phase. This was in line with the Commission Communication on PPPs [COM(1997) 453], broadly endorsed by the Council and the Parliament.

The next issue faced by EU policy makers, having taken the decision to undertake Europe's own GNSS, was how to manage and pay for it. This "how" was analyzed during the definition phase, whose output was expected by the end of 2000, as depicted in Figure 5.

[28] New Russian government under President Vladimir Putin ruling.

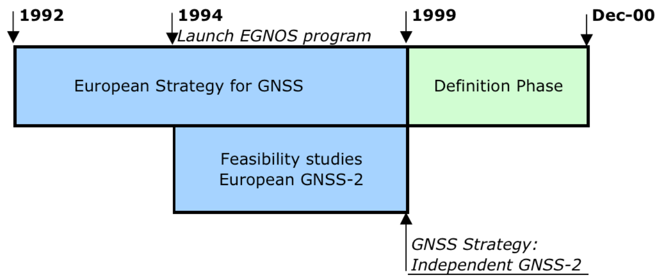

Figure 5: European GNSS strategy timeline in 1999.

This definition phase required a detailed analysis and evaluation of the different options to undertake Galileo that will be tackled in the next Chapter 7.

6.2.2. Identification and evaluation of impediments

Europe's strategy to have its own GNSS are identified had several impediments:

- **Europe's lack of experience in satellite navigation systems.**

  Satellite navigation is a leading-edge technology in which Europe has poor expertise. The technical complexity of a GNSS system poses technical risks, for which Europe cannot rely on past technical experiences. Besides, none of the existing global satellite navigation systems incorporate "integrity data" in their own navigation messages. This is a technological challenge Europe has to deal with.

  Counteraction: The EGNOS experience enabled the European Union to start developing a technical capability and know-how in the advanced sector of satellite radio navigation. EGNOS validation and operational phases were to serve partly as a test-bed for the implementation of Galileo, even considering that EGNOS does not involve the development and deployment of space infrastructure.

- **Europe's lack of experience in the development of pan-European infrastructure projects.**

  There are few, if almost none, European infrastructure projects that have been pursued at pan-European level comparable to the Galileo project. This poses both political and industrial risks. Europe is at risk of underestimating the difficulties of managing a pan-European project and its political implications in a complex European framework. Furthermore, cross-border industrial integration is weak and the upstream industry for Galileo is highly biased with national politics and strongly backed by national interests. Consequently, the allocation of Galileo program activities – and funds – among the various Member States industries is expected to pose difficulties.

Counteraction: As a precursor of Galileo, EGNOS was to prepare Europe to face the institutional challenges of Galileo, introducing Europe in the international policies on satellite navigation. It also laid the foundations for Community funding for Galileo. Besides, In the defense sector, various forms of cross-border industrial cooperation, such as the Eurofighter project [COM(96) 10], had existed for decades, from which Europe can benefit from the lessons learnt.

- **Dominance of national interest to the detriment of a common European interest.** Experience has shown that large-scale projects that involve different national budgets, as the Airbus 380 in Europe, are prone to opportunistic national interests, internal conflicts of interests, and competitive maneuvers within nations. Galileo involves many different national budget authorities, and it is difficult to define a single interest that gathers Europe as a whole.

  Countermeasure: The developing of a stronger European cohesion must be promoted. Close collaboration of the member estates must be stimulated, safeguarded and enforced.

- **Inertia of the EU institutions.**

  The development of a Global Navigation Satellite System is an ongoing process that will have to be reviewed and adapted periodically. Therefore it requires to return to the subject regularly in order to update its program regularly if necessary.

  Countermeasure: This fact was foreseen in the Council resolution of 19 December 1994 on the European contribution to the development of a Global Navigation Satellite System (GNSS) [94/C 379/02], albeit it was not adequately enforced.

- **US initial opposition to EU satellite navigation initiatives.**

  US tried to persuade Europe that there was no need for Galileo, and that Europe should concentrate its funding efforts on pure military capabilities. There was a fundamental need to come to terms with the US authorities on interoperability and compatibility issues.

  Counteraction: Europe had to focus on establishing a proper negotiation framework with the US, calming the American concerns about the security threats and introducing Galileo as an endeavor that will not only favor the European interests but those of the users worldwide, by providing better performance and robustness to the current GPS. Americans should not see Galileo as a competitor but a complementary system to their GPS, not interfering their signal and providing enough guarantees in terms of international security aspects.

- **Market entry barriers.**

If Galileo is to be regarded on purely market grounds, it would face three market entry barriers:

1. GPS is already in the marketplace. GPS receivers are widely used in diverse sectors and its penetration is expected to increase in the future. GPS has the advantage of having been the first mover in the GNSS market. Historical development paths play a key role in market development. Therefore, Galileo has to counteract the path dependence and hysteresis effects associated with GPS.

2. Time plays against the success of Galileo. Time to market is a critical point in view of the international race on GNSS. Late market entry would consolidate the US dominance in the marketplace and Europe would find it more difficult, and probably impossible, to enter the market [COM(1999) 54]. There is a window opportunity associated to the update of GPS in 2008. However, as depicted in Figure 6, this deadline should not be considered a fixed date. The advent of Galileo creates a reaction in its competitors, which would speed up their work and aim at earlier operational dates. This competition also creates incentives for Galileo to achieve an earlier operational capability as well. Thus, the effect of competition for the time to market creates a reinforcing (R) dynamic. On the other side, competitors' reactions decrease the relative Galileo time to market with respect to them, thus balancing (B) the effect of a particular operational date for Galileo in its market entry.

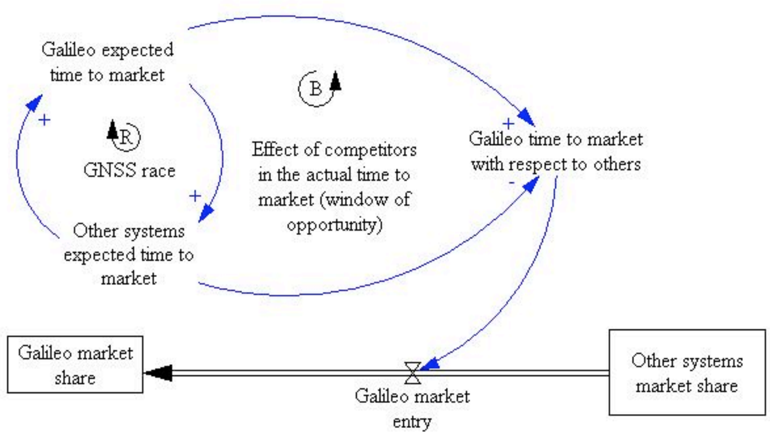

Figure 6: Time to market dynamics.

3. Finally, many have been skeptical of Galileo's ability to sell its services, particularly in an environment where GPS and GLONASS were free of direct user charges.

Counteractions:

1. Compatibility with GPS is the only way to support Galileo's introduction in the market and ensure the maximum market growth. Therefore, signals must be compatible with the equipment designed for GPS. In addition, receiver cost increases with the number of frequency bands received. European systems should operate in frequency bands that overlap with the ones used by GPS. Europe should advocate GPS/Galileo receivers become de facto standards for GNSS user equipment.

2. The risk associated to delays in the program should be strongly considered. The target to have Galileo operational should be addressed in consideration of the international GNSS schedule and the reactions of its competitors. This implies having Galileo operational in 2008, in consistently with the scheduled deployment GPS III, although this may vary. It is recommendable to update and revise the policies according to changing circumstances external to the project itself.

3. To investigate other ways of getting direct revenues, if so.

- **Risk of delay and cost increases**
  Delays not only diminish the prospect of benefits, but also increase the costs. In the US, the WAAS (scheduled for 1997) has been delayed, despite the know-how of the Americans in this domain. Besides, progress on some other priority projects of the European Commission has been slower than anticipated. Europe should take these precedents into consideration when making timing estimations. Besides, space programs usually face growing budget restrictions, evidenced in the recurrent uncertainties over the long-term future of the International Space Station. Infrastructure projects are generally very expensive and costs tend to rise in the implementation phase.

  Counteraction: Use of flexibility and uncertainty in the methodologies used in the policy-making process. Use of control mechanisms and enforcement measures.

- **Financial constraints**
  The budget allocated for Galileo is not assured in the long term, since the EU budget is approved every seven years. Besides, it requires negotiations within the Member States. As long as policy makers intended to count with the private sector involvement, a certain degree of commitment on financing from the public sector was to be assured.

- **Regulatory and legislative framework**

  Legal impediments and uncertainties regarding PPPs affect both the public and private sector, and represent an obstacle to effective competition. In 1995, an EC report to the Madrid European Council regarding the progress on trans-European networks examined the provisions of existing legal terms with regard to their application in TENs and PPPs. Two distinct sets of public procurement rules apply for selecting, on a competitive basis, the contractors for the execution of a given piece of transport infrastructure, ensuring value for money; these are Directive 93/97 for public authorities or Directive 93/98 for the so-called utilities. The EC evaluated the compatibility of these public procurement rules with the technique of project financing for concessions, and the need to associate the private sector as early as possible in the analysis of the feasibility and conception of an infrastructure project. Having been concluded that the Directives do permit such activities, the EC decided in 1995 that no legal action was required as for a legal framework for the participation of the private sector in the award of concessions by public authorities in the TENs priority projects, which included Galileo.

  However, this legislative approach was not that realistic and posed several impediments. While public contracts were subject to the detailed rules of the public procurement directives, the award of service and works concessions was mainly governed by the broad EC Treaty principles[29]; specifically, transparency, non-discrimination and proportionality. These general principles left many questions open when it came to awarding these concessions.

  Countermeasure: The Commission took a number of initiatives to clarify the legal framework of PPPs. In 2000 it published an interpretive communication on concessions and Community public procurement law in which it defined the outlines of the concept of Concessions in Community law, on the basis of the rules and principles derived from the Treaty and applicable secondary legislation [Burnett, 2005.]

6.2.3. Development of a tactical plan

Once the Galileo definition phase was launched in cooperation with ESA and the Member States, the Commission was to be responsible for the political and strategic dimension during this phase, leading the international negotiations, and ESA was to be in charge of the definition of the space and ground segments

[29] The rules on the internal market resulting by the EC Treaty, including the rules and principles governing public contracts and concessions, apply to any economic activity, even if it is intended to provide a "public service". Therefore, any act in which a public authority entrusts the provision of an economic activity to a third party must comply with the Treaty principles of freedom of establishment (Article 43 of the EC Treaty) and freedom to provide services (Article 49 of the EC Treaty). [Interpretive Communication of the Commission on concessions in Community Law, OJ C 121, 29 April 2000.] These Articles cover the principles of transparency, equality of treatment, proportionality and mutual recognition.

under the GalileoSat Program. The Community provided half of the budget and the other half came from ESA.

The aim of the definition phase was to perform further analysis on institutional, economic, technical, operational and legal aspects. Part of this analysis was already approached in parallel with the analysis performed a EU level to precipitate the adoption of Galileo as Europe's strategy.

Chapter 7

The European strategy for Galileo

This chapter addresses the development of a strategy and tactical plan for Galileo, once the EU policy makers decided to launch the Galileo program, on the top of the analysis already carried out as described in the previous chapter. This new loop of the policy-making process is required to come up with the best strategy Europe should adopt in order to develop and implement the Galileo Program.

Further "analysis" was performed, after which general "strategy" was defined in 2001. The implementation plan defined the different phases of the project: design, development, deployment and operation. The EU envisaged a Concession with a private Concessionaire in 2005, in order to fully deploy the system by 2008 and operate it under a PPP financial scheme for the next 20 years.

7.1. Policy analysis

7.1.1. Problem definition and current conditions

The European Council launched the definition phase of Galileo in July 1999. Consequently, a number of studies were to be carried out in order to demonstrate the technical and financial viability of the project, continuing the ones started in 1994. Initial development of the project was under the umbrella of EU's Framework research Program, with the participation of ESA. Overall responsibility was then vested in the EC DG TREN. The target date for the Council to take the decision whether to continue the project was December 2000. During this definition phase, the overall architecture of the system was defined through EC studies, while the technical aspects of the space segment were assessed by ESA. Furthermore, a strategy on financing, Galileo services, management structure, business case and policies needed to be accomplished.

7.1.2. Definition of needed change

From then on, a strategy on financing, Galileo services, management structure, business case and policies needed to be accomplished. In 2001, the Parliament formalized the need for a navigation agency to be in charge of the development of the project was formalized. A clear single administrative structure was an absolute precondition for the coordinated management of the development, deployment and operation of the program and for any plans to convince interested parties from the private sector of the institutional stability of the project.

7.1.3. Policy options and instruments

Analyst's perspective

As previous chapters indicate, the analysis of this policy-making process requires a solid understanding of the interaction of political, technical and economic aspects, in the context of great uncertainties.

System architecture requirements should match the needs of the users

The aim of the system architecture was to meet user needs and allow for the adaptation to market trends, minimizing risks and costs. The fist step consisted in investigating the needs of the potential users, in order to define the services meeting their demand. On other words, to define in some detail what requirements would apply to Galileo, in terms of service definition. Accordingly, EC and ESA conducted several definition studies during this phase, aimed at the identification of these requirements, definition of the services and the definition of the system architecture accordingly:

- GEMINUS (EC): Definition of the services meeting the requirements off the users.
- GALA (EC): Definition of the Galileo Architecture matching system architecture and user needs. 60 firms were involved in GALA and it demonstrated that Galileo is technically feasible in Europe. This project also investigated the commercial service opportunities and the PPP mechanisms.
- GalileoSat (ESA): Definition of the space and ground segment (technical studies).

Complexity of the economic analysis

Besides, economic analysis must address the complex dynamics of the impact of satellite navigation technologies in a broader scope. Quoting Paul Verhoef (European Commission's Head of Unit for Galileo) "in this business, added security or sovereignty qualifies as return on investment just as well as service quality, new jobs, or straight cash" [Verhoef, 2008.] Beyond direct user benefits (signal provision), satellite navigation leads to political, industrial and socio-economic benefits of a significant order of magnitude, that can be can be classified as follows:

- Political benefits: Galileo will place the EU in a stronger negotiation position with respect to many issues of foreign policy: European independence, security, sovereignty and influence. Industrial politics. Strategic value, in line with the Lisbon Strategy[30] and other Community policies.

[30] In March 2000, the Council established an agenda for economic and social development in the EU, termed the "Lisbon strategy", emphasizing the role of innovation as a motor for economic change. In particular, it encouraged public investment in technologies that would bring wide ranging economic and social improvements.

- Technological benefits: Increase of the European technological know-how. Satellite radio navigation is a leading-edge technology. Technological know-how will be gained in the course of Galileo's development and deployment, helping to boost the technological potential of Europe. Galileo will pose a number of important technological challenges that will enable Europe to develop its industrial capability for the future. It should also help encourage further restructuring in the space industry, increasing its global competitiveness. Besides, satellite navigation will have synergy with other technologies; in the long term most cell phones will integrate satellite capability in them.
- Indirect economic benefits to providers of GNSS-enabled products and services: economic benefits from equipment sales and value-added services in the satellite navigation market do not count as direct revenues for the project. Besides, impact of any European action in this field in the global GNSS market; both in global figures and in the share of the European firms within it, must be considered, as follows;

  1 – How Galileo will enlarge the GNSS market, considering that together with GPS, they will provide a more accurate and reliable service. Accordingly, forecasts suggest that this combination will boost the penetration rate of these technologies.

  2 – How Galileo will increase the share of the European firms in this market.

  In addition, the negative impact of potential substitute technologies in the GNSS market must also be considered in a proper market analysis.
- Economic benefits to the overall economy (macroeconomic benefits): Global market shares, global competitiveness of all segments of the value chain. Employment potential (estimated as 100,000 people by 2025). Cost savings and efficiency gains in economic sectors such as agriculture, fisheries, and transport.
- Social benefits: There are aspects of Galileo as public good that benefit society though they do not accrue to a specific producer or user. Improved safety of transport systems and search-and-rescue services. Environmental benefits (reduced road congestion, shorter and more direct routes reducing fuel consumption).

<u>The private financing decision</u>

For the PPP approach to be feasible for a project, the public authority should undertake a feasibility study identifying the project objectives, alternative forms, benefits and costs estimates. At a political level, it was highlighted that financing would have to be predominantly provided by the private sector. Therefore, analysts should assess carefully the convenience of this approach. PPPs can generate substantial benefits for customers and taxpayers. However the scope of potential benefits will depend on the type of project being undertaken and the exact terms of the contract governing the PPP. In essence, the value for money (VfM) of a project is improved if a risk is transferred to the private sector, as long as the private sector is in better position to manage that risk. Otherwise, the VfM will be reduced. Therefore one of the main questions analysts should face is the structure of the optimal risk-sharing contract is most convenient, especially in cases in where there is such substantial exogenous demand risk.

The policy debate often emphasizes that PPPs have the desirable benefit of putting capital expenditure outside government budgets. This might have been the leading principle of the Council to justify their willingness to advocate for private participation. However, even if the impact on current budget balances of PPP schemes is most likely to be smaller compared with the alternative of pure public procurement, the long-term impact of PPPs on public finances is to be assessed carefully.

Even assuming that competitive tenders for the selection of private actor are feasible and efficient, a PPP scheme may not be optimal when there are reasons that justify some form public sector of control of the project by the public sector; for instance, due to political strategic reasons. In any case, formulating this policy issue primarily in economic terms (and most specifically on the expected direct revenues that would advocate for private sector involvement) would lead to a situation in which the private sector has a disproportionate influence on the goals of the system, to the detriment of the public objectives. Private sector involvement in the system exploitation would lead to a system intended for the maximization of the direct exploitation revenues in detriment to broader socio-macroeconomic benefits or externalities.

When the project concerns the delivery of pure public goods or when externalities are particularly relevant as in the Galileo case, regulation mechanisms may not be sufficient to ensure that public objectives are satisfactorily met [COM(2003) 283.] It is universally agreed that the public sector has to play a role in the provision of public infrastructure on the grounds that the private sector cannot take account of "externalities" [Yescombe, 2007.] Besides, it might be difficult to raise private capital for large initial investments on which only a very long-term return can be expected, without the public sector support.

Analyst should consider uncertainty

Finally, it is very important that analysts are aware of the fact that large-scale projects have uncertain outcomes [de Neufville and Scholtes, 2006] and take into high consideration the significant sources of uncertainty that are inherent to the Galileo program; changes in national priorities, market fluctuations, technological changes, public pressure, competitors positions, delays, and private sector internal problems associated to the complexity of the special purpose company organization. Managers should not only think about the uncertainty associated to a project's deployment but also about the uncertainty encompassing the long-term commercial value of the system [Scholtes, 2007.] Neglecting demand uncertainty can lead technically brilliant projects to collapse.

The history of the Iridium satellite system provides an example of a successful engineering project that ended up being a disaster commercially, with Iridium having to file for bankruptcy [Scholtes, 2007.] It has been argued by Richard de Neufville [de Neufville, 2006] that this failure could have been avoided if the project planners had built in flexibility to cope with commercial uncertainty.

Another example from which analyst can learn some lessons is the case of the earth observation satellites. Already in 1992, the European Commission [COM(92) 360] acknowledged a growing demand for space data for the implementation of public policy in many areas, and identified the increasing commercial value of the information obtained by earth observation satellites. Some years later, the public sector remained as the major consumer and driver in the market for these applications, and the commercial sector had not taken off, which increased the risk that the demand for this information would not be met. Likewise, the use of satellite navigation data for public regulated services (PRS) is foreseen to represent one third of the market revenues, however it is still uncertain. In addition, even if Europe had become a leading supplier of earth observation data, its capability for converting this data into operationally useful information had been inadequate. Analysts should be aware of the fate of the Galileo predecessors, and be prudent on their predictions.

Analyst's methodologies

- Cost Benefits Analysis (CBAs) should not be restricted to basic direct income and expenditure figures. It should include its indirect effects; wider economic and social benefits or costs (namely, "externalities"), which may be difficult to quantify in monetary terms. Furthermore, it must be strongly accounted that some of the main benefits of GNSS are political rather than economic. The use of CBAs raises key questions to answer such as; how can we price the priceless?, how much is European independency worth in euros? and European security? how can we quantify the social surplus? Besides, a key element of the CBA is the discount rate used to future costs and benefits. If high, it may undervalue the future benefits in the long-term and discourage public investment. [Yescombe, 2007.] Nevertheless, it is important to give particular emphasis to the fact that even if the overall benefits obtained by means for the CBA account for the economic desirability of Galileo, they not necessarily do for its financial viability, which is strictly related to the direct revenues derived from the commercial sales to all worldwide users.

- Business plans[31] play a key role in identifying opportunities (as different direct revenue mechanisms) and provide a guideline for decision-makers to be specific about what new technology ventures intend to do and hope to accomplish. They are effective tools for the description and dissemination of business opportunities and should be the final deliverable of the evaluation process [Mikati, 2009.] However, large-scale projects that install systems with a long operating horizon are more subject to uncertainty and risk than other types of undertakings [Scholtes, 2007.] The expected revenues of Galileo will depend on the evolution of the program, as well as on the competitors' evolution with respect to the Galileo Program. Therefore, there is no single optimal plan, but a set of multiple optimal paths conditional on the ways this uncertainty is resolved. As such, the methodologies used for this analysis should be dynamic, considering uncertainties and basing decisions on how best to take action according to each outcome. Hence, adapting the path to follow. Accordingly, dynamic business plans that allow identify critical uncertainties and incorporate flexibility are more convenient than the traditional static ones [Mikati, 2009.]

- Risk assessment techniques define key risk factors of the project ("risk mapping") and their input in the outcome of the project. Risk management tools must be used along the policy-making process to consider these risks and to incorporate the appropriate strategies for coping with them [de Neufville, 2003b.] Technical and business complexity of the program is a key differentiator since it indicates the risks that are intrinsic to it. Analyst should perform an evaluation of the risks of the project in technical, market and political terms, in order to evaluate the risk transfer and most effective risk allocation between public and private sectors, if the PPP route is adopted.

    - Technical risks are a function of the existence of experience in earlier similar projects. Europe cannot rely on prior experience in designing, deploying and operating a satellite navigation system beyond EGNOS, which in any case lag far behind critical technologies that are necessary for Galileo. This technology jump implies a risk.

    - Market/revenues risks are associated with a market underperformance and/or loss of exploitation revenues product of a late time-to-market originated by the deployment delays. They are a function of competition, regulatory support, commercial viability and the volatility of the market. Rational policies for the effective development of large-scale engineering projects, must acknowledge the risk and uncertainties associated with any forecast about the future performance and acceptance of any technology given the inherent uncertainties of markets and competition [de Neufville, 2003b.] Galileo's markets risks sources come from the both governmental and mass-market products and services. Analysts must be prudent and avoid relying on best guesses about the project evolution, treating those guesses as facts, as for example the expected revenues. There are many features and conditions (both inherent and external to the project) that are uncertain and have a major impact in the success of a project. These uncertainties have a remarkable impact in the expectations envisaged by simple models. Besides, other risks should be taken into account, such as those associated with the third party liability against potential lawsuits for damages that Galileo users may bring to the owner of the system. This introduces the risk of potential claims payouts to exceed the levels of insurability, caused by either an insufficient market capacity or the lack of control over jurisdiction of claims. This is a problematical issue of Galileo that is not faced by its GPS and GLONASS counterparts.

Identify the alternatives

As in other any infrastructure project, Galileo planning was structured in phases. The financial schemes of these phases needed to be decided. The early times of Galileo had been funded by the EC and ESA on a 50%-50% basis. The development and IOV phase was agreed to continue being funded by public sources.

In this sense, several alternatives for this public procurement could have been studied:

1. Funding coming by the EC and ESA, on a 50%-50% basis, as in the definition phase.
2. Funding mainly coming from the EC, delegating the management of the program and the awarding of contracts to ESA, under a delegation agreement, making sure that EC public procurement regulations prevail.
3. Funding mainly coming from the EC, with a participation of the Member States.

As for the deployment and operation phases, the main decision was whether to keep on following a public procurement scheme, or get the private sector involved in the financial aspects.

In a typical public procurement (known as "design-bid-build") the public sector sets up the specifications and design of the infrastructure, calls for bids and pays for the deployment of the infrastructure by the private sector contractor. The public sector is in charge of cost overruns, operation and maintenance of the infrastructure. Private sector takes no responsibility for the long-term performance of the infrastructure beyond the warranty period.

There was a political mandate that they were better financed under a PPP scheme. However, a public procurement scheme should have been evaluated, specially considering that this had been the financial formula undertaken by the US for the GPS. A public sector comparator[32] would have provided the basis for judging the attractiveness of any PPP scheme. Supposing that the public sector decided that a certain project is economically justified, the VfM and the public-sector comparator help the public sector to evaluate whether it is convenient doing so via a PPP, and under which conditions [Yescombe, 2007]

Two potential strategies were identified as for the structure of a PPP, leading to different governance scenarios and private participation at different levels;

[32] An estimate of what the project would cost if traditional procurement methods were used. It is used to help determine whether private finance offers better value for money than traditional procurement.

1. Joint Venture: The public and private sectors would jointly invest in a single entity. A joint venture model is a coherent way of meeting most of the public sector's objectives. However, developing a project through a joint venture adds a further layer of complexity to the process. Generally, industry is concerned about potential conflict of interest with the public sector if they are both equity investors [Yescombe, 2007.] Figure 7 shows the structure of a Galileo Operating Company as a joint venture.

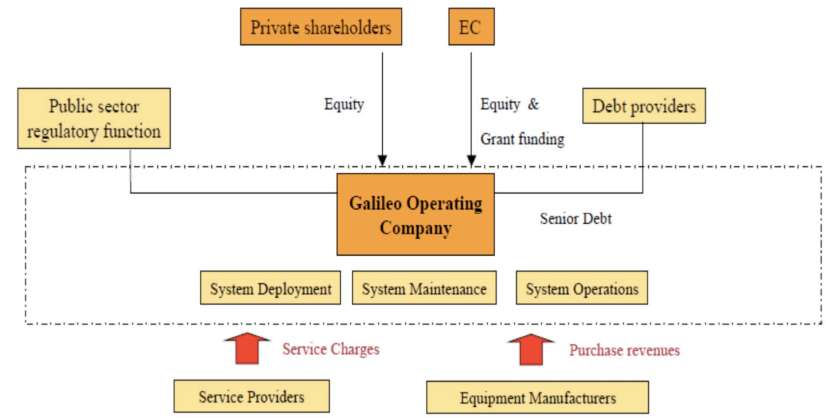

Figure 7: Joint venture financial structure.

2. Concession model: As the one introduced in Chapter 5, Figure 8 depicts the typical structure of a Concession, including the relationship between public owner and the Special Purpose Company (SPC).

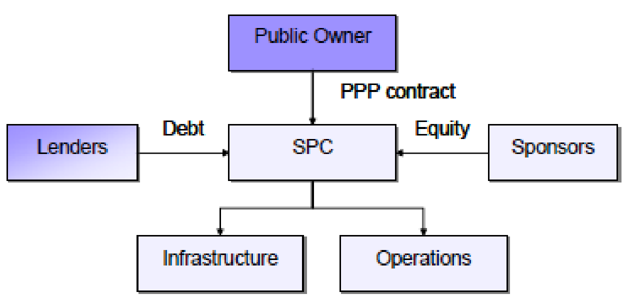

Figure 8: Concession financial structure.

7.1.4. Definition of options and means

A cost benefit analysis carried out in 2000 for the EC showed Galileo to be profitable and sufficiently attractive to make public financing unnecessary after 2007 [SEC(2000) 2140.] It estimated a strong positive IRR of around 75% including the full range of economic and social benefits. This high IRR, combined with a strong set of strategic and political benefits, was regarded a compelling case for public sector investment.

An independent business plan study [PWC, 2001] for the deployment and operation phase was produced by a consortium led by PWC as financial advisers in 2001. This study identified substantial markets for Galileo across a range of sectors and estimated an overall benefit cost ratio for the operator at 4.6. The operator was expected to achieve positive cash flow, and therefore to start making operating profits, in 2011; all these estimates used conservatory assumptions (worst case scenario). This means that initial public sector funding would be needed for CAPEX on the deployment/operation phases.

As for the technical issues, ESA created the “Galileo Project Office” within its navigation department, to manage all technical matters associated to the development of the ground and space infrastructure, and to interface with industry.

A Galileo “Frequency Task Force” was established by the EC to work on a frequency plan to make Galileo compatible and interoperable with GPS, for which a negotiating committee was in charge of the negotiations with the US. Likewise, a “system security board” was created to deal with security issues associated with the project. Finally, a “Private Public Partnership Task Force” was in charge of all aspects regarding the PPP decision.

It was decided that funding was to be obtained by ESA and the EC on a 50%-50% basis. Feasibility studies and demonstration projects were eligible for financial aid under the TEN [COM(2000) 750], as a part of the EU budget agreed for the financial perspective 2001-2006. Besides, grants of risk-capital participation for investment funds were allocated under TEN budget, and European Investment Bank (EIB) loans provided interest-rate subsidies.

Likewise, co-operation with third countries may allow sharing of the costs. The aim would be for the project to be self-financed by the operational phase. This fact was considered much more an assumption than a possibility. No analysis was performed considering a more traditional financing model through conventional public works contracts.

Figure 9 depicts the revenue mechanisms that were conceived in 2003 for the Galileo operator, in which revenues were mainly to be obtained via royalties from chip manufactures (at user level) and access fees from the service providers (services level), which originally comes from what they charge to end users.

Besides, the public services was to obtain extra revenues from taxes. VAT[33] due to Galileo was calculated by applying the average EU VAT (around 20%) to the estimate of the gross market revenue of Galileo derived from products and services [SEC(2000) 2140.]

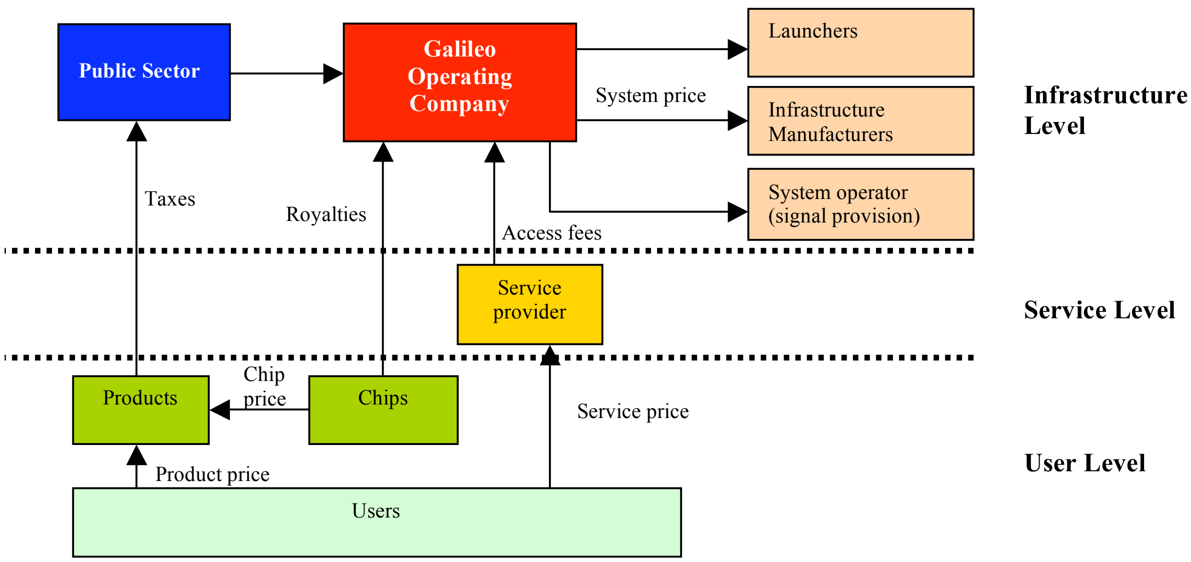

Figure 9: Revenue streams among the infrastructure, service and user levels.

7.1.5. Cast of characters

The European Council summits in Cologne in 1999 and in Feira and Nice in 2000 emphasized the strategic importance of Galileo, as well as the need for a decision on the continuation of the program after the end of the definition phase in December 2000. The need for largely private backing of the system was again stressed. The transport ministers faced pressure from several sides: from the EC and ESA, which had planned on opening a new era of increased collaboration in space activities; from the European Parliament, which endorsed the program as one more measure of European unity and integration, from industry (including European aerospace firms, equipment manufacturers, and service providers), which saw Galileo as providing equity with the United States in GNSS competition, and from specific nations — above all, France — which claimed that not having control over a critical GNSS infrastructure would undermine European sovereignty, security, and autonomy in the future.

June 2001, a speaker of the Committee on Budgets of the Committee on Regional Policy, Transport and Tourism, supported the Commission approach but evinced his doubts about the economic feasibility of the project. He stated that the project could not be based on uncertain financial plans, like PPPs, which might not become a reality as the Commission envisaged. Furthermore, he pointed out that Galileo might have a higher impact on the general budget than initially foreseen. In November 2001, this Committee added that

[33] Value added or sales tax (VAT) is taxation levied on the value of goods and services sold by firms (a more realistic

seven years before the system comes into operation, it was "not essential to call for significant financial contributions from industry" yet. The Committee was also concerned about competition law aspects if participating firms are granted a preferential position in the future operation [Langenhagen report, 2001.]

The Belgian Presidency (July-December 2001) strongly supported the Galileo project, but others feared the high costs. The British refused to commit because they were concerned that private sector partners had been slow in pledging funds.

Internationally, the advent of Galileo created a new competitive scenario between GPS, Galileo and GLONASS (among others to come) in terms of commercial aspects and political influence [Ashkenazi, 2005.] Under the influence of Europe's efforts to develop its own satellite navigation system, on 1 May 2000 the United States unexpectedly improved the accuracy of the GPS by switching off "selective availability"[34]. This coincided with the official opening of the Galileo Program Office on 4 May 2000 in Brussels and the GNSS-2000 Conference in Edinburgh. Still, there was no guarantee for this situation to last. Furthermore, the absence of a legal framework for civilian use of the systems remained, thus services were not available with sufficient guarantees. In other words, the GPS operators took no responsibility for the use of their system by non-military users 'at their own risk'.

The unfortunate September 11, 2001 terrorist attacks in the US reinforced the concerns about the vulnerability of critical infrastructure dependent on GPS. American policy-makers realized this was not simply a US problem, but a global one, for which they would welcome the advent of Galileo under some conditions. Besides, satisfying the future demand for substantially expanded real-time positioning would require considerable investment for the US. Consequently, in this context Galileo was welcomed by the US. Nevertheless, US worried that the Galileo signals would interfere the GPS ones, since both systems were to operate on overlapping frequency bands. Negotiations with this respect were required.

December 2004, the President of the US authorized the new Presidential GPS Policy. The policy recognized that "commercial and civil applications of the Global Positioning System had continued to multiply and their importance had increased significantly". Besides, it stated "services dependent on GPS information were then an engine for economic growth, enhancing economic development, and improving safety of life." The U.S. GPS industry welcomed this new GPS policy as an evidence of the governmental full support to sustainable long-term growth of navigation-related economy. The obvious recognition of commercial, civil and scientific applications is further materialized by the formal involvement of civil government bodies, in an area that has previously been the predominant responsibility of the U.S. Air Force. In addition, the US Government planned to improve the GPS service for the civil community and

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calculation applies only to those sold to citizens).

[34] "Selective availability" designates a system, which gives the GPS position data a higher margin of error at the level of the receiver, i.e. artificially raises the level of inaccuracy. Position data accuracy can be affected by as much as 100

launched the GPS III modernization program, aimed at meeting the stated Presidential goal of establishing GPS as a world standard. The system's evolution continued being governed primarily by US defense requirements.

Similarly, the Russian GLONASS system also planned an extensive modernization program, launching new satellites to supplement and replenish the system constellation. Furthermore, Russia prepared a new generation of satellites, to be launched over a period of several years, starting in 2008 [Ashkenazi, 2005.]

7.2. Policy formulation

Considering that private sector involvement is the key for commercial orientation with a view to the generation of revenues and efficient management, studies recommended a "concession" scheme as PPP model, similar to a DBFO in which the private sector recovers costs from fees obtained from the chip manufacturers, user charges and/or availability payments[35]. The Galileo business model anticipates generating revenues from fee-based services. The rational of this business case is that users will be willing to pay for superior services beyond the basic services provided by the free signals. Studies emphasize that Galileo it is very important that operations start by 2008 to make this happen. In addition, he Commission has suggested that it was going to be necessary to provide some "exceptional public financing" during the first years of the commercial operating phase, as the market develops.

7.2.1. Definition of strategy

EC proposed a detailed financing, organization, R&D, and implementation plan for Galileo in November 2000 [COM(2000) 750], as a result of its findings during the definition phase, during which the system was designed and its elements determined, and called for rapid decisions to be taken by the Transport Council of December 2000.

Three other phases were formally defined for the undertaking of the project after the initial "definition phase"; a "development and in-orbit validation phase" (IOV), a "deployment phase", and a "commercial operational phase", to be carried out as follows:

1. The development and IOV phase, which encompassed the launch of two experimental satellites, to be followed by the launch of a "mini-constellation" of four fully-fledged Galileo satellites, allowing the in-orbit testing of the system. This phase was to be accomplished between 2001 and 2005.

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meters. The reason for the introduction of 'selective availability' was the American military's fear of use by enemy forces.

[35] In the case of availability payments, the private sector would receive payments according to the availability of the service provided, regardless of the level of use. Availability payments would be the most suitable paying mechanism because this would guarantee a minimum return to the private sector while still providing incentives for performance.

2. The deployment phase (2006-2007), which involved the establishment of all the space and ground-based infrastructures and its operations associated. It includes the building and launch of the remaining twenty-six satellites and the construction of the ground infrastructure. At the end of this phase the system should have achieved its Full Operational Capability (FOC).

3. The commercial operations phase, to involve the exploitation of the system; including the infrastructure management, maintenance and operation activities, and the constant improvement and renewal of the system. The Commission's assumption was that the system would be fully operational in 2008

At the Nice European Council of Heads of State in December 2000, it was finally agreed that the financing of the development and validation phase should be jointly financed by the EC and ESA, which was appointed as the "design authority" for the development of the space and ground segments. As for the deployment and operation phases, the Council decided they should be carried out as a PPP. Consequently, both the public and the private sectors were to finance the "deployment phase" and "commercial operational phase" in the framework of a public private partnership.

Subsequently, the EU Council of Transport Ministers adopted the Commission proposal in April 2001 and agreed to make some funding available for the start of the program. However, the Council requested further studies to be developed as for the business plan of Galileo.

It was not until March 2002 that Galileo was definitively approved by the Council of Transport Ministers and became an official program at EU level, and the development and validation phase was launched. The rest of the funding for this phase was made available, matching that already committed by ESA. It was more than one year past the original decision deadline in December 2000. This delay was caused mainly by differences over financing, the Galileo business case and services, management structure and policies. In addition, discussions among ESA Member States on their industrial participation delayed ESA's endorsement to the Galileo program until May 2003, when finally, the Galileo infrastructure was authorized for construction. This was more than two years later than it was planned. This delay was mainly due to disagreements between the governments of the Member States on the distribution of the industrial contracts to be awarded.

Concerning the management structures, a provisional, coordinated management structure involving the Commission and the European Space Agency was created in 2001, to be followed by a definitive single management and financing structure gathering ESA and the EC. For procedural reasons, a Joint Undertaking solution was retained, under the auspices of Article 171 of the Treaty of Amsterdam. In May 2002, the Council authorized the establishment of this Joint Undertaking (named as Galileo Joint Undertaking, or GJU) was authorized in May 2002, to be in charge of the management and financial aspects of the program between 2002 and 2005. An analysis of this procurement strategy, as well as a description and analysis of those envisaged for the rest of the project phases is assessed separately in Chapter 8.

Figure 10 depicts the planning for the implementation of Galileo, as envisaged in March 2002:

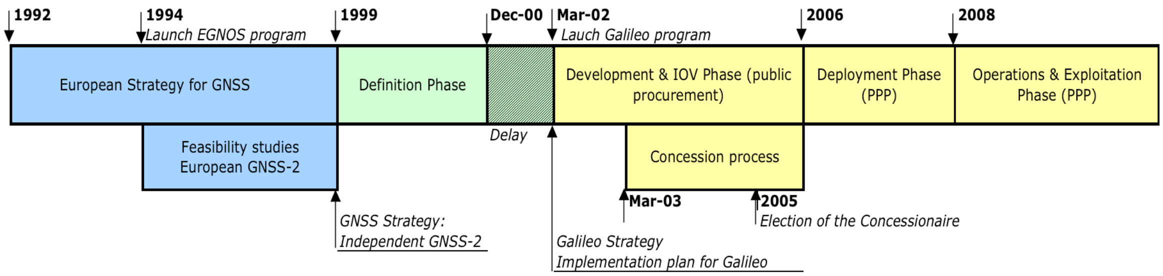

Figure 10: Timeline for Galileo implementation (as envisaged in March 2002).

7.2.2. Identification and evaluation of impediments

Note that management structures and procurement are covered in chapter 8.

- **European Space Agency and European Commission co-operation raises several concerns.**
  - There is not a long cooperation relationship between ESA and the EC on large space programs. ESA and the EC (on behalf of the EU) are working together for the first time to lead a major program.
  - Total membership of the EU and ESA is more than 20 nations (varying over time). Some do not belong to both. More are expected to join in the future. They all have to come into terms.
  - The cooperation between EU and ESA is hindered by ESA's "*juste retour*" principle (fair return of benefits to the Member States, in relation to their financial contribution to the project). Thanks of this procurement policy, ESA has allowed the creation of a distributed industrial and technological capability in Europe; however it does not always encourage evolution towards more efficient industrial structures. ESA's funding represents 50% of the total funding. Consequently, the "fair return" drawback would only affect half of the budget, in theory. In practice it is not possible to apply such rules to 50% of an activity that is managed as being one and indivisible, and the "fair return" will affect the whole budget.
  - Besides, satellite navigation displays a great degree of common ground between civil and military applications. Regarding a potential dual civil/military use of Galileo, any future

change in the European policies would interfere with ESA's regulations that exclude the Agency from engaging in any military activity. This hinderance would frustrate the synergy between civil and defense technologies to be exploited in a future. In particular, we refer to the "spin-in" effect [COM(96) 10] that consists on the defense-related industry making use of the technologies, components and products of civil origin (other way around of the "spin-off" effect from defense activities to civilian externalities). This way, the defense industry benefits from the technological dynamism of the civil sector.

Countermeasure: Weak governance or procurement strategies could be a source of further delays and costs overruns. If ESA is to manage procurement, the EU should formalize the contractual relationship as soon as possible with ESA towards the establishment of a European Space Policy. Evaluate other procurement schemes that would allow EU procurement rules to prevail.

- **Lack of European cohesion**

  In 2002, Loyola de Palacio, European Transport and Energy Commissioner, admitted that Europe was "lacking a decision by the Governments of the European Union" and acknowledged that the urgent need to begin dialogue with the U.S. on this issue had "highlighted Europe's lack of coherent policy and an effective decision making structure."

- **Multinational cooperation**

  Experience has shown that large-scale projects that involve different national budgets, as the Airbus 380 in Europe, are prone to opportunistic national interests, internal conflicts of interests, and competitive maneuvers within nations, in which political dimension prevailed over the commercial and even technical considerations. Galileo involves different national budget authorities, and it is difficult to make a single interest that gathers Europe as a whole to prevail. This fact juxtaposes with the common approach that the U.S. has for the development of its satellite navigation systems.

- **Matching users' needs**

  The first issue of the mission requirements (High Level Mission Definition, HLD[36]) was distributed to user groups and Member States for discussion twice within 2001. It was aimed at identifying the services to be offered, establishing their technical characteristics and required performance (quality) in order to match the user needs. The consolidated version was published in September 2002. Still, the risk of failing when matching user's needs with services and system

[36] The HLD also contained a description of the infrastructure at high level and the program planning. At ESA level, the HLD was linked to the Galileo mission requirements documents (MRD), Service Interface Control Documents (ICD), and other security-related requirements documents.

architecture remained. In this respect, in view of the fact that the main economic impact of Galileo is to be expected from the user segment, the space and ground segments need to be developed according to the user community needs. However, the only available client involved in the development phase was the European Space Agency, which represents the space systems supply sector, not the users sector.

The Eurotunnel project[37] serves as an example of a project whose client was composed of the engineering companies who were contracted to build the infrastructure. Sir Alistair Morton, Chairman of Eurotunnel, stated that the greatest mistake made in that program was "not to have a real client." In fact, the client should have been an organization, which had been motivated by making a success of the operation of the Tunnel, instead of from a deployment perspective.

Countermeasure: In order to create services that meet the perceived needs of the users, the European governments must ensure that a suitable user-oriented organization is identified and/or created in time ensuring that the specifications of the system (that led from the requirements previously established) are appropriate. Besides, when involving private sector in the Galileo program, the public sector should ensure that system operators and service provider companies are appropriately represented, and that not only system suppliers are represented in private sector.

- **Project funding for the coming phases is not assured**

  GPS enjoys a distinct advantage over Galileo in term of project finance [Ashkenazy, 2005.] It is fully funded by the Department of Defense, whereas Galileo's PPP is still to be defined and fleshed out. However, Galileo's funding lacks of a long-term commitment from the European Institutions. In addition to identifying this impediment, the Parliament showed its concerns regarding the economic viability of the project, surrounded by a great deal of financial uncertainty in view of the lack of commitment expressed by the private sector so far. The main leaders of the European industry disregarded the EC call to assure the private investment. In addition, the costs evaluated are prone to rise, for different reasons. In particular, they were based on a preliminary Galileo system architecture baseline and its operational concept, which wers still being developed and most probably were to experience significant changes. Actually, the (completed) definition phase total cost was €133 million[38] – €50.5 million more than the cost initially estimated in 2000, resulting in an increase of 61% in costs.

  Countermeasure: Lack of commitment and details on the future budgets from the public sector inhibits the private sector to engage in investment. A firm expression of financial endorsement

[37] UK, 1996 – 90-year DBFO concession.

[38] The costs listed here are very rough estimates and should be treated with caution. The estimates are calculated on different bases (in some cases a 2000 cost base, and in others a 2007 cost base). The figures are also taken from several

from the public sector would alleviate these concerns. Besides, a margin of error in the costs estimate should be taken into account when defining the financing needs of the project.

- **Uncertainty has not been properly addressed nor modeled in the analysis**

  Investments in technology are characterized by considerable uncertainty concerning the degree of success in the development of this technology (technical risks), the extent of commercialization, the behavior of the demand and competitors (market risks), a changing political and industrial environment (political and industrial risks), and costs increments [Mikati, 2009.] Thus we arrive at an important question: how enlightening are in reality the detailed analysis performed, when we know that the outcome of the Galileo project is uncertain in so many ways?

  The DCF method used is conceptually straightforward, though imperfect because it considers neither the intrinsic and extrinsic uncertainties of the project, nor the ability of the policy-makers to respond to them, even if they incorporate a reasonable degree of flexibility [Mikati, 2009.]

  Countermeasure: Being Galileo said to be the flagship of European innovation, innovative business and strategy tools should be employed, rather than the old-fashioned management ones. Besides, there is a need to update the revenue predictions often, so that at any particular decision point, policy-makers can base their judgments on realistic and up-to-date data, even if considering that these cannot be taken as facts. Besides, an early clarification of the PRS use from governmental authorities will help decrease the degree of uncertainty that still surrounds one third of its expected revenues.

- **Impediments for the Safety of Life service certification**

  In addition to the technical risks the development of this innovative technology poses, Galileo's Safety of Life service will need to be certified by appropriate bodies (such as ICAO) in order to be used for safety-related applications. There is a risk associated to this certification, which may arrive late. A satisfactory resolution of the certification activities is critical so that Galileo is available in time to be competitive.

- **Other risks: Third party liability and un-insurability**

  On the top of the market, technical and political risks that Galileo faces, there are risks associated with service guarantees (third party liability) and un-insurability risks associated to an insufficient insurance market capacity or a conscious strategy to rely on own resources rather than insurance.

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different sources, and it is therefore possible that some figures will contain small overlaps, i.e. where a cost is included in more than one cost estimate.

These risks will probably pose of the largest complications for any future negotiation with private partners for the exploitation and commercial phase.

- **Fee on receivers**

The EC proposed a levy to be introduced throughout the EU and applicable to all receivers sold or imported into the EU. This strategy, though it generates significant revenues, may hinder the introduction of Galileo in the chips in a market in which GPS chipsets are becoming a commodity, as shown in Figure 11.

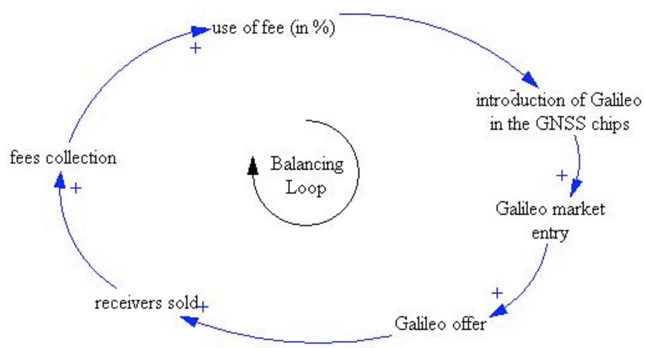

Figure 11: Negative effect of the fees on the Galileo market entry.

Countermeasure: The convenience of the fee on the receivers should be questioned in the Galileo revenue's model.

- **Interoperability and compatibility with GPS not to be achieved**

A marketplace certainty is that almost all user equipment would be integrated GPS/Galileo receivers [Gibbons, 2001.] The marginal cost of incorporating both systems in one chip would be negligible compared with the added value. Galileo, therefore, must achieve interoperability and compatibility with GPS (as well as with GLONASS). This poses a risk if negotiations with the United States do not progress accordingly. Beyond signal compatibility, these negotiations will also cover World Trade Organization (WTO) competitive issues.

Countermeasure: The "Signal Task Force" was created in order to work for the interoperability and compatibility between Galileo and existing GNSSs. In fact, in 2002, the Council of Transport Ministers stressed the need to negotiate a EU-US agreement as soon as possible. Later on, in 2006, the United Nations created the International GNSS Committee (IGC) as the place for coordination regarding interoperability and compatibility in a multi-constellation word.

- **Signal structure and frequency plan**

  As far as Galileo's signal structure and frequency plan is concerned, the coordination of frequency spectrum access at international level was successfully done at the WRC 2000. However, Europe must seek confirmation of this frequency spectrum to; 1) ensure that it has the flexibility needed for Galileo to provide all the planned services, and 2) allow downstream manufacturers to develop Galileo-enabled products on time.

  Countermeasure: Europe should place special emphasis on the confirmation and release of its frequency plan. The award of contracts for the research and development of receivers that incorporate Galileo signals should become a priority; it will smooth the way for manufacturers to the implement the Galileo capability in their products on time. Finally, Europe needed to launch the first satellites[39] before the deadline set up in these international negotiations in order to ensure that the spectrum awarded is not missed.

- **Project schedule risk**

  Schedule risk is defined as uncertainty in the project completion, and the subsequent impact on costs and benefits. Delays may increase costs and result in delivery of systems too late to have the desired effect (thus reducing benefits). In particular, further delay in developing Galileo would have serious consequences for the notified time window[40] of 2008. Timeline for Galileo completion was too ambitious and not very realistic.

  Countermeasures: The thoroughness of the Galileo project approach and plan should be properly evaluated. Besides, plans should incorporate risk mitigation techniques, and consider the impact of not meeting the project's anticipated timeline.

7.2.3. Impediments associated to the adoption of a PPP route

The PPP route cannot be considered a miracle solution. For each project, it is necessary to assess whether the PPP option offers real value added compared with the public procurement route [COM(2003) 283.] The use of PPPs as endorsed by the Council for Galileo raises several concerns; PPPs are unfamiliar matters for many in European-level governments even if they are being pressed by Europe's finance ministries in order to increase the value for – taxpayers' – money. Despite the effort the EC has spent encouraging PPPs, progress in their implementation have not been particularly good, probably because most European institutions have better experience at budget management than value management.

[39] Fist Galileo experimental satellite (GIOVE-A) was launched in December 2005.
[40] Linked to the plans to update the GPS (GPS II), and for the industry.

There are considerable obstacles to implementation of PPPs for particular projects in Europe. Specifically, regulatory and administrative procedures in the public sector are still ill suited to their use, thus diminishing the prospects off attracting private sector participation. Besides, other particularities of the Galileo project question the convenience of a PPP scheme for its financial structure; such as conflict of interest between of public and private goals, the significant socio-economic returns, the multinational profile of the project, and its inherent complexity; as assessed below:

- **Lack of experience and time for preparation**

  Rigorous preparation and planning is needed to ensure that the PPP approach sustainably delivers value for money. However, there was a tight timeframe in the Galileo plans to organize a PPP at such dimension. Besides, the development of PPPs usually involves long and costly negotiations, especially in cases where there is no previous experience. The implementation of PPPs requires a set of skills within the public sector, involving the preparation, conclusion and management of contracts; it requires highly skilled, focused, dedicated and experienced staff on both public and private sides. The lack of expertise in such matters may limit the capacity of the public sector to deliver a good PPP. The European Commission has scarce experience in multinational PPP. Galileo was to be the first PPP ever to be undertaken at EU level. By contrast, previous European experience on PPPs at multinational level, as the rail tunnel beneath the English Channel project, only required bilateral cooperation between France and the UK. Furthermore, PPPs in the space sector show unique features in comparison with other sectors. So far, the only significant PPP/PFI space program to that date was the UK's Skynet, and still, it entailed a national procurement.

  Countermeasure: The development of a specific PPP task force for public authorities would have been very recommendable. Besides, the EIB offered its advice to support investments in the area of TENs, though this valuable resource was not fully exploited.

- **Significant public externalities generated compared to the private benefits**

  It is considered that Galileo will create a lot of value, and enable a huge downstream market in terms of products and services related to satellite navigation, beyond merely the direct exploitation revenues that the concession holder would collect, in terms of access fees to the signals from service providers and royalties from chip manufactures mainly. Furthermore, Galileo generates large indirect, macro-economic revenues and broader public benefits, some of them difficult (if not impossible) to quantify in monetary terms. Direct revenues that justify the PPP approach represent only a tiny portion of the value Galileo will create. As for some other international transport infrastructure projects, research done for the EC has demonstrated that the socio-economic return is greater than previously thought, which would justify a higher public sector investment.

- **Conflicts of interest between the private and private sector as for the aims of the project.**

  As for the concession contract of any PPP scheme, the public sector objectives must be aligned to, or balanced with, private capital objectives. In this case, public and private sectors have different interests and aims. The main interest of the private sector is to maximize the direct revenues, to the detriment of the other political, macroeconomic and social benefits. In addition, the award of a PPP may imply a loss of management control by the public sector that is not convenient for this project.

- **The inconvenience of the Council imposition**

  PPPs cannot be considered as a panacea for all projects. For each case, it is required to assess whether the PPP option presents real added value in comparison with other traditional procurement methods. It is important that the public sector understands that PPP procurement is just one of the several alternatives for procuring the Galileo infrastructure. In case the concession activities do not progress as expected, the public sector must be able to identify any deviation from the original plans and readapt without delay its strategy considering other alternatives. A public sector comparator should be carried out providing a benchmark that would allow evaluating the overall benefit of PPP bids in comparison with the public procurement route. In any case, it would help the public sector to determine its negotiation position when awarding a PPP contract. In the Galileo case, the traditional public procurement alternative was neither adequately considered nor investigated before choosing the PPP option. The EC work mainly focused in the development of a business plan and the choice of the appropriate structure for a PPP, proposing a PPP in form of concession as opposed to a joint venture model.

  In fact, some of the arguments used by the EU for promoting a PPP for Galileo were made *ex-post* to justify a decision that had already been taken for merely budgetary reasons. Decision-makers should question whether these budgetary constraints were created by artificial rules, such as the Maastricht Treaty limitations on budget deficits in the UE, which may have hindered the public-sector investments for large infrastructure projects. PPPs cannot be justified only because they free public funds [Engel et al, 2008.] Besides, the DG for Economic and Financial affaires recalled that it was important to avoid recourse to PPPs where they are solely motivated by a desire to bypass budgetary constraints by putting capital expenditure outside the public budgets [COM(2003) 283.] This could lead to PPP projects, which entail higher overall costs, which would not be in line with the objective of sustainable public finances. Besides, VfM arguments should be of considerable political importance in supporting a PPP program. However, this should not be taken as a fact unless risk transfer to the private sector, such as deployment and market risk transfer, can be properly demonstrated [Yescombe, 2007.]

- **Lack of a clear PPP legal framework**

Of numerous ambiguities surrounding the PPP decision, the lack of any reference to an applicable law and uncertainties as to what rules apply are remarkable.

In 2003, the Commission published the "Guidelines for Successful PPPs", that defined key issues affecting the development of successful PPPs: ensuring fair competition, maximizing the value added to citizens and assessing the most effective type of PPP with relation to a balanced risk and role sharing, and appropriate duration. This document highlighted the need for: rigorous preparation, sustained political and public support, true understanding of the needs and objectives of the parties, and a conductive legal, regulatory and financial framework.

Concessions are legislated in Public Procurement Directives [Burnett, 2005.] In February 2004 a new Directive on the "co-ordination of procedures for the award of public works contracts, public supply contracts and public service contracts" (2004/18/EC[41]), generally applying to PPPs, was published. Still in this directive "works concessions"[42] are less regulated than public works contracts, while "service concessions" remain entirely outside the scope of this Directive and are only subject to the application of the EC Treaty principles. There was no explicit further reference to PPP in this public procurement law, and no other special rules in EU law covering PPP.

Despite the growing interest in PPPs, the term public-private partnership (PPP) was not defined at Community Level. Community law still did not lay down any special rules covering it [COM (2004) 327.]

This new Directive also introduced a procedure to make the awarding of PPPs easier. The "competitive dialogue" (Article 29 or Directive 2004/18/EC) allows the public authorities to open a dialogue with the candidates with the purpose of identifying the technical solution that would best satisfy the public authority needs and objectives. The field of application for the use competitive dialogue is those cases that involve a "particularly complex" market, high technical, legal and financial complexity.

In the absence of specific legislation, in April 2004 the EC published a Green Paper (EU consultative paper) on PPPs and Community Law on Public Contracts and Concessions [COM(2004) 327.] This was aimed to launch a debate over the regulatory issues for PPPs in Europe and ensure their development under conditions of effective competition and legal clarity. Many voices considered that these rules were insufficiently clear and lacked homogeneity between the different Member States, creating a significant degree of uncertainty. In addition, the

[41] Transposed into national law in the EU Member States by the end January 2006.
[42] Granted for building infrastructure or other public facilities.

Community law applicable for the award of concessions is derived primarily from general obligations that involve no coordination of the legislation of Member States. The absence of clear and coordinated rules leads generates legal uncertainty that may particularly hinder the projects organized at transnational level.

The development of a PPP must be undertaken under sound conditions of effective competition and legal clarity. An appropriate legal and financial framework must be created as soon as possible in order to secure the private funding. Financial backing from investors can only be expected when these framework conditions are established. Any delay in this respect would produce delays in the whole program and the inherent market risk would dissuade industry from becoming fully involved in the program.

- **Complexity in Galileo**

  PPPs in complex technology policy projects need to be analyzed very carefully before any decisions on a partnership are reached. One of the disadvantages of using a PPP is the longer time and greater skills required to work out a contract, since it requires greater effort on finding the most effective risk-sharing distribution. Furthermore, financing deals are even more expensive to agree than conventional procurement under uncertainty [Iron, 2002.] The use of a PPP for the Galileo increases the complexity of a project that is already intrinsically complex.

- **Weak industry financial commitment to the PPP scheme**

  No single company has shown the willingness to commit any real funds to the project since the PPP approach was discussed in 1999. In fact, back in 2001, the European Parliament reported that in a public audience organized by the EC at the beginning of that year, the industry warned that they would only invest in the project as long as the public sector provided the infrastructure first. In addition, in 2003, the EC [COM(2003) 132] acknowledged that there were too many unknowns regarding the use of PPPs in TEN projects, for which the private sector would be reluctant to commit to financing them.

In any case, it was not clear whether a Concession scheme from the deployment phase on was the most adequate structure in comparison with another PPP schemes to be implemented after FOC concerning the exploitation and operational phase. Europe has no real need to decide years ahead, which option is more convenient regarding the private sector involvement. A more flexible planning and the deferment of such decision as much as possible would eliminate part of the uncertainty that surrounds the project in that particular time. Decisions are better taken when uncertainty is solved. By making a decision ahead in time, Europe was not making use of its option value.

7.2.4. *Development of a tactical plan and implementation*

The undertaking of the Galileo project was organized according to a "targeted action" launched by the commission in December 2000 under the auspices of the 5th Framework program. This specific action taken by the EC identified the different necessary procedures necessary for implementation (defined by domains such as interoperability, international cooperation, standardization and certification, and legal and regulatory aspects, among others described below. Subsequently, implementation is generally the longest and most arduous part of a policy-making process; this was especially true in the EU because of its federal character. The main aspects included in the Galileo's tactical plan were:

- To formalize the relationship with ESA towards the establishment of a European Space that concluded with the signature of a "framework agreement" for cooperation in space activities in May 2004. Later on, in 2007, twenty-nine European countries signed a European Space Policy in May 2007, creating a common political framework for space activities in Europe (aligning ESA's approach with those of the European Union Member States).

- To launch the public procurement contracts awarding for the development phase, and consequently, for the "in orbit validation" phase. This required defining required response by industry and move toward most acceptable position with industry. It also involved negotiations with the Member States, by means of ESA's PB NAV (Program Board Navigation) meetings. The public sector also had to assure that actions were monitored and enforced, so that all in the industry were to get together and perform as agreed. The implementation of this procurement is assessed in the Chapter 8.

- In parallel, to launch the concession process. Chapter 8 also assesses the implementation of this procurement.

- To establish a management structure for the procurement and operation of Galileo, as Chapter 8 describes.

- To deploy the first operational satellite before February 13, 2006, in order to maintain the frequency allocations granted during the negotiations of the WRC 2000 for Galileo.

- To pursue international negotiations with the US and Russia in order to ensure the appropriate frequencies availability and its interference-free operation, to come into terms as for the commercial trading basis, and solve any dispute over security matters. Finally, the EU and the United States signed an agreement in June 2004 to ensure compatibility between their respective systems, with the intention to create a single international standard for satellite positioning signals. In other words, users will be able to get information from both systems. Besides, a compatibility working group with GLONASS as planned.

- To investigate international cooperation agreements with other third countries, with the purpose to set up the basis for deployment of ground infrastructure (mainly antennas stations) around the world, reinforce the political and industrial expertise, promote Galileo as a standard and stimulate third country market penetration.

- To make contacts with third states in order to develop the interests manifested by these countries to participate in the Galileo system in one form or another. In particular, an initial cooperation agreement was signed with China on 30 October 2003, in which China indicated its readiness to contribute the sum of €200 million to the program (before it revealed its strategy to launch the Compass system). This European-Chinese cooperation alarmed the US. Agreements with Israel and Russia, among others, were signed in 2004 and 2006 respectively.

- Galileo is intended to be a civilian project, but there have been concerns that the PRS could be put to military use. Then it was needed to clarify the defense role of Galileo and the security policies, by means of the establishment of a Galileo Security Board.

- To develop a regulatory framework to stimulate an internal market for Galileo-based products and services. With this respect, regulatory action is a valuable policy tool to promote the emergence of new applications and added-value services. Besides, regulation policy should be undertaken in parallel with the design of the system so that it accommodates the objectives of the policy and *vice versa*. Regulation not only concerns writing the rules to be implemented, but also requires they are enforced.

- To develop a solid legal framework as required considering that certain Galileo services, such as the Safety of Live and Commercial services, will be provided with "service guarantees" of performance, and "liability" clauses from the operator. Accordingly, a regime defining the scope of liability for different applications, that may require different levels of assurance, must be established; as well as the judiciary complaints procedures.

- To work on the certification of the Galileo services. For instance, certification is required in order to use Galileo for safety-related applications. Given the international outreach of satellite navigation systems, the institutional parties, the industry and the certification authorities will need to interact and cooperate efficiently. Regulators also have a role in the licensing of service providers and applications at EU level.

- To review oligopoly, collusion and antitrust legislation, so that it guarantees a faire competition in the procurement process.

Chapter 8

The procurement process

This chapter details how the procurement of the program was accomplished from 2001 to 2007, including a review of the public procurement scheme for the development phase and the activities regarding the negotiations aimed at the signature of a Concession agreement for the subsequent phases. Finally, it provides a evaluation of the failures of these procurement schemes and how they affected the outcome of the Galileo program.

The high-level procurement process consisted of a four-year (2001-2005) development an validation phase, during which the public sector is to be in charge of the award of contracts under public procurement "scheme". After the validation phase, the public sector was to transfer responsibility to the private sector for both the full deployment phase (2006-2007) and the subsequent operations phase (from 2008 on). In parallel, the public sector was to prepare the Galileo Concession competition for these phases accordingly.

This parallel procurement process entailed a complex blend of competition rules, negotiations and collaboration activities. As we will assess, it also resulted in several difficulties that seriously affected the outcome of the procurement; but first we introduce the management structure designed for the procurement.

8.1. Management structures

8.1.1. The role of the Galileo Joint Undertaking (GJU)

The Galileo Joint Undertaking was a joint company between the EC and ESA created to manage the development and validation phase and carry out the procedure for awarding the concession. It operated from September 2003 to the end of 2006. The core of the GJU was the Administrative Board, but the political oversight was maintained by a UE Supervisory Board and by an ESA program board (in this case, the PB-NAV), which incorporated representatives of their respective Member States (making decisions by QMV) [North, 2004.] On the user side, delegates from the EU Member States represented their national transport departments, whereas on the supply side, delegates from ESA Member States represented their national space departments.

ESA and the EC had an equal number of votes on the GJU Administrative Board, requiring a consensus for all decisions. Still, the GJU had no regulatory powers in the field of GNSS, which remained under the EU institutions control.

8.1.2. *The role of the GNSS Supervisory Authority (GSA)*

Control of the Galileo was gradually transferred to the GSA, a semi-autonomous Community agency set up by Regulation 1321/2004 to manage the public interests relating to the European GNSS programs, vis-à-vis its concession holder, and to act as the regulatory authority during the deployment and operational phases of the program. Besides, it was to become the owner of the system.

The GSA acted as the licensing authority in charge of the signature of the concession contract with the Concessionaire elected, upon completion of Galileo's development phase, ensuring that it meets its contractual obligations. The GSA was to be established early in 2005, though this date was deferred until 2007.

8.1.3. *The role of ESA*

ESA developed and validated the technology of the system's core infrastructure during these phases, for which it shared the costs on a 50%-50% basis with the EC.

The distribution of roles and responsibilities before and after the transition from the public sector to the Concessionaire is detailed in the Figure 12.

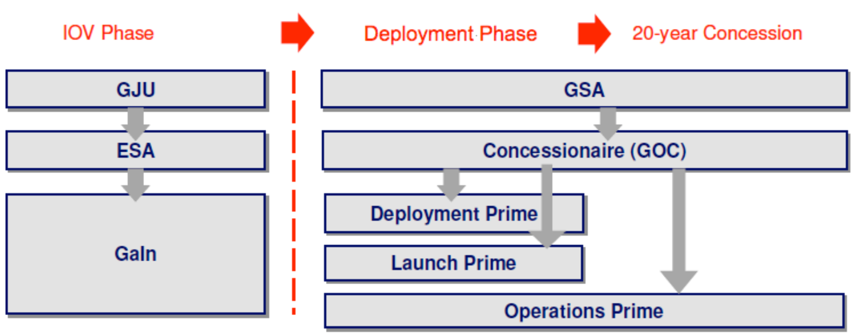

Figure 12: Distribution of roles and responsibilities before and after the transition to the Concessionaire

8.2. Development and validation phase public procurement

In 2000, Galileo Industries[43] (GaIn) was created, as a joint venture of leading European firms, to act as industrial prime for the phases that remained under ESA management. Between 2001 and 2004 ESA placed several contracts with GaIn that suffered from significant delays and costs overruns. As for the IOV phase, the launching of the IOV satellites is critical with regards to the rights to the use of the required frequencies. This launches suffered significant delays.

[43] To avoid punitive damages, GaIn was renamed as European Satellite Navigation Industries (ESNIS) in January 2007.

In June 2006, a Commission Communication [COM(2006) 272] presented an updated timetable for the program, setting the new full operational capability deadline in 2010, two years later than scheduled, as depicted in Figure 13. The conclusion and signature of the concession contract was deferred until 2007, and the Full Operational Capability (FOC) milestone was deferred until 2009-2010.

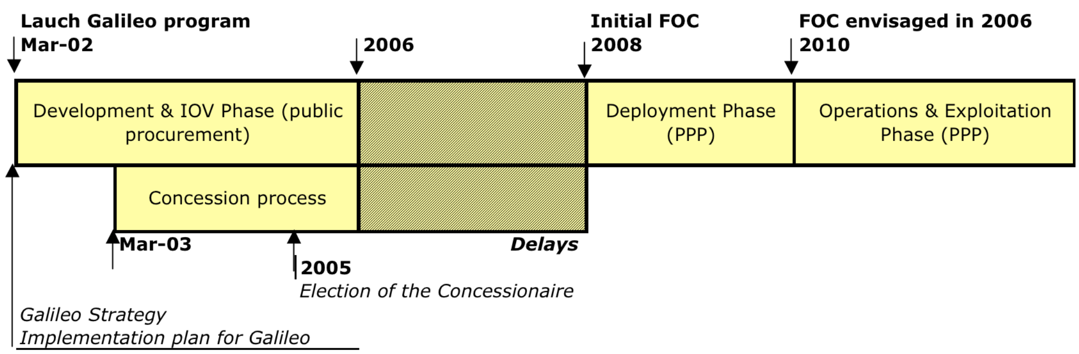

Figure 13: Status of the planning for the development and IOV, deployment, and operation and exploitation phases as for 2006, acknowledging delays and a deferment of the FOC deadline.

8.3. Deployment and operation phases procurement

8.3.1. General premises of the PPP scheme.

The PPP/PFI structure initially adopted for the Galileo project required the private sector to finance, operate, maintain, replenish and exploit the system in exchange for the right to develop market revenues for a specified period of time and to receive availability payments.

The Concession contract entailed awarding a Concessionaire exclusive right to the operation and exploitation of the infrastructure for a period of 20 years, in return for which the Concessionaire bore at least two-thirds of the infrastructure construction costs in the deployment phase. As we introduced before, the infrastructure remained in public ownership via the GSA.

According to this model, the Concessionaire (eventually named the Galileo Operating Company or GOC) awarded three main subcontracts for the deployment and operation phases: system deployment, launches and operations.

In monetary terms, the framework for negotiating the concession contract assumed a two-thirds contribution from the private sector for the €2.1 billion deployment phase and all of the €220 million annual expense of operating and maintaining Galileo. It was adopted a standard 90:10 gearing[44] (Debt/Equity ratio).

[44] The gearing should be driven by the risks, which themselves are driven by the complexity of the project. [Beltran

The key driver was value-for-money for the Public Sector and the party best capable to manage it should retain risk. Unlike other "standard" PPP/PFI projects, the Public Sector was in charge of the design development, after which, an effective risk transfer from Public to Private sector became essential. The concessionaire would raise the money for its share of the work through equity from their members and debt. Thereafter, revenues would come from the concessionaire's control of intellectual property rights associated with the project, and from the two subscription services—the Commercial Service and the PRS.

Figure 14 depicts the main risks allocation in the Concession approach, as envisaged in 2006.

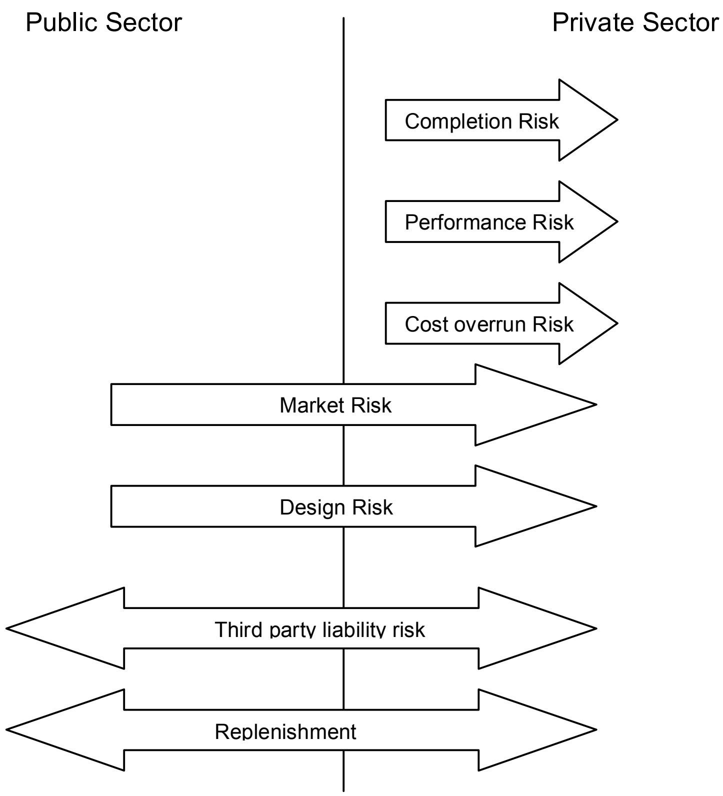

Figure 14: Risk sharing allocation between the public and private sectors for the Galileo Concession.

8.3.2. Competitive process towards a Concessionaire (bid evaluation)

The competitive process to obtain the Galileo concession was ruled by the principles of equal treatment, fairness and transparency. The prevailing principle was to achieve the best value for the public. It started in October 2003, when the GJU launched a "call for tender"[45]. Four consortia answered by the end of 2003, namely; a consortium led by Eutelsat together with Logica CMG, Hispasat, and AENA; a joint bid from Inmarsat Ventures plc, EADS Space Services, and the Thales Group; the Navigator Consortium, headed by OHB Technology AG; and Alcatel along with Finmeccanica and Vinci Concessions.

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and Vidal, 2005.]

Two consortia were selected: Eurely (core members: AENA, Alcatel, Finmeccanica, Hispasat) and iNavSat (core members: EADS Space, Inmarsat, Thales). They included most major European aerospace and satellite companies as a whole. Negotiations then took place with both consortia, leading to the submission of a final bid in January 2005. Consequently, negotiations on the concession contract with these two consortia started in March 2005.

The two consortia expressed their intention to join forces in May 2005 after the GJU was unable to find any significant difference between the two and expressed difficulties in making a choice. The companies said in a joint statement that by combining their efforts they would "significantly reduce the contributions of European taxpayers". An analysis showed that this did not pose difficulties with regard to public procurement and competition rules. Thus, the final two bidders formed the so-called Merged Consortium, founded by eight European aerospace firms, and delivered a joint bid in June 2005 combining the complementary possibilities from both consortia. Seven days later, the GJU chose this joint bid merging the two initial competitors as the Galileo concession holder.

Official press releases stated that the evaluation of this joint proposal showed "substantial improvements" over the separate bids; "an increase in the foreseen commercial revenue (likely to be 20% higher) thanks to a concentration of the know-how of the two bidders" and "a significant reduction in the financial contribution from the public sector", without leading to any delay in the program. Jacques Barrot, EU Commissioner for Transport, was "delighted" with "the significant improvements" of the combined offer, which apparently showed better value for the public, the overriding criterion in the decision-making process.

Two days thereafter the European Union (EU) accepted the Merged Consortium common bid for the 3.2 billion Euros contract to run the Galileo satellite navigation system. The Merged Consortium became responsible for managing the deployment (then expected for 2006-2007) and the operational phase (then expected from 2008 onwards) of Galileo in compliance with contractual terms to be concluded before the end of 2005.

The eight members of the Galileo Concessionaire, which became shareholders on equal basis of the Galileo Operating Company (GOC) were (in alphabetical order); Aena (Spanish), Alcatel Alenia Space (Franco-Italian), EADS (Franco-German), Finmeccanica (Italian), Hispasat (Spanish), Inmarsat (UK-based), Thales Group (French) and the TeleOp group (German).

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[45] The practice of advertising for, then receiving and evaluating offers or bids from different private sector companies to operate the services under the public private finance and concessions deal, with a view to achieving the greatest value for money.

8.3.3. Negotiations with the elected Concessionaire (post-bid evaluation)

Negotiations with the chosen Concessionaire followed the submission of the Joint Tender on June and October 2005. The process first examined risk sharing and other fundamental issues before the implications and financial commitment involved. Nine blocks of risks were identified: cost overrun, construction, performance, design, revenue and markets, deployment, coverage of project risks, compensation in the event of termination of the project, and refinancing. In line with PPP principles, the aim of the negotiation process was to determine the party best suited to bear each of these risks. Financial closure and the signature of the concession contract by the GSA were expected by December 2007. Prior to this, the Commission expected to provide the Council and Parliament with a summary of the risk sharing and the distribution of rights and obligations between both sectors.

However, the concession negotiations between the public and private sectors proved to be more difficult than anyone anticipated. Internal disputes over the share of industrial work among the members of the private Concessionaire burdened the progress of the Concession negotiations, acknowledging its own internal disunity. The expectations regarding the contracted work shares associated to each company collided, leading confrontation among the interests of the respective national flags they represented.

At the end of June 2005, continuing discussions led by Germany concerning the allocation of contracts and responsibilities returning to national industrial companies in regards to the nation's investment in the Galileo program. At the end of this year, the sum of these internal industrial disagreements, complicated by national political interests, needed external mediation. Multi-sided talks by representatives of five governments (France, Germany, United Kingdom, Italy, and Spain) and the eight companies were hold under the mediation of ex-Commissioner Karel van Miert concerning the division of role, work shares, responsibilities and locations of the major ground infrastructure of the system. As a result, the members of the Merged Consortium signed the Karel van Miert agreement in 5 December 2005, which rescued Galileo from a months-long deadlock.

Under this agreement, the key components of the Galileo operations were reallocated among the five leading space nations in Europe as follows (Figure 15);

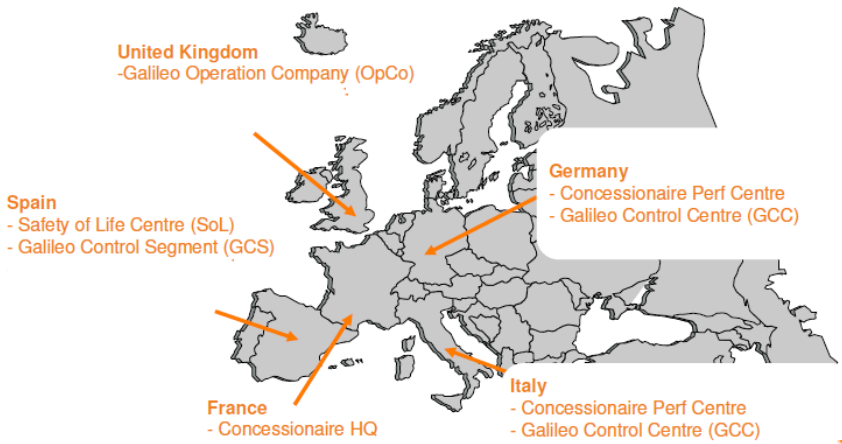

Figure 15: Distribution of main Galileo FOC Ground Infrastructure sites and control entities over Europe, as agreed in the Karel Van Miert Agreement.

- The headquarters of the Galileo Concessionaire (GOC) were located in Toulouse (France), with administrative and market development responsibilities.
- Inmarsat was to have overall management leadership of the operations company (OpCo) based in the United Kingdom and responsible for global network operations, including performance monitoring and operations security.
- The two control centers (for constellation and mission) were to be located in Oberpfaffenhofen (near Munich, in Germany) and in Fucino (near Roma, Italy) along with two performance evaluation centers supporting the concessionaire headquarters.
- Spain was to host backup control centers as well as facilities related to Galileo safety-critical applications (GCS and Safety of Life Center), even if this new ground infrastructure was not originally included in the system design.

Table 1 presents a resume of the Galileo Concessionaire selection process:

Galileo Concessionaire Selection Process	
17.10.2003	Opening of Pre-Selection Tender based on "Mission High Level Definition" (MHLD) and "Mission Requirement Document" (MRD)
05.12.2003	Closing of Pre-Selection. Three of four bids were accepted for competitive bidding
07.05.2004	Opening of Competitive Concession Tender
01.09.2004	iNavSat and EUrely submitted Concession Proposals
10.11.2004	Opening of Extended Tender
25.01.2005	Deadline for Submission of Extended Tender
01.03.2005	Announcement of selection of two preferred bidders and invitation of parallel negotiation.
20.06.2005	Submission of Joint Proposal by iNavSat/Eurely to GJU
27.06.2005	GJU Press Release on "The GJU's evaluation of the joint proposal clearly showed better value for the public, the overriding criterion for the decision-making process. This can only be achieved with the merger, as the joint proposal combines complementarity and possibilities from the two consortia."
21.10.2005	Joint bid Submission of the Merged Consortium to GJU
05.12.2005	Agreement between the partners of the prospective Galileo concession

Table 1: Timeline of the Galileo Concessionaire selection process

However, the Karel van Miert agreement on the industrial shares failed to resolve all the disputes and led to discussions among the members of the Concessionaire regarding the interpretation of its terms.

In particular, the award of the new ground centers to the Spanish companies caused major controversy. Some stakeholders complained that this redundant new infrastructure was unnecessary in terms of technical performance whereas it increased the technical complexity, and incurred unnecessary extra costs and delays. Nevertheless, the Spanish companies defended their legal right to be awarded their share of the pie in compliance with Karel van Miert's agreement, which had been previously signed by all members of the Concessionaire.

Apart from the internal conflicts of the Concessionaire, private and public sectors did not come into terms over the profitability of the project, whose expected revenues were not so promising anymore. Thus the private sector was reluctant to bear the market risk. Beyond economical uncertainty and market risks, there was no agreement on the risk sharing associated with the program at technical level either. Negotiations stalled in March 2007. The way this impediment was overcome is addressed in Chapter 9.

8.4. Failures associated to the procurement strategy

The procurement strategy had considerable effect on the implementation of the PPP.

- **Reduced competition in the development phase**
  - ESA's industrial organization was led by a single prime contractor, GaIn, on questionable competition grounds.
  - The negotiation of ESA with GaIn according to its rules and procurement procedures ("fair return"), at least as for the 50% of the budget of GJU (the one associated to ESA sources), lead to industrial distribution constraints rather than cost and schedule efficiency within the selection of GaIn subcontractors.
- **GJU structure**
  - ESA was both a founding member of the GJU and a "contractor", receiving funding and and responsibilities under ESA/GJU agreement. This conflict of interest within the GJU inhibited the later's ability to supervise ESA effectively. Co-financing affected the public governance, as the financing role of ESA was difficult to reconcile with its role as *maître d'ouvre,* as seen in Figure 16.
  - GJU intended to balance not only the aspirations of EC and ESA, but also those of their respective Member States, the space industry and the user community of satellite navigation; often in conflict.

- Besides, GJU was a new organization, involving a novel legal set-up, newly assembled team, new chief and no past experience in concession negotiations. New institutional working relationships take longer to work out. So do their decisions they take.

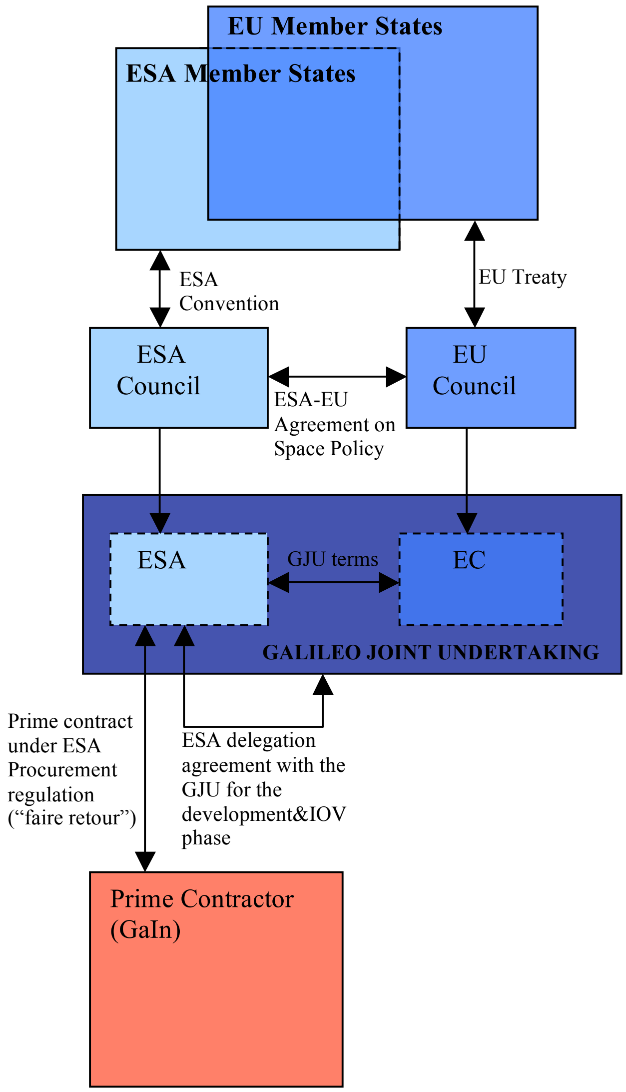

Figure 16: Relationship between the Member States, ESA, EU, the GJU and the prime contractor.

- **Interdependencies associated to the transition path between the development and deployment phases**
    - The concessionaire was composed mainly of the same industrial actors that participated in the development and validation phase, as seen in Figure 17. Therefore they had a visibility on their own performance at the design phase. In economic theory, there is a principal-agent problem when the agent who controls a business has access to more information than the agent who owns it. This asymmetry of information favors the agent, which may obtain an unreasonably large share of the benefits of the business

[Yescombe, 2007.] In this particular case, after having designed the system for a length of time, the industry formed a better idea of its quality than the public sector that owned it. Then, when the public sector negotiated the system transfer to the private sector; the buyers had better knowledge of the quality of the system, and the technical risks associated to its design. In other words, there were differences in the valuation of the system that handicapped the position of the public sector in the evaluation of the bids and the concession negotiations. Besides, this asymmetry will increase in the long-term when the private sector will take charge of the operation of the system, leading to potential excess profits for the private-sector supplier

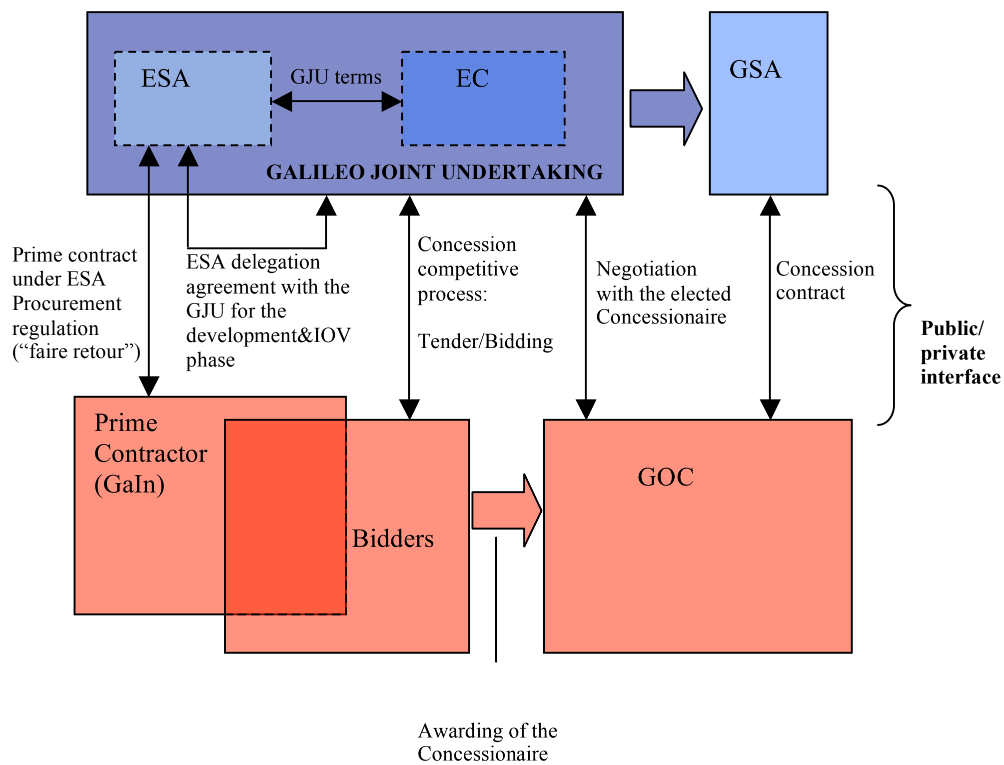

Figure 17: Public-private relationships before and after the awarding of the Concessionaire

- On the other side, concession negotiations took place when the technology had not yet been validated in the IOV phase, leading the bidders to engage a lower-risk approach. Design-bid-build procurement schemes, as this one, have the endemic problem of initial low bids from the private sector being inflated by change orders (DCNs) as the public authority develops any changes in the system. In these cases, the risks of cost overruns and failure to complete the infrastructure are borne by the public sector [Yescombe, 2007.]

- **Competition Concession**

Appropriate, competitive procurement is one of the key conditions for success of a PPP. Once again, competition issues arose in the concession negotiations.

  - As for the public sector, it chose a Concessionaire on rather questionable fair competition grounds, considering that after the merger of the last two candidates, the public sector seemed to be at a disadvantage. Besides, there might have been a tacit collusion in the creation of the Merged Consortium to become the Galileo Concessionaire.
  - At the time the joint bid was evaluated, the regulatory framework at EU level governing the choice of private partners for PPPs was argued to be incomplete, uncertain, lacking clarity and unable to guarantee fair competition. Although public contracts were subject to the detailed rules of the public procurement directives, the award of concessions was mainly governed by the broad principles of the EC Treaty, specifically, transparency, non-discrimination and proportionality, which were unclear. Only a few detailed provisions of secondary Community legislation existed for works concessions, granted for building infrastructure or other public facilities. Therefore, the uncertainty as to what set of rules applied was an obstacle to effective competition in the award of a given Concession.
    The European Commission admitted that fair competition was not guaranteed throughout the Community at that time [COM (2004) 327]. European Commissioner McCreevy stated in November 2005 that fair competition was still not guaranteed, and the choice of private partners for PPPs was incomplete or lacked clarity. Once again, the European Policy Forum (9 November 2005) concluded that the Commissions approach with respect to PPPs was inadequate and suggested to distinguish between PPPs from Member States and those to which the European Union participates itself, for which an European framework is required. Finally, COM(2005)569 recognized that EU Treaty Principles did not provide enough legal certainty as for the award of concessions.
    It was not until November 2005 when the European Commission adopted a Communication[46] on PPPs and Community Law on Public Procurement and Concessions which set out the Commission's views on future policy in order to make public authorities choose their private partners for PPPs on a more competitive basis than was done before that date. Notice this Communication was published months after the election of the Concessionaire.
  - Besides, ESA awarded the IOV contract to a single prime contractor, which enjoyed competitive advantage for the deployment phase competition.

- **Concession financial structure**

  The gearing ratio adopted for the Galileo concession (90:10) appears relatively too high considering the project's complexity in comparison with other PPPs. By default, PPPs are usually characterized by high gearing ratios for projects with limited complexity, and low gearing for very complex projects [Beltran and Vidal, 2005.]

- **Galileo Operation Company composition**

  The members of the Merged Consortium are mostly system suppliers that benefit from the deployment of the infrastructure, whilst a PPP would ideally require a consortium led by service providers and other downstream industries that were underrepresented.

- **Internal GOC conflicts**

  Beyond the blessings of combining efforts that were acknowledged, the actual situation was far less idealistic than it seemed; companies never outlined how they would share control of the project if merged, and it was uncertain whether EADS (the long-time favorite to be lead contractor) would be chosen to play that role. In fact, this merge was prompt by unexpected changes in the European aerospace sector as for the concentration of big companies, which drastically changed the equilibrium between the two bidders Eurely and iNavSat in the last quarter of 2004.

- **Qualified majority voting**

  A number of problems are associated with voting and majority rule. It represents several problems in the attainment of effective negotiation settlements [Yescombe, 2007.] Despite its democratic appeal, it fails to recognize the strength of individual preferences, regardless of how convenient they are. Consequently, QMV does not promote integrative trade-offs among issues. Most specially, within groups that demonstrate "egoistic" motives (in the case of Galileo, as opposed to a common European interest), QMV leads to more distributive and less integrative behavior. Furthermore, it does not eliminate conflicts of interest, but instead, provides a way for group members to live with conflicts of interest. It hides disagreements within groups leading to decisions that are not be stable in the long-term.

- **The post-bid phase is not covered comprehensively by EU legislation**

  Community secondary legislation on concessions does not cover the phase following the selection of the Concessionaire. The principle of equality of treatment and the principle of transparency resulting from the Treaty generally rule out any public sector intervention after selection of the private partner. However, the often complex nature of the arrangements in question, the time that may elapse between the selection of the Concessionaire and the financial close, the relatively long

[46] Later on, a Commission Interpretative Communication was published in February 2008 addressing the application of Community Law on Public Procurement and Concessions to Institutionalized Public Private Partnerships.

duration of the contract and, the frequent recourse to subcontracting mechanisms, sometimes complicate the application of the Treaty principles. [COM(2004) 327]

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Chapter 9

Rethinking the strategy for Galileo

The first attempt to finance Galileo via a Public-Private Partnership scheme failed. The terms envisaged for the Galileo concession were found to be inappropriate in 2005-2007 when they were negotiated between the public and private sectors.

The lack of progress in the concession contract negotiations hindered the completion of the project within the timeline and foreseen budget. This was especially critical because of time-related costs and loss of benefits that were involved. Following to a letter submitted by the Merged Consortium to the EU Presidency, the Council of Transport Ministers asked the EC in March 2007 to report the overall progress of Galileo, most specifically on the concession negotiations, and to propose alternative scenarios. Consequently, the EC publicly reported that the negotiations were failing because the Concessionaire was unwilling to accept the transfer of risk at the price proposed by the public sector [COM(2007) 261], and that they had "little chance to be concluded in favorable terms in good time". In this kind of situation, negotiations should not last forever and setting a final deadline on the negotiations is recommended [Yescombe, 2007.] Therefore, the EC proposed that the Galileo strategy and roadmap needed to be adapted to enable the program to meet the 2010 deadline, by when the system was expected to be fully operable. ESA estimated a total of €3.4 billion[47] for the completion of the system infrastructure of Galileo (including the costs of the exploitation and operations of EGNOS in the period 2008-2013). This figure represents €2.4 billion more that the amount originally stated in the proposal adopted by the Commission on 14 July 2004.

Both the Council and the Parliament, in March and April 2007 respectively, requested the Commission to assess and report on overall progress of the project and submit alternative scenarios for the financial and governance structure of Galileo. In May 2007, the Commission invited both the Council and the Parliament to take notice of the failure of the PPP negotiations, and the need of additional funding. Consequently, the European Council (in its Resolution of 8 June 2007) re-affirmed the value of Galileo, concluded to stop the PPP concession negotiations, agreed in principle to a re-profiling of the European satellite navigation program and recognized the need for such additional funding.

Since that moment, several alternatives to the previous Public-Private Partnership scheme were under study in the European Commission. The analysis of the collapse of the aborted Galileo Concession negotiations

[47] The larger proportion of these costs are associated with the space segment (building and launching the Galileo satellites, estimated at 1.6 B€); the ground segment infrastructure (400 M€); operations (275 M€); and systems engineering services to ensure the integrated functioning of all the above elements with the foreseen technical baseline (150 M€).

had many important lessons about the mistakes to avoid, and set a baseline for the use of Public-Private Partnerships for large infrastructure projects of this nature at a European Union level.

9.1. Policy analysis

9.1.1. Problem definition and current conditions

When negotiations stalled in March 2007, the continuity of Galileo was uncertain. Both the public and the private sectors had already invested budget and years of effort in the development of the project. In addition, there was an urgency to speed up the project due to the economic consequences of potential loss of market share due to the accumulated delay. Galileo had accumulated five years of delay with respect to the initial calendar. The projected completion of the system to its Full Operation Capability (FOC) was now the end of 2013, according to most optimistic forecasts [COM(2007) 549.]

The risks for the private sector were higher than presumed, while their revenue forecasts were lower than expected. Revenues were insufficient for the high risks associated, considering that the market for the concession holder remained uncertain. Furthermore, there were significant system infrastructure extra costs that neither the public sector, nor the private sector were well disposed to assume. The concession negotiations failed revealing that they had contemplated an ineffective division of roles and responsibilities between public and private actors and a poor risk sharing allocation. In particular, this failure demonstrated that the political risks had been unrealistically underestimated and refuted the assumption that the market risk could be fully transferred to the private sector.

The European Parliament stated that it was "deeply concerned by the fact that the concession negotiations had been at a standstill for several months and that such delays will have a significant impact on the overall cost".

The estimated costs of the Galileo program have increased at every stage of its history. In 2000, the overall cost of the Galileo system was first estimated at €3.25 billion [SEC(2000) 2140] for the definition, development and validation, and deployment phases. Current estimates almost double this figure. The deployment phase is by far the most costly pre-operational phase, and initial projected costs have risen significantly. In 2000 (also in 2004), the total cost of this phase was estimated to be €2.1 billion, of which European Union would have paid one third of the costs (€700 million) and the Concessionaire would have paid the remaining two thirds (€1.4 billion). In 2007 the cost of this phase was re-estimated at €3.4 billion[48], which meant an increase of 60%. In case the Public Sector ends up financing all this phase, this will mean an increased commitment from the public purse of more than €2.4 billion[49] just to get the system into orbit. This would mean that European taxpayers would face an effective cost increase of 385%.

[48] It included EGNOS exploitation and operations (2008-2013).
[49] €2.4 billion is the additional funding sought for Galileo.

After FOC, Galileo (including EGNOS) operational costs were estimated to be €220 million per year in 2000 (also in 2004). That sums up a total of €4.4 billion in 20 years, from which an exceptional contribution of the public sector for the first few years of €500 million was expected. The 2007 estimations were a total of €7.96 billion.

Timing played against Galileo and the accumulated delays affected the positioning of Galileo with respect to its competitors within the evolving global satellite navigation market. In the face of a free GPS and a growing international GNSS offer, competition in the market of satellite navigation had increased[50]. Significant revenue losses were expected resulting from a late arrival on the market in the face of the emerging global competition of GPS-III, which is going to introduce a number of equivalent services free-of-charge. One of the main concerns and uncertainties came from the commercial use of the Galileo signals in the context of a free of charge GPS civil signal. As well, it was uncertain to what extent and when the public authorities are politically prepared to use (and pay for) the PRS signal of Galileo.

9.1.2. Definition of needed change

There is a need of action, since further delays jeopardize the revenues due to the arrival of GPS III. The public governance of the project needs to be improved. The structure and role of the GSA with relation to the EC concerning the project management responsibility over Galileo needs to be clarified. It urges, then, to research a public governance structure that minimizes this high political risk for multinational projects like Galileo and the ones to come in the European Communities. It should be designed on the basis of a clear division of roles and responsibilities between the EC, ESA, GSA, EU Member States and EU Council.

In view of the previous experience, the European Union also needs to ensure robust and fair competition rules. An updated business case and sound risk management for Galileo have to be pursued. In addition, since the deployment of the program would require additional public funding, policy-makers need to assess the feasibility of amending the regulation on the funding of the program. Finally, Europe also needs to re-evaluate the role of Galileo in the downstream market.

[50] China's proposed new Compass system, the U.S. GPS III initiative, and restoration of Russia's GLONASS are all scheduled (perhaps wishfully) to take place before or about the same time as Galileo is expected to reach full operational capability.

9.1.3. Policy options and instrument

Analyst's perspective

When evaluating the new strategy to follow, analysts' perspectives should assess the following issues:

An increase of the public sector investment is justified by the political strategic value of Galileo.

The European Parliament has recognized the need for Galileo to serve the European Union's defense and security. The primary motivation for Europe's ultimate support of Galileo is political; regarding sovereignty and leadership in world affairs. From this perspective, Galileo should be owned by the public sector because it is deeply related with the European security. Besides, an exploratory evaluation of the EC indicated that there was a "substantial, additional value of Galileo for the European Member States of €50-60 billion over the 20 year period until 2027", beyond the direct exploitation revenues.

GPS currently enjoys a distinct public funding advantage over Galileo. It is fully funded by the US Department of Defense and the US Government has a clear vision that the direct costs of GPS are worthwhile, not only because of its military applications, but also because of the externalities of GPS, in terms of indirect economic, industrial and commercial benefits that the US derives from it. This is consistent with the strategic and political value of the system.

In addition, Galileo has gained such a high profile that considerable political "face" would be lost if the project collapses because of the disagreements at the table of negotiation for the Concession contract.

Technical risks for the deployment phase are better to be borne by the Public Sector before the system reaches its Full Operational Capability.

Long before the negotiations failed, several voices complained that the initial structure was unrealistic, and advocated the sole public funding of the deployment costs of the system, as the financial structure that should have always been envisaged in order to make Galileo succeed.

A later transfer of technical risks provides better value-for-money. It would be very convenient if most of the technical risks are dissipated before decisions on a PPP concession are taken. Public sector should then pay early and sufficient attention on assuring the technical performance and stability of the system. Otherwise the concession contract might not represent a good deal for the public sector. In other worlds, the public sector should make use of its option value, postponing the decision until uncertainty is dissipated. In addition, in cases where competitive market pricing would lead to loss of socio-economic benefits or distort behavior, infrastructure would be better provided or facilitated by the public sector [Yescombe, 2007.]

Successful certification of the system and possible commitments for long-term use of PRS from governmental agencies should be a priority so that the policy and legislative risks are mitigated, and therefore the public sector can get a better VfM when negotiating with the private sector.

<u>Anticompetitive behaviors</u>

As already stated, ESA's practice of spreading contracts and revenues among program participants in direct proportion to their contributions has hindered the competition and decreased the efficiency of the program. On the contrary, EC rules support competitive practices without a requirement for national allocations.

<u>Political risks should not be underestimated</u>

Galileo is a long-term technological project with an important political substrate. Political changes over time could drastically impact its evolution. Besides, European politics at EU level, gathering so many national actors, are complicated. The expected geographical allocation of industrial contracts and disagreements over national shares has been a significant political constraint for the Galileo project since it was launched, incurring delays and extra costs.

It is likely that, the difficulties of managing a pan-European project and its political implications were underestimated in the early times of the program. Lack of Europe-mindedness and common interest often obstructed the progress of the Galileo project, in which the political complexity has often proven to be more difficult than the technical challenges.

<u>Reality check of risk transfer</u>

If the private sector investors in the PPP get it wrong, they may lose their investment but have no obligation to put further money in it to rescue the project (they can just assume the previous investments as sunk costs). If a PPP fails, the public authority will most likely incur in the extra costs of keeping the public service going. In other words, the public sector takes back responsibility for the risks. Thus, the advantages of risk transfer fail anyway. The Galileo case, as it was conceived, was prone to become one of those in which profits are privatized while looses are pushed onto society. In financial language, the private sector had a put option from the government: if they win, they benefit from profits, whereas the government will cover their losses. Then, analysts should question themselves: how real is any risk transfer for the Galileo project?

<u>Private-public sector interlinks</u>

Even if the European Commission, acting as public sector, advocated for common European public interest as a whole, the European institutions still depended politically on the Member States, which support indirectly their national interests, often to the detriment of the European public interest. The private sector also did not either have a common position. There were many internal conflicts among the different companies that were part of the Concessionaire. Moreover, public national authorities back their respective national companies and put pressure safeguarding their national industrial interests on the decisions taken at European level. Thus, conflicts among the industrial stakeholders (private actors) incurred political divergences among the Member States (public actors). Thus, there was not a defined line separating public and private main interests at high level. This lack of strong and clear public governance from the European Institutions led to complex dynamics and multiple conflicts of interests among the stakeholders. The dynamics of these relationships are shown in Figure 18.

<u>The initial terms of the Concession misjudgment that market/revenues risks could be transferred to the private sector.</u>

The profitability of PPP projects is often subject to large exogenous demand uncertainty, which is often not considered properly when designing the contracts. This explains why renegotiations take place when demand is lower than expected [Engel et al, 2008.] Besides, demand risk is often something that the private sector cannot manage because its crucial factors may be controlled by public decision. Transferring the demand risk may therefore decrease the VfM for the public sector as it involves pricing risks outside the control of the contractor. This is especially true, when the public side is a major customer itself [Beltran and Vidal, 2005.] Market risks should be only shared or transferred when a reasonable certainty can be achieved in revenue forecasts with little or no dependency on public support. The revenues obtained from the PRS (public sector) represent one third of the potential direct revenues and are still uncertain. In addition, the future use of PRS depends on regulatory measures to be taken at EU and national levels.

<u>Public's sector negotiation position was weak</u>

Galileo has huge strategic and critical value to Europe as a whole, making it clear that collectively Europe cannot let Galileo fail. This perhaps exacerbated the political brinkmanship. It is possible that this implicit government guarantee probably had a negative impact in the defense of the interests of the public sector and led to a political bargain. In addition, the Concessionaire knew a priori that even if the Concession was cancelled, they were still going to supply the technology for the deployment of the system, so they could push the situation to the limit.

Generally, when time-related costs are involved, setting a final deadline on a negotiation can be helpful. This was not the case of Galileo, since the public sector threat to walk out if not coming to agreement was not that threatening for the private sector; if the public sector wanted to continue the project, the deployment of the infrastructure would have been awarded to the private sector anyway. The public and private sectors' bargaining zone was negative (in other words, there is no positive overlap between both actors' reservation points.) This caused negotiators to spend fruitless months trying to reach an agreement, incurring worsening. In this situation, the private sector may have exercised its best alternative to a negotiated agreement (BATNA[51]) and force the public procurement route.

In any case, these negotiations were not a one-shot situation in which no future ramifications were to accrue once the concession contract had been signed. After the financial close, there would have been repetitive negotiations in which public and private actors would have needed to renegotiate the terms of the contract on a regular basis along a long-term horizon. Besides, the public sector had some negotiation power coming from the fact that the private sector is recipient of EC and ESA contracts for programs besides Galileo. Private sector should safeguard its reputation as negotiator, since in a future they will have to come back to the public sector for other programs and project funding.

Negotiations were not integrative

Negotiators made the mistake of focusing on a single issue to negotiate, such as the financial terms, when they could have added value to the negotiations by putting other issues on the table; such as public control of the infrastructure and the safeguarding of public interests in the exploitation of the system.

Differences in preferences, beliefs and capacities that may me profitably traded off can create joint gain. This is what in negotiation argot is referred as “win-win” negotiation (“expanding or maximizing the pie”). Revealing information about preferences and priorities help negotiators discover better win-win agreements and achieve a higher mutually beneficial deal. In fact, this is also the basis of the principles of risk sharing mechanisms. The Document Change Notices (DCNs) requesting some changes in the system development, which the private sector tried to negotiate with the public sector were a good example of that. Even if they incurred in extra costs for the public sector, they were aimed at improving the commercial applications of the system, thus generating future revenues.

PPP laws

Analysts should take into account that the legal framework regulating PPPs improved. In 2007, the Internal Market department of the EU-Commission started an initiative on “PPPs and Community Law on Public Procurement and Concessions” aimed to set up a clear legal framework concerning these legal matters. Finally, a Commission Interpretative Communication was published in February 2008 addressing the application of Community Law on Public Procurement and Concessions to Institutionalized Public Private Partnerships.

[51] Point at which the negotiator is prepared to walk away from the negotiation table. Negotiators should be willing to accept any set of terms that is superior to their BATNA. Once the BATNA is identified the negotiator can determine his reservation point, which represents the quantification of the BATNA.

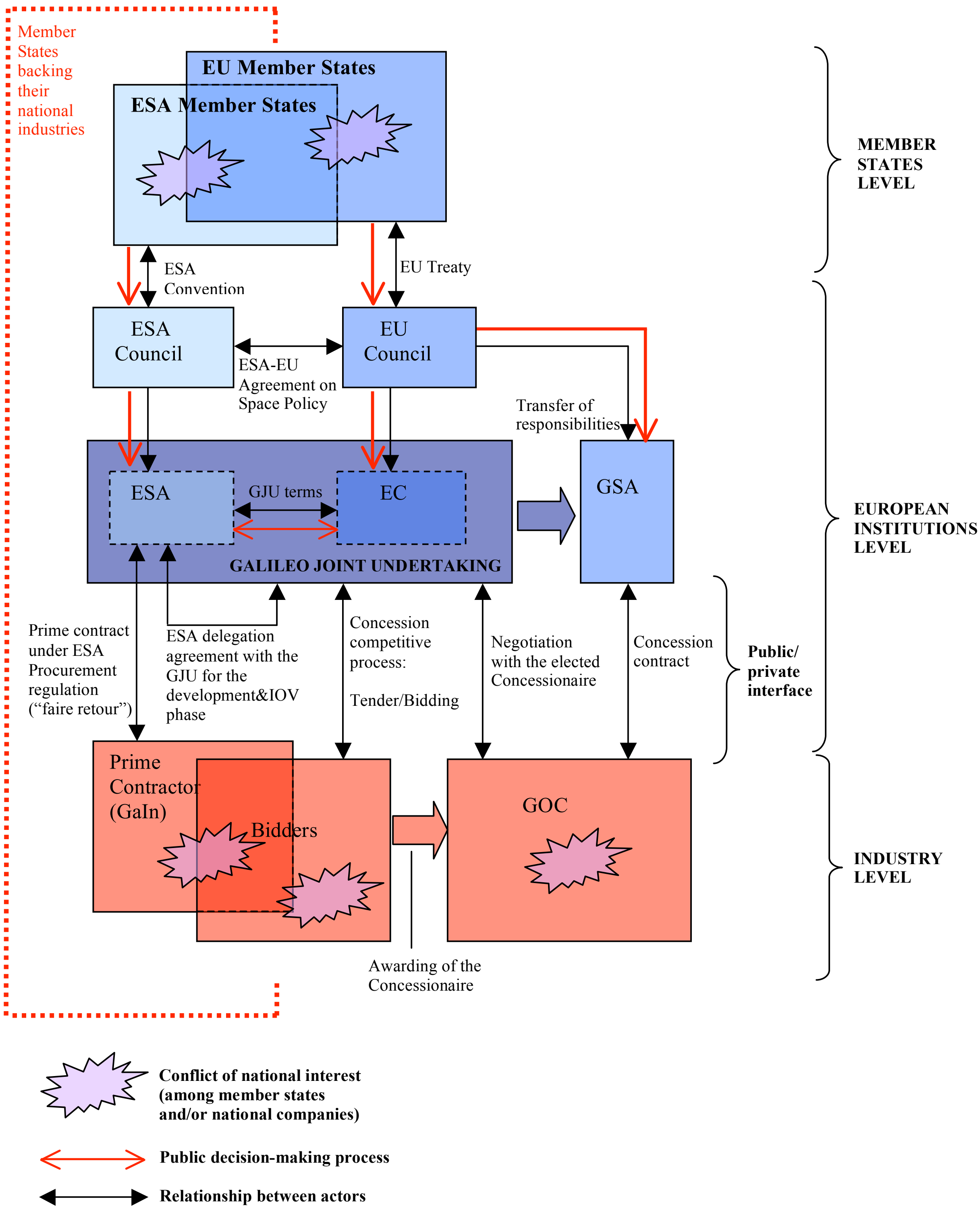

Figure 18: Distribution of roles and responsibilities before and after the transition to the Concessionaire

Analytic methodologies

The acknowledgement of the deficiencies of part of the previous strategies adopted, can bring the analysts many lessons to learn and lead them to reconsider whether the methodologies previously used were the most appropriate, or were well implemented.

Cost-benefit analyses undertaken many years ago were based on assumptions that no longer hold true. Therefore, they could not be relied upon to decide any particular course of action in 2007 or 2008. In addition, new risks assessments were undertaken according to the up-to-date conditions of the system, as follows:

- An initial underestimation of the technical complexity of the program led to a disagreement on the sharing among public and private partners of the design risks, which were difficult to eliminate or at least to quantify. Besides, as we introduced in Chapter 8, differences in valuation due to the asymmetry of information between both sectors hindered any agreement on these aspects. In general terms, Galileo's design and deployment risks, and their likelihood, are typical to a space program. In the particular case of Galileo, these risks are related to the possibility of not achieving its targeted performance caused by technical problems.

    - The most important design risks identified are related to the lifetime of the satellites atomic clocks and the constellation orbit behavior, which both have a negative impact in the satellites lifetime once deployed, the performance of the Safety-of-Life service, and the integration of security requirements.

    - In addition to the design risks, they are deployment risks associated with the technical integration and testing of the system, and satellite launch failures, which drastically increase the risks of the deployment phase. A failure of a launch implies a total loss of the embarked asset and increases the insurance costs and contingencies. Regarding the deployment of Galileo's 30-satellites constellation in orbit, launchers will carry several satellites per launch. This strategy is very cost saving and effective in terms of schedule, but on the other side, it increases the risks associated with launch failure.

- As for the market risks, in 2007 the Commission's calculations indicated that the expected aggregate direct exploitation revenues of Galileo (combined with EGNOS) over a 20-year period (from 2008 to 2027) accounted for a total of some €9.1 billion in the baseline case, after which the compounded actual growth rate is estimated at around 4%. However, these estimates varied over time and were not properly updated. Considering uncertainty[52], these revenues were estimated at

[52] These uncertainties are related to the commercial use of Galileo, considering that the GPS civil signal is free of charge, and the use of the Public Regulated Service (PRS) from the public authorities is still unknown.

plus one-third and minus half of the base case (within a range between €4.6 billion and €11.7 billion). The market risk was then considerable, up to half of the foreseen annual revenue base.

Table 2 depicts the estimated split of these exploitation revenues per service, charging mechanism and sector of origin, as forecasted by the Commission in 2007, in line with the market prospects the Merged Consortium stated in the joint bid [COM(2007)534/2].

Split of Galileo/EGNOS exploitation revenues					
per service		per charging mechanism		per sector	
Open Service – normal use	0%	terminal manufacturing	46%	road transport	30%
– special use	54%	governmental clients	29%	PRS	29%
PRS	29%	service providers	14%	mobile telephony	17%
Safety of Life	10%	receiver manufacturing	7%	professional services	9%
Commercial Service	7%	end-users	4%	aviation	5%
Search and Rescue	0%			others	10%

Table 2: Galileo/EGNOS exploitation revenues per service, charging mechanism and sector

We can extract several conclusions from these figures: the PRS was expected to provide a significant contribution to revenues (29%), which posed a high risk considering how uncertain the use of this service was. It is important to bear in mind that the PRS contribution comes from governmental clients (public sources.) Thus, it can be regarded as a “shadow toll”. Revenue predictions were significantly affected by what the final public service (PRS) requirement was to be, and by the use governments were to make of this service.

SoL only was to provide a 10% of the revenues, that might not justify the cost of implementing this service, from a purely business point of view. In addition, the SoL service is associated with a highly regulated sector, in which the public authorities have an important say. The CS, which was initially considered to drive the private involvement decision, represented only 7% of the revenues and thus was still undeveloped. As for the charging mechanism, revenues expected from the service providers and end-users represented a total of 18% (mainly associated with the SoL and CS), whereas royalties and IPR license fees obtained from the terminals and receivers manufacturing represent a 46% (mainly associated with the use of the OS). This later was a high figure considering how inadvisable it was to use this fee for the entry of Galileo in the GNSS market.

Identify the alternatives

Different alternative scenarios can be studied;

- Continue the current negotiations with the Merged Consortium: This involves resuming the negotiations on the technical baseline, handover conditions, risk transfer and the establishment of a joint business development roadmap. It requires the private sector to resolve its internal arguments and agree on a common position, and the EU to ensure financial certainly in the long-term. This approach was not recommended taking into consideration the political and market failures assessed, and the delay this alternative would have led to.

- Total cancellation: Abandoning the project would have had a disastrous impact on the image of the EU as regards its capabilities. It would have also increased the dependence on US and other countries and generating a major macro-economic loss for the European companies.
- A complete EU takeover of the project for the deployment and operational phases: This way, Galileo would have followed the same public procurement strategy adopted for GPS. The goods of private involvement would have been totally lost.
- EU takeover of the project for the deployment phase, postponing to a later stage the decision concerning the operation and exploitation phase. This way allows Europe to save the project, avoid the problems already analyzed as for the previous strategy, and make use of its option value concerning the subsequent phase decision.
- Partial public financing. This alternative implies a partial EU takeover of the system for the deployment phase, adopting a public procurement scheme until IOC (Initial Operational Capability). This alternative allows partial mitigation of the technical design risks before the remaining risks were transferred, and enhance the public sector negotiating position so that a better VfM was achieved.
- Cut-price Galileo project: *a priori*, a smaller-scale project of some kind (such as one with fewer satellites) could have represented a good value for money. However, implied potential major modifications to requirements and a redefinition of services would offset the cost-saving benefits. A radical change in the system required a time-consuming re-bidding of the industrial contracts, which would have incurred in further delays. In any case, it required to question whether the cost-savings compensated for the costs associated to this redefinition, and the loss of the investment made so far. In conclusion, a very late entry-to-market of a system with degraded performance (low competitiveness against new systems like GPS-III) would have lowered the economic profitability.

9.1.4. Definition of options and means

The EC concluded that these negotiations should be ended and recommended the takeover of the program from the public sector. Compared with the other alternatives, it argued that this scenario offered the most advantageous time line and the best value-for-money. In addition, it substantially reduced the overall budget commitment appropriation and allowed to develop more clearly the conditions for a subsequent PPP phase. With this model, the European Union would assume responsibility for the entire outstanding cost of Galileo. In other words, the EU budget would foot the bill for the cost increases already noted as well as the costs originally to be borne by the PPP concessionaire. Very significantly, however, the Commission did not investigate the alternative of traditional public procurement and did not estimate its cost.

Without any involvement of PPP concessionaires, the Galileo project had to be funded by either additional contribution from Member States through ESA, third countries and international organizations, or through the EU budget.

The first option was rejected by several Governments; particularly the UK, Germany and the Netherlands [House of the Commons, 2007.] Germany advocated this option since German companies were not to receive a proportionate share of contracts under the EC procurement rules. The second alternative was rejected due to the complexity that it would had added to the project and the time that would have been required to come into terms with those third countries and international organizations. The Parliament also opposed combining of community and intergovernmental additional funding.

The alternative favored by the Commission, the European Parliament and many Member States was to fund the entire project through the EU budget. Those €2,4 billion required were to be obtained from other line items in the EU's 2007-8 budget and from budget allocated to R&D activities for GNSS under the 7th FP (€2.1 billion and €0.3 billion, respectively.)

In September 2007, the EC proposed [COM(2007) 549] a revision of the Financial Perspective 2007-2013[53]. Since the sum of funds to be moved was below the 0.03% threshold of the EU GNI, only a qualified majority was required in Council[54]. The budget increase required fell short of the threshold that would have triggered the unanimity procedure. This must be noticed considering that the final cost was uncertain and may rise above that ceiling, changing the decision-making procedure in a way that countries would have been able to execute their veto right. This required amending the interinstitutional agreement of 17 May 2006 on budgetary discipline and sound financial management as regards the multiannual financial framework [COM(2007) 549.]

9.1.5. Cast of characters

Stakeholder positions

Member states had conflicting opinions as to whether Galileo was a worthy project or not, whether it should be financed only by the public sector. British Ministers continued to push for other types of private sector involvement including other, smaller, PPP schemes. Germany, UK and the Netherlands expressed doubts about the EC plan, and stressed their commitment to the PPP principle and its concerns about the increased costs for the public sector [House of the Commons, 2007.] Even if the PPP scheme for the

[53] The Financial Perspective 2007-2013 governs the allocation of funds to broad budget priority areas for the 2007–13 period.

[54] Once a Financial Perspective has been agreed, decisions to move significant funds from one budget heading to another require the agreement of the Council of Economic and Finance Ministers. In case the budget needed is superior to a 0.03% of the EU GNI the unanimity procedure is required. Otherwise, only a qualified majority is required.

deployment phase were no longer viable, they continued to push for other types of private sector involvement.

The EP and the EC reiterated their support for Galileo as a key project for the EU, (resolution 24 April 2007). In addition, in July 2008 Parliament recognized the need for Galileo to serve the EU's defense and security (European Security and Defense Policy, and Common Foreign and Security Policy), and supported a prospective use of Galileo for military purposes.

Fortunately, in the case of Galileo the EU had the backing of its citizens for the creation of an independent satellite navigation system for Europe. A survey[55] that examined European citizens' views about Galileo concluded that 63% of examined citizens were willing to allocate public funds for the completion of the Galileo project. This was a huge percentage considering that in general terms there is not a single European public opinion either, but many different national public opinions.

The landscape for GNSS will be quite different in 2013 as compared to 2008. GPS remains the current commercial leader. In March 2007 the US released a final request for the GPS-III space segment. It is not only GPS that was changing. Russia enhanced its strategy and organizational capabilities and continued accelerating the restoration and modernization of GLONASS. The total number of Russian operational satellites in orbit was expected to be 18 by the end of 2007. In addition, it was considering incorporating an interoperable CDMA signal (in line with GPS and Galileo spread spectrum technology). Other countries were also entering the market with global or regional systems; the Chinese Beidou-II system, which currently was expected to expand from four to 35 satellites and provide full global coverage for both civil and military use, threatened the economic rationale underlying the Galileo program [Marks, 2006.] Both India and Japan were planning their own regional systems. The Japanese system, QZSS (Quasi-Zenith Satellite System) was designed to have three satellites, the first of which was to be launched in 2008. The Indian regional system, IRNSS was expected to be operational in 5–6 years.

9.2. Policy formulation

9.2.1. Definition of strategy

The EU took over the Galileo Project and delegated to ESA the construction and deployment of the system, assuming all the costs required for the completion of the infrastructure. On the private side, the European aerospace companies remained involved in supplying the technology, without assuming financial risk. As for the operation and exploitation of the system once the space and ground infrastructure were built, the EU postponed to a later stage the decision on the process and guidelines for contracting (or not) with a system private operator. The EC identified the need for a period of analysis to determine the most appropriate approach to the operational phase, which was accepted and supported by the Council and Parliament at the

[55] Published in the Official Journal of the EU, 27.10.2007.

end of 2007. The EC remained committed to the early involvement of the private sector in the operations and exploitation phases (in form of various variants of PPPs, service contracts, or publicly owned corporate entities) [COM(2007)534/2.]

Figure 19 depicts a diagram of the role transition from the IOV phase to the subsequent phases.

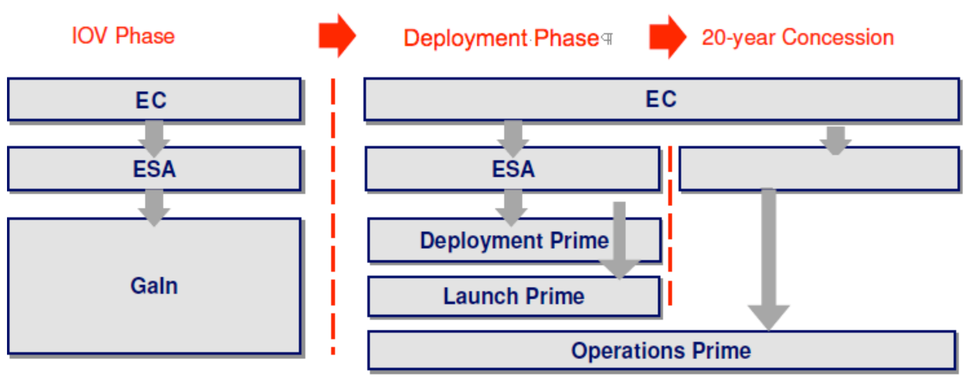

Figure 19: Distribution of roles and responsibilities before and after the transition to the Concessionaire

As for the funding, the European Parliament raised €3.4 billion transferring money from agriculture, administration, and research categories in the EU budget; instead of re-allocating money from other projects within the 'Lisbon priorities' area.

Following the disappearance of the PPP element from the governance model, the European Commission proposed a revised and simplified governance model that established a new role and responsibility sharing among the public stakeholders [COM(2007) 534/2], as depicted in Figure 20.

- Political oversight role to belong to the EU Council and Parliament. They remain the Budgetary authority and ultimate political decision-making bodies for the overall program objectives and the definition of the services to be provided by the system, for the procurement principles and for the decisions on the subsequent phases of the program;
- The EC adopted a new role as program manager and contracting authority. Behind the EC, the transport departments of the EU and representatives from its Member States were actually responsible for Galileo (all gathered in the "European GNSS Program Committee");
- ESA and the GSA were given an execution role.
    - ESA retained its role as the procurement body and designing authority on behalf of the EU. ESA has to exercise its technical expertise, overseeing the engineering work and contracts leading to the deployment of the infrastructure, under EU rules and subject to

overall EU management of the program. An ESA-EC delegation agreement in all industrial contracts was established.

- GSA to be under the jurisdiction of the EC, in charge of the preparation and commercialization of the system, including market analysis. It is also responsible for the technical certification and security accreditation, assisting the EC for the execution of the program.

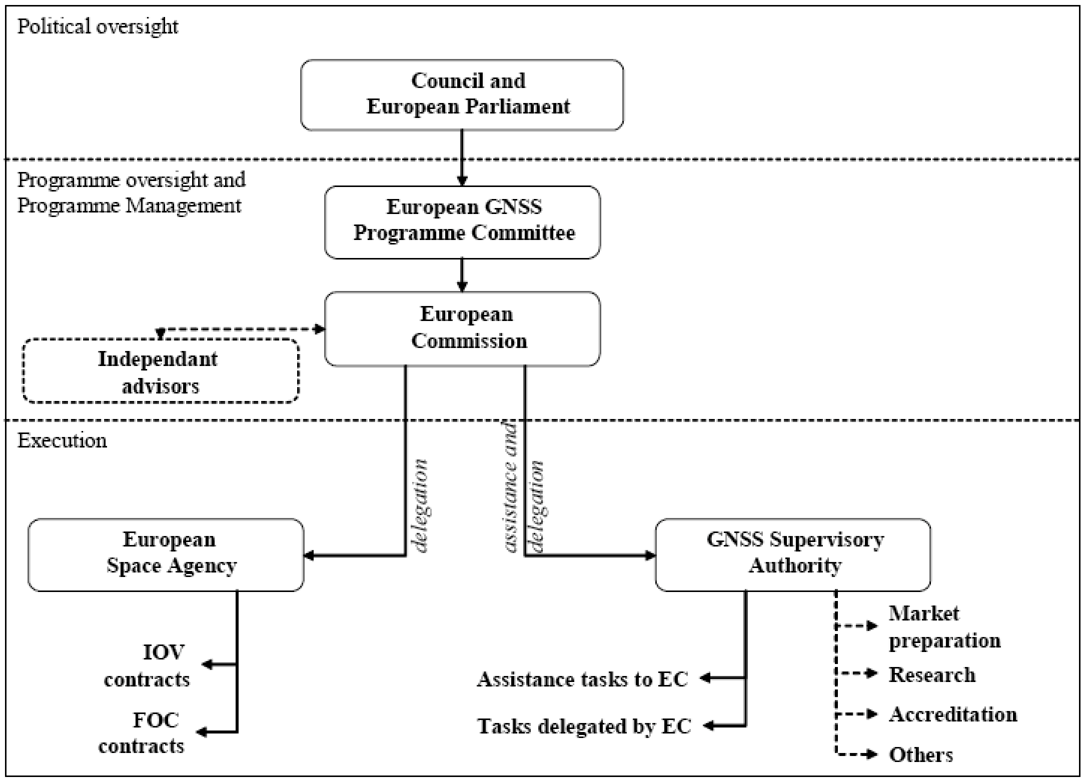

Figure 20: Public sector governance structure for the Galileo program [COM(2007)534/2.]

Within this new structure, program oversight and program management roles were separated. The Commission was in control of all policy-related questions, while ESA had a say on the technical side. This new structure strengthened the public governance of Galileo, giving the European Union the political responsibility and leadership role, providing a better organizational framework and increasing funding support for its activities. In addition, this new role of the EU was to enhance Europe's position within the GNSS international sphere [Futron Space Competitiveness Index, June 2009.]

Concerning the procurement principles, the EU readapted its strategy and advocated Community's public rules[56] to apply, by awarding the Commission the role of contracting authority. This measure was to

[56] Title V of the Council regulation 1650/2002 and relevant Implementing Rules nr 2342/2002 as amended by their respective revisions.

introduce robust and fair competition to deliver value for money, overcoming the past failures[57]. Besides, there was also clear support for the principle of competition in the supply chain by including multiple simultaneous procurement streams (double-source procurement wherever possible in order to prevent from possible abuse of dominance or long term dependencies on single suppliers). No company or consortium was allowed to bid for more than two of the six work packages, and prime contractors had to subcontract a minimum if 40% of the work to companies not affiliated to them.

9.2.2. Identification and evaluation of impediments

Despite of the major improvements accomplished concerning the public governance and decision-making process for Galileo, several impediments remained and needed to be addressed.

- **New procurement strategy**

  If the European Space Agency (ESA) is to manage procurement, a strong contractual relationship between ESA and the Commission needs to be established right from the beginning. This may pose some difficulties for ensuring that competition is guaranteed in the procurement process at all contract levels.

- **The expected geographic allocation of contracts may still remain.**

  Leading European industrial companies, often backed by their respective national governments, heavily invested in their expectations of a particular share in the contracted work. It was unavoidable that many of this conflict of interest remained. In particular, there was a political agreement between Italy and Germany on the Galileo Ground Centers and their roles as for the operation of the system.

- **Urgency of decisions taken by the Council**

  The Council was required to make a decision at the beginning of October 2007, on the basis of the documents provided by the Commission only few weeks before (19 September). This short time for analysis questions the convenience of the decision adopted by the council, specially considering the significant amount of work to be done by the Council working groups. The sense of urgency associated with the lost of benefits that further delay would have cost was understandable but still does not justify that it led to a precipitate decision that was not well founded. This rush prevented a sound analysis, including a comprehensive re-assessment of the full range of alternatives under study and their costs or benefits. Even if the Council pressed for a CBA, it is remarkable that it did not request the zero-option and the option of reducing the scope of Galileo to be further evaluated. No decision on the future should be made before all the options have been properly appraised.

[57] Community rules support competitive practices without a requirement for national allocations, whereas ESA practices a policy of *juste retour* that hindered competition.

- **The impact of delays might not have been properly accounted**

  The market prospects the Merged Consortium stated in its joint bid were assessed in 2004-2005, and therefore their current validity was questionable. In addition, estimates were calculated on the assumption that Galileo would be operational in 2013, disregarding the scenario that the GNSS internationally would be rather different. Finally, the FOC milestone deferred until 2013 was prone to suffer further delays.

- **Cost increases**

  Operation and maintenance costs are probably the most difficult to predict [Yescombe, 2007.] There is no reason to believe that the current cost estimations will not suffer from further future increases.

- **Uncertainty on the use of PRS still remains.**

  PRS policy should be ready in time in order to eliminate the PRS implementation uncertainty. An early political agreement on PRS must be pursued. The Commission suggested that the service could be used by immigration and customs agencies for tracking smugglers of people and goods; by peacekeeping forces in or close to areas of conflict where NATO military operations require all unencrypted GNSS signals to be blocked; or for civilian humanitarian operations in such areas.

- **Obstacles to releasing a commercially usable SIS ICD[58] are affecting the time to market of Galileo-enabled products.**

  The cost of putting Galileo into a combined chipset with GPS is almost negligible (estimated as 2.5%). Costs are mainly associated to the development costs. Nevertheless, manufacturers need to have a firm advanced knowledge of the signal modulation schemes and access to Galileo simulators before investing in dual receiver developments (in particular those companies involved in the DSP block of the receivers).

  This information, contained in the SIS ICD, has been cautiously delayed because of the value it represents for a potential concession holder. At this moment Europe is still following a conservative/protectionist approach over this matter in order to safeguard the interests of the private sector in case a future PPP is developed for the exploitation of the system. This approach is well founded to a certain extent. However, at this stage of the program, the locus of concern should move to the downstream market and this delay is incurring in a high risk for manufacturers to go ahead with Galileo development in the receivers. The time to market for Galileo-enabled products and services is as important as the system operation deadline. The Japanese case proves that little connection exists between operating a system and having a competitive downstream market; Japan has been a leader in GPS user products and services even though the government is not directly involved in the GPS program [Gullish and Vaccaro, 2009.] Thus, publishing a solid and manufacturer-oriented SIS ICD for Galileo is as important as getting the satellites fully operational into orbit before a certain deadline. Advance knowledge is required for a consequent product development. A decision on the release of a commercially usable SIS ICD would mitigate the market risk. The marketplace requires that interoperable and multi-GNSS products are properly prepared, with applications up and running, and the development of Galileo-enabled products would require a minimum of 18-24 months. Policies should create incentives for suppliers to enable chipsets with Galileo on time and facilitate the early market entry of Galileo-enabled products, not on the contrary. For Galileo to be a major power in the mass market, a firm and manufacturer-friendly SIS ICD should be published providing the same level of disclosure as GPS and other established systems. Contrary to the Galileo SIS ICD, the GPS ICD is available without restraints on commercial developments. Therefore, the Galileo case is one of those in which it is better to disclose standards rather than protect them. Otherwise, this strategy would impede the future entry of Galileo-enabled receivers in the marketplace.

- **Licensing fees**

  The lack of clarity on licensing terms for the commercial use of the IP contained in the ICD could affect the costs and the commercial success of Galileo-enabled products. Thus, it poses a risk for the downstream industry. GPS and GLONASS IP are public. November 2009, the EU announced that this special license to manufacture and sell Galileo receivers was no longer required [Cameron, 2009.]

- **Report to Congress by the US Trade Representative on US industry access to Galileo markets challenges Galileo to fulfill level-field commitments.**

  The rules of international trade apply to satellite navigation. In May 2009, the United States Senate acknowledged the risks associated with the lack of access to the Galileo system by US position, navigation and timing (PNT) user equipment manufacturers, in view of the EU having apparently restricted commercialization and intellectual property rights in the uses of Galileo signal information in user equipment products. Given the importance of PNT to the US economy the American manufacturers would be placed at a major competitive disadvantage compared to their European counterparts without equal and timely access to the operational signal information. When the US was developing the GPS, the US government gave full and open access to European user equipment companies, while providing a level playing field for everyone, sustaining open markets benefits the world economy.

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[58] The Signal in Space Interface Control Document (SIS ICD) is a document that provides the technical details of the signals to be transmitted by the Galileo satellites for the different services. SIS ICD usually refers to the OS SIS ICD, which is the version that provides the information concerning the open service.

- **Safety of Life service**

  Technical progress on the development and implementation of the SoL service is particularly delayed with respect to the other services. This is due to the high technical complexity associated with the algorithm required to calculate the integrity parameters and to the difficulties concering the certification of this system for safety of life operations.

  Counteraction: In any case it will not be necessary to wait for the completion of the Galileo project before taking advantage of some of the improvements it will bring. There is no need to wait until all the services are up and running; they can be offered gradually. This is particularly true considering that the mass market only requires the use of the Open Service. Here as well, Europe can make use of its option value and focus on providing the open service signal first, as soon as possible, for which it would get the majority of the benefits. There is not such a need for Europe to commit at this moment on a deadline for the provision of the other services (Safety of Life, Commercial Service, Public Regulated Service). This can be given at a later stage, when possible. This would allow Europe to take maximum benefit of early deployment capabilities.

9.2.3. Development of a tactical plan

The tactical plan for the continuation of the Galileo program was as follows:

- IOV contract was cancelled and renegotiated. ESA to take over as prime contractor for the IOV. IOV launches of four fully-fledged satellites beginning in 2010[59].
- ESA and EC to formalize a "delegation agreement" outlining the responsibilities and principles under which ESA should act as the prime contractor, which was signed in December 2008.
- Contracts awards in view of the need to meet the FOC deadline by 2013; the full Galileo public procurement for the completion of the Galileo infrastructure was launched by the EC (with the support of ESA) in July 2008, with an invitation to companies to submit requests for participation as prime contractors for six work packages (WP) and eleven contenders were selected in September 2008.
- Other 26 satellites to be launched in 2011-2013 to complete the space segment.
- To establish the legal framework for operation of the system, IPR, regulatory measures and liability regimes.
- According to the EC regulations[60], in 2010, the Commission was to submit to the European Parliament and the Council, the revenue-sharing mechanism for the exploitation phase, and objectives for a pricing policy. This was to include a reasoned feasibility study of the advantages and disadvantages of the use of service concession contracts or public service contracts with

[59] The first two In Orbit Validation (IOV) satellites are scheduled for launch in November 2010, and the next two in April 2011, though delays in this matter are expected.

private sector entities. The EC then launched the Exploitation Study in the Context of the GNSS programs with the purpose to investigate how Galileo is to be exploited. This included how to cope with the exploitation and maintenance costs, how to collect revenues and how to market the services. This is assessed in the next Chapter 10.

[60] Regulation (EC) No 683/2008, Article 4.

Chapter 10

Recommendations for the exploitation and operation phase

The main remaining questions concern the convenience of the involvement of the private sector in the exploitation and operation phase of Galileo. The Commission almost abandoned the PPP route for the Galileo project right after the full completion of the infrastructure (at least for the early exploitation of the system). This postpones the decision to adopt a potential private investment (and therefore, the scope of our thesis question) for a few years later.

Recommendation 1: Involvement of the private sector participation may still be convenient

The use of PPPs as an innovative financing scheme gained many detractors based on the previous experience. However, Galileo still represents huge economic and strategic value for both public and private sectors in Europe. There is no doubt there are huge market opportunities in the world of the satellite navigation and the role of the private sector is indispensable for Galileo to reach its full potential. This is why the public sector should not automatically neglect private investment for the next operations and exploitation phase. Public and private sectors can still together achieve market and policy success, if these policies are properly designed.

Galileo system providers will have an important influence over all essential decisions affecting the users, such as defining or updating the standards, defining the industrial export control policy and serving the future needs of the users though system upgrades. The more the private sector is involved in these aspects, the better the commercial orientation for certain services will be. Galileo business case still attracts private investment and the early involvement of private sector is important - to a certain extent - for providing Galileo with a sufficient commercial orientation to revenue generation, and for increasing the effectiveness of the project. Putting the operation to a large extent into the hands of a private consortium would impose more commercial discipline. While Galileo should have never been regarded as business case as a whole, considering the large political and macroeconomic and social benefits provided, this fact does not eliminate the commercial opportunities Galileo brings.

However, decisions made in the best interests of direct revenues are not recommendable if taken to the detriment of the public sector interest. Policies must deliver what is needed on the basis of clear objectives. The wide range of public and private objectives associated with the Galileo program were identified but not properly prioritized. Policies were mainly oriented to the maximization of direct revenues, and this rationale was inconsistent with the main aims of the project. This does not mean that direct revenue generation should be disregarded now.

The best risk sharing allocation in any public-private undertaking is one that maximizing the benefits for both parties (expanding the pie). Capital is a scarce resource that all businesses, and even government agencies, must compete for and use efficiently [Pettit and Stewart, 1999.] The interests of society and stakeholders are best achieved when these scarce resources are allocated to their most productive uses. Therefore, the incentives that support the decision making process must be aligned with strategies to maximize the Galileo value. The interests of Galileo stakeholders and of society are best satisfied when its investment is employed to its most productive uses in the most effective ways.

Galileo must provide customer-valued products and services effectively and efficiently in order to maximize the investment. Whenever and wherever Galileo can be regarded as a business case, there is a need to manage for value. After all, this large institutional investment represents the savings of everyday European citizens. This concept is in line with Javier Solana's (EU High Representative for the CFSP) quote "the nature of power itself is changing. Power has shifted from governments to markets […] These days, if you want to tackle international problems, negotiations among government officials are seldom enough…" For Galileo to play a leading role in the GNSS world, the involvement of the European industry (to the highest possible level safeguarding the public interests) should be encouraged.

The case of the Skynet 5 project (UK, 2003) provides an example of a PPP/PFI adopted in the space sector for a military satellite communications project. Its concessionaire was to deliver core military satellite communications to the British Ministry of Defense, and entitled to commercialize the spare data with third parties [Beltran and Vidal, 2005.] Private sector funding would still be welcome, but on a case-by-case analysis on a service basis.

In any case, as previously introduced, the public sector showed how low their break-even point[61] was when the European Parliament raised funds to cover the extra costs and completely financed the deployment phase. Considering a new PPP model for the operation phase, analysts should be aware of the implicit government guarantee that can negatively impact on the defense of the interests of the public sector in a potential next round of negotiations with the private sector. The public sector must develop a strategy aimed to safeguard its main interests above those of the private sector in a way that is not regarded as a weakness but a power; that of awarding or not significant revenue to the private sector under certain conditions.

Recommendation 2: The use of PPPs in Europe should be clearly defined and regularized

There is no need to emphasize this recommendation anymore. Europe should work on enhancing legal certainty for PPPs, as well as assuring transparent and competitive procurement processes. The EU Commission should provide guidance on PPPs for the public sector, which includes guidance on

[61] The point when the cumulative value of savings is equal to the cumulative value of investment.

procurement procedures, particularly in the case of pan-European PPPs. Many lessons can be learnt from the Galileo experience.

It seems desirable to create or sustain public-sector centers of expertise (such a European PPP agency, or national PPP Centers of Excellence.) It does not make economic sense for the public sector to maintain staff with PPP procurement skills in all the project teams as it is often difficult to use the expertise gained in a PPP for another. The EIB offers a great number of advantages for supporting the evaluation of PPP investments: decades experience, in-house sector expertise, comfort regarding political risks… etc, and therefore the EU should make use of this resource as much as possible, when needed [Barret, 2005.]

Recommendation 3: Funding for long-term projects of this magnitude should be assured

Long-term infrastructure projects such as Galileo require substantial funding assured along their timeframe. The lack of such financial guarantee has hindered the commitment of the private sector to the project. In the future, it should be avoided that funding depends on the approval of 7-years financial perspectives. Therefore, it is recommended that public authorities state a formal commitment to include a significant minimum input awarded to the operation and maintenance of the Galileo project in the EU budget in the years to come.

Recommendation 4: Identification of technology based business opportunities

Multiple concepts of implementation of a single technology can generate multiple forms of commercialization, in a way of linking technical capabilities with customer needs. Europe should focus on identifying new business opportunities arising from the satellite navigation technology and the performance Galileo will offer, such as;

Turn the security threats existing in GNSS into commercial opportunities

GNSS has emerged as a global infrastructure utility, complementing public services such as energy distribution, global transport, and voice and data communications. Many civil applications need secure, assured information (asset tracking, fleet management) and there is a growing demand for geosecurity LBS (hardware configuration and management, virtual site licenses and digital rights management).

The more the world depends on satellite navigation, the bigger the consequences of breach-of-service are. System outages and failures in trust pose safety and security concerns that are associated with the lack of integrity[62] and authentication[63]. Because GNSS can be used to authorize actions, trust and authentication are required for proper implementation and enforcement policy.

[62] Integrity provided to ensure that the position, navigation and time (PNT) information is trustworthy.
[63] Authentication provided to ensure the users the information they receive is authentic.

Unfortunately, GNSS is vulnerable to malicious intrusion and spoofing. Intentional interference may cause denial of service. This concept is known as jamming[64]. Besides, malicious signals can be transmitted so that the receiver computes an incorrect position. This concept, known as spoofing, implies “hacking” the signal in space (satellite-to-receiver signal) interface. Jamming and spoofing pose dual concerns: The authenticity of the signals that a receiver processes, and the validity of the assertion from other parties about the signals they receive (for example, when a supplicant party submits its position to a permission-granting agent.)

GPS does not incorporate these features for civil signals. Galileo will possibly employ such features as a fee-based service, creating significant commercial revenues.

<u>Secondary revenues to be obtained from the Commercial Service</u>

The private sector may be able to generate additional revenues when the system is not fully used as public-sector infrastructure [Yescombe, 2007.] Although the Public Authority as owner of the system could provide commercial services, private sector management skills may be more effective in this respect. Considering that the Commercial Service is provided in an independent message (C/Nav) broadcast in an independent frequency band, the involvement of private sector in the exploitation of this service minimally interferes with the provision of the rest of the services concerning the internal data flows within the ground infrastructure.

<u>Recommendation 5: Use of regulation as a driver for demand</u>

In 2010, Europe is at a critical stage due to the financial crisis. So far, it has focused mainly on the demand side of the innovation policy. Regulation has been underused for pulling through innovation and public procurement has been mainly used for the provision of goods and services. Europe needs to engage business through a combination of supply side measures for the promotion of RTD (research and technology development) and demand side measures to create innovation-friendly markets. The Lisbon strategy advocated demand-side policies. This entails supporting economic policy actions that are designed to affect aggregate demand. The public sector can use its powers and resources to improve the economic status of certain industries. Regulation is a public sector basic resource from which industry can be better off thanks of the public sector influence. This recommendation is based on the importance of the public actors to enable the development of commercial services and applications. The European Union has a dual role for the Galileo program, as both the owner of the system and as policy-maker (regulator), which can and should make the best of it.

The value of Galileo will be driven by both the market and regulation. Market development will be a private matter, whereas a regulatory framework will be key to enable the penetration of GNSS products and services in certain areas where the use of these technologies can be turned into a benefit for users. Since

[64] Intentional transmission of signals that disrupt the GNSS ones by decreasing their SNR (signal to noise ratio.)

2000, GPS is regarded in the US as the fifth utility (alongside water, electricity, gas and the telephone), due to the advantages it provides to almost all economic activities [Conti, 2000.] As Galileo gets closer to FOC, the interests in GNSS services is expected to increase in other cross-sectors.

GOC's revenue profile by financing category for the period 2006-2025 presented in the Joint Bid estimated of 46% of revenues for regulated/certified applications. European regulation can enforce the business community to invest in GNSS products and services, and to increase the demand for GNSS numerous emerging applications from the end-users, paving the way for the use of those ones that make use of the European systems. As introduced before, the use of PRS, which depends on legislative support from the public sector, was estimated as one third of the revenues.

Recent examples are given by regulation concerning the need to locate accurately any emergency call in the US (E-911) or in the EU (E-112). This is also applicable to law enforcement applications, new LRIT[65] specifications in the maritime sector, fisheries surveillance, and many other applications in the agricultural, leisure and environmental fields (the use of satellite navigation for precision farming, mining and civil aviation contributes to the reduction of CO2 emissions.) GNSS allows Europe to effectively implement the EU transport policy objectives (road tolling, regulation of the transport of dangerous goods.) Besides, the services provided with guarantees of performance will enable the use of GNSS for numerous applications that are currently reluctant to use it as sole means of navigation (for instance, the implementation of APV[66] procedures for aviation). European regulatory requirements could also envisage the use of information systems relying on satellite navigation signals. The regulatory environment, certification and standardization issues also have an impact on the revenue generating capabilities.

Recommendation 6: Increase European cohesion

The conflicts of interest among national parties (sharing the pie conflicts among the different Member States) has proved to be one of the major difficulties the Galileo program has suffered. Concerning major pan-European projects, a stronger EU supranational decision-making power must be established.

In addition, mandate often lacked focus. The control of Galileo was diffuse. Unclear division of roles between ESA and the EC resulted in poor public governance. Many decisions relating to Galileo were affected by the fact that no one actor assumed full responsibility: the decision in favor to separate development and deployment phases, the choice of a PPP, the acceptance of the Merge Consortium proposal, and the ESA/GJU agreement were all decided on questionable grounds. The EU difficult making process made it unclear which actor was actually deciding in the Galileo program.

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[65] Long Range Identification and Tracking (LRIT) of ships specifications established by the International Maritime Organization (IMO).

[66] APV is the International Civil Aviation Organization (ICAO) term for an airline approach with vertical guidance, in many cases, involving the use of GNSS for navigation.

The Commission has been a key promoter for the GNSS programs. However, the extent to which it should be seen as a really powerful actor on the European scene is highly controversial. Beyond being an independent and supranational body that has a will on its own, its internal decision-making processes are influenced by national interests [Egeberg, 2002.] Figure 21 depicts the key actors in the Communities legislative process and how they influence the policy-making process. It is clear to see how much the national representatives of the Member States influence the process.

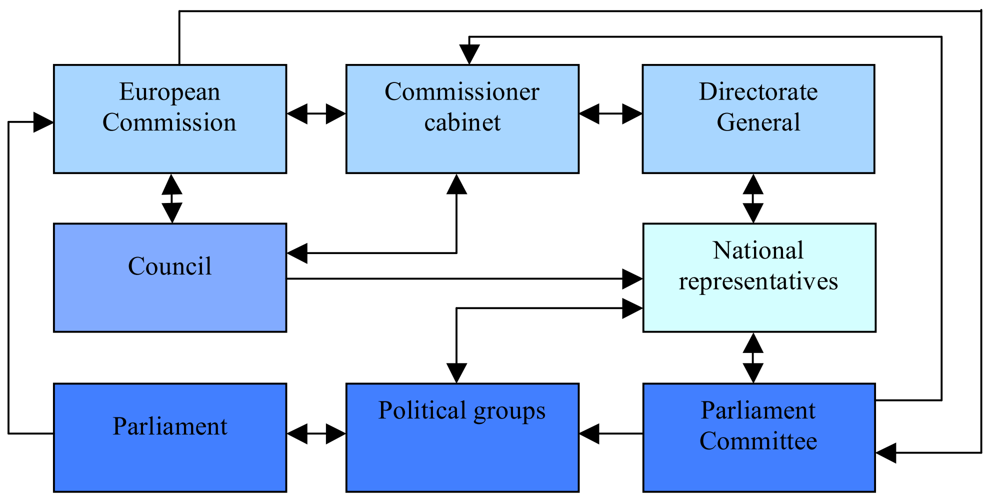


Figure 21: Detailed diagram of the Policy Making Process

Besides given the implications of any decisions on Galileo, it was inevitable that heads of state and governments insisted on having a voice. Therefore, it was hardly unavoidable that the European Council, which generally only meets quarterly, constitute the final executive authority for the control of Galileo. The reality of the EU politics meant that the EC had limited powers to make things happen and none of the institutions had the ultimate decision-making power. On the other side, ESA is mainly an agency for the R&D of space technologies and systems. ESA's interests are mainly those of the supply chain, but not those of the downstream. It is essential that resources are put together and work better in the common interest of EU citizens. Effectiveness depends on taking decisions at the most appropriate level and on implementing policies in a proportionate manner. To this respect, the new governance structure has improved the decision-making process. Besides, if rules are not supported nor adequately enforced, the implementation of the policies fail.

Considering that the Council is the main forum for representation of the national interests in the EU decision-making process, we can conclude that the Community has limited decision-making powers by itself. This means that all three institutions play an active role in the decision-making process, and none of them has the ultimate decision-making power on the program.

Recommendation 7: Speed up the European decision-making process

This recommendation is related to the reform of European governance identified by the Commission as one of its four strategic objectives in early 2000 [COM(2001) 428.] Slow legislative processes lead to slow implementations. Decision-making in the EC tends to be slow, and even more considering the highly technical aspects associated with most of the decisions on Galileo. Decisions may take even longer whenever they conflict with the interests of some Member States. Consequently, on purely political grounds, it might be difficult to secure a mandate for action.

The EU should work towards better and faster regulation. This requires improving the quality, effectiveness and simplicity of regulatory acts. The level of detail in EU legislation means that adapting the rules to technical or market changes become complex and time-consuming, hindering the overall flexibility and damaging the overall effectiveness. Policies must be able to react quickly to changing market conditions and new problems, and adapt the system to these circumstances by reducing the long delays associated with the slowness of the policy-making process. In may cases, the adoption and implementation of Community rules may run to several years. In the case of Galileo, there were often situations in which there was tension between faster decisions and better, but – time-consuming – effective analysis.

From the beginning of a policy, a number of factors can change and new ones can arise. This creates new opportunities and challenges, together with attendant problems and risks. Flexibility does not only allow decision-makers to react on time to the actual situations and conditions as they arise to deal with bad situations, but also allows them to take advantage of new opportunities [de Neufville, 2003a.]. This requires updates of the project status to be provided to decision-makers so that they can establish correcting actions timely.

Already in 2004 there was evidence that the 2008 deadline was not going to be accomplished, on the contrary to what the EC stated consistently. Even though the concession process was deferred twice, Galileo timetable was not officially updated until 2006-2008. Frequent reviews of the costs, risks and likely revenues from the Galileo services should have also been done. Instead, decision makers were not able to handle realistic information and were neither able to consider properly the information they had, nor to react to the failures promptly enough. Progress must be measured by establishing points in the project timetable at which a review of the project's continued viability should be evaluated. Regular reports and detailed reporting requirements were recently established, and a Galileo Inter-institutional Panel (GIP) was set up to monitor progress on the overall implementation of Galileo. The GIP is composed of three members each from the Parliament and the Transport Council, and one from the EC, and is to meet four times a year to decide on key aspects of the program. In any case, different measures should be established so that the decision making process does not slow down the implementation of the changes required on the basis of the GIP evaluations.

Recommendation 8: Use of methodologies that account for uncertainties.

The policy making for large technological projects is subject to a wide range of failures that can arise from many sources. Many of the failures that Galileo needed to face were due to the fact that the analyses neither incorporated risks or uncertainty into the decision-making process, nor built flexibility into the tactical plan that would have allowed to cope with these risks and reshape the plan easily over time according to the events as they occurred [de Neufville, 2003a.] This flexibility would not only have provided a guarantee against the paralysis Galileo suffered for years, but it might have also opened doors to opportunities for success that would not have been able to capture otherwise [Scholtes, 2007.] In other worlds, a higher degree of flexibility in the decision making process would have allowed managers to transform the inherent risks of the project into opportunities.

The financial measures, tools and management methods have to keep pace with the more complex and rapidly changing business environment [Pettit and Stewart, 1999.] Traditional valuation methods, such as discounted cash flows, have been shown to evaluate innovative developments as the Galileo program inappropriately, as they are unable to account for the value of updated information and flexibility in future decisions. Likewise, the use of conventional CBAs was not the most appropriate methodology.

Galileo program's surrounding uncertainty requires us to complement traditional projection-based appraisal techniques by valuation schemes that account for the value of flexibility. Designing flexibility into projects increases the value of projects significantly: it reduces the maximum possible loss, and increases the maximum possible and the expected gains [Mikati, 2009.] Analysis should adopt a "real options"[67] approach that emphasize the value of keeping options open, so that decisions are taken when uncertainty is solved.

The prevalent mindset used for Galileo based on a "delivery to specifications" with its focus on cost and time and on "avoiding the downside" must be complemented by a mindset of "value maximization" for a system over its lifetime, including the exploitation of its upside potential. Thus, a large-scale project team that has to deal with uncertainty should be guided by leaders who approach each stage of the planning, designing, development and procurement process in a pro-active way, as proposed in the Figure 22 (adapted from [Scholtes, 2007.]) This way of running a project will prevent unpleasant surprises while also potentially creating new business opportunities.

[67] Real Options Approach – The real options approach is a financial technique for valuing investment alternatives. This approach is primarily a decision tool that indicates whether or not to proceed with an investment after pre-established decision points are reached. This approach is more suited to large scale, multi-year acquisition projects where the EU would need to decide whether to continue spending or abandon a specific project. This approach integrates NPV techniques with a decision-tree framework to determine the whether a project should proceed or be terminated.

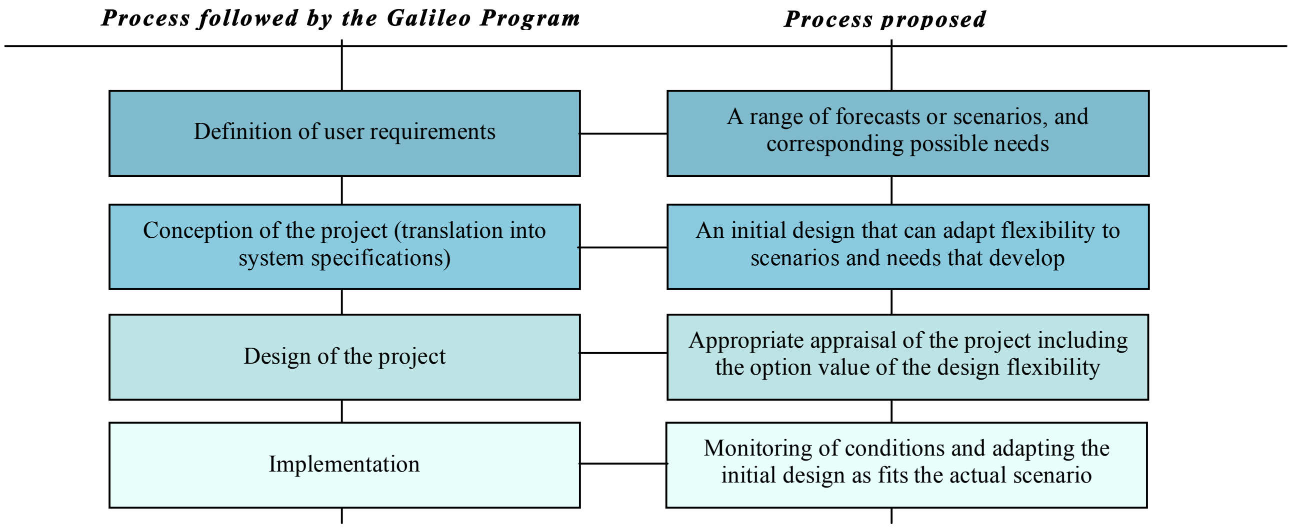


Figure 22: Proposed process for the design and implementation of Galileo as a large-scale project

PART C

Appendix A

Satellite navigation fundamentals

Satellite navigation technology has been developed over the last 30 years or so, originally essentially for military purposes. Its operating principle is based on the personalized signals that a group of satellites emit from the space to Earth (signal in space, downlink). Broadly speaking, these signals contain messages (navigation messages) indicating the orbital position of its corresponding satellite (ephemeris), and the precise time the signal has left each one of them. Time is measured very accurately thanks of atomic clocks in these satellites. Down on Earth, a ground receiver, incorporated for example into a mobile phone, can detect these signals and read their corresponding messages. Consequently, the receiver will recognize the particular satellite in origin of each signal, and determine the time it took to arrive from the orbital location of the satellite to the receiver. Considering that these signals propagate at the constant speed of the light[68], the receiver can calculate its distance from each satellite[69]. Combining the distances of the user to a minimum of four satellites simultaneously, the receiver can compute its exact position within a few meters, as depicted in the Figure A.1.

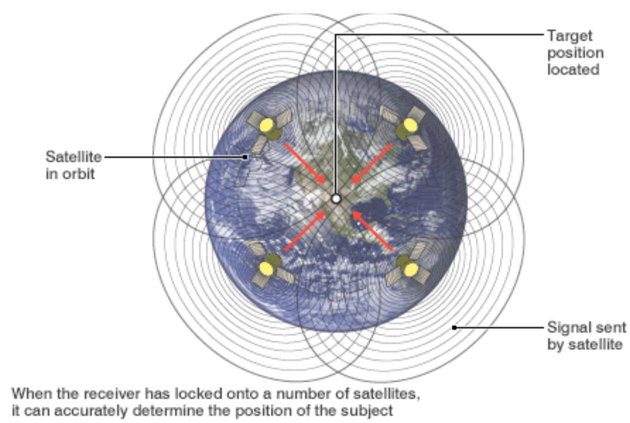


Figure A.1: How Global Navigation Satellite Systems (GNSS) work[70]

[68] Approximately 300,000 Km/s
[69] Distance = speed * time. Radio navigation signals travel at the speed of the light, which is constant, approximately 300,000 Km/s. Multiplying this constant with the time a signal has been traveling until the user received it, we calculate the distance from the satellite to the user.
[70] BBC News website at http://news.bbc.co.uk/1/hi/sci/tech/4555276.stm

The satellite constellation (space segment) is monitored and controlled from the system's ground infrastructure (ground segment), which is also in charge of generating most of the information that the satellites disseminate to the users. Contrary to what is generally thought, the satellites mainly redirect information that has been previously calculated on ground. This makes the ground infrastructure an essential part of the system. The ground infrastructure is composed of a redundant number of ground control centers, and multiple stations (antennas) connected to these centers and distributed worldwide. These antennas receive information from the satellites and send it to the centers, *vice versa*, or both, depending on their function.

All around the world, a specialized network of sensor antennas (Galileo Sensor Stations or GSS, in case of the Galileo System) captures signals emitted from the satellites on a frequent basis, and sends them to ground control centers (Galileo Control Centers or GCC) afterwards. These raw data are processed in different facilities that compute the corrections required in order to update the information that the satellites have to broadcast to the users so that they continue providing an accurate timing and positioning. For instance, since the ionosphere affects the quality of the signals, these facilities will generate some correction parameters that will be contained in the messages the satellites broadcast. Subsequently, these updated messages will be sent up to each of the satellites by means of another network of specialized antennas (Up-Link Stations or ULS), and the satellites will disseminate this up-to-date data to the users afterward, closing the loop. Depending on the nature of the different data that the satellites emit, different update rates are required for a target performance of the system.

The Satellite-Based Augmentation Systems (SBAS) are not autonomous. They are composed of several satellites (not necessarily a constellation) and a ground infrastructure of control centers and sensor antennas distributed over a region. These antennas collect the data broadcast by the satellites of the global systems (GPS or Galileo, for instance), and sent them to the centers where these data are analyzed. In particular, they measure the quality of the signals disseminated by the global systems, ascertaining how trustworthy they are, and compute corrective parameters that would improve the accuracy obtained from these global systems alone. Thereafter, this valuable complementary information will be broadcasted to the users via the SBAS satellites, which will be read by the receivers and computed in relation to the data they already obtained from the core global navigation satellite systems (GPS and/or Galileo, for instance) the SBAS augments.

In addition, considering that satellites usually are capable of transmitting more bits per second than needed for navigation purposes only, these navigation satellites can also disseminate other data in their messages together with the basic navigation data, increasing the versatility of this technology.

Appendix B

The infrastructure: the Galileo System

The Galileo system is to be composed of a constellation of 30 navigation satellites, positioned on three different orbital planes at an altitude of nearly 24 000 kilometers, providing precise timing and location information to users on the ground and in the air worldwide. There will be two redundant “Ground Control Centers” (GCCs), located in Germany and Italy, and a network of different antennas/stations connecting them with the satellites. Five “Telemetry, Tracking & Control” Stations (TT&C) distributed worldwide help track and control the satellites from the ground. Another network of “Galileo Sensor Stations” (GSS), also distributed worldwide, captures the signal emitted from the satellites and sends it to the centers for its processing, after which, updated navigation messages are sent to the satellites from the ground centers by means of a network of “Up-Link Stations” (ULS), closing the loop. A high-level picture of the Galileo infrastructure is depicted in Figure B.1.

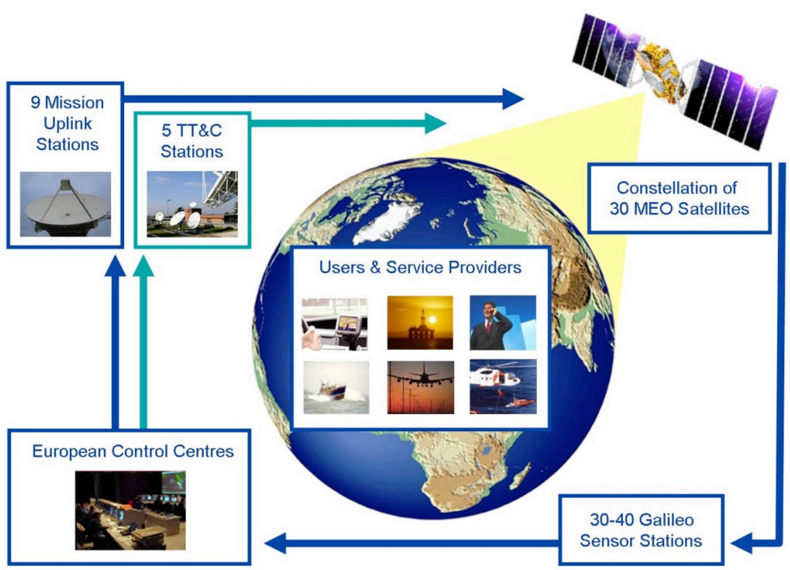
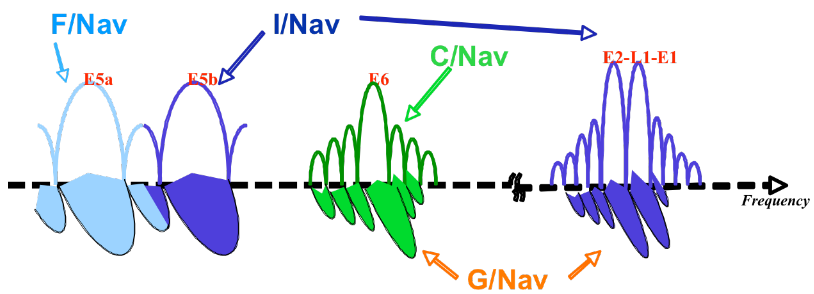


Figure B.1: High-level picture of the Galileo System. (Source: European Commission)

The following Figure B.2 depicts a mapping between frequency bands, navigation messages broadcast, and services provided. It is important to have a rough knowledge of the different services of Galileo at signal and data level, in order to evaluate the feasibility of different levels of private involvement in the exploitation and operation of the system.



Frequency Bands	Message Type	Message Data Content					Service
		Navigation	Integrity	Search & Rescue	Supplementary	Service Management	
E5A-I	F/Nav	•					OS
E5B-I & L1-B	I/Nav	•	•	•		•	OS/CS/SoL
E6-B	C/Nav	•			•	•	CS
E6-A & L1-A	G/Nav	•	•			•	PRS

Figure B.2: Mapping of Galileo frequency channels, navigation messages and services.

Appendix C

Competition-cooperation dynamics between Galileo and GPS

Figure C.1 depicts the dynamics between Galileo and GPS (or other competitors) in the marketplace. As we can see, all systems balance (compete) and reinforce their revenues (cooperation) at the same time. This graph also shows how important it was for Galileo to achieve interoperability and compatibility with GPS to accelerate its market entry, as well as the effect of other technologies competition. The main conclusion obtained from the analysis of these dynamics is that even if competitors (for instance, GPS), lose part of their market share, they all are expected to increase their total revenues. Besides, users will benefit from better applications and products and be better off.

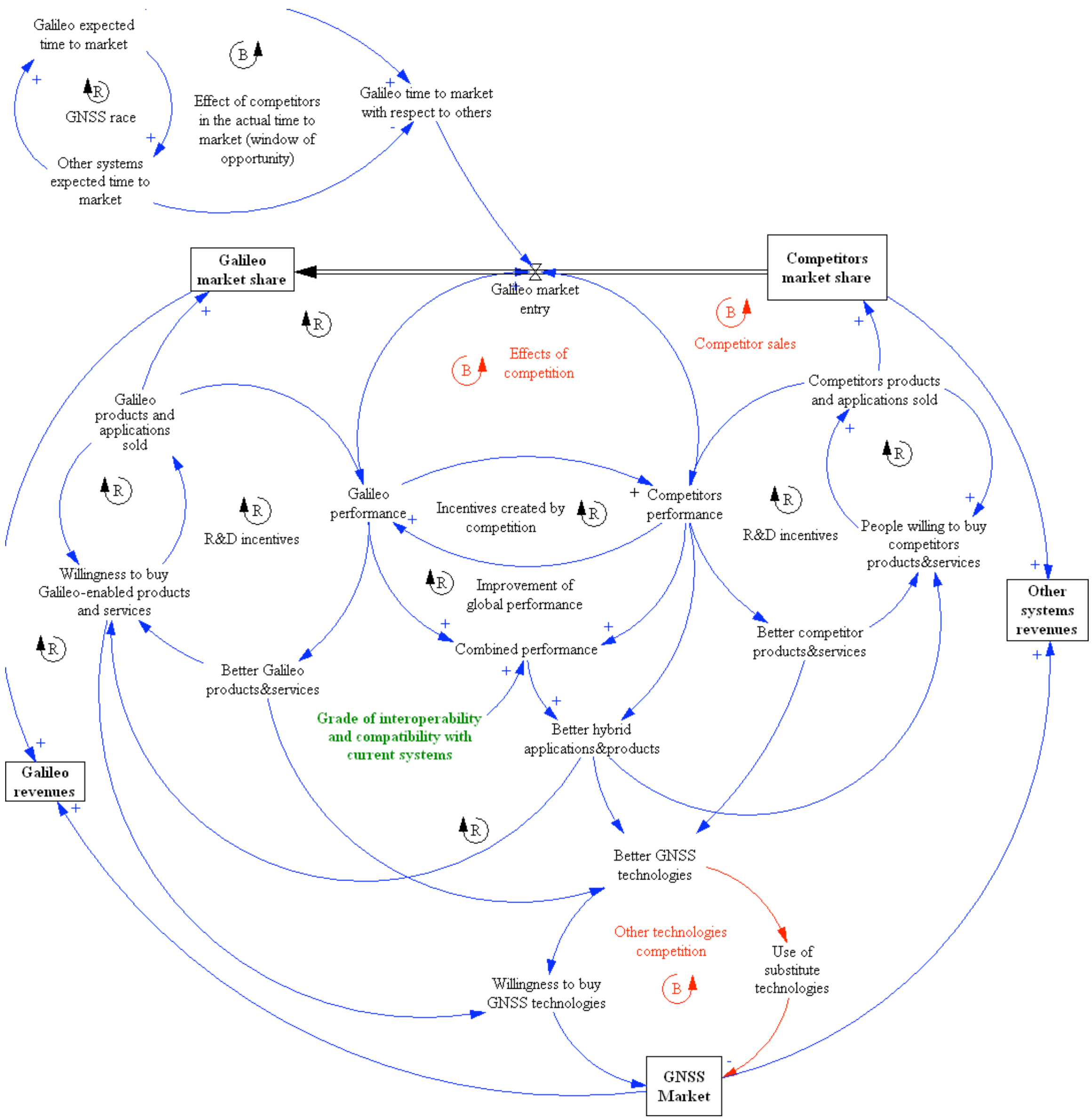


Figure C.1: Competition-cooperation dynamics between Galileo and other GNSS systems (particularly GPS)

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