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ASSESSING SATELLITE NAVIGATION INFRASTRUCTURES FROM A MANAGEMENT PERSPECTIVE: MAIN OBSTACLES FOR ADOPTION OF GALILEO-BASED SERVICES

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The Galileo project intends to deliver the primary satellite navigation infrastructure supporting civil services. Nevertheless, to accomplish this, alongside the development and implementation of the Galileo satellite navigation system, it is also crucial to ensure that this critical infrastructure will be intensively used. To this end, it is required to pay particular attention to mainstream developments affecting the adoption of Galileo-based services. On the face of this, this paper investigates the potential obstacles that can get in the way of the realisation of a widespread adoption of services based on the Galileo system.

Keywords: Galileo; Satellite Navigation, GPS, Adoption, Risk Assessment

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1 Introduction

Satellite navigation is currently experiencing a tremendous growth throughout the world. As increasingly more people become aware of the potential benefits provided by satellite navigation services, a growing diversity of such services are being developed based on spatial coordinates. Consequently, interest in this type of technology is rising very rapidly (Trautenberg, 2004). This is also emphasized by the fact that a massive adoption of those services is expected in the coming years. Towards 2010, satellite navigation technologies are estimated to represent a € 50 billion market with 3 million receivers (Campagne and Surre, 2000). Very aware of the huge potential for expansion that this market holds, both private firms and governments have started off architecting their strategies to maximize their share in this promising mass market.

At present time, however, most positioning services available in the market rely on signals generated by the American NAVSTAR Global Positioning System (GPS). From a European perspective, this situation of total dependence on GPS is yet not desirable for a variety of reasons. First of all, this satellite navigation system was initially developed and launched by the US Department of Defence (DoD) for purely military purposes (Department of Defence, 2003). The trouble here is that, since the DoD obtains no revenue from the provision of GPS services (Blanchard, 2003), it is not legally obliged to provide a guaranteed level of service. Additionally, although the DoD has a clear public commitment with US citizens and military to maintain a stable and reliable GPS service provision, there are no reasonable guarantees for non-American users who actually take a 'free-ride' on the GPS system by using free of charge services (Last, 2004). Apart from the problems already mentioned, there has been traditionally a serious problem concerning the positioning performance delivered by the GPS infrastructure. The accuracy achieved by GPS receivers is in fact relatively poor and not consistent over time (Blanchard, 2003). For all these reasons, the GPS system, as it is now, does not serve as a trustworthy base infrastructure for the development of critical positioning services. Hence, in the light of the enormous potential of satellite navigation based services, a more reliable infrastructure is badly needed, especially for non-American parties.

In order to eliminate this absolute dependence on GPS, Europe initiated the development of its own satellite navigation system, which is called Galileo. In essence, Galileo will be an independent and certifiable satellite navigation system under European control (European Space Agency, 2004). This European system is envisioned to be fully interoperable and, at the same time, independent from the

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American GPS (Trautenberg, 2004). One of the major drives behind Galileo is to solve the lack of GPS performance guarantees by initiating a civil-based system operated with civil users as its main concern (Blanchard, 2003). Technically, though, Galileo is very similar to GPS. The major technical difference is the incorporation of some additional technical features to accomplish higher service levels such as accuracy and stability (Bornemann, 2004). Nevertheless, the detailed technical innovations to be introduced by Galileo will not be discussed in detail, as this aspect lies outside the scope of this paper.

Despite similarities between GPS and Galileo when it comes to the technical configuration, two essential differences distinguish the two satellite navigation systems. First, while GPS was developed by a government body, Galileo will come about through a public private partnership (PPP) arrangement involving the European Commission (EC), the European Space Agency (ESA) and private firms. The second difference regards the end user adopting technology. In contrast to GPS, which was designed for military purposes and has been funded by the US DoD, the maintenance of Galileo system may rely mostly on the revenues generated from private end users (Commission of the European Communities, 2004). Given these profound differences, the Galileo system will need an intensive adoption of its services in order to generate sufficient revenues to maintain the system according to the original intention. The purpose of this paper is thus to provide insight in the obstacles for the Galileo project in accomplishing a widespread adoption of Galileo-based services by making an assessment of the transition moment from the GPS to the Galileo system.

This paper is organized as follows. Firstly, the structure of this study will be defined. Here attention will be paid to the definition of both the transition moment as well as the research framework to analyse it. After that, the research object will be explored accordingly. Finally, in the end, conclusions will be put forward.

2 Understanding the Transition Moment

As this paper addresses the transition moment from GPS to the Galileo satellite navigation infrastructure, it is necessary to provide more specific clarification on the differences between the development patterns of the two satellite navigation infrastructures. For this purpose, the development of both infrastructures shall be characterized here.

2.1 From GPS

The GPS satellite navigation infrastructure is fundamentally a system developed and maintained by the US Department of Defence to serve military purposes. It is a space-based positioning, velocity and time distribution navigation system (Department of Defence, 2003). Its basic concept design was produced in the early 1960 (RAND Corporation, 1995).

A distinguishing characteristic of the development of this infrastructure is that it followed a sequence of different generations of satellites (Campagne and Surre, 2000). This evolution pattern has allowed the addition of extra functionalities to the new generations of satellites according to a sequential process. A prominent example of this evolution is given by the fact that, in the course of time, the potential for civil services became evident. In response to this, the Standard Positioning Service of GPS was made available to civil users free of charge. Nevertheless, due to strategic reasons, the Selective Availability (SA) was introduced to degrade deliberately the accuracy provided by the civil mode (Last, 2004). This service mode developed for civil users is managed by the US Department of Transport (DoT) since 1987 and is gaining importance over time (Rand Corporation, 1995).

Furthermore, another indication of the evolutionary character of GPS regards the architecture of the space segment. While the original architecture comprised only six satellites in the early sixties (RAND Corporation, 1995), the current architecture is based on a constellation of twenty-four satellites in Medium Earth Orbit (MEO), at approximately 20.000 km altitude (Campagne and Surre, 2000).

In summary, the GPS system is being subject to continuous technical improvements that have been enabling incorporation of new features over the years. However, the governance patterns defining the strategic decisions on the GPS system remains entirely on public hands, thereby restricting influence of end users on the system.

2.2 To Galileo

Although the research object has to do with a transition moment, which might suggest for some the total replacement of an old infrastructure by a new one, it should become clear that the Galileo system is definitely not being designed to replace the GPS system completely. The Galileo system has in fact a different nature in comparison to the American GPS system, as its development is rather devoted to overcome the shortcomings of GPS when it comes to the provision of services for civilian users. In contrast to GPS, Galileo will be a civil satellite navigation system, designed and operated under a certain level public control (Kries, 2003). Beyond this, the combination of Galileo and GPS will provide the basis of the Global Navigation Satellite System (GNSS) (Vejrazka, 2007). Within the GNSS, Galileo should provide the signals for services requiring guaranteed quality. Nonetheless, to gain access to such services end users will have to pay access fees and part of those fees will be used to fund the maintenance of the Galileo infrastructure.

The Galileo system comprises a satellite constellation of 30 satellites in three circular orbits at 23600 km (Bornemann, 2004). Galileo will thus employ a similar architecture for the space segment as GPS in order to benefit from low technical risk and more predictable performance. However, some technical improvements will be realised to enable the system to provide users a positional accuracy of, at least, 10 meters, or even 4 meters in locations with optimal line of sight, and service reliability close to 99 % (Campagne and Surre, 2000).

In short, with Galileo, Europe will have at its disposal an independent Satellite navigation system under civil control with potential to become the principal infrastructure supporting civilian oriented services.

3 Research Method: Service Adoption Framework

To identify obstacles for Galileo's adoption in the context of the transition moment outlined in the previous chapter, the Service Adoption Framework will be used as the primary tool of analysis. The purpose of this chapter is to explain the origin of this framework as well as the way it will be employed in this paper.

3.1 History of the Service Adoption Framework

The Service Adoption Framework, which is illustrated in Figure 1, was mainly delineated by the outcome of insights through examination of various literature addressing current developments in the field of ICT infrastructures [Trautenberg (204); Last (2004); Cano (2003); Blanchard (2003), Bounds (2007)]. This Framework was designed to address the most relevant aspects of a transition moment associated to ICT infrastructures from an interdisciplinary system perspective, as it combines elements from different disciplines such as economy, law, business administration, information technology, and so on. In practice, it intends to provide a framework for discussions with regard to the introduction of new ICT infrastructures.

The Service Adoption Framework comprises five dimensions, which include Stakeholders, Strategy/Process, Technology, Adoption and Market. Each dimension contains attributes representing the most important issues within the dimension. The broad range of issues covered by the framework makes it very suitable for examining case studies concerning transition moments, such as the one addressed in this paper. The case study is a well-known research strategy characterized by the broad scope and qualitative approach of the research object (Verschuren and Doorewaard, 1999).

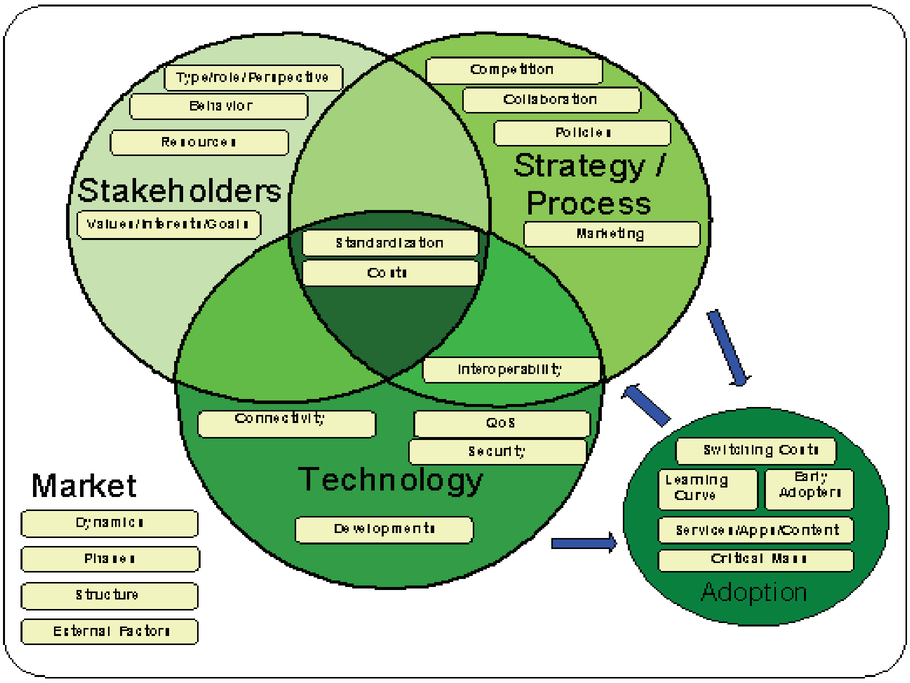

Figure 1: The Service Adoption Framework

3.2 Applying the Framework

Given the combination of the broad coverage provided by the Service Adoption Framework with the specific focus of this particular analysis, it seems necessary to select the most relevant elements of the Framework. This selection ought to reflect the research perspective through which the transition moment will be analysed. The research perspective can be referred to as a pair of glasses to observe the to examine the research object (Verschuren and Doorewaard, 1999). Since the research perspective is directed towards potential obstacles for adoption, it is worthwhile to reflect on the dimensions that are more likely to yield the most serious obstacles. For the sake of clarifying the research perspective, the relevance of each dimension is briefly discussed.

With regard to the dimension Market, it is unlikely that this dimension will contribute to reveal substantial bottlenecks. If we look at the estimates for the size of this market, we see that the world market for satellite navigation doubled from 10 billion in 2002 to 20 billion in 2003 and it is estimated to amount nearly 300 billion by 2020 (Commission of the European Communities, 2004). In essence, there is and there will be certainly demand for satellite navigation services. What remains unclear is whether the Joint Undertaking will manage to conquer this market rapidly.

The dimension stakeholders, in turn, will be explored, but in a more indirect fashion. For all dimensions certain conflicts will be revealed that are motivated from competing values of the involved parties. So this idea of competing values and interests will be present throughout the whole analysis.

Both the dimension Process/Strategy and Adoption will be explored, because they are expected to reveal some interesting insights in the adoption process. Although these dimensions are separated and do not share any attribute, it is quite reasonable to assume that some strong interesting causal relationships are likely to exist determining the way Process/Strategy influences Adoption.

When it comes to the dimension Technology, there is evidence, within the context of this study, that most attributes of the dimension technology will be of limited value for this analysis. This results the fact that GPS is up and running enables those involved in the Galileo project to observe the technical solutions used by GPS, and attempt to come up this better solutions based on the observations (Bornemann, 2004). In practice, the only meaningful attribute is Developments, as this attribute is likely to influence somehow the adoption of Galileo-based services.

In conclusion, the further analysis will concentrate on the dimensions Process/Strategy, Technology and Adoption. Consequently, the research perspective, or the pair of glasses to analyse the transition moment, consists of a set of relevant attributes belonging to these dimensions. By making use of attributes belonging to these three dimensions according to the research perspective of this analysis, the most significant aspects of the noted transition moment will be covered.

4 Exploring Obstacles for Galileo's Adoption

To identify the obstacles for the adoption of Galileo it is necessary to address the circumstances through which this project is being carried out. In this chapter, the transition moment from GPS to Galileo will be explored by examining relevant attributes of the selected dimensions.

4.1 Strategy/Process Dimension

The Strategy/Process Dimension has to do primarily with the institutional arrangements designed to govern the relationship between the different parties involved in the transition moment. Here attributes Policies and Collaboration are taken into account, as these attributes reflect the way public values have shaped institutional arrangements and the implications for the project participant.

4.1.1 Policies

This attribute concerns the policy setting that shapes the Galileo project. In this sense, the Galileo programme results from a collective effort to realise a European satellite navigation system. This effort, however, was initiated by the EC whose role in this project was that of project initiator (Commission of the European Communities, 2004). This initiating role was motivated by public values embodied by the EC, which include employment, reliability and long-term security of supply. But, at the same time, the principle of the minimization of public funding of large infrastructure projects played a role as well in the policy setting attached to Galileo (Blanchard, 2003).

Given those public values embraced by the EC, there are apparently three major reasons that motivate the selection of a PPP arrangement. First, a certain level of public intervention was required, as private parties alone were not in a position to provide sufficient financial resources to cover all the costs associated with the project. Second, the prospects of generating substantial revenues from the exploitation of satellite navigation services provide a strong indication that this infrastructure cannot be considered merely as a provider of public-good. So, the potential demand for the services seems to motivate private parties to step in and commit significant investments. Third, public participation is also desirable to ensure security of supply in the long run.

A major issue emerging from this arrangement is, tough, the maximum contribution of the EC for the project. The task of determining the proportion between public and private share is an important and challenging one (Taylor, 2007). On the one hand the public actors want to minimize the utilization of public financial resources, but on the other hand there is a need to ensure a sufficient level of funding to the project and security of supply. This tension will be further clarified by discussing the collaboration patterns resulting from the arrangement.

4.1.2 Collaboration

Following EC's policy guidelines on large infrastructure projects, the Joint Action was established. This agreement defines the aspects of the operation of the European satellite navigation system through the specification of the structures for management responsibilities for the system (Commission of the European Communities, 2004). In principle, the Joint Action can be seen as a set of contracts between the involved parties that intends to create more certainty for the involved parties. Such set of contracts establishes the governance arrangements through contractual allocation risks and incentives to various project participants (Miller and Lessard, 2000). In the end, the collaboration patterns result chiefly from the terms defined in those contracts.

The contractual relations established by the Joint Action reflect the EC policy towards the minimization of the commitment of public financial resources in infrastructure projects. This becomes clear when one understands that the contracts were deliberately designed to make sure that there would be a significant contribution from the private sector (Commission of the European Communities, 2004). It has been defined that the required investment will be collected by allotments of public funds provided by the EC, by ESA, and complemented by private investors (Campagne and Surre, 2000).

The immediate consequence of the shift of costs and risks to private parties is that the infrastructure development gains a more commercial nature. As a result, the overall profitability becomes automatically a central concern. This is emphasized by the fact that private firms often borrow money from banks to invest large engineering projects (Miller and Lessard, 2000). In this regard, two observations can be made:

- The pressure for the Galileo project to provide the first revenue as early as possible tend become very strong.
- The cooperation among the involved private parties tends to be influenced by the expectations created by contracts. So, cooperation tends to become unstable if levels of revenue generated by services turns out to be significantly above or under the expectations. This can create a big hustle and bustle, where the participants may engage in disputes regarding the division of revenues and costs. This problem is widely known as a hold up problem and becomes more likely to emerge when private participation increases.

4.2 Technology Dimension

As mentioned previously, Galileo is intended to become the primary satellite navigation infrastructure for civil services. However, an interesting technologycal development that may impact the accomplishment of this objective is the evolution of the GPS infrastructure. Alongside the implementation of Galileo, the GPS system will be subject to enhancements in its capabilities of meeting civil requirements. The introduction of precise positioning service (PPS) based on GPS will enable improvements in terms of accuracy, reliability and availability (RAND Corporation, 1995). Beyond this, it is expected that developments of better receivers with innovative antennas and the introduction of augmentation mechanism will permit significant improvements in positioning performance (Last, 2004). This may well increase the competitive pressure on Galileo.

The current pace of technical evolution indicates consistent improvements prior to the scheduled start of the operational phase of Galileo in 2008. Therefore, the obstacle that emerges is that Galileo the performance advantage of Galileo tends to decrease as the GPS performance is enhanced.

4.3 Adoption Dimension

This dimension refers to the process of having end users actually purchasing (adopting) the services supported by the infrastructure. Although it is widely known that consumers, in general, are interested in reasonable prices and satisfactory quality of service, it is necessary to understand what other less straight-forward aspects determine this decision of end users.

In this paragraph, the attributes of the dimension Adoption are examined. Nevertheless, not all attributes of this dimension are taken into consideration. Literature research revealed that it is likely that the provision of Galileo-based services will follow the development pattern of mobile telephony where the supply of free of charge hardware is compensated by charges associated with subscription to various services (Campagne and Surre, 2000). Not to mention that the price of receivers tend to decrease significantly over the years This removes the need to address the attribute switching costs, which loses relevance in this particular transition moment. However, the other attributes are very meaningful and are therefore taken into consideration.

4.3.1 Early Adopter

The fundamental role of this adopter category is to evaluate the innovation and influence others through interpersonal networks. This is possible because early adopters have an onion leadership within most social systems, which derives from both their interest in technological innovations and their capability to provide advice to the late majority adopting a certain technology or service (Everett, 1995). Given this distinctive role, it is reasonable to assume that the early adopter will determine the outcome of the initial market trials of Galileo services. Accordingly, the experimentation of the early adopter with the new services is likely to provide to provide a clear picture of the ability to generate revenues from those services.

The early adopters are thus able to contribute directly to reinforce demand for a certain innovation, but also spread a bad reputation in no time as well as. Consequently, the premature introduction of Galileo-based services without adequate positioning performance or without usable interfaces may have a devastating effect in terms of market acceptation. By linking back this scenario, with the observation made in paragraph 3.1.2 that a PPP arrangement will lead to a pressure for obtaining revenues as early as possible, it becomes clear that this combination forms a significant obstacle to adoption. In practice, it takes years to ensure total reliability of a complex infrastructure like the Galileo system, as it requires extensive testing (Blanchard, 2003). Beyond this, it is valuable to point out that huge costs are likely to be associated with an extended testing phase. As a result, spending enough time and financial resources with development and testing may seem very tricky when there is an enormous pressure from investors to introduce the services in the market as early as possible.

4.3.2 Learning curve

The learning curve refers to the period that takes for people to get familiarity with a new concept or technology (Ortt, 1998). The learning curve for end users will also have an impact on the rate of adoption of Galileo based services. This is simply because the more similar Galileo-based services are to the GPS services, of course, the shorter the learning curve will be. However, the more similar the applications are, the lower the incentive for end users to incur costs so as to adopt the Galileo services. By understanding this it is reasonable to say that the degree of differentiation of Galileo-services, in general, can be pointed out as a potential obstacle to adoption. There is a need to provided extra added value, without introducing radical modifications.

4.3.3 Services/Application/Contents

The availability of a reliable supply of a broad range of valuable services is certainly a central requirement for the accomplishment of widespread adoption of Galileo's services. A good indication of the availability of services is given by the fact that Galileo will be fully interoperable with GPS. This will allow adopters of the Galileo system to use existing applications.

The main risk associated with interoperability is that, as mentioned in paragraph 2.1.1, GPS-based services are offered free of charge and the maintenance of the Galileo system will rely on revenues generated by end users. Apart from the free of charge services, Galileo will provide three satellite-only-based navigation services, from which revenues should be generated. The commercial service (CS) providing value-added mobility services, the public-regulated services (PRS) to provide public applications such as civil protection, governmental activities and emergency or rescue services, as well as equipment synchronization services (Trautenberg, 2004).

Thus, the question Services/Applications in this transition moment seems not to be whether they will be available, but rather whether the three categories of paid Galileo-based applications will be capable of providing a sufficient degree of differentiation to justify the payment of a service fee. This question leads to uncertainty regarding the generation of a sufficient level of revenue per user so as to enable overall system profitability.

4.3.4 Critical Mass

The critical mass is the first step in achieving a large customer base. This term refers to the point where the benefits from externalities outweigh the costs for a single end user. According to economic theory, the developers of a certain infrastructure, say the private firms, governments, or both, will need to subsidize the initial growth until critical mass is reached, after that, an upward spiral in adoption initiates automatically (Noam, 1992). This attribute of the dimension adoption can be regarded as the result of the other four attributes. Hence, achieving critical mass rapidly will depend on the resolution of the problems presented in the other dimensions.

By reflecting on the adoption process, it is quite straightforward to understand that the opinion of the early adopter will have a major impact in the rate of adoption. The better the initial quality of the applications, the easier it will be to achieve critical mass rapidly. Beyond this, the learning curve for end users will also have an impact on the rate of adoption. The more similar Galileo-based applications are, the shorter the learning curve. However, the more similar the applications are, the lower the incentive to adopt the Galileo services. By understanding this it is reasonable to say that the level of differentiation of Galileo-services, in general, can be pointed out as an additional potential obstacle for adoption.

5 Conclusions

The analysis conducted to write this paper has contributed to increase understanding of the main obstacles for the adoption of Galileo based services by bringing some of them to the light. Preliminary conclusions suggest a certain tension between elements of process and adoption dimensions. While collaboration in a public private partnership arrangement creates pressure on private firms to generate revenue as early as possible, the adoption dimension indicates that an important requirement for adoption is the initial quality of applications. If quality is not high, early adopters tend to spread a bad reputation for the technology/infrastructure. Therefore, there is a pernicious trade-off for those parties involved in the Galileo’s Joint Action between a fast introduction of services and careful testing. The longer the tests, the more likely initial applications will have an acceptable quality. Likewise, the longer the tests, the longer the first revenues will be delayed and the higher the costs for all project participants.

Another important obstacle seems to be the competitive pressure generated by the GPS system. Given the expected GPS performance improvements in terms of accuracy, delays in the development of the Galileo system will create additional possibilities for the enhancement of GPS positioning performance. Despite this additional pressure for a rapid market introduction, it is important to remember that the launch of services after an incomplete testing phase may prevent the Galileo system from delivering the promised positioning performance, which may also contribute to decrease the performance gap between both satellite navigation services. Thus, competitive forces between infrastructures may play a significant role in this transition moment. An obstacle that may well affect long-term adoption of Galileo-based services refers to the degree of differentiation between GPS and Galileo based services. There are evidences to be found that end users will demand a certain degree of differentiation, perhaps beyond just positioning performance, in order to justify the payment of service fees, provided that free of charge service is available with GPS. However, the analysis demonstrated that too much differentiation may result in a longer learning curve for end users. Since a long-learning curve affects short-term adoption, it is necessary to find a balance between the delivery of value added service differentiation and the relevant experience accumulated by end users with GPS based services.

The final consideration is that this paper ought to be seen as a brief analysis from a helicopter view on developments attached to a large-scale ICT infrastructure. Given the strategic importance of Galileo and the fact that few publications have been published specifically focussed on the challenges for the adoption of Galileo, further research on this area is certainly required to clarify certain knowledge gaps. In this respect, most important directions for further research include more specific analyses in research directions, such as Contract Research, Process Management, Project Management and Risk Analysis. In all these research directions the Service Adoption Framework can play an important role by revealing some crucial aspects of the selected transition moment. In this way, other researchers will not need to start designing a new research framework from scratch. So, instead of reinventing the wheel, other studies can build upon the Service Adoption Framework.

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