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Sustainable Governance of Global Navigation Satellite System (GNSS) Continuously Operating Reference Station (CORS)

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Abstract

Acquiring a precise position on the earth is an essential factor in many activities today and will be a prerequisite for future activities. Global Navigation Satellite System (GNSS) Continuously Operating Reference Station (CORS) network or GNSS CORS is an infrastructure that plays a crucial role in precise positioning. However, running GNSS CORS requires significant investments to establish and maintain the service. How to run GNSS CORS in a sustainable manner is unknown. Countries that are running GNSS CORS have different policies and perspectives about GNSS CORS. In some countries, it is an open public service fully supported by government budgets. Other countries rely on the private sector GNSS CORS services available at market prices. Several types of research have been proposed and covered aspects of GNSS CORS. But there still exists a challenge to identify sustainable governance model of GNSS CORS. And there is not any tool for the case.

This study aims to investigate models of sustainable governance of GNSS CORS infrastructure with a specific focus on the business model of GNSS CORS. Through a System Dynamics methodology, the first version of GNSS CORS generic governance model will be constructed and drawn as Casual Loop Diagram (CLD) to elaborate structures and relations of CORS GNSS elements. The next step is to transform the CLD into a stock and flow diagram. In parallel, existing GNSS CORS governance models in the Netherlands, Indonesia, the US, Australia and Japan will be explored. The model will be further developed and validated through the process based on the exploration and empirical data. The generic model will be useful for policy testing especially for examining the fit for purpose business model and accompanying access policy of GNSS CORS. The research will also design a graphic user interphase decision support tool. This tool will allow policymakers in different countries to be able to learn, understand and test policy choices on GNSS CORS governance.

Keywords: GNSS CORS, sustainable governance, business model, access policy

1. Introduction

Global Navigation Satellite System (GNSS) Continuously Operating Reference Station (CORS) network is an important infrastructure nowadays. The initiative was developed for domains requiring a high standard of positioning such as geodesy, surveying and mapping and another kind of engineering standard. But technological evolution has allowed ordinary uses such as agriculture, road service, personal navigation etc., to benefit from GNSS CORS. [1-3]. The scope of GNSS CORS service use expands every day. Besides, the reliability, promptness and accuracy of the hardware and techniques will continue to improve in the future, especially when the number of available satellites continues to grow from year to year [1]. More areas of activities on the earth will be more dependent on this service.

However, the cost of establishment and operating GNSS CORS could be considerable. Many countries that are running such services have a different policy, instrument, and tools to ensure the stability and existence of this service. In some countries, GNSS CORS is free of charge service. In many other countries, GNSS CORS service requires a subscription with a fee. In some countries, GNSS CORS are operated by the public sector, in others by the private sector, and in some, it belongs to both the public and private sectors. As a consequence, each of these countries has a unique governance model. Research on the performance of these governance models is scant. This has resulted in a lack of information on the performance of the current governance models and as a consequence cannot provide guidance to those countries that are considering the implementation of a GNSS CORS system.

Governance of GNSS CORS could be considered as a complex issue. It has to deal with both technological and non-technological aspects [4, 5]. The most difficulties could be in non-technological aspects [6, 7]. Similar to other infrastructures, CORS relates to multi-stakeholders and requires big-budget. The benefit of operating CORS is intangible. It also requires a long time to show up. With these characteristics of CORS, it could be a complicated issue. The complexity of CORS GNSS governance is then a challenge for policymakers or governments in many countries to deal with. Since it includes delay, non-linear behaviour and some feedback exist.

There have been several types of research on GNSS CORS in various aspects. Rizos and van Cranenbroeck [7] suggests the service should be paid by users to improve the quality of service. Weston and Schwieger [8] proposed a consideration about wage different perspective on the cost of operation between developed and developing countries where wage may be significantly differences. BAKICI, ERKEK [9] elaborates best practice of CORS GNSS business model of Turkey it focuses more on service and management. However, there is no academic research that considers Operating GNSS CORS as a complex system.

This paper aims to investigate the sustainable governance of GNSS CORS infrastructure. Currently, the research is in a preliminary stage. Several concepts, relating to formulating a conceptual model of GNSS CORS have been explored. GNSS CORS generic model is constructed and drawn as Casual Loop Diagram to elaborate structures and relations of the system. The model requires further steps, such as building stock and flow diagram, initialize model and model validation and analysis. The complete model will then be used to test different treatments to seek sustainable policy on CORS GNSS governance. The policies may lead to comparing between open/close access to service and different business model such as Public Private Partnership (PPP). The model will further be developed towards a decision support

tool. The final outcome is a graphic user interphase decision support tool that allows policymakers in different countries to be able to learn, understand and test policy choices on GNSS CORS.

2. Problem

In the last few years, the demand for GNSS service has been increasing. It is projected to grow in the future. Based on GNSS Market Report by European GNSS Agency (see *Figure 1*), the installation of GNSS in all three main sectors will be doubling from 2015 to 2025. This could reflex the demand for positioning services which also could double in the future. Ensuring of GNSS CORS service is an issue to be considered. With inappropriate treatments to GNSS CORS may lead to the collapse of the service. This study addresses two main challenges.

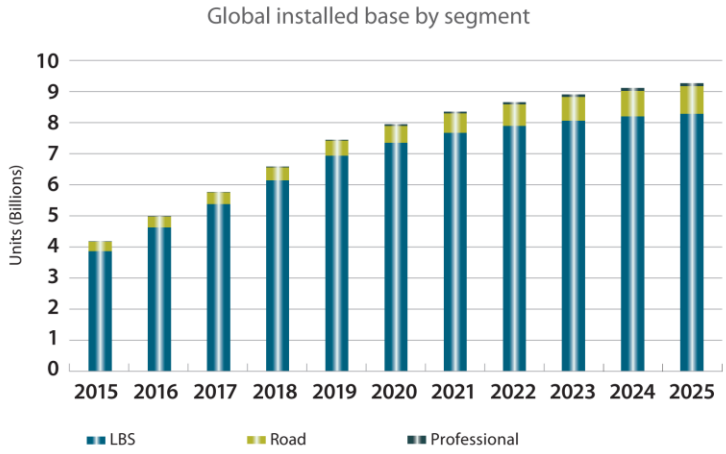

Figure 1 Source: GNSS Market Report, Issue 5, copyright © European GNSS Agency, 2017

The first challenge is to develop a model to assess the sustainability of access policies for GNSS CORS services. In many countries, GNSS CORS data service is free of charge. While there are also many countries that gain revenue from the service, the two scenarios may produce different results based on the necessary conditions of each country.

Secondly, in addition to the GNSS CORS services, GNSS CORS is an infrastructure that requires significant budgets. It is not only about allocating budget for establishing, but it is also about maintaining the infrastructure in the long term what business model should be applied for maintaining and further development of GNSS CORS in different conditions.

3. Conceptual Model

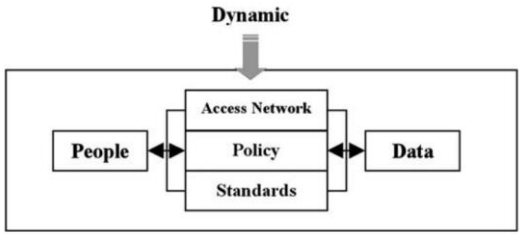

Figure 2 Concept of relations of Spatial Data Infrastructure elements [10]

The concept of GNSS CORS governance in this study is adapted from an SDI development approach by Rajabifard [10]. He proposed two aspects of SDI development. The first approach

is product-based which considers SDI development targets the existence of GI to communities. The second approach is process-based where SDI is considered as a link or a facility between spatial data to users. Such approaches could be adopted to CORS governance in the way that governance of CORS will facilitate and allow CORS service to be existing for users. In this study, CORS governance will be perceived in both product-based and process-based. From the product-based perspective, governance of CORS is about existing of CORS service to users. And from the process-based perspective, it is about how providers in both government and private sector could maximize and assure services of CORS to users.

According to Figure 2, there are two sides of the system including data and users (people). The dynamics of the system exist in between the two sides. The conceptual model formulated here is adapted by considering GNSS CORS infrastructure as a source of data. The data will be serviced and utilized by users.

Transforming the concept into a causal loop diagram (CLD), there are three feedback loops in the conceptual model including two balancing loops and one reinforcing loop[11]. These three feedback loops, by hypothesis, should generate S-shape behaviour. The S-shape behaviour could represent social change according to CORS governance implementation. As society requires time to realize at the beginning of any change, the earlier period would cause slowly change. After society realizes the impact of what to be changed and adopt it, society then changes rapidly. While the gap is gradually filled, the change will decay, and society reaches to new balance stage.

The reinforcing loop R starts from raising of GNSS CORS, and it is serviced at any levels. The levels of service could be different policies of access or type of subscription etc. The more service level is, the more users will utilize service for any purposes. The utilization will generate various benefit, in particular, the economic benefit which will be returned to revenue and use to maintain and improve GNSS CORS. However, a time delay exists from utilization and economic benefit.

The balancing loop B1 is started and driven by the gap between the level of service and demand for service. This gap will increase the desired number of GNSS CORS when the number of GNSS CORS increase, the level of service will increase. The gap will be filled.

The balancing loop B2 represents the feedback of utilization. The utilization will generate more users, more products, awareness of use etc. These factors exist but are not included in this conceptual model. But they will raise the demand of service which will make the gap of service bigger. And finally, raise the desired number of GNSS CORS.

The conceptual model will be transferred into the stock and flow diagram. The model will be remodified during the whole process of study.

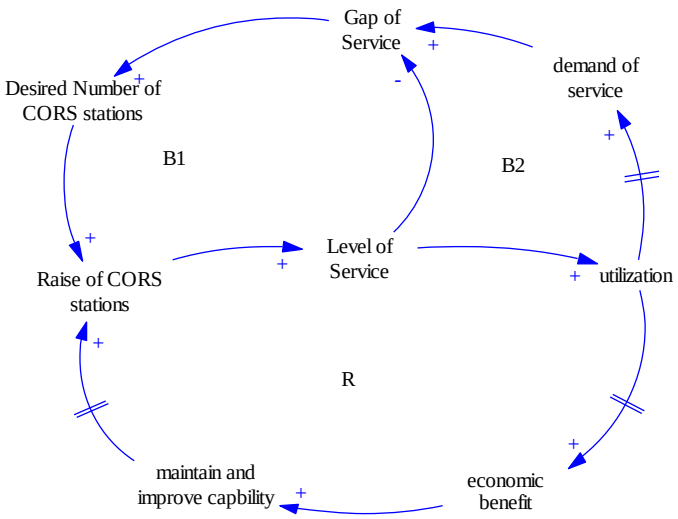

Figure 3 Casual Loop Diagram

4. Data and Model Validation

This study's data sources are documents and official information of Public and Private sectors those are relating to GNSS CORS. Stakeholders' interview and theoretical perspectives would be accounted to define structures and relations in the model. At this stage, the exact scope of the model has not been clearly defined. Hence, it is not possible to state endogenous and exogenous variables.

To validate the model, the historical data, such as users, access, economic and social benefit, revenue, location-based enterprises etc., should be collected and formulated as reference mode for model validation.

5. Policy

There are two main related areas of policy to test as mentioned in the problem statement including access policy and business model (see Figure 3).

First, for access policy, the principle of data access policy is controversial. Some may consider openness; the government should provide services free of charge as a public good. However, there are also reasons that the government should not provide free service. Since it may intervene economic mechanism in particular business ran by the private sector. And in the longer term, it may cause a tragedy of the (information/ data?) commons (REF). However, service from GNSS CORS is information that can be reused and it is not one-time use. In this study, access policies referring to Loenen [12] will be formulated and introduced to the generic model. The policies tested could be between open access and no open access.

Second, as operating GNSS CORS requires a tremendous amount of money. The budget for maintenance of the infrastructure is critical for. Meanwhile, the economic benefit is hard to define and takes time to show. A business model to support GNSS CORS in these conditions should be investigated. The question here is what the business model should be testified. At this stage, the Public-Private Partnership (PPP) concept is a potential treatment for the system. Based on Alasad, Motawa [13] they apply SD methodology forecast demand in Toll Roads under PPP. The same concept may be adopted here. However, more business models should also be explored and applied to the case.

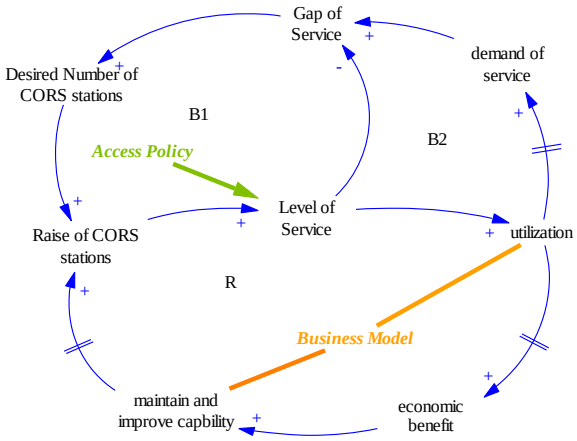

Figure 4 Potential Policies Testing

6. Conclusion

This paper elaborates preliminary research on building sustainable governance model of GNSS CORS network. Two main problems are identified including access policy and business model of GNSS CORS. System Dynamics methodology will be applied to formulate a generic model and investigate the problems. Currently, the stage of the study is exploring and formulating a conceptual model based on theoretical and empirical evidence. Further steps will be building stock and flow diagram and validating the model. The model is expected to produce behaviour of potential study cases of the Netherlands, Japan, China, Singapore and Indonesia. The challenges are how to model some qualitative variables, such as awareness, the demand for use, attractions etc.

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