ANALYSIS OF PUBLIC USE BICYCLE SYSTEMS FROM A PRODUCT-SERVICE SYSTEM PERSPECTIVE

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ABSTRACT

ANALYSIS OF PUBLIC USE BICYCLE SYSTEMS FROM A PRODUCT-SERVICE SYSTEM PERSPECTIVE

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Recent studies on sustainability indicate that the concept of the Product-Service System (PSS) is a promising approach to dematerialise the economy and reduce the environmental impacts of industrial activity.

Considering the urban scale, mobility is one of the challenges that should be addressed and improved for a better quality of life for residents and lower pollution levels for the environment. In this respect, this study aims at analysing Public Use Bicycle (PUB) systems from a PSS perspective. Six PUB systems implemented in different countries in Europe have been investigated based on the products and services they contain and the business context they are in. The results of this investigation indicate that PUB systems have the potential to increase the use of public transport and hence to decrease the environmental load of personal mobility activities. Further, it has been determined that how the products and services are combined, and how the business context is structured are important considerations in the design of sustainable PUB systems.

In this study, a PUB system scenario is developed for tourists in the context of Rotterdam, to reflect on the literature review on PSS and to show the findings of the investigation of six PUB systems in more concrete terms.

Keywords: Sustainability, Product-Service Systems, Public Use Bicycles systems.

ÖZ

KAMUYA AIT BİSİKLET SİSTEMLERİNİN ÜRÜN-HİZMET SİSTEMİ AÇISINDAN İNCELENMESİ

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Son dönemde sürdürülebilirlik üzerine yapılan çalışmalar ürün-hizmet sistemleri (ÜHS) kavramının ekonomideki ürün yoğunluğunu düşürmede ve endüstriyel aktivitelerin çevre üzerindeki etkilerini azaltmada umut verici bir yaklaşım olduğunu göstermektedir.

Kentsel düzeyde düşünüldüğünde, ulaşım dikkate alınması gereken problemlerden birisi olarak gözükmektedir; kent sakinleri için daha iyi yaşam standartlarına ve çevre için daha az kirlenme seviyelerine ulaşılabilmesi için ulaşım iyileştirilmesi gereken bir husustur. Bu anlamda, bu çalışma kamuya ait bisiklet (KAB) sistemlerine ÜHS bakış açısıyla yaklaşmayı amaçlamaktadır. Bu çalışmada Avrupa'da farklı ülkelerde yugulanmakta olan altı adet kamuya ait bisiklet sistemi örneği, içerdikleri ürünler ve servisler ile içinde bulundukları ticari bağlam açısından incelenmiştir. Bu incelemenin sonuçları, kamuya ait bisiklet sistemlerinin toplu taşıma araçlarını kullanmayı arttırdığını ve dolayısıyla kişisel ulaşım aktivitelerinin çevresel etkilerini azalttığını göstermektedir. Ayrıca, ürünlerin ve servislerin nasıl biraraya getirildiğinin ve ticari bağlamın nasıl planlandığının, sürdürülebilir kamuya ait bisiklet sistemleri tasarımında önemli faktörler olduğu belirlenmiştir.

Literatür taramasının ve altı adet kamuya ait bisiklet sisteminin analizinin sonuçlarını daha somut bir şekilde gösterebilmek amacıyla, çalışmanın sonunda Rotterdam şehrini ziyaret eden turistler için bir kamuya ait bisiklet sistemi senaryosu geliştirilmiştir.

Anahtar kelimeler: Sürdürülebilirlik, Ürüm-Hizmet Sistemleri, Kamuya Ait Bisiklet sistemleri.

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CHAPTER 1

INTRODUCTION

1.1 Motivation for the Study

The negative effects of industrialization on the environment and social lives accelerated research on the causes of and solution to the current problems we face today in the world. Because of the increasing consumption and population levels, it has become a necessity to take radical steps to overcome the problems and to affect the society in a holistic way. Technological innovation focusing more on production is not alone sufficient to overcome the challenges on the system level to achieve a sustainable society. In this respect, earlier methods and approaches, such as cleaner production, cleaner technologies, waste minimization, and recycling approaches, and ecodesign remained rather weak in addressing the environmental problems within the last decade (Mont, 2002). System level improvement requires also a change in consumption which should move the demand for products and services into a more "dematerialized" pattern (UNEP, 2002).

Dematerialization means reducing the material flows in production and consumption while ensuring better environmental performance. This can be achieved through the combination of products and services that provide utility at the same level of performance and quality offered through products alone (Mont, 2002). Hence, the concept of Product-Service System (PSS), developed within the discussion of sustainability, has been seen as a potential for dematerializing the economy. Further, PSS have implications not only in the minimization of resource consumption and waste generation, but also in necessary social change for dematerialized consumption.

Considering the urban scale, mobility is one of the challenges that should be addressed and improved for a better quality of life for residents and lower pollution levels for the environment. In this respect, research on sustainability and PSS prior focused on car sharing models. However, mobility is a broad issue including several modes of transport. One of the modes of mobility is bicycle which is a common way of commuting for short distances. Bicycles offered to the public as a mobility service, commonly referred to as Public Use Bicycles (PUB), have been

implemented in many cities throughout the world over the past 35 years, most of which is in Europe, some in North America, and a few in Asia (DeMaio, 2001).

1.2 Aim and Scope of the Study

The aim of this study is (1) to evaluate the PUB systems from a PSS perspective and (2) to demonstrate the findings of this investigation in more concrete terms through a scenario study for the mobility of tourists in Rotterdam. Amongst others, the following PUB systems have been developed in Europe and will be investigated in this study.

- Bycyklen, Denmark
- OV-Fiets, the Netherlands
- Adshel, France
- Call a bike, Germany
- Vélo'v, France
- BikeDispenser, the Netherlands

The above cases have been chosen according to their innovativeness in terms of products and services and organizational schemes, from simple to complex, to demonstrate the development of four generations of PUB systems. It is important for this study to use the previous knowledge through the cases and integrate it into an optimized sustainable PUB system. Because PSS are highly context dependent, this study will focus on developing a PUB scenario for tourists in Rotterdam. In addition to the existing systems in Rotterdam, an alternative way of commuting for tourists with improved features would add to the quality of transportation, while decreasing traffic congestion. This mobility system should be designed to provide freedom and independence through the offer of bicycles and guidance which will enable tourists to move around the city in a convenient way.

1.3 Research Questions

The questions to be addressed through the case study are as follows:

- What is the role of sustainability in PUB systems?
- What does product innovation mean for PUB systems?
- What are the requirements for the successful implementation of a PUB system?

1.4 Structure of the Thesis

Chapter 2 will focus on the concept of sustainability, its development and the role of design in solving world problems from a sustainability point of view. The chapter also aims to give basic insight on PSS and its importance in sustainability. The development of PSS, its definitions, classification and elements are explored in this chapter. Then the drivers for and barriers from adopting PSS for business are identified. Lastly, the methodologies developed for PSS so far are discussed.

Chapter 3 gives a general overview of the concept of the Public Use Bicycle (PUB) system, its history, development, classification and its connection to PSS. The role and importance of bicycle design in such systems, influence of technological improvements and the business context are explored in this part.

In Chapter 4, a close-up is made on six case studies, the majority of which is implemented, and one under development. The cases are given with the order from simple to complex; one is 2nd generation, one is 3rd and the other four cases are 4th generation. The cases are evaluated based upon Mont's (2004) definition of PSS, which is a function of five elements: products, services, infrastructure, networks of actors and organizational layout. The final part of this chapter discusses the findings of the analysis and summarizes the results in comparison tables.

Chapter 5 aims to develop a scenario for a new PUB system for tourists in Rotterdam, reflecting on the literature review on PSS and the cases of PUB systems studied. In this scenario, the focus is on Rotterdam and the tourists, the existing bicycle rental shops, and innovative technologies which may require a learning process for the user and bring new ways of doing.

The research questions are answered and the conclusions are presented in Chapter 6 based on the theoretical background, findings of the case studies and scenario. Finally, possibilities for further studiy to improve PUB systems in a sustainable manner are discussed.

CHAPTER 2

PRODUCT-SERVICE SYSTEMS

2.1 Introduction

Today's industrial and economical practices have destructed the balance on earth through excessive and unresponsible use of resources and accumulation of waste. Braungart and Bollinger (2004) remark that the current industrial system is characterized by a one-way flow of materials, in which the raw materials are transformed into products which are then used, disposed of and eventually destroyed in landfills or incinerators. This trend has enabled the development of new technologies to improve the lives of people, while causing unintended negative consequences and resulting with both environmental and social degradation. Orr describes this degradation as follows:

> If today is a typical day on planet earth, humans will add fifteen million tons of carbon to the atmosphere, destroy 115 square miles of tropical rainforest, create seventy-two square miles of desert, eliminate between forty to one hundred species, erode seventy-one million tons of topsoil, add twenty-seven hundred tons of CFCs to the stratosphere, and increase their population by 263,000. Yesterday, today, and tomorrow (Orr, 1992: 3).

These discoveries in degrading ozone layer, polluted air, water and soil, and decreasing cultural and biological diversity have formed a sense of emergency to minimize damage, reduce waste and conserve resources - under the name of *sustainability*.

Although the terms like 'sustainability' and 'sustainable development' are widely used, there is a huge confusion about their meanings. The term 'sustainability' first appeared in Dennis Pirages' book "The Sustainable Society" in 1977, followed by Dennis Hayes' book "Repairs, Reuse, Recycling - First Steps Towards a Sustainable Society" in 1978 (Tekeli, 1997). However, the time that the term gained central importance for the environmentalism movement was after the report "Our Common Future" - also known as “Brundtland” report - published by the World Commission for Environment and Development in 1987 (Tekeli, 1997). The report defines sustainable development as “meeting the needs of the present without compromising the ability of

future generations to meet their own needs" (WCED, 1987: 24). In other words, living on income, not capital (Orr, 1992).

Since the publication of "Our Common Future", the concept of sustainable development has gained attention by policy makers and researchers that created a variety of views and meanings of sustainable development (Hediger, 1997). The term has been used by different groups to express different ideas which brought confusion instead of good communication (Palmer *et. al.*, 1997).

The term 'sustainable development' is an oxymoron since it constitutes conflicting values of economic development and environmental protection (Palmer *et. al.*, 1997). In most cases development dominates the equation, while environment is considered only when resource shortages or side effects of consumption pose a threat to the economy. In this human-centered view, the quality of life is tied to economic wealth, while ensuring the exploitation of environmental resources (Palmer, et. al., 1997).

Currently, sustainable development is based on the principles of economic, environmental and social factors. Further, the role of industry and new production patterns are underlined for reaching sustainable development (Mont, 2004).

2.2 Design and Sustainability

Regarding environmental issues in industrial activity, research on sustainability formerly focused on production to reduce the negative side effects of the processes that are used. Moving away from *pollution control* and *end-of-pipe* approaches, *cleaner production* has become an accepted approach, defined as "the continuous re-design of industrial processes and products to prevent pollution and waste generation at their source and minimize risks to humans and the environment" (UNEP, 2002: 3). The outcome of these approaches, on product level, was Ecodesign or Design for Environment (DfE). In the ecodesign approach, environmental consideration is shown in all stages of the product development process for lowest possible impact throughout the product lifecycle (Brezet and van Hemel, 1997). The underlying assumption of the ecodesign approach is that 75% of the environmental impact of a product is at the design stage of its entire lifecycle (Ottman, 2004). However, Mont (2004) remarks some inherent problems with the ecodesign approach. One problem is that even though a product is designed with environmental considerations, its environmental load can be much higher at the use phase. Thus, when the whole product lifecycle is considered, its environmental impact might be the

same or higher than a product not ecodesigned. Another problem is that the focus of ecodesign is products and the infrastructures that products operate within remain untouched, e.g., the electrical cars that do not fit the existing infrastructure.

To sum up, mentioned approaches alone remained insufficient to lead to a sustainable system of consumption and production that truly supports the health and well-being of future generations. They are rather add-on solutions that delay the inevitable exhaustion of raw materials and saturation of waste sinks (Braungart and Bollinger, 2004). These approaches are commonly technical and focused mostly on the reduction in material and energy use, through the re-design of the current production methods. However, Lamvik (2002) indicates that technological innovation alone is not sufficient for the shift to a sustainable society, and a holistic view is necessary. This includes a change in consumption which should move the demand for products and services into a dematerialized pattern (UNEP, 2002), and result in a higher environmental performance.

In this respect, the concept of product-service system (PSS) is widely accepted to have potential to accelerate the transition to a sustainable society since PSS is not merely selling material products but also immaterial services (Mont, 2004). PSS is often defined as "a marketable set of products and services capable of jointly fulfilling a user's need" (Goedkoop *et al.*, 1999: 18). There is already an ongoing shift in the market where the value creation more and more comes from the services rather than the manufactured goods. In the transition to sustainability, the companies which are specialized in specific areas of manufacturing and lack knowledge and organization in service development should be prepared to compete in the market. So, PSS may help businesses to take advantage and grow successfully in the competitive market which is shaped by environmental concerns and regulations (Tischner and Vezzoli, 2004).

2.3 Defining PSS

PSS is not merely selling physical goods or services but designing a combination of products and services where the focus is given to environmental concerns, economical feasibility of the systems and social issues (Tischner and Vezzoli, 2004). In Manzini's (UNEP, 2003: 4) words, it is "the result of an innovation strategy, shifting the business focus from designing and selling physical products only, to selling a system of products and services which are jointly capable of fulfilling specific client demands." In a PSS strategy, the concept of *product* is not just the result of traditional production processes but rather the result of a system of physical products and services which are mutually combined to satisfy a specific client demand. In a service

economy - also called functional economy, the central value of products is exchanged with the value of utilization where the customers pay for performance (Mont, 2002). In such a scenario, different types of relationships have to be established so that the system will be more favourable to customers than the traditional production system.

At the **customer side**, consumption is a satisfaction-based process and tangible products are not the only way of providing this to customers. In other words, customers are not searching only for products or services but rather for a system of products and services that satisfy their needs and desires (UNEP, 2003). Therefore, a PSS should be designed in a way that will be more desirable to customers than tangible products alone (Ryan, 2000). Mont (2002), further claims that the added value of a product previously came from the production processes that transform raw materials to products. But today this is changing and the added value comes from all the non-material aspects of a product, which are technological improvements, product image, brand name and aesthetic design. At the **business side**, therefore, companies are moving away from mass production to mass customization and using more and more services to compete and differentiate in the market (Mont, 2002). This means that the company should better understand its customers, which requires a tight relationship of customer and the company. Furthermore, such an approach brings different kinds of partnerships with other producers and suppliers, public bodies and non-profit organizations for an integrated solution to satisfy customer needs (UNEP, 2003).

It should be noted that a PSS does not necessarily result in sustainable solutions. On the contrary, some PSS generate undesired side effects. When a PSS re-orients the unsustainable trends in production and consumption into a sustainable way, then it can be referred to as sustainable product-service system (UNEP, 2003). So, a PSS strategy forces the industry to focus on a cyclic/system thinking (Lamvik, 2002) with the aim of optimizing the interests of all the bodies involved in the PSS and also improving resource usage and environmental quality.

2.4 Classification of PSS

According to the ownership structure, it is possible to classify PSS under three main categories (Figure 2.1).

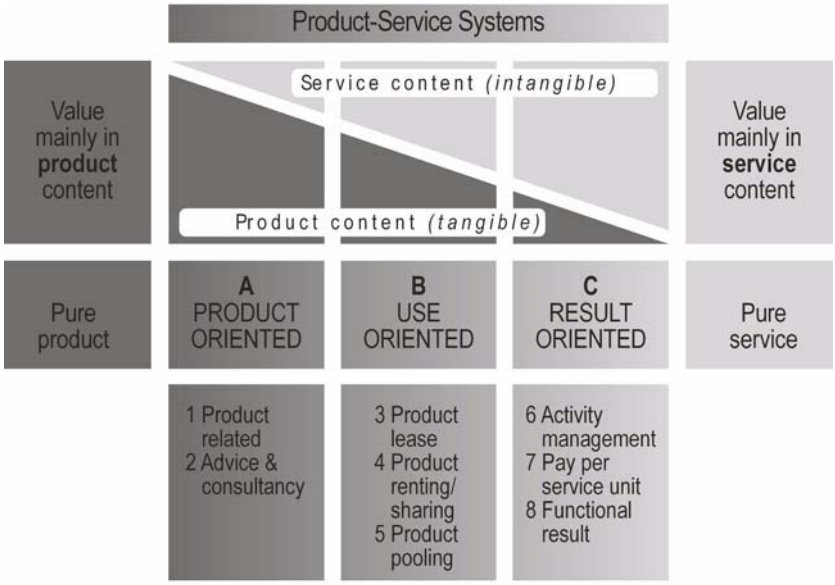

Figure 2.1 Classification of PSS according to ownership (Tukker, 2004, p. 248)

A- Product-oriented PSS: Product-oriented PSS are the additional services adding value to the product through providing functionality and durability (UNEP, 2002). The ownership of the product belongs to the user; therefore s/he is responsible for the product during the use phase. Product-oriented PSS can be sub-categorized as *product-related services (1)*, and *advice and consultancy (2)* (Tukker, 2004). The first group is related with the repair, maintenance, upgrading and take-back of the existing products (Heiskanen and Jalas, 2003). The latter is giving advice on how to use the product most efficiently (Tukker, 2004).

B- Use-oriented PSS: In use-oriented PSS, company holds the ownership of the product and offers access to the products so that customers can get the results they desire (UNEP, 2002). User pays for using the product instead of the product itself and also is responsible for the quality s/he gets through the use of product. Tukker (2004) sub-categorizes use-oriented PSS under three groups: *product lease (3), product renting or sharing (4),* and *product pooling (5).* In product lease services, the user has an unlimited access to the product during the time interval of the lease contract, whereas in product renting services the user does not have this unlimited access since the renting is for much shorter times and furthermore, the product is used by other users at different times. Product pooling is similar to product renting; however in product pooling services, the products are used simultaneously, whereas, in product renting services products are used sequentially (Tukker, 2004).

C- Result-oriented PSS: In result-oriented PSS, the company maintains the ownership of the product, as in use-oriented PSS. Additionally, it is also responsible for the quality achieved by the use of product. Customer pays for the service provided by the company (UNEP, 2002). It is possible to find three types of result-oriented PSS: *Activity management/outsourcing (6), pay per service unit (7),* and *functional result (8).* The basic idea of activity management is outsourcing of an activity of a company to a third party (such as outsourcing of catering and office cleaning). In this case, a company becomes the customer of another. In pay per service unit, user buys not the product, but the outcome of the product (such as pay per-print formulas adopted by some copier producer). The last category is based on the delivery of a result in which the provider is free on how this delivery is done (for instance, companies delivering a specified 'pleasant climate' in offices rather than gas or cooling equipment or companies ensuring a maximum harvest loss to farmers rather than selling pesticides) (Tukker, 2004).

In addition to the above classification, **"non-material services" (D)** may be mentioned as a fourth classification, which are actually not alternatives to the products but rather services born within the discussions of ecological modernization. Medical and personal care, training, legal services, and new IT-based services are some examples to such services. The potential of these services in dematerialization is due to the increase of knowledge-based production rather than traditional product-based production (Heiskanen and Jalas, 2003).

Another classification offered by Heiskanen and Jalas (2003), is **"eco-design with service" (E)**. In this approach, the design of products with eco-design efforts reveals a different understanding where the focus is given to utility achieved through the function of the products and the use of less material. FRIA cold-storage chamber is an example to an eco-efficient substitute for refrigerators; the product concept is changed with the focus given to service development. FRIA is designed to be more durable than a traditional refrigerator and works through the utilization of the heat difference between the inside and outside of the house, thus it is built into the outer wall of the apartment (Heiskanen and Jalas, 2000). However, products designed with this approach may end up with a radical result which is so different than the traditional product concept that this may hamper user acceptance.

2.5 Elements of PSS

This section is based on the work of Mont (2004) who defines a PSS as a function of five elements, namely *products, services, infrastructure, networks of actors* and *organisational layout.* This definition arises from the need to develop shortcut solutions that fasten the transition proc-

ess of companies to develop PSS and include environmental criteria in this process. The elements of PSS should be designed concurrently and need to be continuously adjusted to each other to ensure system innovation and optimisation (Mont, 2004).

2.5.1 Products

Products are the first elements of a PSS and need to be improved for system optimisation. In shared use of products (such as washing machines, cars, bicycles, etc.), eco-design or product improvement is included, in some cases, as a criterion in business-to-business (B2B) cases, however there are few examples of business-to-consumer (B2C) cases that facilitate changes in product design. One reason for this is the service organisations, which have rarely a link to producers, and hence face difficulties in optimising the product design and reducing environmental impact associated with products (Mont, 2004).

2.5.2 Services

Mont (2004) classifies the services in PSS concept as in Figure 2.2. Since the environmental performance of the services affects the overall environmental impact of the system, they should also be optimised in coordination with the product development process, requiring the involvement of actors from different fields.

Especially shared use systems, such as leasing, sharing, pooling and renting, have a high potential in reducing the environmental impact of the use phase; however their environmental success and customer satisfaction depend on how they are organised (Mont, 2004).

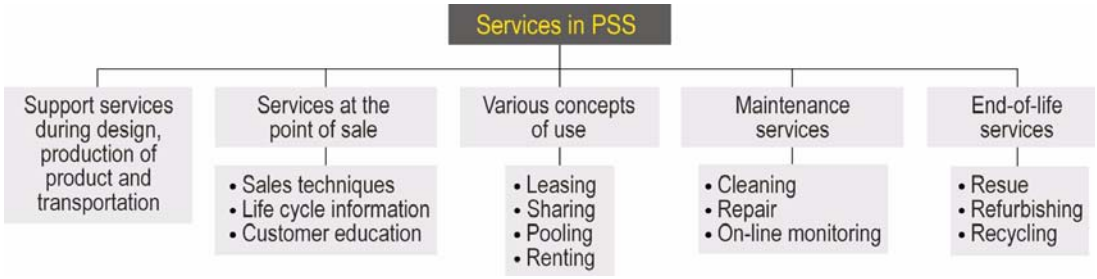

Figure 2.2 Services in PSS (Mont, 2004: 75)

2.5.3 Infrastructure

Products and infrastructures are co-dependent and transform each other in time. The most obvious example of this is the car, which transformed the cities around the world in a great magnitude. As the products have shorter life cycles, it is easier to stimulate the development of eco-efficient products than to change the infrastructure. However, improvements beyond products, including infrastructure, are necessary for a shift in the system level (Mont, 2004). These supporting infrastructures, for instance parking facilities for shared bicycles or bicycle lanes and signage, should be developed to manage the products, ensuring reduced environmental impacts.

2.5.4 Networks of Actors

A PSS generally consists of different types of products and services in one system. Accordingly, this requires the involvement of different actors, as well as the development of a network of companies, besides products and services. This, in turn, affects the supply chain structure and alignment of companies to fulfil consumer needs with a better environmental performance. The following actors have important roles in PSS (Mont, 2004).

Suppliers: Suppliers may introduce system thinking to the chain, for instance the chemical management services, in which the supplier provides technical expertise instead of chemical substances. Another example is the traditional activity outsourcing, such as canteen services, industrial cleaning and security services, transport services, or IT services.

Producers: Producers are often the most suitable actors in the chain for introducing functional thinking, since they have knowledge about the regulations and marketing data regarding their products.

Retailers: Retailers are generally poor in introducing system thinking to the supply chain, since they generate value from the process of selling material goods. However, they have a direct relationship to customers, and the success of PSS depends on the quality of information and the skills of the sales personnel. Moreover, retailers are an important source of information about the customer, their preferences and demands.

Consumers: There is still a lack of demand by the private consumer for products' functions and environmental consideration, which may cause difficulties in the implementation of B2C solu-

tions. Amongst others, maintenance, ease of operation, and diversity of disposal possibilities are strategies to affect use behaviour.

End-of-life actors: End-of-life actors may place requirements on the quality of the end-of-life of products, which in turn, contribute to product design with better environmental results (Mont, 2004).

2.5.5 Organisational Layouts

Shifting to solution/function oriented strategies necessitates some modifications and improvements in organisational layouts of companies. The following changes are observed in organisational functions and structure of companies that have shifted to PSS (Table 2.1) (Mont, 2004).

Table 2.1 Changes in organisational functions (Mont, 2004: 81)

Functions in organisation	Traditional system with focus on products	System based on PSS
Materials	• Procurement of virgin materials • New components and modules	• Use of recycled materials • Reuse of modules from old products
Product developmet	Continuous development of new products and models	• Products designed for durability, repair, ease of maintenance, reuse, recycling • Service development as a part of PSS design
Production processes	Manufacturing of new products	Additional to manufacturing of new products process lines for remanufacturing of used products
Offer on the market	Products	Products and services
Cost centre	Product based	Function and value based
Relations with customers	Short-term, transaction based	Long-term, relation based
Ownership	Customers	Customers/providers
Company strategy	Producing material goods	Offering services to customers

Considering materials, product development and production processes, the design team may need to work closely with different actors in the production chain, such as suppliers, product-service providers, and managers of remanufacturing activities. The change in the ownership

structure requires the increased responsibility of the company for products - offering maintenance services, and remanufacturing activities, and for customers - educating them on alternative modes of consumption and about how the products should be used and where they should be returned. Consequently, relations with the customers become tighter in the long-term. Marketing team and sales personnel also may require to change their activities since they become responsible for selling functions instead of products. Thus, this results in a shift in profit centers - selling additional functions or upgrading services, leasing or renting products instead of selling them (Mont, 2004).

2.6 Drivers and Barriers

Development of PSS in companies is a difficult process. In order to encourage companies to act in the direction of sustainable solutions, it is important to be aware of the potential barriers and driving forces. These barriers and drivers can be classified in two broad categories under *external forces* and *internal pressures.* External forces may compel companies for actions, but on the other hand, may also hinder them from reaching their goals. Likewise, internal pressures may both propel and hamper the companies' development towards sustainable solutions (Mont, 2002).

Mont (2004) classifies the external drivers as coercive drivers (1) and market drivers (2), and internal drivers as resources drivers (3), risk reduction (4), and drivers to improve environmental performance (5). On the other side, external barriers are classified as barriers related to relations with actors along the value chain (6), and context-related barriers (7). Internal barriers are cost-related barriers (8), concept design barriers (9) and organisational barriers (10) (Table 2.2).

Table 2.2 Drivers and barriers (Mont, 2002b)

	Drivers	Example
External	1 Coercive	Constant public concern and development of legislation *(For instance, chemical industry is subjected to strict health, safety and environmental legislation. Some companies, such as Dow Europe develop Chemical Management Services to comply with legislations and make profits.)*
External	2 Market	New possibilities for growth *(DuPont extends the range of its offers by services.)*
Internal	3 Resource management	• Financial savings and revenues *(IBM and Xerox perceive service-orientation as a survival strategy and earn revenues from high volume of leasing and remanufacturing operations.)* • Secondary source of raw materials *(Closing product cycles, which is also the business model of Xerox, allows companies to have a constant flow of "raw materials", which, after certain treatment, can be used for further production.)*
Internal	4 Risk reduction	Professional handling of hazardous wastes
Internal	5 Environmental performance	Electrolux and Interface Inc. state that environmental improvement is the main driver for the shift towards service-oriented solutions.
	Barriers	**Example**
External	6 Related to relationships between actors	• Conflicts of interest between different actors *(Some companies often explicitly aim to reduce sales volume of material product, while traditional interests of retailers is to sell more products.)* • Difficulties of gaining customer acceptance *(Xerox states that customers demand to buy products together with the possibility to lease products, since product ownership does not only provide function, but also status, image and a sense of control to the user.)*
External	7 Context-related	• Relatively low prices of resources *(Carpet recycling at Interface Inc. is not a profitable activity, since it is more expensive compared to carpet production based on the use of virgin materials.)* • High prices on labor, especially for companies providing labor intensive repair and maintenance services
Internal	8 Cost-related	• Uncertainties about the cash flow *(Service-oriented solutions provide medium/long-term profits, while traditional product sales provide short-term profit.)* • Lengthening time to market *(Environmental considerations and service development is often perceived to lengthen the product development cycle.)*
Internal	9 Concept design	Difficulties of balancing environmental goals with satisfying customer priorities *(Environmental benefits of service-oriented solutions may result in lower comfort levels for customers.)*
Internal	10 Organisational	Organisational resistance to change *(Extended responsibility of the producer for products beyond point of sale is identified as a major barrier in some studies.)*

2.7 PSS Methodology

Although research until now has been motivated towards services as sustainable solutions, at the company level, sustainability concerns are rarely incorporated into the service development process. A viable methodology lacks to measure the impacts of services. The service development process is not well defined and lacks the tools and methods (Young and Charter, 2001).

Every PSS is unique in nature and has its own system conditions, which makes it difficult to outline one general guideline for PSS design. On the other hand, the developed methodologies of PSS have quite a lot of similarities in the process. Accordingly, the following sections focus on the methodologies developed for PSS design within the last decade to reflect on the similarities and differences within these approaches and to show their practical implications for a scenario study at the end of this thesis. The seven different approaches to the service development process discussed are:

1. The Design of Eco-efficient Services (DES) Method
2. Kathalys Method
3. Highly Customized Solutions (HiCS) Method
4. Methodology for Product Service Systems (MEPSS) Project
5. The United Nations Environmental Program (UNEP) Method
6. Script Approach
7. Service Modelling/Engineering Method

2.7.1 The Design of Eco-efficient Services (DES) Method

DES method was developed within the research project "Designing Eco-Efficient Services" (DES Project) through collaboration between Delft University of Technology and the Dutch Ministry of Environmental Affairs. The focus of the project was to design Eco-efficient Services (ES) which perform the functions with a minimum environmental impact, while creating maximum added value for different stakeholders. The methodology is based on the product development methodology of Roozenburg and Eekels with the underlying assumption that product and service development methodologies are quite akin (Beereport, 2004). However, product design basics and environmental tools are still needed to be adapted for service development

process. Therefore, starting with the product development methodology, DES method was developed in a linear fashion (Figure 2.3). However, it should be noted that in practice, the service development process is never linear like in the figure and iterations and interactions between the different phases are necessary. The aim of this methodology is not to bring strict guidelines for service development, but to structure the framework conditions for the desired service and further communicate different activities between the stakeholders (Brezet *et. al.*, 2001).

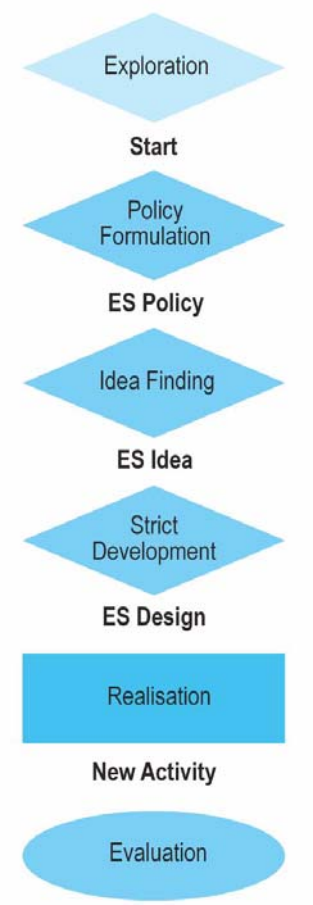

Figure 2.3 DES method (Brezet *et. al.*, 2001: 13)

Different than the product development methodology of Roozenburg and Eekels, DES method includes a complex initiation phase, named *exploration.* During the exploration phase, ideas are generated for the purpose of a function or system level innovation in which sustainability

is an important consideration. Since system level innovations require the involvement of different stakeholders, it is necessary to form partnerships or coalitions between companies. Therefore, the expected result of this phase is a new business, a team with a mission, a project plan and a description of the system within which the innovation should take place (Brezet *et. al.*, 2001).

The service development process is never linear in practice and it requires one or more sub-processes like outsourcing activities of a company for some tasks of a project. For instance, in a service oriented project, the design of the product may be outsourced to the design department or a product design company, as illustrated in Figure 2.4.This way, products and services are developed in parallel, requiring strict collaboration of the stakeholders involved in the system (Brezet *et. al.,* 2001).

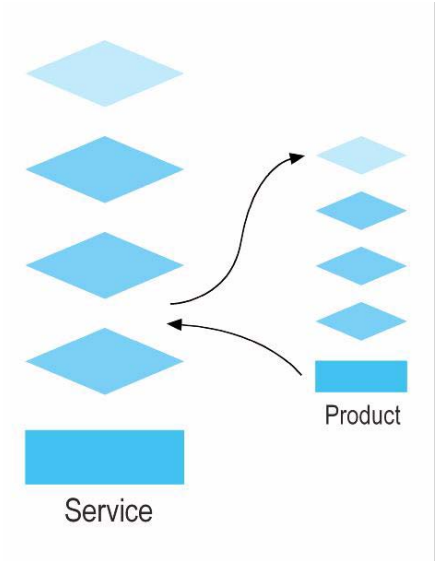

Figure 2.4 Sub-processes in DES method (Brezet *et. al.*, 2001: 19)

The steps required in the design and development of eco-efficient services in DES method (Brezet *et. al.*, 2001) are summarised in Table 2.3.

Table 2.3 Steps of DES Method

Steps	Actions	Results
1 Exploration	• Formation of a project team of companies to develop a PSS • Appointing a project manager • Formulation of a vision and goals • Determination of the system • Analysis of the current situation • Assessment of the environmental load and the economical value of the system • Identification of future users	• A business coalition/new business • A team with a mission • A project plan • A description of the system within which the innovation should take place
2 Policy formulation	• Setting more specific goals • Determination of the roles of the partners • Specification of budget and tasks • Making a time schedule • Refining the project plan with the PSS policy in it • Development of the first list of requirements	• A policy which at least contains the statement that the outcome of the project will be an Eco-efficient Service • Time schedule
3 Idea finding	• Defining accurate problem definition • Refinement of the list of requirements • Generation of ideas with the project team • Selection of one or more ideas to be further developed • If necessary, starting sub-processes with participants or future suppliers	A design brief
4 Strict development	• Defining the variables (for the involved products their specifications and for the services their protocols of executions) • Making an assessment of the prototype • Checking if the PSS complies with the list of requirements • Testing the design and making adjustments if necessary • Executing regular meetings with all people involved in designing the different parts of the system	Design of the PSS
5 Realisation	• Communication of the new PSS to the market • Producing or purchasing the necessary products • Hiring staff • Maintenance of the service (managing time, place and people) • Marketing the PSS	Eco-efficient PSS
6 Evaluation	• Monitoring market response • Measuring the environmental impact of the new system and comparing it with the old one • Measuring financial effects for the involved companies • Evaluating project process	A final report, including the environmental and economical effects

2.7.2 Kathalys Method

Kathalys, the Centre for Sustainable Product Innovation, was an institution established through the agreement of the Ministries of Economic Affairs, Housing, Spatial Planning and the Environment of the Netherlands in 1997 and was run by TNO Institute for Industrial Technology and Delft University of Technology. Kathalys method is developed during the project run by the institution between the years 1997 and 2001 and has been applied to several cases, which, in turn, supported the design of innovative products and services.

Similar to DES method, Kathalys method is based on product development methodology. The method consists of five phases:

1. Exploratory research and definition

2. System design

3. Product/service specification

4. Elaboration and practical experiment

5. Implementation

Different than DES method, five tracks are defined where sustainable innovation is ensured through the process of system development. These are:

1. Product-service combination

2. Sustainability

3. Organization

4. User

5. Economic feasibility

The focus of each track changes per phase. Therefore, at each phase tracks are ensured through different processes. However, economic feasibility is the criterion used through the entire process (Kathalys, 2001).

2.7.3 HiCS Method

Highly Customized Solutions (HiCS) is an international research project funded by European Union and is developed for the generation of PSS that bring context-specific solutions for specific customers in specific socio-cultural and physical habitats. HiCS method is based on Solution Oriented Partnerships (SOP) which is about partners coming together for visioning, design and development of more sustainable solutions (Evans, 2006). The basic idea of SOP is to bring together companies to work together in the form of a partnership with the aim of delivering a solution, which satisfies the specific customer demands in a specific context-of-use (Collina, 2003).

HiCS method basically follows two phases: platform phase and specific phase. Platform and specific phases consist of divergent and convergent steps in which the ideas are first *explored* and then *developed,* allowing iterations between phases (Beerepoot, 2004). The seven steps can be summarised as in Table 2.4.

Table 2.4 The steps of HiCS method (Rocchi, 2005)

Step	Action
1 Generating the tentative solutions	Bringing together the organizations with similar interests in developing HiCS
2 Defining the solution direction	• Filtering the rough ideas by three criteria: context-of-use fit, match of partners' interests, and sustainability requirements, • Making a tentative qualitative assessment with the aim of defining the system boundaries for each solution *(These solutions are then grouped according to their common features and used to create a platform vision for promoters. The results of this phase are first solution ideas and an identified context-of-use).*
3 Developing conceptual ideas	Conforming to the common technological and organizational elements
4 Defining platform	Clarifying the players involved in the solution, the context-of-use, and the added value with new proposals including sustainability benefits
5 Designing specific solutions	• Detailing the products, services and organizational components of the solutions • Distinguishing the core platform elements from the specific elements to contextualize the solutions on the local scale
6 Assesing all the solutions	Evaluating the performance of solutions according to the three dimensions of sustainability: economic, environmental and social
7 Formalizing the final solution	• Processing the feedback from the previous step to achieve more sustainable results • Prototyping the products, organising the services and developing the business plan

2.7.4 MEPSS Project

MEPSS (Methodology for Product-Service Systems) is a research project realized by European research consortium and supported by European Commission under the fifth Framework Programme. MEPSS mainly focuses on three aspects of PSS:

- Design and implementation of PSS;
- Assessment of the impacts of PSS innovations on the dimensions of people, planet, and profit;
- Success and failure factors in the development and implementation of PSS (including consumer acceptance, and stakeholder perspectives), taking into account the functional offer of PSS (Halen *et. al.*, 2005).

MEPSS is organised in a modular structure and consists of five phases (Table 2.5). Each phase is structured in *steps,* and steps are described by a series of *processes.* This 'phase-step-process' hierarchy offers a systematic and innovative PSS development model (Halen *et. al.*, 2005).

Table 2.5 'Phase-step-process' hierarchy of MEPSS (Halen *et. al.*, 2005: 70-72)

Phases	Steps	Processes
1 Strategic analysis	Prepatory phase	Getting prepared, management meeting (**D.N. 1**), project planning
	Stakeholder identification	Definition of stakeholders, planning their involvement
	Evaluation strategy	Discussion of visions, definition of assesment strategy
	System analysis workshop	Carrying out a workshop
	Elaboration of results	System analysis results, preparing the decision
D.N. 2		
2 Exploring opportunities	Preparing scenario workshop	Stakeholders involvement planning, update sustainability aspects, exploring customer needs, strategic options for scenarios, prioritise sustainability guidelines (level 1: scenario)
	Performing scenario workshop	Building PSS scenarios
	Eloboration of results	Elaboration of scenario's format, scenario preliminary sustainability assessment, visualise sustainability aspects of PSS scenario
D.N. 3		
3 PSS idea development	Prepatory phase	Prioritise sustainability guidelines (level 2: PSS idea)
	PSS idea design	Idea development through the inputs of stakeholders
	Eloboration of results	PSS idea sustainability assessment, visualise sustainability aspects of PSS idea, selection of best PSS version
D.N. 4		
4 PSS development	Preparation	Attuning to customer preferences, stakeholders input integration
	PSS design	PSS dimensions design, customising to target groups
	Eloboration of results	PSS specifications, PSS sustainability evaluation, visualise sustainability aspects of developed PSS
D.N. 5		
5 Preparing for implementation		

Design | Assessment | Success & failure factors

D.N. (Decision Node)

The phases of the methodology are linked to each other by *decision nodes.* At decision nodes, results of the preceding phase are evaluated, and conclusions are drawn by the management of the company. These results and conclusions are then fed into the execution of the later phases (Halen *et. al.*, 2005).

2.7.5 UNEP Method

UNEP (United Nations Environmental Program) method aims to develop both products and services together strategically and efficiently leading to more sustainable business and consumption strategies. The method suggests that a pilot project is conducted with the aims of an-

alysing PSS business opportunities, exploring the new PSS design and development processes, experimenting with new PSS tools, and finally developing new PSS solutions and testing them. Therefore, UNEP method describes how this pilot project should be developed. It consists of five steps and provides a description of suggested tools to be used in each step (Table 2.6) (Tischner and Vezzoli, 2004):

Table 2.6 Steps of the pilot project in UNEP Method

Steps in pilot project	Suggested tools
1 Exploring opportunities - identification and analysis of the existing reference system	• Drawing a system map / Blueprinting • Sustainability SWOT • Checklist for analysing existing reference system
2 PSS idea generation and selection of the most promising concepts	• Sustainability Guidelines (Level 1) • Format of PSS concept description • PSS Sustainability Screening Tool • Portfolio Diagram Sustainability and Feasibility
3 Detailing selected PSS concepts or PSS design	• Sustainability Guidelines (Level 2) • Extended system map of the new system / Blueprinting • Extended description of the new system • First advertisement for the new system
4 Evaluation of the detailed concepts and testing	Sustainability radars for the three sustainability dimensions with six criteria each
5 Planning and implemetation	• List of specifications for PSS implementation • Business plan for the new PSS

This pilot project provides the basis for reconstructing the whole organization before the implementation of the new PSS. First of all, it is necessary to identify the existing production-consumption reference system in which the company is active. Accordingly, defining a *functional* or *satisfaction unit* is essential. For instance, "cleaning clothes" is a satisfaction unit for a washing machine producer, or "having nice interiors in private homes" for a furniture producer. In this way, the boundaries of the existing reference system can be defined. For the washing machine producer, for example, the system includes the following elements: producing and purchasing materials, manufacturing the machine in the company, selling it, using it, repairing, recycling and final disposal, but also providing the water, the energy and the cleaning agents for the washing in the private household. Further, another part of this process is the determination of the customer needs which are fulfilled in the existing system, and the needs which are not yet covered by the existing system and which have a potential as starting points for a new offer by the new PSS (Tischer *et. al.*, 2004).

The next steps follow a similar pattern to the previously described methodologies of PSS design. The main difference of UNEP method is the pilot project which guides the whole process by sustainability criteria and helps in evaluating the concepts before implementation of the PSS in the market. Beereport (2004) remarks that UNEP method does not give any specific description of the implementation phase of the PSS.

2.7.6 Script Approach

Script approach has been developed and applied previously in the field of technology studies on the level of single artefacts, focusing on usability and gender questions (Akrich, 1992; cited in Jelsma and Marjolijn, 2004). The approach was then applied for redesigning the scripts of household appliances to engage users in more eco-efficient practices of dish washing for instance, or refrigerator use (Jelsma, 1999; cited in Jelsma and Marjolijn, 2004). Recently, it has been proposed as a useful design approach also for the design of sustainable services.

Script approach aims to mediate human action by non-human (material) environment, which is called 'scripted', meaning forcing action in certain directions by specific design characteristics, such as shape, mechanism, signals, etc. (Akrich, 1992; cited in Jelsma and Marjolijn, 2004). A good example of scripting is laptop, which has been used more and more in new environments (such as trains), because of its convenient and portable size. Jelsma and Marjolijn (2004) suggest that the inscription of values (such as sustainability) and rules in the artefacts and infrastructures offers incentives for behavioural change and can make sustainable behaviour become easier and more routine.

From a PSS perspective, service is a highly scripted environment since it consists of an interrelated set of materials and infrastructural elements that influence the behaviour of the user. In this respect, services have a high potential for encouraging or discouraging certain forms of use, in relation with the logic of their users. Therefore, realisation of effective inscriptions begins at the use side of the service. Sustainable behaviour is the outcome of the combined actions of the users and the PSS. Designers can reconcile the desires of the users for achieving better environmental performance, while at the same time making life easier through the design of PSS (Jelsma and Marjolijn, 2004).

The Script approach consists of six steps, which are summarised in Table 2.7.

Table 2.7 Steps in Script approach

Steps	Description
1	Mapping and categorising current practices and use logics in a certain behaviour of the user, in relation to lifestyles and characteristics of the use environment, and making an environmental analysis of the current service practices.
2	Recruiting groups of users and non-users of current services; reconstructing their logics and tracing elements of the service scripts that attract or repulse these users, and that guide their behaviour.
3	• Matching the data of both steps to see whether non-use of current services can be traced back to mismatches between (i) certain elements of scripts of these services and (ii) the logic of their users and non-users as reconstructed. • Critically evaluating the concept(s) of the new service against the use logics and scripts that were identified in Steps 1 and 2, and, if necessary, doing additional research it may turn out that the knowledge about certain elements of use logics needs to be refined.
4	• Developing the concept(s) of Step 3 into detailed service designs with adequate scripts, by capitalising on the data collected in the foregoing steps; involving providers and proponents of relevant user groups, preferably groups with the most unsustainable styles. • Adding special experts for safeguarding and assessing the sustainability of the designs proposed.
5	Testing the service systems designs in small scale pilots in order to learn from experience
6	Improving the concepts and scaling up.

2.7.7 Service Modelling/Engineering Method

Service engineering is proposed by Tomiyama *et al.* (2004) as a service design methodology to increase the added value and quality of the existing services, and to develop new services with better environmental performance. The method is very much conceptual and still under development, however better formalisation may allow computer-based implementation of service design.

First of all, it is an engineering method that aims to include engineering in service design, taking service *activity* and *added-value* as the core principles. The elements of the service are defined in Table 2.8. In this respect, taking "car rental" and "house cleaning" as examples of the offered service, it is possible to define the service elements as in Table 2.9.

Having defined the elements of service, Tomiyama *et.al.* (2004) formulate the added value by service (V) as a function of service environment (E), realised service (M), service goal (G), and service quality (Q). Assumptions in Table 2.10 are applied in this formula.

Therefore, the added value (V) that service as a whole creates is formulated as follows:

V [E(P, R, Ch, Co), M(AP, A, T) - G(AP, A, T), Q]

Table 2.8 Service elements

Elements	Denoted
Service environment	E
Service provider	P
Service receiver	R
Aim of the service receiver's activity	AP
Service target	T
Service body (as an activity)	A
Service channel	Ch
Service content	Co
Service information	I
Service goal	G
Realised service	M
Service quality	Q

Table 2.9 Service elements in the examples of car rental and house cleaning

Elements	Car rental	House cleaning
Aim of the service receiver's activity	Traveling	Cleaning the house
Service target	Traveler	Property of the receiver
Service body (as an activity)	Offer of a car	House cleaning
Service channel	Cars, shops	Tools, detergents
Service content	Material	Cleaning
Service information	Requirements for the car, customer details	House details
Service goal	Achieving aim (enabling), convenience, state change (positional change)	Achieving aim (representation, enhancement)

Table 2.10 Assumptions used in the formula

Assumption	Explanation
E(P, R, Ch, Co)	Service environment is a function of service provider, service receiver, service channel and service content.
$G \subseteq I$	Service is performed when service information I is agreed upon by both the provider and the receiver. I may include promised service goal G.
G(AP, A, T) M(AP, A, T)	While the service goal and realized service are determined by various elements, they are dominated by, among others, contribution of the service to the aim of the service receiver's activity.
V(E,M–G, Q)	The value added is measured by the degree of achievement of the service goal and the service quality.

Tomiyama *et al.* (2004) suggest that the added value that service provides can be increased by increasing the realized service (M) or service quality (Q), while service environment (E) is the same. M can be measured by the degree of the service receiver's aim or state change, while Q can be measured by various factors such as capacity, efficiency, cost, time, timeliness, frequency, punctuality, flexibility, customizability, convenience, security, safety, comfort, and accessibility.

This formulation can be used as a strategy to increase the value of service, and also to develop a new service. In the first one, the formula is used to improve the existing services, rather than designing new services. In the latter one, this method is used to develop a new service that did not exist in the past. This is done, first, by understanding the service elements relevant to the service receiver's activity and defining these elements as in Table 2.9. At this stage, Tomiyama *et al.* (2004) assume that it is possible to find out non-existing services, such as 'massage type service' that offers information which is not available now, or an 'enabling service' that makes the service receiver's activity easier and cheaper. Then, the collected information is reorganized according to the following criteria: possession of the products (belonging to user or the service provider), reuse of the products, location of the products offered by the service provider (this depends on the ownership structure), and work done (by user or the company). If the service channel is an artifact, it is possible to produce other scenarios by changing the ownership of the artifact.

2.7.8 Summary of the Methodologies

The methods of PSS are presented in this chapter with the aim of providing an overview of PSS design methodology. Table 2.11 summarises these methods, focusing on the characteristics, phases in the design process, and the differences of methods.

Although the focus of each method is different, the methods, in general, follow a similar structure and consist of similar phases. The first phase is the *exploration phase,* where the current situation is analysed and opportunities are assessed. The next phase is *idea generation,* through brainstorming, a workshop or a scenario study. After idea generation comes the *development of the system*. In this phase, products, services, relevant actors and their specific roles in the system are detailed. The last phase is the *implementation* of the PSS. Different than other methods, UNEP method and Script approach suggest a *pilot project* before the implementation of the PSS in larger scale. However, while UNEP method is based on this pilot project, Script approach proposes the steps and the tools for the development of the actual

Table 2.11 Characteristics of the methodologies for PSS design

Method	Phase	Process	Focus	Difference from other methods
DES	[1]Exploration [2]Policy formulation [3]Idea finding [4]Strict development [5]Realisation [6]Evaluation	Linear	Sustainability, function/system innovation	Based on product development methodology
Kathalys	[1]Exploratory research and definition [2]System design [3]Product-service specification [4]Elaboration and practical experiment [5]Implementation	Linear	Product-service combination, sustainability, the organisation, the user and economic feasibility	In every step of the PSS development, designer focuses on the different aspects of sustainability and the organizational aspects
HiCS	[1]Platform phase (explore and develop) [2]Specific phases (explore and develop)	Iterative	Value-added solutions through Solution Oriented Partnership (SOP)	The different phases can happen more than once
MEPSS	[1]Strategic assessment of opportunities [2]Scenario developmet [3]PSS idea development [4]Monitoring PSS after introduction	Linear	Design and implementation, assessment, and success and failure factors of PSS	'Phase-step-process' hierarchy, offering systematic PSS development
UNEP	[1]Analysis of the existing system [2]Exploring opportunities [3]Developing PSS ideas and selecting the most promising [4]Detailing selected PSS ideas [5]Planning the implementation	Linear	Environmetal, socio-cultural and economical dimensions of sustainability	A pilot study conducted
Script	[1]Mapping the current practices and use logics [2]Reconstructing the use logics and tracing the elements of the service scripts [3]Evaluating the concept of new service [4]Detailed service design [5]Testing the system in small scale [6]Improvements and scaling up	Linear	Sustainability and user logics	A pilot study conducted
Service Engineering	[1]Defining the service elements [2]Exploring opportunities (e.g. non-existing services) [3]Reorganising the information [4]Detailing service design	Linear	Environmetal consideration, creating added value for customers	Formulation of the service

system. Methods, like DES and MEPSS propose a *monitoring* phase after implementation. Monitoring the system provides opportunities to upgrade the system after implementation, and also improve the sustainability requirements that are defined at the previous phases of the PSS design and development.

Sustainability is an important consideration in all methods; however its effect on the whole process is in different magnitude in each method. In most cases, sustainability requirements are defined in the first phase of the design of PSS, and afterwards the system is checked if it meets these requirements. However, in some methods, like Kathalys, MEPSS and UNEP, the tools for ensuring sustainability is elaborated almost at each phase of the process.

Majority of the methods in principle follow a linear path. However, in practice iterations between different phases may be necessary. The only method proposing iteration between the phases as a guideline is HiCS method, in which the feedback of the previous phases is used to ensure more sustainable results for the next phases and end results.

Beerepoot (2004) remarks that the majority of the methodologies developed so far originated from the product design methodologies and are enhanced with tools for service development and sustainability aspects. However, because the services are intangible, it is more difficult to test their usability and acceptability in small scale, which may not match the real life results. Therefore, special attention should be given to the implementation phase.

CHAPTER 3

PUBLIC USE BICYCLE AS A MOBILITY SERVICE

This chapter gives a general overview of the concept of the Public Use Bicycle (PUB) system; its history, development, classification and its connection to PSS. The role and importance of bicycle design in such systems, influence of technological improvements and the business context are explored.

3.1 PUB Systems

The basic idea behind the concept of PUB system is sustainable transportation since it offers citizens options to meet their transportation needs in an environmentally sound manner. A PUB is a bicycle which one may use to reach a destination and then leave at that location for another person to use (DeMaio, 2001).

PUB systems, also referred to as community bicycle programs or bicycle sharing, are currently implemented in various ways and shapes in cities throughout the world. The main goal of these systems is to decrease traffic congestion and city air-pollution through reduction of car use for short trips inside the city (Wikipedia, 2006a).

Within the PSS context, the reason to consider PUB system as a potential alternative for mobility is the social, economical and environmental *advantages* of them over other types of public transport, as summarised in Table 3.1 (DeMaio, 2001):

Table 3.1 Advantages of PUB systems over other types of public transport

	advantages
social	• provide on-demand transportation • reach destinations that are not transit accessible • do not add to congestion • decrease theft of personal bicycles • provide the user with the added benefit of exercise
economical	• require less infrastructure than other modes of transportation • are less expensive to produce and maintain
environmental	• do not create pollution • use less resources

In spite of advantages, some inherent *problems* exist with PUBs. First of all, PUBs cannot be relied upon year-round in many cities because of the weather conditions in winter which may be snowy or icy, making cycling inconvenient. Therefore, this problem may cause rebound effect and limit the environmental benefits of cycling because other forms of public transport are offered vast enough to handle travelling needs without bicycles. In other words, even though other forms of public transport are used less in cycling season, they are still established to provide the same quality of service also in summer months. As a result, pollution levels may remain the same, independent of use of bicycles (DiDonato *et. al.*, 2002).

Another problem is theft and vandalism, which has resulted in the termination of the majority of the first generation PUB systems. To solve this problem, painting bicycles yellow, white, or another solid colour is used as a strategy in first PUB systems, which helped in deterring theft since painted bicycles have little resale value. Further, coloured bicycles help to get the word out about the program (Wikipedia, 2006a).

PUBs are, in some cases, abused for someone's personal convenience, i.e. keeping the bicycle for convenience and availability for next uses, instead of leaving it for others to use (DiDonato *et. al.*, 2002). Another type of misuse is the use of PUBs out of the designated boundary of system. The boundary of the system is determined according to the density of public transport network, and is generally the center of the city. Therefore, the use of PUBs out of the boundary decreases the availability of them for other users in the center.

Although different types of surveillance methods are in progress in different PUB systems, all of the above mentioned misuses occur, decreasing the number of bicycles in use each year.

3.2 Classification of PUB Systems

PUBs have been implemented in about 50 cities throughout the world over the past 35 years, most of which exist in Europe, some in North America, and a few in Asia (DeMaio, 2001). Considering the organizational scheme and the technologies involved, it is possible to categorize these implemented cases of PUBs into four generations (DiDonato *et. al.*, 2002), the development of which is shown in timeline in Figure 3.1.

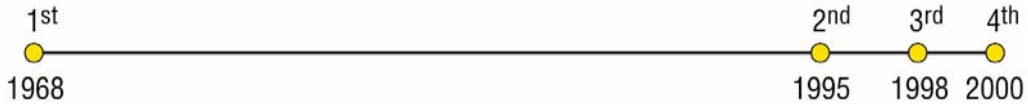

Figure 3.1 The development of four generations of PUB systems

3.2.1 First Generation PUBs

The PUB concept appeared first in Amsterdam, the Netherlands in 1968, through the design of “White Bike” program (Figure 3.2) by Luud Schimmelpennink along with the Amsterdam city government. The aim of the project was to bring an alternative, sustainable as well as cheap solution to the existing public transport, through the placement of a small number of PUBs in the city (DeMaio, 2001). Due to lack of methods for preventing theft, bicycles distributed on the streets were stolen and taken apart for parts (DiDonato *et. al.*, 2002). As a result, the program collapsed within a few days (DeMaio, 2004).

The first generation PUB does not have a custom design. Donated mass-market bicycles painted usually one solid colour -in Amsterdam case, white- are offered to public use (DeMaio, 2001). Therefore, first generation PUB systems have generally low setup costs, which make them popular. On the other hand, because the donated bicycles are various in brand and quality and are not designed for frequent use, maintenance costs of the first generation PUBs are high (DiDonato *et. al.*, 2002). There are no pre-determined locations or specifically designed racks where the PUBs must be picked up from or returned to. One can find or leave the bicycle anywhere on the street. First generation PUBs are usually free to the user. The service provid-

er is generally a community group, who receives financial help from the local government to administer the PUB system (DeMaio, 2001).

Figure 3.2 White bikes are introduced to public (http://www.gkf-fotografen.nl/albuo12/aai)

3.2.2 Second Generation PUBs

The first case of second generation PUBs is launched in Copenhagen, Denmark in 1995, and is the longest running PUB system in the world (DiDonato *et. al.*, 2002). Considering the problems related with the first generation PUBs, this time, custom designed bicycles were used in the system. This is an important characteristic of the second generation PUB systems, since it is possible to see here the effect of service design on product design. The bicycles are designed specifically considering the system as a whole, in order to reduce the problems faced during first generation PUBs. The main criteria used in the design of second generation PUBs were theft and vandalism, different sized users, durability for extreme and heavy use, therefore maintenance and associated costs.

The result was a design that looks different than mass-produced standard bicycles (Figure 3.3), and which has components incompatible on other bicycles requiring special tools to disassemble (DeMaio, 2001).

Figure 3.3 Bycyklen (Copenhagen) - an example of the second generation PUB (DeMaio, 2000)

Second generation PUBs are, thus, more reliable and less likely to be stolen. Further, these bicycles are designed to be more utilitarian and durable to decrease maintenance costs. Some features like solid tires, larger spokes in the wheels, steel frame and extended fenders provide ease of maintenance, while increasing the weight of the bicycle, which is approximately 10-12 kg (Dijkstra and Levelt, 1998). Moreover, second generation PUBs have one-gear and pedal breaks (instead of extra components for front and rear handbrake) to decrease production and maintenance costs (Rosado, 2005). In turn, this emphasis on durability and maintenance paves the way for a handful of maintenance personnel to solve the problems of thousands of bicycles in a city (DiDonato *et. al.*, 2002). On the other hand, these features decrease the usability of the bicycle. For instance, one-gear results in limited flexibility of speed, pedal breaks create discomfort and solid tires cause concussion during use.

Because the cost of the system is compensated by the sponsorship of companies for bicycles, they host advertisements on their horizontal frame and disk wheels (DiDonato *et. al.*, 2002).

The racks of second generation PUBs are also designed special so that one may take away and bring back the bicycles to the racks located strategically at train and bus stops, shopping districts and other areas that receive high volume of foot traffic. Like first generation PUBs, second generation PUBs are also free of charge, however they are based on coin deposit system to ensure that the bicycles are returned to the racks (DeMaio, 2001).

Because of higher setup and maintenance costs of the second generation PUB systems, a non-profit organization is usually involved to operate the system. Local government, similar to first generation PUBs, assists the system with funding. Different than first generation PUBs, added value of the second generation PUB systems is the sponsorship of companies that provides additional funds through the advertisements on the frame and the disc wheels of the bicycles and on the billboards by the racks (DeMaio, 2001).

Third generation and fourth generation PUBs, also referred to as Smart Bikes, rely upon the second generation PUBs, and have many similarities in bicycle design (DeMaio, 2001).

3.2.3 Third Generation PUBs

The problem of theft continued to be a challenge also in second generation PUB systems, even though many improvements had been made through bicycle design and the coin deposit system. Hence, this problem gave rise to the third generation PUB systems, with a tracking method different than its second generation ancestors (DeMaio, 2003). They include high tech solutions like electronically locking racks, telecommunication systems, and magnetic stripe or smart cards that provide ease of tracking as the user's identity is known (DeMaio, 2001). Besides the applied advanced technology, third generation PUB systems are different than the second generation ones in their organizational layout and business model. Following features can be noted for third generation PUB systems:

- In most cases, the user is charged with a fee for using the bicycles.
- They are offered by a commercial company, in co-operation with public authorities.
- They have a different access technology for the check-out process, such as card systems or mobile phones (Bührmann, 2005).

The technological features that the third generation PUB systems offer have great improvements over earlier systems, which relied solely on customer honesty (DeMaio, 2004). In a third generation PUB system, one may take a PUB from an automated rack with the use of a smartcard or magnetic stripe card, which is received through a registration process and includes the user's personal data (DeMaio, 2004). After swiping the card through a reader, the rack releases the PUB (Figure 3.4) (DeMaio, 2001). Then, the user has to return it back within the allotted time for its use, otherwise s/he can be charged for the PUB's replacement cost (DeMaio, 2004).

Figure 3.4 Adshel (Rennes) - release of the PUB through the use of a magnetic stripe card (http://veloa-lacarte.free.fr/smartbike.html)

3.2.4 Fourth Generation PUBs

Fourth generation PUB systems are still being developed and are similar to the third generation PUBs. The main difference is the possibility of combining a PUB system with other means of public transport through the use of smartcards with increased storage capability.

Fourth generation PUBs give users the chance to coordinate all of their mobility activities with a single card. In this respect, this also provides system managers to track the use patterns and adapt the network to meet the needs of the community (Rosado, 2005).

Fourth generation PUB systems have a similar business scheme as the third generation ones. They are offered by a commercial company, in co-operation with public authorities so that the government, companies and community benefit from this synergy.

An example of fourth generation PUB systems was applied in Washington D.C. The system was able to integrate the use of public bicycles with the Metrorail subway system, since over 175,000 customers already had smartcards for the city subway system (DeMaio, 2001). In this respect, fourth generation PUB systems have a faster initiation phase, since they are integrated with an existing system.

There exist two different types of fourth generation PUB systems according to the technologies involved. The first one is similar to the third generation PUB systems, the user accesses the bicycles at racks by the use of a smartcard.

In the second type, an automated lock is provided on the bicycle itself (Figure 3.5). One should first register to the system to announce his/her personal data. S/he may, then, call the telephone number placed on the lock to ask for the entry code to unlock the bicycle (GMCC, 2006).

Figure 3.5 Call a Bike (Berlin) - locking technology on the PUB (http://www.callabike-interaktiv.de/)

CHAPTER 4

CASE STUDIES

This chapter presents six case studies in order to asses the PUB systems from PSS perspective and to integrate the findings for a scenario study for the context of Rotterdam. First, the methodology of the study is clarified through an overview of the aim of the study, methods used and shortcomings of the methodology. The final part of this chapter presents the findings as the result of this analysis and lists the requirements for a successful PUB system.

4.1 Methodology

4.1.1 Aim of the Case Studies

The main aim of this study is to investigate the PUB systems from PSS perspective. With this purpose, a close-up is made on six case studies, the majority of which is implemented, and one under development. The cases are chosen from simple to complex; one is 2nd generation, one is 3rd and the other four cases are 4th generation (Table 4.1). The aim of choosing the cases from different generations is to make an overview of the development of PUB systems. In other words, the change in the development of products and technologies involved in PUB systems, the way the organisation is structured, and the variety of the services offered are analysed. Furthermore, the cases are implemented in different countries which enables to see the different approaches and strategies for the development and design of PUB systems. In particular, the reason for choosing Bycyklen and Adshel in this study is that these cases are one of the well-known examples of 2nd and 3rd generation PUB systems and are considered to be successful since they are still in use even though they remain quite old fashioned for the current time, in terms of products and technologies involved. Similarly, Call a Bike and Vélo'v are considered to be successful examples of 4th generation PUB systems that achieved to attract the attention of the public in a short time after their implementation. OV-Fiets is also a successful example of PUB systems implemented in the Netherlands and has various differences compared to the other systems in terms of the products and the renting procedures. Another

reason for including OV-Fiets in this study is to acquire knowledge on the relevant actors in the Netherlands in the field of PUB systems. This knowledge and the results of this chapter are used for a scenario study for the context of Rotterdam. Although, BikeDispencer is not an implemented project yet, the reason for choosing it as a case in this analysis is its potential applicability to the Rotterdam context, since the concept is developed in the Netherlands.

Table 4.1 The six cases investigated in this chapter

Cases	Country	Generation
Bycyklen	Denmark	2nd
Adshel	France	3rd
OV-Fiets	the Netherlands	4th
Call a Bike	Germany	4th
Vélo'v	France	4th
BikeDispenser	the Netherlands	4th

4.1.2 Method

Mont (2004) defines PSS as a function of five elements: products, services, infrastructure, networks of actors and organisational layout. The analysis was conducted based on these elements. However, it should be noted that the infrastructure component of this definition has not been explored in detail, since all of the cases accommodate infrastructure due to the existing bicycle culture in the contexts where the PUBs are applied: north central Europe. Further, the network of actors are explored under business context, together with organisational layout when it was possible to reach the relevant information on the organisations. Therefore, the cases are examined under four headings: system overview, business context, products and services. The checklist used for the analysis of the cases is presented in Appendix A.

System overview gives a general information on the cases, how the user interacts with system and how the system is tracked. *Business context* explores the relevant actors, their specific role in the system and their interaction. Under the heading *Products*, the main two products of the systems, namely the bicycle and the racks, are explored. Finally, *Services* explains the common services included in the system, such as surveillance, maintenance and distribution.

As the cases are implemented in different countries, it was not possible to investigate them at their location. Further, the amount of the published resources related to the PUB concept, and specific to cases were limited. For these reasons, an internet-based research was conducted for the investigation of the cases. It is possible to categorise the used internet resources into three main groups, as below.

Experts

This group includes the personal sites of the researchers and the web pages of certain magazines in which it is possible to find articles and reviews related to the cases.

Government sites

The involvement of government in PUB systems, whether in funding the system or managing it, is common. Therefore, it is possible to reach qualitative and quantitative information about the cases on the official web pages of the municipalities or governments.

Non-governmental organisations, foundations and institutions are also included in this group.

Company sites

This group includes the companies which have a role in the PUB systems, whether providing the system, or supporting it by developing products and introducing new technologies.

As the last step of the study, a scenario is developed for the context of Rotterdam (see Chapter 5), using the findings of the internet search. The scenario study is made to present the findings in more concrete terms.

4.1.3 Shortcomings

Although, internet is currently a commonly used search tool, its credibility is a questionable topic in the research field. Therefore, internet-based research used for the case study brings some shortcomings with it. For instance, although the government and company web sites are reliable in terms of being official and regularly updated, and can be considered to offer trustworthy information, personal sites and magazines may not be considered as reliable as the other two groups.

Moreover, it is not always possible to reach same type of information for each case because each site is designed differently and contains different types of information. Therefore, in using the available information and during analysis, certain cases have necessitated estimations. These are indicated on the relevant tables.

4.2 Bycyklen, Denmark

4.2.1 System Overview

This project, initiated by Morten Sadolin and Ole Wessung, aimed at providing an efficient means of transportation for the downtown of Copenhagen, decreasing the need for parking, as well as making the city safer to live and work in, through solutions for urban problems, such as vehicular pollution, traffic congestion, and bicycle theft (DeMaio, 2000). The system started in 1995 and is currently in use in Copenhagen. The City Bike Foundation (CBF) of Copenhagen provides the system free for both frequent users, namely residents of Copenhagen, and tourists.

The system is funded by the City of Copenhagen and by private sponsors who advertise on the bicycles (Politiken - Danish newspaper, Netto - supermarket chain, Post - national Danish mail carrier, Coca-Cola, 2V - Danish real estate company, the Girl Scouts of Denmark, and others) (DeMaio, 2000). It should be noted that there is very little interest in sponsorship by companies due to the program's bad public appearance caused by problems associated with vandalism and misuse. The main income of the system, therefore, comes from government funds and the company AFA JCDecaux which advertises on billboards located around the bicycle racks (DiDonato *et. al.*, 2002).

The data on the number of users is difficult to reach, since the system is based on coin-deposit, which provides no information on the users and frequency of use of bicycles. Description of the system is summarised below, focusing on the use and tracking of bicycles.

Usage

The system is based on coin deposit, which makes the procedure easy for the user. The user can take a bicycle from a bicycle rack by placing a coin worth 20 Danish kroner (about € 2.5) into a slot placed on the handlebar of the bicycle in order to unlock it, as shown in Figure 4.1. After using the bicycle for an unlimited time within the designated boundary of the city (Figure 4.2), s/he can return it back to any of the 120 city-bike racks located around the city at train and bus stops, multi-storey housing flats, shopping districts and touristic locations. After locking the bicycle, s/he can recover the coin which was placed previously for unlocking (DeMaio, 2000).

Figure 4.1 Coin deposit system (http://ruk.ca/article/2870)

Figure 4.2 Designated boundary of the city (http://www.bycyklen.dk/)

Tracking

The type of rental, namely coin deposit system, makes it difficult to monitor the bicycles and control the users' activities, thus causes some problems related with misuse and vandalism. This results in the disappearance of 200 bicycles in average every year and, in turn, leads to small rotation of available bicycles and loss of publicity funds (Rosado, 2005).

4.2.2 Business Context

Bycyklen is a joint project of government, non-profit organisations and companies. Each actor has a certain role in the system. These relevant actors are listed and explained below.

CBF

CBF is a non-profit organization that arranges budget to sponsor Bycyklen for buying more bicycles every year. Because the cost of the system is compensated by the sponsorship of companies, CBF has a vital role in communicating with the companies who will advertise on the bicycles and the billboards located by the bicycle racks. Further, another responsibility of CBF is the maintenance of the bicycle racks and the area around the racks (DiDonato *et. al.*, 2002).

City of Copenhagen

City of Copenhagen is the local government who is responsible for lending CBF spots of land for bicycle racks and rights to have a billboard at each of these spots (DiDonato *et. al.*, 2002).

AFA JCDecaux

AFA JCDecaux is an advertising agency who is in charge of the signs and billboards located around the racks. Since 2002, AFA JCDecaux pays a fixed fee of 2,000,000 kroner (about € 270,000) per year to CBF (DiDonato *et. al.*, 2002), which is enough to fund Bycyklen over the next several years.

Reva Center

Reva Center is the outsource company that aims to offer a social service to the community by training the unemployed for the maintenance of Bycyklen, and thus contribute to the workforce. The task of Reva Center in the system is to fix, repaint, collect and distribute the bicycles (DiDonato *et. al.*, 2002).

Bicycle manufacturer

A bicycle manufacturer based in Taiwan receives the bicycle specifications made by Reva Center (Rosado, 2005).

4.2.3 Products

Bicycle

The Bycyklen system is considered to be one of the good implemented cases of second generation PUB systems. The bicycles of Bycyklen carry the characteristics of second generation PUBs (Figure 3.3), as explained in Chapter 4, Section 4.2.2. The name of the bicycles is City-Bike and there exist a total number of 2000 bicycles in the system.

Racks

Rack design is an important part of the Bycyklen system and some special features should be considered when designing a rack for public use bicycles which are standard. Some basic criteria when designing bicycle racks can be summarized as follows: visibility, accessibility, location, and attraction. These criteria are especially important for Bycyklen system which relies on the sponsorship of companies, advertising on the bicycles and the racks. The total number of the racks in the system is 110.

The bicycle rack has very simple design consisting of a long cylindrical tube with two ground supports and chains (Figure 4.3), each of which can be connected to a bicycle (Figure 4.4). Therefore, the racks rely on the bicycle's kickstand to keep it standing, which may cause the bicycles to tumble over, potentially taking two or more bicycles with it. This causes negative visual impacts (Figure 4.5) and increases the maintenance cost (DiDonato *et. al.*, 2002).

Figure 4.3 Bycyklen racks (DiDonato *et. al.*, 2002: 48)

Figure 4.4 Chain is connected to the bicycle (http://ruk.ca/article/2870)

Figure 4.5 Racks rely on bicycles' kickstand (http://membres.lycos.fr/audanemark/image/citybike.jpg)

Vans

Four vans work in Bycyklen for maintenance and distribution purposes. Vans make the necessary small repairs on-site, collect the ones which need intensive maintenance to be taken to the repair shop and distribute the bicycles fairly through the racks in the city.

4.2.4 Services

Surveillance

The use of City Bike outside of the designated boundary is considered as theft and has a penalty of 1,000 kroner (about € 135). Surveillance of the system is done by police, which is not very strict (DeMaio, 2000). Besides police, other users and citizens are provided with a direct telephone line so that they can inform the system about the abandoned bicycles, repair needs and abusive use (Rosado, 2005).

Maintenance

Maintenance service is one of the important elements of the Bycyklen system offered to customers. It helps to identify the daily repair requirements of the bicycles (Rosado, 2005). The cost of maintenance for each bicycle is about € 60 per year. This is a considerable amount compared to the cost of one bicycle which is about € 160. The reason of this is entirely due to vandalism and abuse. Main task of the maintenance service is, therefore, repainting the bicycles to get rid of the graffiti and repairing the physical damage caused by vandals (DiDonato *et. al.*, 2002). Because of the weather conditions, the system does not work during winter months, from January to April. Yearly maintenance of the bicycles is done in this period (Rosado, 2005).

4.3 Adshel, France

4.3.1 System Overview

Adshel has been offered to the public of Rennes by Clear Channel Adshel - an outdoor advertising company - since 1998. The project was initiated through a joint call for bids for street furniture, launched by the municipality of Rennes. The objectives of the project were (1) to offer an alternative way of transport which is efficient and complementary to the public transport; (2) to increase access to the town center through several rental stations; and (3) to encourage people to use bicycles by installing racks close to bus stops, stations and relay parks as well as close to university centers (Energie-Cités, 2001). Adshel is currently implemented and is free of charge, however it requires user to pay a one-time refundable deposit of € 23. The number of the users in the system is 2500 and user profile consists of the residents of Rennes, residents of the districts of Rennes (32 neighbouring villages and towns), students enrolled at local universities and tourists (Clear Channel, n.d.).

Although the system is financed mainly through advertisements, it is economically not feasible to be operated stand alone. Therefore funds of local authorities and user fees are vital incomes of the system.

Usage

The racks are equipped with docking stations (Figure 4.6) where the bicycles are locked in (Figure 4.7). One should use a magnetic stripe card to unlock the bicycles (Figure 4.8). For operation purposes, a visual and an audio signal system is inserted in the docking stations. There are three LEDs that inform the user about the status of the docking station. In case of no activity, no visual sign is given. When a card is inserted into the card reader, a bicycle is released mechanically. After this, yellow “OK” LED blinks and buzzer sends a repetitive beep. If there is a problem with the card, red “Probleme Carte” LED blinks and buzzer sends a repetitive beep. If the docking station is out of order because of any problem, red “Hors Service” LED is always on (CreaCom, n.d.).

Figure 4.6 Docking station (http://www.creacom.be/Smartbike/index.htm)

Figure 4.7 Bicycles are locked in docking stations (http://www.creacom.be/Smartbike/index.htm)

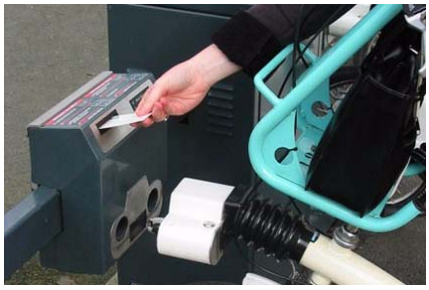

Figure 4.8 Use of magnetic stripe card to unlock the bicycle (http://veloalacarte.free.fr/smartbike.html)

The system allows stops between parking stations. The maximum allowed use period is two hours (Rosado, 2005) but multiple renting is possible throughout the day (Bührmann, 2005a). At the end of two hours, one should return the bicycle in the same way to one of the racks located in the city.

Tracking

Tracking is done through the smartcard technology which enables the storage of the personal information of the user. Further, the bicycles are equipped with microchips and assigned a serial number, that provide online monitoring. By this way bicycles are protected from theft and vandalism, since online monitoring locates the bicycles anywhere in the network (Rosado, 2005).

In case of time exceed in the renting process, the card of the user is locked by the system. If any of the information registered on the card does not match when the bicycle is returned and the card is re-introduced, the card is locked. Unlocking of the card is only possible by the remote host operator (CreaCom, n.d.).

4.3.2 Business Context

Adshel SmartBike is a company-based PUB system that provided economic viability of PUBs for municipalities. Involvement of Clear Channel Adshel as an outdoor advertising company in the system provided profit to the company on the one hand, and gave the Rennes Municipality the chance to provide urban displacements inside Rennes on the other hand.

Clear Channel Adshel

Clear Channel Adshel is the service provider who is responsible for the entire system, including maintenance and a specialized team of three workers. Combination of city furniture and advertising possibilities was the main driver for Adshel to provide the whole system for the municipality of Rennes (Rosado, 2005).

City of Rennes and Metropole Rennes

Municipalities are responsible for contracting service providers and provide the necessary infrastructure for the system to operate right. They also define the goals regarding mobility issues (Rosado, 2005).

Orlians Engineering & Prototyping

Orlians Engineering & Prototyping is the outsource company of Adshel. The company developed the whole project for Adshel, working with the partners CreaCom and XLN-t (CreaCom, n.d.).

CreaCom

CreaCom develops mobile data terminals and high-tech communication devices via the use of GSM, and satellite and radio networks. It is the development partner of Adshel, and was responsible for writing the project specifications and assisting Adshel in the concept development, production and installation phases (CreaCom, n.d.).

XLN-t

XLN-t is a company specialized in hardware and software development for industrial products. The company brought in expertise on Smart Proximity Cards and made the complete hardware design of the docking station and station controller of the racks (CreaCom, n.d.).

4.3.3 Products

Bicycle

Adshel consists of 200 bicycles named SmartBikes. SmartBike was designed to meet specific criteria such as reliability, identification and ease of use (Figure 4.9). It is reliable and resistant to shocks, vandalism and component tampering. Apart from these criteria, identification was another important issue so that bicycles were equipped with microchips for ease of tracking. Further, they are designed with four speed gears, and easy regulation of handlebars and saddle to make them convenient for the user. The following technical specifications were applied:

- Automatic lights
- Reinforced extra low steel frame
- Built-in 4 speed gears in the hub
- Back-pedal breaking
- Two microchips on the frame
- Mudguards
- Reinforced tyres
- Waterproof saddle (Energie-Cités, 2001).

Figure 4.9 Adshel PUB (http://veloalacarte.free.fr/smartbike.html)

Racks

As the majority of people use the bicycles along with other means of transport, the racks are located at bus interchange points following a *park and ride* pattern (Figure 4.10) (Bührmann, 2005a). The number of the racks is 25 and each rack includes 12 spaces for bicycles and has been supplied with docking stations and a station controller (Figure 4.11).

Figure 4.10 Rack locations (http://veloalacarte.free.fr/smartbike.html)

Figure 4.11 Adshel rack (http://veloalacarte.free.fr/smartbike.html)

Controller consists of a GSM modem and a CPU (Central Processing Unit). A central computer downloads the information stored at each docking station through the use of GSM technology (Bührmann, 2005a).

Docking station

Docking station is the physical box from where the bicycle is locked in and out (Figure 4.12). It consists of a card-reader, a twin antenna tag read unit for bicycle tag and lock tag, a display with three LEDs and the necessary software to lock a bicycle (CreaCom, n.d.).

Figure 4.12 Docking station (http://www.creacom.be/Smartbike/index.htm)

Station Controller

Each rack contains an intelligent station controller (Figure 4.13) for local network management and communications hardware which is based on GSM protocol (CreaCom, n.d.).

Figure 4.13 Station controller (http://www.creacom.be/Smartbike/index.htm)

Magnetic stripe card

The user needs a magnetic stripe card (Figure 4.14) to access the bicycles. The card contains the personal data of the user making it possible to track bicycles if they are not returned. The central computer authenticates users' cards and compiles the user data (Bührmann, 2005a).

Figure 4.14 Magnetic stripe card (http://veloalacarte.free.fr/smartbike.html)

Van

The vehicle is called “navette”, meaning shuttle in French. It ferries the bicycles when necessary (Figure 4.15), makes minor repairs on-site and takes those needing more serious repairs back to the workshop (Energie-Cités, 2001). The smart software of the docking station communicates with the shuttle via GSM protocol (by sending a SMS), independent from the host controller. By this way, service personnel have control over the racks and according to the needs make the necessary adjustments and allocations of the bicycles between different racks (CreaCom, n.d.).

Figure 4.15 Navette (http://veloalacarte.free.fr/smartbike.html)

Host controller

Host controller is a remote computer that is linked to racks and dispatch vehicle via GSM. It is equipped with NT server version 4.0 or higher, Back Office for NT and a digiboard with multiple serial channels for modem management (CreaCom, n.d.). It serves as database and allows the following tasks to be done (Clear Channel, n.d.):

- Allocation and return of the bicycles in different racks;
- Geographical repartition of the park;
- Instructions to the dispatch vehicle;
- General survey;
- Data collection for statistical use for the continuous development of the system.

4.3.4 Services

Surveillance

The surveillance of the Adshel SmartBike is made by the system itself, since every bicycle is monitored online via microchips. System tracks the location of the bicycles and keeps the record of the user who is in possession of the bicycle. User is held responsible and subject to a fine in case of damage or misuse (Rosado, 2005).

Maintenance

Maintenance of bicycles and the racks is made by the dispatch vehicle which is linked to the central system through GSM. Because the system was planned to bring solutions for real time needs, dispatch vehicle does a great amount of trips everyday, on average 130 km, resulting also in 3 tons of lift of bicycles per day. This may potentially have a negative impact on the environment due to the fuel and energy consumption.

Distribution

As there is a limited amount of space at each rack, in case of a decrease or increase in bicycle or parking space number, bicycles have to be distributed from one rack to the other. The information on the availability of bicycles or parking spaces is achieved through the use of GSM technology. An SMS is sent to the dispatch vehicle to fix the right number of bicycles by adding or removing some of them (Rosado, 2005). This ensures the enough number of bicycles for users to find and parking space to return their bicycles.

4.4 OV-Fiets, the Netherlands

4.4.1 System Overview

Name of the alternative mobility is OV-Fiets. The letters O and V stands for openbaar and vervoer respectively, which means public transport. Therefore, OV-Fiets means *public transport bicycles*.

Commuters, who do not travel by car, generally need different means of transportation from one place to the other. Train network between cities in the Netherlands is well-established, which makes the train almost compulsory from one city to the other. Apart from bicycle; walking, bus, metro and tram are other alternatives from the railway station to a final destination. Therefore, OV-Fiets has been designed to bring solution for those who want to cover the distance between the railway station and their final destination by bicycle (OV-Fiets, n.d.) and for this reason, it is more for frequent users than for tourists and is offered countrywide.

OV-Fiets, which was started in 2003 by ProRail and Cyclists Union, is currently in use and is being subsidized by government since the development phase of the system continues until the end of 2006. The cost of renting a bicycle is € 2.75 per 20 hours, with a subscription fee of € 9.50 per year. Payment is done on a monthly basis through the member's bank account in the Netherlands (Emmen *et al.*, 2004). Currently, 20 000 commuters use the system.

Usage

The system is based on membership. Members should have an annual season card to use railways or a separate OV-Fiets membership card (Figure 4.16) to rent a bicycle at any OV-Fiets rental point located at over 80 train stations in the Netherlands.

Figure 4.16 OV-Fiets membership card (http://www.optimum2.org/downloads/itiefengels.ppt)

Maximum rental period of an OV-Fiets bicycle is 60 hours. At the end of the maximum rental period (OV-Fiets, n.d.), the bicycle should be returned to the same office it has been collected from. Delivery of the bicycle at a different location has an extra cost of € 10. Majority of the rental points are operated by the bicycle parking facility operator who was, in most cases, previously running the traditional bicycle rental facility. In this case, rental of the bicycles is made manually (Figure 4.17), by scanning the barcode at the back of membership card.

Figure 4.17 Renting process (http://www.optimum2.org/downloads/itiefengels.ppt)

At a few rental points, distribution of bicycles is made automatically from a bicycle locker (Figure 4.18) that one may unlock by swiping the membership card through a reader (Emmen *et al.*, 2004) and entering the pin code of the card.

Figure 4.18 OV-Fiets locker (http://www.optimum2.org/downloads/itiefengels.ppt)

Tracking

Tracking, as in the case of most third generation PUB systems, is done through the membership card, in which the personal data of the users are stored.

4.4.2 Business Context

Because the main goal of the OV-Fiets is to offer solutions for those who want to cover the distance between the railway station and a final destination by bicycle, the system encourages the commuters for the use of train. 36% of the commuters, in a survey, say that they use train more often because of OV-Fiets. This is the main reason of the involvement of ProRail in the system as a stakeholder.

From the financial point of view, the money received from the customers is just enough to keep the system running. ProRail, at the beginning of the project, was responsible for setting up the system and investing for the three pilot projects, which took place in Delft, Utrecht and Alphen aan den Rijn. However, the local governments are now expected to take care of the costs associated with maintenance and management of the locks and the infrastructure in the stations.

Relevant actors and their role are summarised below.

Foundation of OV-Fiets

Foundation of OV-Fiets is the service provider and is responsible for the management of the system.

ProRail

ProRail is the rail infrastructure manager of the Dutch railway network instituted by the government, and is responsible for capacity, reliability and safety on and around the tracks. ProRail is the creator of the concept of OV-Fiets and holds the intellectual property rights. It is responsible for the feasibility study, presentation of the work to the government, investment of bicycles and the design of the renting system (Maartens, 2006).

Dutch Railways

Dutch Railways is the governmental institution which is responsible for managing the infrastructure of the railways and operating the transport. The role of Ducth Railways in OV-fiets is to inform the commuters about OV-Fiets, make the communications and manage public relations (Maartens, 2006).

Cyclists Union

Cyclists Union is a non-governmental organisation which took the initiative with ProRail to start the project of OV-Fiets. The role of Cyclist Union is to take part in the lobbying activities for the government and encourage its members to use the system, through promotions and events (Maartens, 2006).

Doen

Doen is one of the biggest charity organizations in the Netherlands and has donated the system around 600 bicycles at the beginning of the project (Maartens, 2006).

The rental shop owners

The rental shop owners already existed at various stations in the Netherlands, before the implementation of OV-Fiets system. They profited from renting and repairing the bicycles, and also from offering parking facilities for bicycles. The role of the shop owners in the system is, therefore, to manage their own shop at one hand and to keep the system working by renting OV-Fiets to the commuters on the other hand. OV-Fiets provided various advantages for shop owners. First of all, there is an increase in the rental of bicycles after the implementation of OV-Fiets countrywide. Hence, shop owners increase their profit by joining the system. The cost of renting a bicycle for 20 hours is € 2.75, € 2 goes to the shop owner and € 0.75 goes to the foundation of OV-Fiets. Secondly, the system provides ease of rental process to the shop owners since all the paper work and deposit procedure are excluded from the system by the introduction of smartcards, which decreases the theft of bicycles (Maartens, 2006). Finally, with the help of the membership system and custom bicycle design, theft of the bicycles has decreased in a considerable amount and this has enabled shop owners to transfer theft-related problems to an insurance company.

However, it should be noted that, the profit the shop owners gain through OV-Fiets partly covers the operation cost of the shops. Therefore, opening a shop for OV-Fiets without repair and parking facilities may not always be a profitable business (Spapé *et. al.*, 2006).

4.4.3 Products

Bicycle

OV-Fiets has similar design criteria like second generation PUBs. Maintenance is one of the basic considerations, which makes the design as simple as possible (Figure 4.19). Bicycles are not equipped with gears, and have pedal breaks to decrease maintenance costs. There is no male-female differentiation of the bicycles, to ensure the availability of them for customers. Different than second generation PUBs, bicycles do not hold advertisements.

Figure 4.19 OV-Fiet (http://www.optimum2.org/downloads/itiefengels.ppt)

Table 4.2 summarizes the estimated number of stations, number of members and the frequency of bicycle renting within the last four years.

Table 4.2 Frequency of bicycle renting

Year	Number of stations	Number of members	Frequency of bicycle renting
2003	52	6 000	33 000
2004	72	11 000	100 000
2005	86	20 000	189 000
2006 (goal)	110	30 000	350 000

The life time of each bicycle is 1000 times use. For security reasons, namely theft and vandalism, the components of the OV-Fiets are designed not to be suitable with other standard bicycles. Therefore, end-of-life possibility of the bicycles is only to reuse the parts on other OV-Fiets. It is also not possible to sell them as second hand bicycles at their end-of-life (Spapé *et. al.*, 2006).

Card reader

Card reader (Figure 4.17) is a mass produced standard reader similar to the ones in the supermarket. It reads the information of the user through the barcode at the back of the OV-Fiets membership card.

Locker

As the initial cost of the lockers (Figure 4.18) is very expensive, they are not commonly used in the OV-Fiets system; only five lockers have been installed until the current date. Rather, rental shop owners are involved in the system, although there are some disadvantages with them. For instance, there is no possibility of renting a bicycle late in the evening, since the rental shops close at 22.00. Further, the staff working in the shops is expensive. Therefore, OV-Fiets is now looking for a solution in between the lockers and the shops, which will allow the renting of bicycles at any time of the day and be a cheap solution for the system (Spapé *et. al.*, 2006).

4.4.4 Services

Surveillance

Surveillance of the system is made by the system itself, through the membership process. System keeps record of the user details, and pairs the member with a bicycle for that specific use. In case of theft, members should inform the police first to prove that the bicycle is stolen. The requirement to prove that it is stolen is to have the key of the lock on the bicycle. In this case, insurance company pays for the replacement of the bicycle (Spapé *et. al.*, 2006).

Further, because the parts are specifically designed and are not coherent with other standard bicycles, only one bicycle out of 1000 is stolen each year (Spapé *et. al.*, 2006).

Maintenance

Maintenance of the bicycles is made by the shop owners, since this is still a part of their business and they profit from the system.

Distribution

There is no distribution of bicycles; users are supposed to return the bicycles to the station they collect them from.

4.5 Call a Bike, Germany

4.5.1 System Overview

Similar to OV-Fiets, the main goal of Call a Bike is to offer the railway customers an alternative mobility service for covering the distance from a railway station to their final destination; hence, by this way, to increase the use of train. The project was initiated by Christian Hogl and Joseph Gundel in Munich in 2000 and later spread over other German cities, such as Berlin, Frankfurt and Cologne (Bührmann, 2005b). Call a Bike is currently implemented and subsidized by Deutsche Bahn, which is also the service provider in the system.

The charge of the bicycle that is called CallBike is 7 cents per minute with a maximum charge of € 15 per day. At the end of 24 hours, the charge of 7 cents per minute begins again. The charge of the whole week is € 60. Rental fees go down to 3 cents per minute for those who have an annual user's charge or a BahnCard, which is an advantage for frequent public transport users. The number of users in 2004 is estimated 71 000 in Germany, with a user profile of residents who use public transport in combination with a bicycle (Bührmann, 2005b).

Usage

Before using the system, the user should first register by calling the Service Hotline or using the internet, to submit his/her personal data and credit card details, and then can ask for an entry code by calling the Service Hotline whose number is placed on the lock. The entry code is necessary to unlock the bicycles (GMCC, 2006). The bicycles are spread across the city, since there are no racks installed in the system. When the green light on lock blinks, it means the bicycle is free for use. The red light indicates that the bicycle is taken by someone else. After obtaining the valid code for the bicycle from Service Hotline, the user should enter the code in the lock display (Figure 4.20) (Deutsche Bahn, 2006). When finished with using, the user should return the bicycle to the nearest major intersection and lock it to a fixed object. A receipt code appears on the display when pressing the “RETURN” button. This code is necessary for the return call to the Service Hotline and is used to determine the end of rental period and the bicycle's location (Associated Content, 2005).

Figure 4.20 Lock display (http://www.callabike-interaktiv.de/)

There is also a “HOLD” option on the lock, which allows the user to keep the bicycle during the short intervals of use (Rosado, 2005).

Tracking

Related with the rental communication protocol, a GSM device is installed with a serial number on each bicycle. The GSM device determines the location of bicycles and hence, allows their tracking.

4.5.2 Business Context

Call a Bike is a company based PUB system, as in the case of Adshel. Two important points should be noted as an added value to the PUB systems. Firstly, after the successful implementation of Call a Bike in Munich, the system was applied in other German cities, allowing the spreading of equivalent systems. This provided the opportunity for an integrated network of alternative means of transportation in Germany. Secondly, the system combines different types of public transport, namely the train, car and bicycle, providing new means of door-to-door alternatives for its customers.

Deutsche Bahn

Deutsche Bahn is the German railway company that aims to provide its customers added value mobility services by organizing entire mobility chains. By offering railway customers innovative door-to-door solutions, they expect to attract more customers who use the train in combination with car and bicycle. Hence, this is the added value for Deutsche Bahn to take the responsibil-

ity of the whole Call a Bike system and provide it to railway customers. Apart from Call a Bike, Deutsche Bahn also offers car sharing service to its customers.

4.5.3 Products

Bicycle

CallBike has a design similar to the other PUBs mentioned (Figure 4.21). However, it has quite a high initial cost due to the locking technology inserted (Figure 4.22), which is € 1050. Further, it is also equipped with impressive shock absorbers making them very comfortable on the one hand, and heavy on the other hand (Allen, 2003). The number of bicycles in the system is 4200 (Bührmann, 2005b).

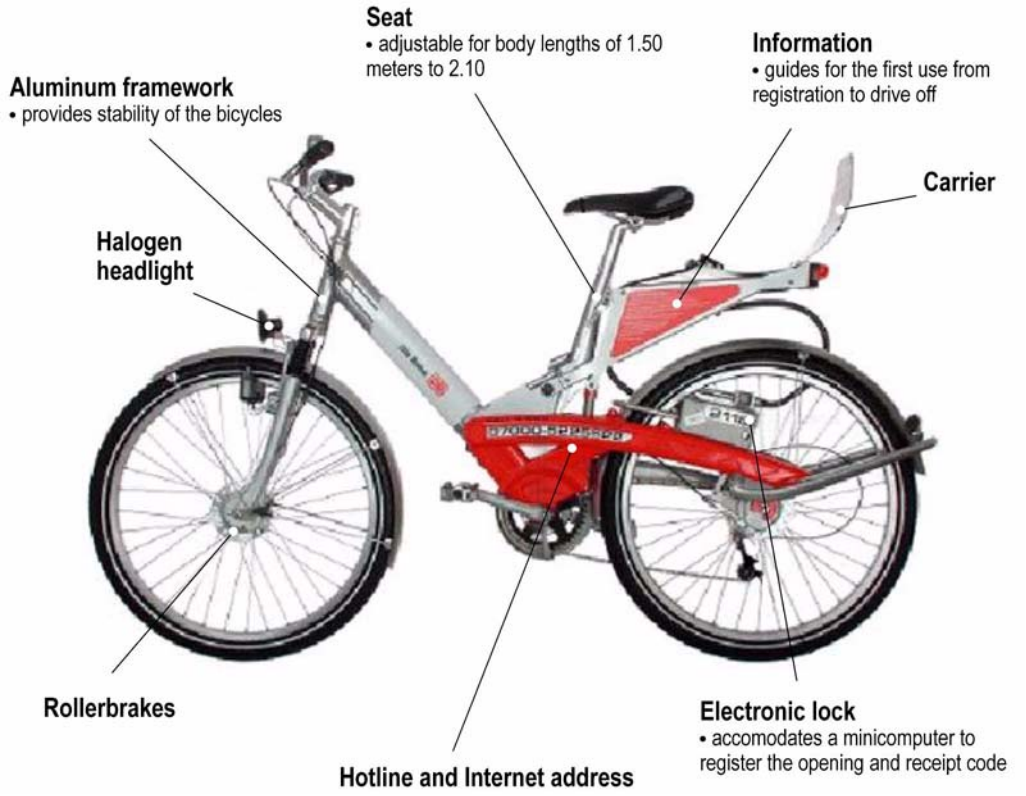

Figure 4.21 CallBike (http://www.optimum2.org/downloads/estr00001on.ppt)

Figure 4.22 Locking technology (http://www.callabike-interaktiv.de/)

Racks

Different than other PUB systems, there are no racks in Call a Bike, since there is no need for a parking space due to the locking technology placed on the bicycles, which makes is easy to track them. Although the locking technology is expensive, it also brings economical advantages since there is no need of rack installation, which considerably decreases the initial cost of the system.

Vans

Three vans work to collect the bicycles to the repair shop. They also relocate the bicycles which are not used for seven days in a row (Rosado, 2005).

4.5.4 Services

Surveillance

Surveillance of the system is done by itself by the use of GSM technology and the automatic payment system, which debits from the user's credit card in case of, for instance, wrong parking or use of bicycle outside the use perimeter (Rosado, 2005).

Maintenance

Maintenance of the bicycles is done in the repair shop. There are, in average, 20 bicycles in a day in the shop with maintenance needs due to degradation of some parts, such as tyres, stand and lights. Compared to the high initial cost of bicycles, maintenance cost is low, which is € 60 per year for each bicycle (Rosado, 2005).

Recollection and Distribution

Minimization of management complexity is one of the strategies of Deutsche Bahn. In this respect, only the bicycles which are not used for seven days in a row are relocated from a low use area to an area where there is high demand for bicycles. Besides that, distribution of bicycles is made only once a year (Rosado, 2005).

4.6 Vélo'v Grand Lyon, France

4.6.1 System Overview

The main objective of the Grand Lyon project is to decrease car use by increasing the use of public transport in combination with bicycle. The system has been in use since 2005 in Lyon and is currently run by JCDecaux, which is an outdoor advertising company. The system is, therefore, financed through the advertisements on public bus shelters. The number of users is estimated 30 000 persons (Collins, 2005).

There are three types of cards for three different charges (Figure 4.23). Long-term card, which is pre-paid, is valid for 12 moths and costs € 5 plus a returnable deposit of € 150, to cover loss, damage or theft. The cost of renting the bicycle is € 1 per hour. It is possible to load the card by using a bank account at the electronic kiosk by the racks. Short-term card is valid for one week and costs € 1. The cost of renting a bicycle with a short-term card is € 2 per hour. One may buy one of these cards from an electronic kiosk at any rack by using a bank card. When the card expires, the cost of the time used is charged from the user's bank account. In the case of loss, damage or theft, the user's bank account is charged up to € 150. Técély is actually a Radio Frequency Identification (RFID) enabled public transport card used in Lyon to pay for bus, tram and metro fares. Customers who already have a Técély can use it as a pre-paid card, like long-term cards, but with reduced rates (€ 1 per hour). Técély costs € 5 plus a returnable deposit of € 150 (Nuttall, 2005).

Figure 4.23 Long-term, short-term and Técély cards (http://www.velov.grandlyon.com/)

It should also be noted that there is no charge of using the bicycles for the first 30 minutes, which means renting a Vélo'v is almost free, since 90% of the journeys last less than 30 min-

utes (Daitha, 2005). The user may ask for a receipt when s/he is passing his/her card through the reader at an electronic kiosk at one of the racks (Vélo'v GrandLyon, n.d.).

Usage

Vélo'v is based on membership that requires users to register in advance. By this way, their personal details are recorded on the database and they are issued with a security code and a prepaid card to use at the electronic kiosk by each rack (Figure 4.24), to access the bicycles (Henley, 2005).

Figure 4.24 Electronic kiosks at racks (http://www.velov.grandlyon.com/)

After inserting the prepaid card and entering the security code, a bicycle is released from the anchor. One may use the bicycle and return it to another rack.

Tracking

Tracking is done through the smartcard technology which enables storage of the personal information of the user.

4.6.2 Business Context

Startup and development costs of the system were high. However, JCDecaux expects economies of scale and believes that these costs will be amortized over time, when the service spreads to other cities. The cost of service is € 1000 per year for each bicycle (€ 2 million in total). Since JCDecaux plans to operate 4000 bicycles in 2007, they expect service costs to increase up to € 4 million (Daitha, 2005).

JCDecaux

JCDecaux is an outdoor furniture company who is responsible entirely for the operation of the system. The company profits from the rental fees that the service collects to Grand Lyon as part of its contract to use advertising space on Lyon's public bus shelters. The contract is for 13 years, which secures the system in the midterm (Daitha, 2005). They are also responsible from providing bus stops and other systems as decided by the local council (Nuttall, 2005). The Vélo'v bicycles are designed by the engineering and design department of JCDecaux, and then manufactured by ORBITA, a Portugal based company (for the company check: http://www.orbita-bicicletas.pt/, for the bicycle: http://www.orbita-bicicletas.pt/site/ingles/men-us.html), and Cycles Mercier, a French based company (check: http://cyclesmercier.com/).

ASK

ASK is a contactless card and reader developer based in France. Before the implementation of Vélo'v, ASK was already providing Técély public transport cards for the city of Lyon. The company is now also supplying Vélo'v cards, and has developed the electronic kiosks that issues the short-term Vélo'v cards (Collins, 2005).

4.6.3 Products

Bicycle

The bicycles of the system is named Vélo'v and there are 2 000 of them in use. They have a custom design, painted with silver and red colours, which makes them distinguishable from the standard bicycles (Figure 4.25). They are equipped with a low step-through frame, since there is no male-female differentiation. Seat height is adjustable. Bicycles are equipped with roller brakes, lights, front wire basket, three speed gears, skirt guard, a solid-kick stand and a partially enclosed chain which prevents snagging of clothes and grease marks (Nuttall, 2005).

Because the bicycles are well equipped, security becomes a big issue. In this respect, bicycles hold a theft protection device (GrandLyon, 2006). Further, every part of the bicycle has security bolts which require special tools to undo. Tube valves are also protected to prevent the tyres from getting flat (Nuttall, 2005).

Bicycles are locked into specially designed bollard-style racks via a clamp affixed around the down tube (Figure 4.26). It is also possible to lock the bicycles elsewhere in the city with a steering lock. A thin cable is used to connect the bicycle to street furniture (Figure 4.27) (Nuttall, 2005).

Figure 4.25 Vélo'v PUB (http://www.velov.grandlyon.com/)

Figure 4.26 Locking at the racks (http://www.velov.grandlyon.com/)

Figure 4.27 Locking in the city (http://www.velov.grandlyon.com/)

Racks

175 racks are strategically located at railway stations, tourist attractions, street corners and transport hubs (Figure 4.28). There are from 10 to 50 bicycles at each rack. Racks are equipped with an electronic kiosk for users to rent a bicycle with their membership cards.

Figure 4.28 Racks (http://www.velov.grandlyon.com/)

Fault sensor

In bicycle renting systems, it is probable that the person who rented the bicycle before leaves it with some problems like a missing peddle, damaged seat or wheel. To prevent this problem Vélo'v introduces a fault sensor on bicycles: a tiny detector that sends information to the control centre about the brakes, tyre pressure, gears and the lights of the bicycles, each time when a bicycle is returned to the rack (Henley, 2005).

RFID-enabled card

Radio Frequency Identification (RFID) is an automatic identification method that uses radio waves. Typically, a reader communicates with a tag (Collins, 2005), which is a small object that can be attached to or incorporated into a product. Tags hold digital information in a microchip, which enable them to receive and respond to the radio-frequency queries from a reader (Wikipedia, 2006b). Técély system was first deployed in Lyon, using contactless RFID-enabled cards. Long-term card uses ASK's 576-bit GTML card and operates at 13.56 MHz. Short-term paper card uses 256-bit C.ticket® and operates at 13.56 MHz (Collins, 2005).

Electronic kiosk

Electronic kiosk (Figure 4.29) is developed by the company ASK, to issue the short-term cards of the system. Users can buy a card or add credit to their long-term or Técély smartcards at any electronic kiosk, which are placed by each rack. The kiosk provides a code number and the number of the bicycle rack for the bicycle issued. The user enters the code number to select that bicycle by using the kiosk. Then the bicycle is unlocked from the rack (Collins, 2005).

Figure 4.29 Electronic kiosk (http://www.velov.grandlyon.com/)

Van

A van is responsible to relocate the bicycles from one station to the other, so that they are available 24 hours a day and seven days a week. Currently, weekday rush hours experience the greatest demand, which indicates that people are using the service to commute (Daitha, 2005). The van is also responsible for the maintenance of the bicycles, and retrieves data from the control center through fault sensor (Reid, 2005).

4.6.4 Services

Surveillance

Surveillance is done by the system itself. In case of a loss, damage or theft, either € 150 is charged from user's bank account or the deposit the user pays at the registration process is seized by the system.

Maintenance

Maintenance is done by the system itself. The fault sensor sends information each time the bicycle is returned to the rack. In case of a problem, the bicycle is locked automatically after the last rental. The maintenance personnel are dispatched to repair the bicycle. The centralized system also gives information about the racks where there are bicycles missing, so that the system can move them to where there is most demand (Reid, 2005).

Control Center

Control center is a service designed to increase the quality of the system. The main duty of the control center is to guarantee the proper functioning of the bicycles, through the use of fault sensors on the bicycles. Further, some racks are used far more often than the others, which may cause shortages in popular spots. Computerized warning system alerts the control center about the availability of the bicycles and racks, so that users can consult the service to find out which nearby racks have bicycles (Henley, 2005). This information is also available at the internet site of the Vélo'v (Vélo'v GrandLyon, n.d.) through an interactive map (Figure 4.30) on which the users can click on the racks they are interested in and retrieve information on that specific rack.

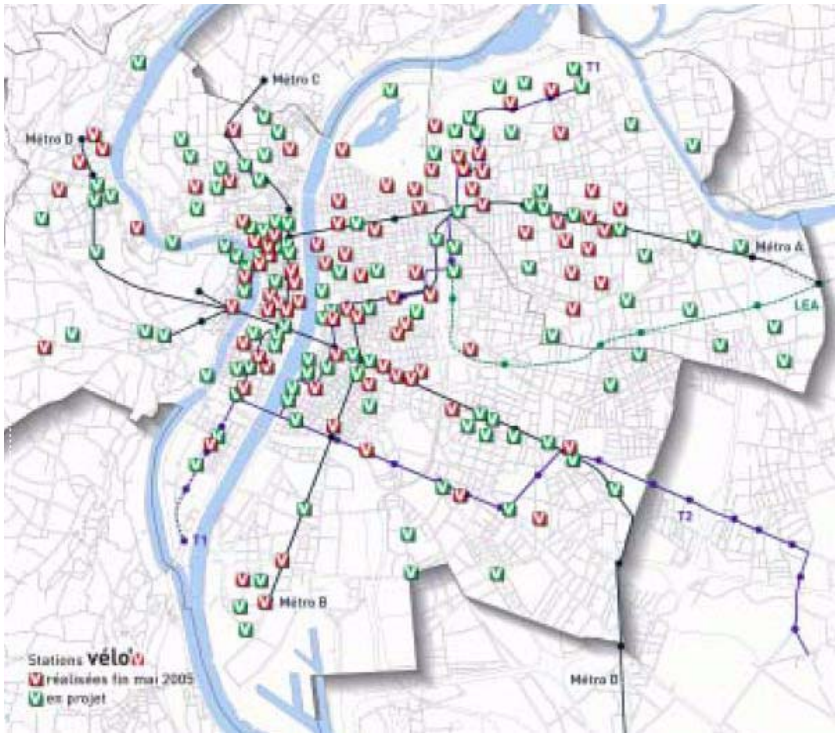

Figure 4.30 Interactive map (http://www.velov.grandlyon.com/)

4.7 BikeDispenser, the Netherlands

4.7.1 System Overview

BikeDispenser is a project developed to increase the ease of accessibility to the business areas lying within three kilometers of commonly used public transportation hubs and junctions. Target group is 80 000 commuters who travel by train to the office. The project is still under development. Eindhoven and Arnhem will be the first cities to test the system on urban scale (Eicode, 2006). However, a pilot project has been implemented in the campus of Philips. The initiators of the project are Anton Brunt and Hans Schreuder from the product design company Springtime.

The estimated cost of using the system when it is implemented in the country is € 2.75 for one time, or € 27.5 per month (Fietsen Web-Log, 2006). BikeDispenser expects to receive subsidies from the government and other interested parties.

Usage

The user holds up a pass in front of a scanning screen and within 15 seconds the automatic lock opens, giving access to the bicycle (Eicode, 2006). When returning the bicycle, the user holds the card up in front of the screen again, opens the door and puts the bicycle back in the 'safe' condition, after which it is replaced in the bicycle shelter (SenterNovem, 2004) (Figure 4.31).

Figure 4.31 Access and return of the bicycle (http://www.plus81.com/ecode/en/020communal_design_in_europevol2/022netherlands_bicycle_slotmachine/)

Tracking

Smartcard technology enables the storage of personal information, and hence tracking.

4.7.2 Business Context

Government's and transport companies' approach to the BikeDispenser concept is positive. The system technically satisfies the most important aspects of an automatic rent system. It is small-scale and cheap. For this reason the implementation of the BikeDispenser seems com-

mercially feasible. Possibly, it has a potential as an additional component to OV-Fiets, which is located at NS-stations for bicycle renting (Fietsen Web-Log, 2006).

Springtime

Springtime develops innovative products in the fields of mobility, sports, brand developments, retail and interior and is involved in strategic innovation consultancy, concept development, industrial design and implementation. The company developed the concept of BikeDispenser, and was responsible for the design of both the bicycle and the dispenser.

Philips

Philips is involved in the pilot project since the application of the system in Philips campus enables a positive image for the company and it also fulfils a practical need because of the long distances in the campus.

4.7.3 Products

Bicycle

The bicycle has a custom design for ease-of-use, low-maintenance and efficiency. For instance, the width of the bicycle is designed to be only 15 cm to increase the space and parking efficiency of the bicycles in the dispenser. Further, bicycles are equipped with LED front and back lights, adjustable seat for different sized users, durable plastic rims, and durable anti-leaking tyres (Figure 4.32). Bicycles are comfortable only for short distances, namely 20 minutes ride.

Figure 4.32 Bicycle design (www.bikedispenser.com)

Dispenser

BikeDispenser is a compact and fully-automated, space-saving storage and dispensary system for rental bicycles. Dispensers are planned to be placed over 70 train stations in the Netherlands (SenterNovem, 2004). The dispenser contains, in average, 100 bicycles at ground level. The dispenser can be built underground or within buildings (Eicode, 2006). It has custom design for ease-of-use, low-maintenance and efficiency in storing the bicycles.

4.7.4 Services

Surveillance

Surveillance is done by the system itself, due to the subscription system. In the case of Philips, the employees are the subscribers and the system stores the information of the users.

Maintenance

No data available.

4.8 Conclusions

Six PUB systems have been investigated within the context of PSS in this study. These cases are explained first by giving a general information on the systems. Then the business context is explored through network of actors and the organisational layout of the systems. Lastly, the products and services offered in the system are listed and described.

The following sections give an analysis of the cases from PSS point of view, highlighting the environmental, socio-cultural and economical dimensions of sustainability. Then, the products and services are analysed to draw conclusions for the proposal of a new PUB system planned for tourists in Rotterdam. Lastly, the network of actors and organisational layouts of the systems are discussed under the title business context.

4.8.1 PUB Systems in PSS Context

Focusing on the general characteristics of the PUB systems and the way they contribute to the three dimensions of sustainability, some highlights have been generated and analysed for six cases (Table 4.3). This analysis has been based on Internet search for each case and estimations are used when required. Because BikeDispenser is not an implemented project, it was not possible to evaluate some of the highlights. For instance, user acceptance could not be determined. In these situations, the highlights are referred to as ’not applicable’ in the table.

With regard to the environmental dimension, all of the cases offer their customers the shared use of bicycles as non-polluting vehicles. They also offer maintenance services to increase the life time of bicycles. Fourth generation PUBs, further, have the potential in decreasing the fuel consumption by encouraging their customers to use public transport in combination with bicycle. For this purpose, registered members who have a public transport card are encouraged to use the PUB system. In this respect, Bycyklen and Adshel are assumed not to decrease the fuel consumption, since the aim of the systems is only to offer bicycles and not to decrease car use by increasing the use of public transport.

In socio-cultural dimension, first of all, the systems offer cheaper access to products for especially those who have limited budget. Further, besides the potential of PUB systems in increasing the community feeling through the shared use of bicycles for very low prices, the most important benefit is their contribution to the workforce by training unemployed people for maintenance service. It is possible to see this in only two cases, Bycyklen and OV-Fiets.

Table 4.3 Main highlights of the PUB systems

	Highlights	Bycyklen	Adshel	OV-Fiets	Call a Bike	Vélo'v	BikeDispenser
Environmental dimension	Shared use of non-polluting vehicle	Yes	Yes	Yes	Yes	Yes	Yes
	Offer of services for maintenance which increase the life time of bicycles	Yes	Yes	Yes	Yes	Yes	Yes
	Decrease in resource consumption, namely fuel consumption	No	No	Yes	Yes	Yes	Yes (estimated)
Socio-cultural dimension	Cheaper than buying a new bicycles, considering both initial and maintenance cost	Yes	Yes	Yes	Yes	Yes	Yes
	Potential in increasing the community feeling through the shared use of bicycles	Yes	Yes	Yes	Yes	Yes	Yes
	User acceptance	Yes	Yes	Yes	Yes	Yes	NA
	Contribute to the workforce by training the unemployed for maintenance service	Yes	No	Yes	No	No	NA
Economical dimension	Funded by government	Yes	Partly	Partly	Yes	No	NA
	Self-supporting system because of advertising incomes	Partly	Partly	Partly	Yes	Yes	NA
	Low initial investment in bicycles	Yes	Yes	Yes	No	No	No
	Low initial investment in racks	Yes	No	No	Yes	No	No
	Increase in use of public transport due to offered new service	No	No	Yes	Yes	Yes	Yes (estimated)
	New chances for rental shop owners to increase their ecoNomical benefits	No	No	Yes	No	No	No

NA (Not Applicable)

For the successful implementation of PSS, PUB systems should also be business wise and self-supporting while providing environmental and social benefits. PUB systems are in general funded by government, especially at the initial phase. Bycyklen and Call a Bike, are still funded by government. However, others like Vélo'v are managed by other companies which have common interests and economical benefits. In the case of Vélo'v, a street furniture company is responsible from the whole system, while it holds the rights of using the advertising space in city's public bus shelters. Adshel, OV-Fiets and Call a Bike, however, still require partial involvement of the government through funding.

Another important economical consideration is the initial cost of equipment and products. In the case of Bycyklen and OV-Fiets, due to their simpler designs, bicycles have a lower initial cost compared to Adshel, Call a Bike, Vélo'v and BikeDispenser, which have an advanced design with technological improvements. Racks also have a high initial cost in most cases, except Bycyklen which has a simple rack design. In the case of Call a Bike, there is no initial investment in racks since they are not used in the system. By this way, the high initial cost of the bicycles are compensated for. In this respect, Vélo'v is the only self-supporting system in the long-term and has achieved success in short time with a high number of registered users; however the initial investment of the system is higher compared to the other cases.

The increase in the use of public transport brings economical benefits to both users and system managers. For users, public transport, in most cases, is cheaper than using private car. For system managers, this provides additional funding of other public transport bodies.

For instance, the national railway company partly or in whole sponsors the system in the case of OV-Fiets and Call a Bike.

Although the majority of PUB systems uses racks for the rental and return of bicycles, in OV-Fiets the existing rental shops provide this function. This enables these shops to widen their business area and increase their profits.

4.8.2 Products

Two main products, the bicycle and the racks, are compared to each other for each case (Table 4.4).

In all cases, bicycles are designed to accommodate non-standard components that are not compatible with mass-produced bicycles. This is an important issue for security reasons and to

Table 4.4 Products of the PUB systems

Products		Bycyklen	Adshel	OV-Fiets	Call a Bike	Vélo'v	BikeDispenser
Bicycle	Non-standard components	Yes	Yes	Yes	Yes	Yes	Yes
	Tyre	Solid	Reinforced	NDA	NDA	NDA	Anti-leaking
	Frame	Steel	Steel	Steel	Aluminum	Steel	Steel
	Weight	Heavy	Heavy	NDA	Heavy	NDA	NDA
	Gear	One-gear only	4 Speed gears	One-gear only	8 Speed gears	3 Speed gears	NDA
	Break	Pedal breaks	Hand breaks	Pedal breaks	Hand breaks	Hand breaks	Pedal breaks
	Lights	Reflector	Automatic	Dynamo	Halogen front light	NDA	Automatic led front & back lights
	Locking technology	No	No	No	Yes	No	No
	Equipped with microchip	No	Yes	No	No	Yes	No
	Holds advertisements	Yes	No	No	No	No	No
	Equipped with theft protection device	No	No	No	Yes	Yes	No
	Fault sensor	No	No	No	No	Yes	No
	Shock absorbers	No	No	No	Yes	No	No
	Carrier on the front wheel	No	No	No	No	Yes	Yes
	Carrier on the rear wheel	No	No	Yes	Yes	No	Yes
	Skirt guard	No	No	No	No	Yes	No
	Enclosed chain	Yes	Yes	Yes	Yes	Yes	No
Rack	Lockers	Yes	Yes	Yes (but not common)	No	Yes	Yes
	Bicycle capacity	NDA	12	Each store has its own capacity	NA	10-50	100
	Equipped with	Chains	Docking stations & station controller	NA	NA	Electronic kiosk	NDA

NA (Not Applicable) NDA (No Data Available)

decrease vandalism and theft. Because of the problems associated with maintenance, solid or reinforced tyres are used, and steel is chosen as the material for the main frame of the bicycles in most cases. However, these features increase the weight of the bicycle, while decreasing its convenience. Bycycklen and OV-Fiets bicycles have a simpler design with only one-gear, pedal breaks and simple lights. On the other hand, due to the technological improvements, the bicycles of Adshel, Call a Bike, Vélo'v and BikeDispenser have a rather complicated design which increase the maintenance costs. It should be noted that because there are no racks in Call a Bike system, an expensive locking technology is used on the bicycles to secure them, increasing the initial cost of the bicycles. Further, theft protection devices or technologies and the fault sensor are the other added features which increase the initial cost of the bicycles of Call a Bike and Vélo'v.

Advertisement is one strategy to compensate for the costs of the PUB systems, and is used by Bycyklen, Adshel and Vélo'v. In this respect, the bicycles of Bycyklen hold advertisements on their horizontal frame and disk wheels, which may cause negative visual impacts. On the other hand, the involvement of an advertising company in the case of Adshel and Vélo'v prevents these visual impacts since the advertising space on public bus shelters are used for this purpose.

In some of the PUB systems, it is possible to see some other features such as shock absorbers, carrier on the wheel, skirt guard and enclosed chain, which increase the added value of the bicycles. In this respect, the bicycles of Call a Bike, Vélo'v and BikeDispenser offer their customers more possibilities to make their journey convenient.

Potentially, it may be suggested that additional features, such as pump, baby seat and rain coat may be used to increase the value of the bicycles and to attract more customers to use the PUB systems.

The other vital component of PUB systems is the rack, where the bicycles are offered to the customers. Apart from OV-Fiets and Call a Bike, there exists a rack system in all cases. In the case of OV-Fiets, existing rental shops, which have their own bicycle capacity, are included in the system. They are responsible for the maintenance of bicycles and the rental procedure. In the case of Call a Bike, the locking technology, which tracks the bicycles, eliminates the need of racks, while possibly decreasing the availability of bicycles at certain spots.

The bicycle capacity of Adshel is 12 at each rack. On the other hand, in Vélo'v it is estimated according to the demand of bicycles at different spots and varies between 10 to 50. BikeDis-

penser has the highest bicycle capacity to ensure the availability of bicycles. For this reason, the bicycle is designed so as to occupy minimum space in the dispenser.

The racks are equipped with different products and technologies for different purposes. In Bycyklen, chains are placed for locking the bicycles to the racks. In Adshel, docking stations are used for this purpose. In addition to the docking stations, a station controller is also placed at racks to inform the maintenance staff about the maintenance needs of the bicycles and for the allocation of the bicycles between different racks. In Vélo'v, different than other PUB systems, an electronic kiosk is placed at racks for issuing the short-term card, renting bicycles and providing the user with a receipt.

4.8.3 Services

Apart from maintenance and surveillance services which make the system work and are invisible to the user, there are also services offered to attract more customers to use the PUB systems. These services are listed in Table 4.5, to make a comparison between cases and draw conclusions for the necessary services of a future PUB system.

All the cases, except Bycyklen which is based on coin deposit system, provide their customers with magnetic stripe cards or smartcards for flexibility in renting and payment and also to ensure the security of the bicycles through the membership procedure. In this respect, OV-Fiets, Call a Bike, Vélo'v and BikeDispenser go one step beyond and offer their customers different payment options through the use of different types of cards, one of which is a public transport card also used for bus, tram, metro, train or even car sharing service (as in the case of Call a Bike for instance).

This way, commuters have the chance to combine different means of public transport with bicycle, which, in turn, decreases the use of car for door-to-door purposes.

Booking or reservation is not a common service offered by PUB systems, however it has the potential to attract new customers because it ensures the availability of bicycles at racks. In this respect, Adshel and Vélo'v provide their customers information on the availability of bicycles at each rack through an interactive online map, where customers can click on the rack names, learn about the number of bicycles and parking spaces available at those specific racks and decide on which rack to collect or leave the bicycle.

Table 4.5 Services of the PUB systems

	Services	Bycyklen	Adshel	OV-Fiets	Call a Bike	Vélo'v	BikeDispenser
	Use of smartcards	No	Yes	Yes	Yes	Yes	Yes
	Flexibility in renting & payment	Yes	Yes	No	Yes	Yes	Yes
	Different payment options (by use of different types of cards or according to use time: 1 day, 2 days, 1 week)	NA	No	Yes	Yes	Yes	Yes
Information services	Call center	No	Yes	Yes	Yes	Yes	NDA
	Sms	No	Yes	No	Yes	Yes	NDA
	Internet	Yes	Yes	Yes	Yes	Yes	Yes
	At racks	No	Yes	No	No	Yes	Yes
Information on	Map of the allowed boundary of the system	Yes	Yes	NA	Yes	Yes	NA
	Maps of the routes & racks	No	Yes	No	Yes	Yes	NA
	Availability of bicycles & racks	No	Yes	No	NA	Yes	NA
	Receipt for using the bicycle	NA	NA	No	No	Yes	NA
	Booking/reservation	No	No	No	No	No	Yes
	Possibility to "hold" the bicycle between stops	No	No	Yes	Yes	Yes	NDA
	Possibility to combine bicycle with other means of public transport	No	No	Yes	Yes	Yes	Yes
	Different membership registration options	NA	No	No	Yes	Yes	NDA
	Possibility of returning bicycle to different racks	Yes	Yes	No	Yes	Yes	Yes
	Whole day operation of bicycles	Yes	Yes	No	Yes	Yes	Yes
	Whole year operation of bicycles	No	Yes	Yes	Yes	Yes	Yes
	Unlimited allowed use during a day	Yes	No	Yes	Yes	Yes	Yes
	Guarantee of proper functioning of the bicycles	No	No	Yes	No	Yes	Yes

NA (Not Applicable) NDA (No Data Available)

All of the cases offer information services through different types of channels. Amongst others, internet is the most commonly used channel to give general information on the PUB systems to the public, including map of the allowed boundary of the system. Further, Adshel, Call a Bike and Vélo'v also offer maps of the routes and the racks, and availability of bicycles and parking spaces at racks which are especially important for tourists and new users until they learn the system. An extra service of Vélo'v is the receipt for using the bicycle, which customers can reach from the electronic kiosk when they leave the bicycle.

Apart from the above services, there are also services which provide customers flexibility while they use the bicycles, such as the possibility to hold the bicycle between stops, different membership registration options (through internet or call center), whole day and year operation of the bicycles, and unlimited use of bicycles during a day. The allowed use time of bicycles of Adshel, for example, is only two hours to increase the availability of them for other users. This is reasonable since Adshel offers the bicycles free to the public.

Another service Vélo'v offers its customers is the guarantee of proper functioning of the bicycles through the use of a fault sensor placed on the bicycles. In case of a problem on bicycle, racks do not release the bicycles until the maintenance staff solve it.

4.8.4 Business Context

Due to the different products and services offered to the customers, PUB systems require the involvement of different actors in the system.

It is possible to see the involvement of government in all cases, since the projects, in general, start with the support of government and also are funded by government -partly or in whole. In this respect, governments have a huge potential in introducing the system thinking to the supply chain in PUB systems. In early PUB systems, the role of the government in decision making related with system design and management is more obvious, while in later PUB systems, the government is rather responsible for bringing the main actors together in the beginning phase of the project.

In most of the cases investigated, namely Bycyklen, Adshel and Vélo'v, the expenses of the system is compensated partly or completely by advertising incomes. As a result, an advertising agency or a street furniture company is involved to design and provide the PUB system, while managing and profiting from the advertising space of the city.

In some cases, another public transport body -for instance the national railway company in OV-Fiets and Call a Bike- is involved in the system, since the aim of offering the PUB system is to encourage commuters to use public transport, which contributes to a decrease in car use.

In early PUB systems, involvement of a non-government organisation, which co-operates with the government is common.The role of non-governmental organisations in PUB systems appear to be as service provider, since there exists no private company which manages the system and profits from it.

Apart from governments, non-governmental organisations, advertising companies and other public transport bodies, there also are different companies involved in different projects, which supply support products to the system, such as cards and card readers, station controllers, or electronic kiosks. Although these companies do not have a direct role in the decision making process, they are necessary to keep the system working.

Moreover, some necessary changes in organisational functions for the successful implementation of PSS are also determined, especially in third and fourth generation PUB systems, such as OV-Fiets, Adshel, Call a Bike and Vélo'v. First one is product development based on the specific system which will be offered. Bicycles, for instance, are in most cases designed for durability, repair and ease of maintenance. Accordingly, maintenance service and how it will work is decided upon the same criteria as bicycles.

The more the PUB systems improve, the more their added value comes from the services. Especially in fourth generation PUB systems, such as Call a Bike and Vélo'v, the services offered to the customers are increased and improved, which provides flexibility and convenience for customers. This also brought the necessity to plan and develop products together with services. As a result, some additional products are also involved in the system. For example, the electronic kiosks in Vélo'v are placed at racks to issue cards and make the renting process easy for commuters. Another example is the locking technology placed on the bicycles in Call a Bike, which provides users to lock the bicycles at any spot in the city center and hold them for another use if necessary.

Additionally, pricing strategy of the system is a very important consideration in achieving success in PUB systems. Table 4.6 presents the pricing of each system. In this respect, Vélo'v has a greater advantage over the other systems since the first 30 minutes of using a Vélo'v bicycle is free. This is especially important at the introduction phase of the system, which fastens the learning process and attracts new users to the system.

Table 4.6 Pricing of the investigated PUB systems

	Bycyklen	Adshel	OV-Fiets	Call a Bike	Vélo'v	BikeDispenser
Price	Free	Free (one-time refundable deposit of € 23)	€ 2.75 per 20 hours (subscription fee of 9.50 per year)	• 7 cents per minute (max. charge of € 15 per day) • 3 cents per minute for those who have a BahnCard (€ 60 for a whole week)	• First 30 minutes is free • Long-term card: € 1 per hour (card costs € 5 plus returnable deposit of € 150) • Short-term card: € 2 per hour (card costs € 1) • Técély: € 1 per hour (card costs € 5 plus returnable deposit of € 150)	Free (for Philips employees), € 2.75 for one time or € 27.5 per month (estimated when implemented in cities)

To sum up, the necessary network of actors for the successful implementation of PSS exists in PUB systems but could be developed further, especially at the initial phase of the design and development of the system according to the needs and requirements. Further, it is also determined that some of the necessary organisational changes more or less exist in almost all cases. However, some data still lack related to materials, production processes and company strategies, due to the methodology used in this research, which is mostly based on internet.

CHAPTER 5

ROTTERDAM CASE

This chapter aims to build guidelines for the successful implementation of a new PUB system for tourists in Rotterdam, reflecting on the literature review on PSS and the analysis of the cases of PUB systems. For this purpose, a scenario study has been applied, focusing on the characteristics of Rotterdam, the tourists that visit Rotterdam and the existing bicycle rental shops, and innovative technologies which may require a learning process from the user.

5.1 About Rotterdam

Rotterdam is the second largest city in the Netherlands after Amsterdam and is located at the province of South Holland, at the banks of the river Nieuwe Mass (Figure 5.1). The city is known for having the world's largest port until recently though it lost the title to Shangai in 2004 (Wikitravel, 2006).

Figure 5.1 Location of Rotterdam in the Netherlands

Rotterdam is the most modern city in the Netherlands since it was rebuilt after a bomb raid in the city in 1940 during World War II. As a result, the city shelters many examples of modern architecture and is an attribute of innovation, creativity, events, leisure and recreation. More than one million people from at least 160 countries live in Rotterdam (Bouwmeester, 2006).

5.1.1 History

The city of Rotterdam derives its name from the river Rotte by which it was built as a small fishing village in the 13th century. The city's economic development has risen in the 17th century when the mouth of the river Maas had silted up. After the construction of the Nieuwe Waterweg (the shipping link with North Sea) and the canals (that link the Rhine and the Mass) in the 19th century, Rotterdam has become a direct, high-capacity connection to the North Sea (Holland.com 2006). The greatest spurt of growth occurred at this time both in the sense of port activity and population, and this gave rise to Rotterdam being an international center of trade, transport and industry (Wikitravel, 2006).

The turning point in the history of Rotterdam is the bomb raid during World War II, which resulted in the complete destruction of the city center as well as the harbour. The efforts to reconstruct the city after the war created a city center with a cosmopolitan appeal. This post-war construction gave Rotterdam also a unique architectural character oriented towards the river with a series of experiments in city planning (Holland.com, 2006).

5.1.2 Architecture

Since the beginning of the 20th century, Rotterdam has become an experimental field for Dutch architects. The innovative new concepts after the war are expressed in structures such as the Groothandelsgebouw, the Cube houses, the Kunsthal, the Luxor Theatre and the Erasmus Bridge (Rotterdam.info, 2006).

Different movements in architecture ranging from the shopping area Lijnbaan with buildings by van der Broek & Bakema and Hug Maaskant to Schouwburgplein are identifiable. New high-rises are also constantly being added to the skyline of Rotterdam (ArchEX, 2004).

Apart from the museums situated in the Museumspark, such as the Dutch Architecture Institute NAI, Kunsthal by Rem Koolhaas and the Museum Boijmans van Beuningen, the new central

station and the surrounding area, and the harbour of Rotterdam are also examples of important architectural features (ArchEX, 2004).

5.2 Current Situation in Rotterdam

5.2.1 Tourists

Rotterdam has a lower tourist activity compared to big cities in Europe, also Amsterdam, Texel, as well as the small islands at the north of the Netherlands. The total number of tourists staying overnight in Rotterdam in 2003 is 685.900, whereas the number of arrivals that spend less than a day in Rotterdam is 389.700 (Table 5.1).

Table 5.1 Number of tourists arriving and staying overnight at Rotterdam hotels and guest houses between 2000 and 2003 (CBS, 2004b)

County of origin	2000		2001		2002		2003	
	A	O	A	O	A	O	A	O
The Netherlands	186,400	292,000	230,700	358,900	174,200	270,700	176,700	250,800
Great Britain	80,200	141,400	80,000	135,800	84,800	161,600	60,800	112,800
Germany	29,100	52,900	25,400	42,600	31,100	66,800	27,300	47,900
France	15,400	26,400	19,400	31,300	19,700	34,000	18,900	34,200
Belgium & Luxembourg	17,600	28,500	18,600	27,500	17,900	26,300	17,300	26,600
Other Europe	68,900	157,500	59,700	111,800	69,200	137,100	50,400	103,300
United States	16,000	40,800	20,700	37,000	21,000	43,000	13,700	42,600
Canada	2,300	4,400	2,200	3,700	2,400	5,300	1,800	4,800
Other America	4,600	9,800	7,400	12,200	7,400	19,000	3,900	13,000
Japan	6.100	11,500	6.200	10,700	8.200	14,100	4.900	10,200
Other Asia	28,800	52,800	32,900	50,600	18,300	36,800	7,300	22,500
Africa	2,700	6,500	4,000	9,800	4,100	9,700	3,000	9,800
Australia & Oceania	2,300	4,300	2,600	5,200	2,600	6,100	1,900	4,500
Total	**462,400**	**833,900**	**511,800**	**840,500**	**462,800**	**834,300**	**389,700**	**685,900**

A (arrivals) O (overnight stays)

The majority of tourists come from the Netherlands itself, which is a total number of 250.800 in 2003. Apart from local tourists, the number of tourists in 2003 from Great Britain (112.800), Germany (47.900), United States (42.600), France (34.200) and Asia (22.500) (CBS, 2004a) are high compared to the tourists from other countries. Majority of these countries mentioned accommodate an existing bicycle culture and an implemented PUB system, as a result this fastens the adaptation process of users to a new PUB system in Rotterdam.

5.2.2 Map of Touristic Sites in Rotterdam

In Chapter 2, it was concluded that the developed methodologies of PSS follow in general a similar pattern. Therefore, an analytical case study has been conducted in Chapter 4, focusing on the previous experience of PUB systems. As the next step, it is important to investigate the specific context of Rotterdam and the general attitudes of tourists that visit Rotterdam. For this reason, the potential touristic places in Rotterdam have been explored through internet search and personal communications with Rotterdammers. This exploration has been used to create a map of touristic places in Rotterdam, which is necessary to define the boundaries of the PSS and to determine the products, services and relevant actors in the system.

According to this initial investigation, it is seen that the attractions for tourists, are mostly concentrated in the city center; although there are other attractions out of the center. Further, bicycle is in most cases used to cover short distances, rather than long distances. For these reasons, the focus of the PUB system to be proposed will be the city center.

Figure 5.2 shows the results of internet search and communications with Rotterdammers on popular touristic places in Rotterdam. However, it should be noted that this map is a draft study, open to development and improvement and should be updated in time by the touristic information sources like the Tourist Information Office (VVV) Rotterdam.

1. Zondagsmarkt Binnenrotte
2. Rotterdam ArchiGuides (www.rotterdam-archiguides.nl)
3. Blaak: Market, Cubic houses (www.kubuswoning.nl), Oudehaven
4. Arboretum Trompenburg (www.trompenburg.nl)
5. Tropicana (www.tropicana.nl)
6. Flag Museum (www.vlaggenmuseum.nl)
7. Leuvehaven: Walk of Fame Star Boulevard (www.walkoffame.nl), Museumhaven (www.kunstas.nl)
8. Kop van Zuid (www.kopvanzuid.info)
9. Spdo Harbour Trips & Events (www.spido.nl)
10. Veerhaven (www.veerhavenrotterdam.nl)
11. Hotel NewYork (www.hotelnewyork.nl)
12. Afrikaanderplein
13. Museumpark (www.kunstas.nl)
14. Witte de Withstraat (www.kunstas.nl)
15. Euromast (www.euromast.nl)
16. Delfshaven (www.delfshaven.info), 'De Delft' Shipyard (www.dedelft.nl)
17. Kralingse Plas

Figure 5.2 Popular touristic sites in Rotterdam

5.2.3 Existing Bicycle Renting Systems in Rotterdam

There are 15 bicycle rental shops in Rotterdam and its surrounding, the majority of which, located far from the center. Table 5.2 gives data on the 12 shops in a systematic way. The type and number of bicycles, and the rental prices in hourly, daily or weekly basis are listed.

Table 5.2 Type and number of bicycles available at 12 shops (Holland.com, 2006)

			price (€)		
Shop	Type of bicycle	Number of bicycles	Per hour	Per day	Per week
1 Koning Fietsspecialist	women	8	-	7.5	27.5
	men	7	-	7.5	27.5
2 Recreatiecentrum De Vinkenwaard	women	10	-	7.0	35.0
	men	10	-	7.0	35.0
3 Ligfietscentrum Brielle	reclining	110	18.0	24.0	120.0
	tandem	8	18.0	24.0	120.0
4 Tweewielerspecialist Hans Maat	women	15	-	7.5	45.0
	men	10	-	7.5	45.0
5 Klaassens Rijwielverhuur	ATB	20	-	10.0	50.0
	women	90	-	7.0	30.0
	men	80	-	7.0	30.0
	children	40	-	5.0	22.5
	tandem	12	-	15.0	35.0
6 Profile Kees van den Burg	ATB	5	4.0	8.0	25.0
	women	30	2.5	6.0	25.0
	men	10	2.5	6.0	20.0
	children	10	2.5	5.0	60.0
	tandem	3	5	12.5	27.5
7 Profile Maasland	women	5	-	6.5	32.5
	men	5	-	6.5	32.5
	tandem	1	-	12.5	60.0
8 Rijwielshop Station Maassluis	women	13	-	6.5	32.5
	men	13	-	6.5	32.5
	children	2	-	6.5	32.5
9 A.J. Verstoep	women	3	-	5.0	-
	men	3	-	5.0	-
	children	2	-	4.0	-
	tandem	2	-	14.0	-
10 Van der Velden	citybike	75	-	5.0	22.0
	bicycle with gears	20	-	7.0	28.0
	children	20	-	3.0	14.0
11 De Krom	women	20	-	7.5	22.5
	children	2	-	7.5	27.5
	tandem	5	-	17.5	85.0
12 All Bikes Mobility	women	10	-	10.0	50.0

Some of the highlights from Table 5.2 can be concluded as follows:

1. The types of the bicycles vary in each shop but in general consist of women's, men's and children's bicycles, tandems, and all terrain bicycles (ATB - also referred to as mountain bicycle). The women's bicycles are often higher in number because they are equipped with low step-through frame which enables both men and women to use them. The shops 5 and 6 offer highest variety of bicycles, which in turn may increase the number of customers.
2. The shop 9 offers the least number of bicycles and in turn cannot offer bicycles on a weekly basis.
3. The shop 3 offers the highest number of bicycles; this increases the availability of bicycles.
4. Only two shops, namely 3 and 9, offer their customers rental bicycles on an hourly basis.
5. Considering the women's, men's and children's bicycles, which almost all the shops retain, the prices are almost the same, in average 7 € per day and 30 € per week.
6. Shop 10 provides its customers citybikes which have a simpler design as in the case of Bycyklen, but it also offers bicycles with gears. This enables the customers to choose the suitable bicycle according to their needs.

Additional to the above highlights, although the opening hours of the shops vary, they in general close at 6 pm. Only Koning Fietsspecialist and All Bikes Mobility are open until 9 pm on Fridays, and Rijwielshop Station Maassluis is open from Monday to Thursday until 10.30 pm, and from Friday to Sunday until 23 pm. Some shops are not open some days of the week. For instance, Koning Fietsspecialist is closed on Mondays; Tweewielerspecialist Hans Maat, Klaassens Rijwielverhuur (during winter months), and Profile Kees van den Burg are closed on Sundays; Profile Maasland, A.J. Verstoep and All Bikes Mobility are closed on Sundays (Holland.com, 2006).

Apart from these 12 bike rental shops, there are three more shops in Rotterdam. One is the OV-Fiets, which has been explained in Chapter 3. OV-Fiets has more advantages for frequent users and may not be favourable for tourists, since the registration process is too long, and may take around one week. Rijwiel located at Rotterdam CS (central station) is another option. However, it may also not be favourable for tourists because of the high cost of deposit and long rental procedure.

Another alternative, which is specifically designed for tourists, is ByCycle. ByCycle not only offers bike rental but also guided cycle tours through Rotterdam. The cost of renting a bicycle is 6 € for a day for a group of minimum six people, and 5 € for every extra day. Opening hours of ByCycle is 10 pm till 6 pm from Monday to Friday (ByCycle, n.d.). The bicycles have to be returned before 6 pm the same day or between 10 and 11 am the following day. Individual bike

rental is also possible through Use-It, which is the information and service center for young tourists in Rotterdam. ByCycle also offer reservation service, which is favourable especially for tourists who stay a few days in the city (Use-It, 2006).

5.3 Advantages of the New PUB System

Considering the current situation in Rotterdam, the new PUB system should offer tourists more advantages over the existing ones. For this purpose, following highlights have been determined to be used in the design of the proposed scenario.

- *Location*: Existing rental shops are currently outside of the city center, which decrease the access of tourists to bicycles. The new system should be designed to bring solution for this since most of the attractions and hotels are located in the city center.
- *Time*: Existing renting systems close at a certain time, therefore those who want to rent a bicycle, for instance late in the evening, cannot access the bicycles. The proposed system should overcome this problem.
- *Diversity of Information*: Information based system frees the tourists from guided tours. Therefore, the proposed new system should be designed to offer various types of information in a convenient way to gives tourists the chance to explore the city on their own.
- *Access to Information*: Different types of information channels should be brought together in one system, enabling tourists to reach information in an easy way and not to spend hours on the internet to search for specific information.

5.4 Use Scenario

Following the exploratory research on Rotterdam, a scenario study has been applied to overcome the problems that the existing rental shops face currently. This scenario study is based on the current situation in Rotterdam, the highlights of which determined in the previous section, and based on conclusions of the case study conducted in the previous chapter. All this information is used to determine what sort of system is required, how the user interacts with it and how products and services interact with each other, i.e. to specify the products and services which should be involved in the PUB. The scenario includes the consideration of the user, the business context, the products, and the services as a whole, and gives a basic insight on how the system should look like and work. Figure 6.3 shows the use scenario of the new PUB system in Rotterdam.

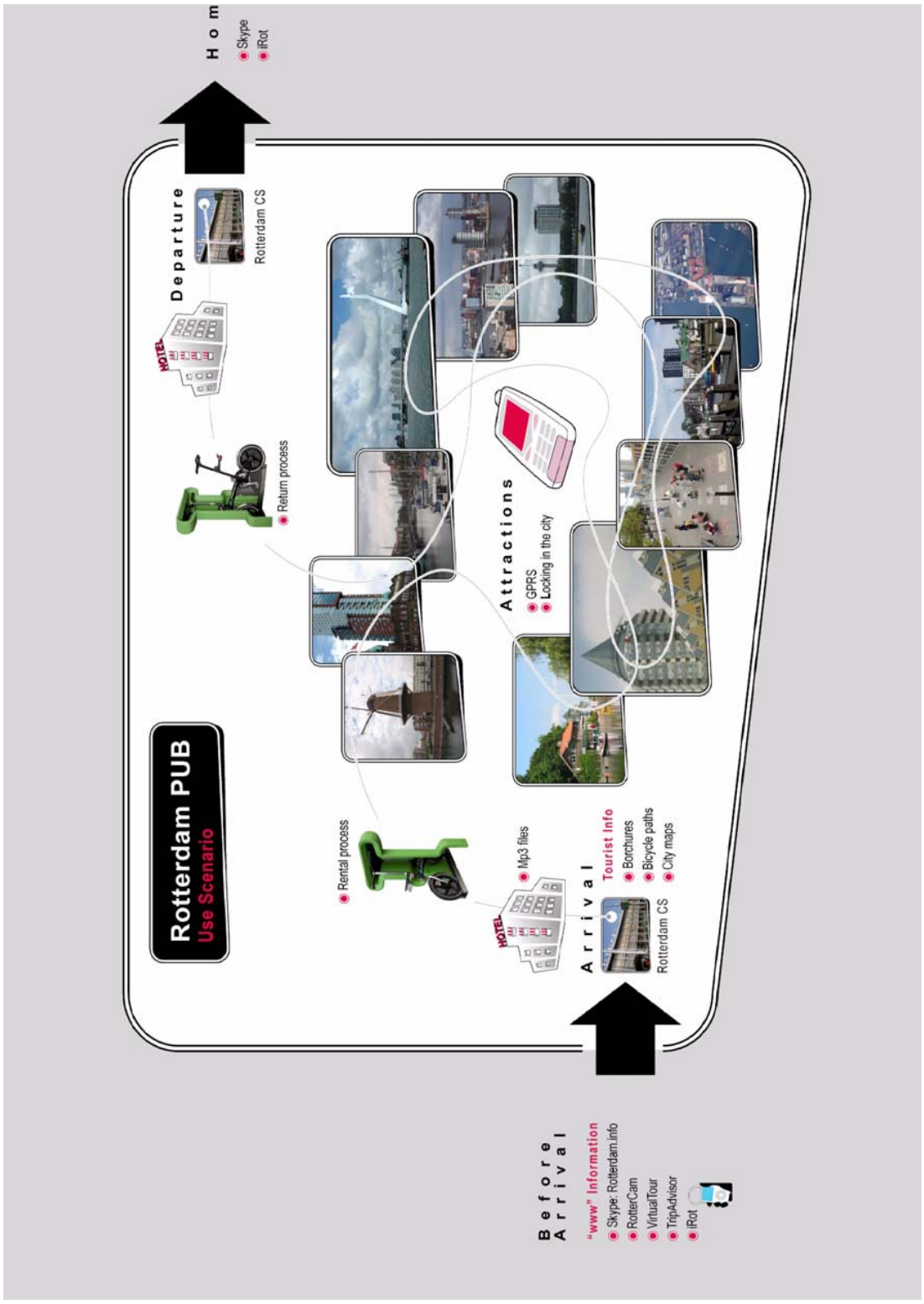

Figure 5.3 Use scenario for the proposed PUB system for tourists in Rotterdam

5.4.1 Concept Summary

Considering tourists who search for information, a GPRS-enabled information service is used in the system. The touristic places which are determined previously are divided into zones (Figure 5.4) to enable the users receiving information when they enter a specific zone. For instance, when a tourist enters the zone of Museumspark, s/he receives information specific to this area, such as exhibitions, events, galleries, or even festivals. The bicycle dispensers are placed with different capacities, depending on the density of tourists in the zones and also the locations of hotels.

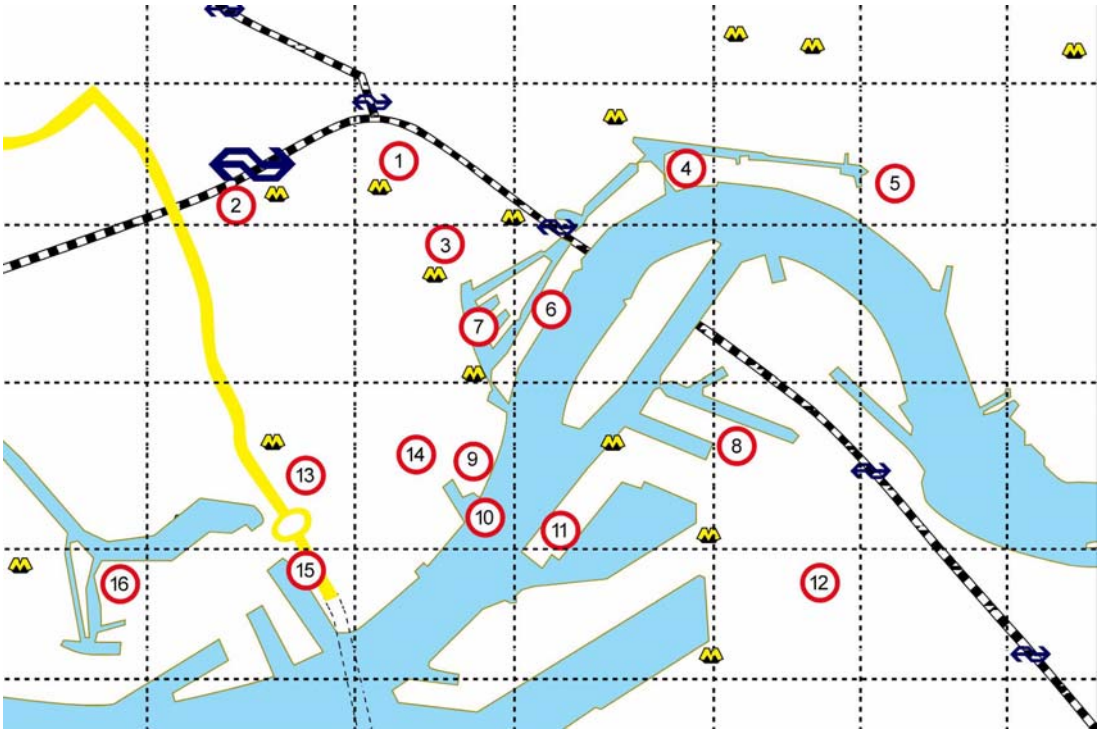

Figure 5.4 The zones of the tourist attractions in the city center

5.4.2 Storyboard

Before Arrival

Internet has become one of the most often used search tools in our daily lives and in the Rotterdam case it prepares tourists for the city before arrival. Tourists who search for information about Rotterdam can find it on the specific page of the system and learn about the features that the system offers, such as the city maps, GPRS, mp3 files, RotterCam, VirtualTour of Rotterdam, TripAdvisor, Skype and iRot (Figure 5.5).

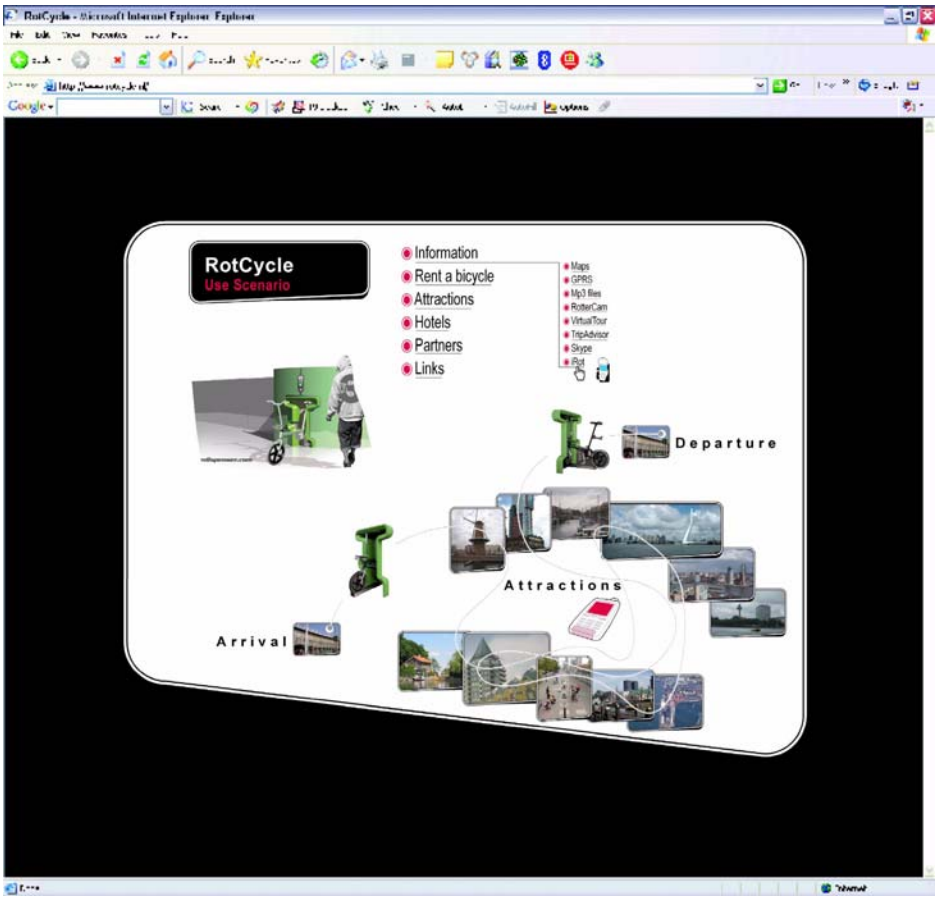

Figure 5.5 Web page of the system

- The *city maps* include the city center as a whole and also the divided zones where tourists receive specific information through GPRS. Apart from this, maps of the bicycle routes and the dispensers are also provided to the tourists through web page. The web page also explains about *GPRS* and how to use it in combination with bicycle renting.

- *Mp3* files are audio files that explain the specific zones of the city center and the attractions and are donwloadable at the web page. Tourists can listen and learn about Rotterdam before arrival or during their visit through these files.
- *RotterCam* gives live videos through the webcams placed strategically at the divided zones of the city. By this way, tourists can watch before they decide where they want to go before arrival. *VirtualTour* of Rotterdam is designed with the same aim, however it offers pictures instead of videos.
- *TripAdvisor* gives information not only on the different paths that tourists can follow and tips about where to go, but also information on how they can arrive at Rotterdam CS.
- *Skype* is another way of getting information on the city and the system; some people may prefer it instead of web page since it enables a direct communication with a person from the system. Therefore, tourists can chat about Rotterdam and the new PUB through adding the username RotCycle to their contact list at Skype.
- iRot is considered also to get information on Rotterdam before arrival. Through iTunes, which the different type of podcasts are submitted, tourists can listen to the comments of other tourists who visited Rotterdam before, or they can even watch the amateur videos of the city and the people that are taken by previous tourists.

Apart from information related to the city, tourists can also learn how to rent a bicycle, where the attractions are and how to go, and the hotels that are in involved in the project.

At arrival

At arrival to Rotterdam CS, tourists can find the Tourist Info, where they can access the brochures, city maps, bicycle routes and the map of the dispensers.

Hotels

Another source of information for those who do not search about Rotterdam through the internet is hotels. According to the statistics, hotels are becoming more popular and they have been considered as a powerful way of communication about the project, web page, and renting a bicycle, especially for elderly tourists. Hotels are a vital component of the system to inform the tourists about the existence of such a system, the web page of the RotCycle and for providing mp3 files about Rotterdam at arrival for those who are not aware of the web page or have not visited it yet.

Renting a bicycle

Tourists can rent a bicycle from dispensers that are strategically placed close to the Rotterdam CS, the hotels (ones who are involved in the system) and the attractions. The user can register

to the system before arrival through the web page or during registration at hotel, or s/he can, during the rental process, send an SMS to the service hotline of the system to be able to rent a bicycle, as in the case of Call a Bike. By this way the rental process becomes faster. Further, since this service is only for those who rent a bicycle from RotCycle, it is extremely important to retrieve user data, including the mobile phone number and credit card number.

Attractions

While tourists are going around the city, visiting the attractions, and passing through the zones of the city center, apart from the materials they have accessed at internet and received at the station and the hotel, they also receive information through GPRS technology to their mobile phones. This information varies from general information on the city, such as history or architecture to real-time information on public transport, to where the closest attraction is or the availability of bicycles in dispensers. This system also enables tourists to receive information related to a specific place, such as the significance of that place, special offers or discounts, events, concerts, and even some interior photos.

Return of the bicycle

The user can return the bicycle to any dispenser at any time through the same process of renting and pays for only the time s/he has been using the bicycle. This is important to provide the availability of bicycles for other tourists.

Departure

After using the system and visiting Rotterdam, tourists can check out from the hotel and leave the city from Rotterdam CS by the same way they arrived.

5.5 Business Context

The bicycle renting system for Rotterdam in this study, aimed at being practical and applicable. Therefore, instead of designing a new product, a suitable product which is already in the market has been chosen to be used in the system. The concept of BikeDispenser is chosen in this scenario and it has been explained in Chapter 4.

Further, the system is designed with the goal of forward looking, and being open to new technologies and introducing new ways of “doing things” in business and society, which are socially and environmentally more responsible. In this respect, the involvement of the GPRS technology opens new ways of bicycle sharing and information retrieval for the future implementation of PUB systems.

The following actors have been considered to play an important role in the Rotterdam scenario:

Springtime

As mentioned earlier, Springtime is a company that offers innovative products in different fields, including mobility. The BikeDispenser that Springtime developed is a suitable concept for the Rotterdam scenario, in terms of both the bicycle and the dispenser. Therefore, involvement of Springtime in the system is important since some modifications and adjustments depending on the specific Rotterdam case may be necessary.

Government

In PSS, it is important for the continuation of the system that involved parties have profit out of the system. Therefore, the support of government may be needed at the beginning of the project until the service provider/manager is determined and the system becomes self-sufficient. Involvement of the government helps also to demonstrate the success of such a bicycle renting system for tourists. This, in turn, encourages hotels, attractions, museums, cafés, restaurants and pubs to be involved in the project.

Hotels

Hotels have an important role in the system. Firstly, they communicate the system to the tourists before they arrive. This is necessary for the advertisement of the system, especially for those who are not aware of the internet page. Secondly, hotels provide mp3 files for tourists who have no information about the system and want to rent a bike through RotCycle. The benefit of the hotels from the system is that they can provide an added value to their customers since the dispensers are strategically placed close to the “member hotels”.

Rotterdam Marketing

Rotterdam Marketing is an organisation who is responsible for the touristic aspects of the marketing of Rotterdam. The goal of Rotterdam Marketing is to encourage recreational, tourist and business visits in and around the city. Rotterdam Marketing aims to achieve this goal though providing information and services and developing products and activities, and also by promoting cooperation between and with partners in business and recreational tourism. In this respect, involvement of Rotter Marketing in the system, not only provides the information on Rotterdam to update the system, but it also helps the promotion of the new system.

T-Mobile

T-Mobile is one of the well-known wireless telecommunication providers in the Netherlands. Since the system is based on GPRS technology, one of the reasons of the involvement of T-Mobile in the system is the infrastructure management. The other reason is the sponsorship of

T-Mobile, since the company has the chance to use the advertising possibilities that the system creates through internet, printed materials, the space on the dispenser and GPRS. Further, T-Mobile may also make profit by renting the advertising space on the dispensers to other companies.

Apple and Skype

The involvement of Apple and Skype has a similar reason to the involvement of T-Mobile. The companies sponsor RotCycle because of the advertising opportunities the system offers.

Attractions, museums, cafés, restaurants and pubs

Attractions, museums, cafés, restaurants and pubs have an important role in the system. They are one of the communication channels used to advertise the system, where tourists collect information. Further, they benefit from the system since they have the chance to advertise themselves through GPRS technology. Attractions, museums, cafés, restaurants and pubs are advertised through the mobile phones of the tourists that receive SMS when they enter the specific zones of the system.

5.6 Products

Bicycle

BikeDispenser, the concept of Springtime (see Section 4.7), is used in the system and has been explained previously. The emphasis on durability and ease-of-use makes BikeDispenser a favourable product for the system. Further, the size of the bicycle provides parking efficiency that increases the availability of parking places in the dispenser.

Dispensers

The dispenser has a compact design and is fully-automated. It gives access to the bicycles through a pass that the user needs to hold in front of a scanning screen. As the system works in a different way in the Rotterdam scenario, i.e. mobile phones and GPRS, the dispenser requires some modifications which would enable the user to access bicycles without a pass or card.

5.7 Services

GPRS

GPRS technology provides ease of getting information on Rotterdam and the attractions. Tourists who do not have the chance to read and search about the city because of time constraints or difficulties in getting information, will not have the chance to miss this information. Another advantage of this service is its providing up-to-date information besides general information on the attractions, i.e. it informs the tourists on the specific place and time. Further, tourists can also retrieve real-time information about the public transport, closest cafés, pubs or restaurants according to their position in the city center.

Flexibility in renting and payment

The system provides flexibility in renting and payment since it releases the tourists from the time consuming formalities of registration process. Registration to the system is as easy as sending an SMS, filling out a form on the internet or during registration at the hotels.

Booking/reservation

Booking/reservation is possible through either the web page or hotels. This guarantees the availability of a bicycle for the tourists when they first arrive at Rotterdam at the central station or at a dispenser close to their hotel.

Information services

As discussed earlier, the system is designed to provide all possible information to the tourists through a variety of information channels, including internet, printed materials, direct communication, GPRS, etc.

Possibility to hold the bicycle between stops

The system offers the possibility to hold the bicycle between stops or dispensers as in the case of Call a Bike, however different than Call a Bike, there is no locking technology on the bicycles. Therefore, locking in the city is only possible through a steering lock. The bicycle can be locked on street furniture.

Possibility of returning the bicycle to different dispensers

It is possible to rent a bicycle from one of the dispensers distributed in the city center, and return it back to another one, depending on the place where tourists want to go.

Whole day and year operation of bicycles

The bicycles and the dispenser operate during the whole day and year, allowing tourists to rent a bicycle even at late hours in the evening.

Unlimited use during a day

Tourists can use the bicycles during the whole day. They can also continue with the same bicycle the next day, since the pricing of the renting is based on the time they use the bicycles.

CHAPTER 6

CONCLUSIONS

In this chapter, the main research conclusions are summarised, based on the theoretical background, the findings of the case studies and the scenario study. The possibilities for further studies to improve the PUB systems in a sustainable manner are also discussed.

6.1 General Discussions

This study was conducted with the aim of evaluating PUB systems from a PSS perspective and integrating the previous knowledge and experience of PUB systems for the development of a scenario for the sustainable mobility of tourists in Rotterdam. For this purpose, a review on the concepts of sustainability and PSS was conducted in Chapter 2, which evinced that the current system of production and consumption is not sustainable. Prior developed methodologies and approaches focused commonly on production, however they remained rather insufficient to solve the current problems and lead to a sustainable society. More radical approaches are necessary for system level improvements. In this respect, the concept of PSS has been seen as a promising approach that focuses both production and consumption through the design of products with improved environmental efficiencies, and the services that stimulate sustainable consumption patterns. This study focused on an example of use-oriented PSS: PUB systems, which was elaborated in Chapter 3. The basic idea of PUB systems is sustainable mobility, which is offered to the public to meet their transportation needs in an environmentally sound manner.

Six PUB systems are analysed based on the theoretical background established through the literature review. Design is essential in PUB systems, considering both PSS and the product itself. The case studies revealed that PUB systems have similarities in terms of products, services and business context. Even though the cases are of different generations and are implemented in different countries, security and maintenance are basic design considerations for both products and services. For instance, for security reasons bicycles are designed to accommodate non-standard components that are not compatible with mass-produced bicycles. Fur-

ther, considering the maintenance issues, they are designed to be more durable for frequent and intensive use. Regarding business context and relevant actors, it is possible to see the involvement of government in all cases, who is responsible for funding the system partly or entirely and bringing together the different stakeholders. Apart from similarities, some differences are also distinguished due to the different technologies included and different business strategies adopted. For instance, involvement of microchips or wireless technologies affects the design of products and services, and brings different means of surveillance and tracking methods. Similarly, in some cases, adopting advertising as a business strategy may affect the design of products, as well as the involvement of different actors.

With the purpose of representing the above findings in concrete terms, a scenario study is conducted in Chapter 5. The scenario study integrated the knowledge and experience of PUB systems into the specific context of Rotterdam.

6.2 Research Questions Revisited

This study aimed at answering three main research questions through the case study. The research questions were presented in Section 1.3.

6.2.1 The Role of Sustainability in PUB Systems

The basic idea behind the concept of PUB systems is sustainable mobility. The findings of the study indicate that PUB systems contribute to the three dimensions of sustainability.

Environmental dimension

PUB systems offer public the shared use of a non-polluting vehicle - the bicycle. This enables the use of bicycles more intensively and efficiently considering their whole lifecycle. However, their most important contribution when combined with other means of public transport is decreasing fuel consumption and thus increasing the air quality levels of the cities.

Social dimension

PUB systems offer public an alternative mode of mobility to the current public transport. Moreover, offer of bicycles for low prices provides low income groups to access bicycles easier, because by this way they are not responsible for the initial and maintenance costs of having a

bicycle. Apart from this, PUB systems contribute to the workforce by training the unemployed people for maintenance service.

Economical dimension

Particularly 4th generation PUB systems are considered to be business wise because of the business strategies they adopted. PUB systems provide private companies economical benefits, at the same time add value to the system by introducing new technologies and offering a variety of services to attract customers.

6.2.2 The Role of Product Innovation in PUB Systems

The reason for choosing the cases from different generations was to inquire about the development of PUB systems, particularly the role of product innovation. Introducing new technologies to the systems requires some modifications on products and services, as well as business strategies. The findings of the case study are summarised below.

Products

- The products of 4th generation PUB systems are, in general, more advanced compared to 2nd and 3rd generation PUB systems. Bicycles of 4th generation are equipped with a microchip, locking technology or theft protection device, that makes the tracking and surveillance of the bicycles much easier compared to the other generations of PUB systems. In addition to this, bicycles of Vélo'v are equipped with a fault sensor that makes it easier to determine the bicycles with problems, and hence fastens the maintenance procedure and increases the availability of bicycles. OV-Fiets is an exception of 4th generation PUB systems, since rather than the product itself, it is the system that has changed. The main reason of this is the traditional business strategy of bicycle renting, i.e. the traditional rental shops that are located at train stations and responsible for the maintenance of bicycles and rental procedure.
- Apart from the bicycle, it is possible to observe improvements in the rack design in 3rd and 4th generation PUB systems. Some additional products, such as docking station and electronic kiosk, are placed at racks to assist the user with the rental procedure. In these cases, the user is provided with a magnetic stripe card, a smartcard or an RFID-enabled card to store the personal information of the user. This is another technology included in 3rd and 4th generation PUB systems to track the bicycles. Besides that, smartcards and RFID-enabled cards enable the user to combine different means of public transport with bicycles. Some

other additional products of 3rd generation PUB systems are the station controller and host controller that use GSM technology to communicate with each other and the dispatch vehicle to make the necessary adjustments of the bicycles between different racks and to collect data for statistical use. All these additional technologies and products add value to the system, through improving the efficiency of bicycles, enabling enhanced security and hence providing better products and services for the customers.

Services

- It is possible to distinguish two different types of services in PUB systems: services that keep the system working and services that are offered to attract more customers. The first one is services, such as surveillance and maintenance that keep the system working and securing. While GSM technology provides introduction of new products to the system, it also enables new means of surveillance and maintenance in 3rd and 4th generation PUB systems. Surveillance is done by the police in 2nd generation PUB systems, however, in 3rd and 4th generation, the system itself tracks the bicycles. GSM technology also facilitates the maintenance procedure by informing the system on problems related with bicycles.
- The other type of services in PUB systems are the services that are offered to attract more customers to use the system, and may vary in each PUB system. Introduction of new technologies and innovative products enables the system to offer a variety of services. For instance, the services offered due to smartcards can be summarised as flexibility in renting and payment, different payment options, possibility to hold the bicycle between stops, possibility of returning bicycles to different racks and possibility to combine bicycle with other means of public transport. In addition to smartcards, GSM technology brings solutions for real time needs in the form of services such as call center, SMS and internet.

Business context

- The way the business is structured demonstrates also changes in different generations of PUB systems. While new technologies bring innovative products, such as cards and card readers, station controllers, or electronic kiosks, new products introduce new stakeholders/ producers to the system. Although they do not have a direct role in the decision making process related with the system, they are vital to keep it running. For attaining a sustainable PSS, they have the potential of introducing functional thinking to the supply chain, since they have knowledge about the regulations and marketing data regarding their products.
- The scenario study revealed that the introduction of new stakeholders may require new services and products. The involvement of hotels in the system, for instance, brings benefits to the hotels in terms of publicity and creating value for their customers and to the sys-

tem in terms of creating new services, such as mp3 files downloadable on internet, and thus new ways of satisfying customers. The stakeholders, such as attractions, museums, cafés, restaurants and pubs, similarly, benefit from the system that offers advertising opportunities, but also they create new communication channels that use GPRS technology and require the use of mobile phones. In addition to this, local companies like T-Mobile, and global companies like Apple and Skype are considered in this study to have a potential to publicize the system and themselves, at the same time bring new communication channels and new ways of doing, such as use of mobile phones, podcasts and mp3 players as information channels.

6.2.3 General Requirements for the Successful Implementation of PUB Systems

After discussing the role of product innovation in PUB context, it can be concluded that technological improvements are necessary for successful PUB systems since products and services designed with new technologies bring advantages to the system in terms of security and ease of maintenance, and to the user in terms of convenience and ease of use. In addition to this, there are also some general requirements for the successful implementation of PUB systems within a given context, and these can be listed as follows:

- *The need of a bicycle culture:* The readiness of the users to accept PUB systems is an important consideration for the application of PUB systems. It is possible to draw the conclusion from the implemented cases that a bicycle culture already exists in the contexts where PUB systems are applied.
- *Geographical conditions:* Steep or unsafe paths may cause inconvenient and dangerous situations for cyclists. Additionally, a flat ground provides ease of riding during cycling. The majority of the cases where bicycle use is common accommodate these features.
- *Governmental support:* The support of the government is important in encouraging companies to take over the PUB system in a later phase and integrate it into their business. In the majority of cases, the projects start with the subsidy of the government to demonstrate the potential and the success of the system. Government, furthermore, has an important role in the publicity of PUB systems, encouraging the public for experiencing the new system.
- *Business wise:* Involvement of companies within the system brings economical and commercial advantages to the PUB systems as in the case of Vélo'v. However, companies are involved in such systems only when these systems are business wise and companies profit out of them.

- *Infrastructure:* The use of existing infrastructure fastens the process of implementation of PUB systems. Although the infrastructure has not been explored in detail in this study, it is possible to observe that the investigated cases accommodate infrastructure due to the existing bicycle culture in the context where PUB systems are applied: north central Europe. These infrastructures have been created by municipalities for bicycles and they include signage (Figure 6.1) giving information and setting rules, and cycle tracks (Figure 6.2) ensuring security for cyclists. Existing infrastructure is an advantage for PUB systems making their implementation easier, especially fastening the initiation phase.

Figure 6.1 Examples of cycle signs

Figure 6.2 Examples of cycle tracks

- *Product design:* In a PSS, products should be designed in parallel with services, taking into consideration the efficiency and sustainability of the system. In this respect, product development process in a PSS is different than the traditional product design approaches. It requires the consideration of different ownership structures and use scenarios, which necessitate the user to learn different ways of using products, and the designer to develop products with different criteria than traditional products.

6.3 Suggestions for Further Study

Based on the findings of this study, suggestions for further study on sustainable PUB systems can be as follows:

- The *design and development of PUB systems* were not investigated in this study. Therefore, it is not possible to draw conclusions on which criteria the cases were based upon and if sustainability was an important consideration in these processes. However, considering the involvement of private companies in 3rd and 4th generation systems, it is possible to assume that the PUB systems are becoming more commercial within time. This may hamper the involvement of necessary sustainability considerations in the design and development of PUB systems. Therefore, the development processes of PUB systems and implications of PSS methodologies should be further studied to ensure more sustainable solutions.
- There is a need to further examine the role of *product innovation* for PUB systems. Alternative technologies should be searched for and their implications for PUB systems should be investigated from a sustainability point of view.
- Although the *business contex*t of cases were investigated in terms of relevant actors, there is a need for finding new business approaches and identifying potential stakeholders for the development of sustainable PUB systems.
- *Business strategy* in terms of new products and services, pricing and customer satisfaction are vital points that should be addressed in the field of PUB systems.

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APPENDIX A

CHECK LIST USED IN THE ANALYSIS OF CASE STUDIES

1. System Overview

Name of the alternative mobility
Year *(start / end)*
Idea / Initiator
Investor
Daily number of commuters using the system
Service provider
Actors involved *(government, NGO's, companies)*
Description of the system *(how it functions, usage, tracking method, size, combination with other mobility systems)*
Target group *(commuting to work, recreation, time of the day, the reason of the need for mobility)*

2. Business Context

Relevant actors involved and how they are structured in the system *(service or product-based company, government, NGO, their specific role, experience, competencies, strategy, vision, engagement with sustainability)*

- **Actor 1**
- **Actor 2**
- …

3. Products

Different type product included in the system - traditional, extreme, innovative, re-designed *(vehicles, video monitors, kiosks, trip-planning systems to deliver real-time information, vehicle control and safety systems, in-vehicle information systems, etc.)*

- **Product 1** (bicycle and rack: description, initial cost and cost for one trip, new technology involved)
- **Product 2** (smart product: technology used - wireless technology, navigation systems, information technology, etc.)
- **Product 3** (depends on the system - e.g. kiosk)
- …..

4. Services

Services that keep the system working *(how the service offeren and by whom, what type of technology used)*

- **Service 1**
- **Service 2**
- **Service 3**
- ...