Clean data for cleaner air? Case study research about data streams concerning low-emission zones and car-free zones

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Abstract

The recent introduction of a low-emission zone and enlarged car-free zones in three Belgian cities led to the development of information systems processing data about vehicles, persons, companies and policy impact effects. The collection, analysis and use of these data brought up certain problems that needed to be solved. This case study research aims to categorize these problems using the sequential problem/solution-model. Furthermore, the research results help to explore some focus areas for a future data governance model in the public sector.

Keywords ANPR - government databases - sequential problem/solution model - data governance - case studies

1 Introduction

In the context of climate change, increased urbanization and the 'smart cities'-movement many cities around the world are taking measures to improve the environment, health and quality of life of their citizens. Some of these measures include the reduction of air pollution and traffic in parts of the city. In the northern region of Belgium, Flanders, the cities of Antwerp, Leuven and Ghent recently implemented policies to diminish and/or avoid (polluting) cars in their city centre. To realize such policies different data streams, whereby number plates play a crucial role, need to be installed and coordinated.

The city of Antwerp has initiated a low-emission zone (LEZ) in their city centre and a part of the city region called Linkeroever. Older diesel-powered vehicles and very old petrol-powered vehicles except for motorcycles may no longer enter the city. Owners of those type of vehicles, who want to legitimately ride throughout the city centre, can only do this by purchasing permits (namely a temporary permit or a LEZ day ticket). These electronic permitting tools are only awarded under strict conditions. Leuven and Ghent introduced new traffic circulation plans, that include among other things an enlargement of the car-free zones - also called pedestrian areas - in their city centres. No vehicles can enter these zones unless they have an electronic permit. Permits are only granted exceptionally, for instance to inhabitants of the zone, practitioners of medical professions, people with a disability, building companies who have to work in the zone, owners of a private garage in the zone, shop suppliers, etc.

The policies of the three cities show the following same characteristics:

- there is a collection and use of data for similar purposes: entrance or prohibition for vehicles in a specific zone;
- the cities need to have access to databases from the Federal government about vehicles, persons and companies;
- the rules are enforced through the use of Automatic Number Plate Reader (ANPR)-cameras along the boundaries of the zones;
- offenders of the rules will receive an administrative fine;
- the impact of the policy on aspects as environment, local economy and traffic are monitored by making use of sensors and statistics.

This involves a complexity of data needs and data streams. The actors involved are the cities (including the city council, the city administration and the local police), the Federal Government as a legislator and owner of relevant databases, the Flemish Government for legal and informational assistance for the low-emission zone (including the Department of Environment and the Flemish Service Integrator) and external IT-partners responsible for the installation of ANPR-cameras, software for fines, etc.

Which kind of problems did the actors encounter when they constructed information systems to master the data needs and data streams for the low-emission zone or car-free zone? The objective of this paper is to answer this question.

2 The information systems

Although information systems in the public sector sometimes suffer from a bad reputation (Pollit, 2011) - for instance caused by extensive, expensive IT-projects which failure received lots of media exposure - the cities of Antwerp, Leuven and Ghent managed to develop and implement effective ways to handle their needs concerning data for their low-emission zone respectively car-free zones. The main fundaments of the information systems are set in place but moderate adjustments to improve certain components are still possible.

2.1 Data streams and data infrastructure

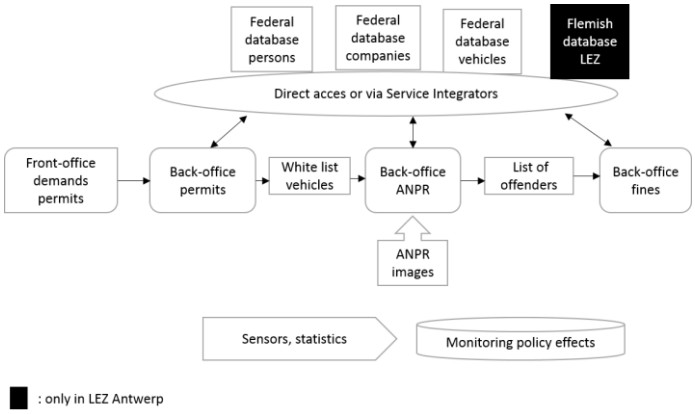
As illustrated in figure 1, the chosen policies to control the entrance of (certain) vehicles in parts of the cities of Antwerp, Leuven and Ghent are accompanied by data streams that deal with

- the demands of citizens and companies for permits to enter the zone and the processing of these demands by the city;
- direct or indirect access to databases of the Federal Government concerning vehicles, persons and companies to check a) information on the permit demands (e.g. the domicile of a demander who claims to live in the zone or a company that claims to have a branch address there); b) technical information about a vehicle (e.g. carburant type, degree of pollution) or c) the name and address of number plate owners to identify offenders;
- the automatic reading of number plates entering the zone, the filtering of those number plates that are permitted and the manual validation of the list of potential offenders;
- the processing and sending of administrative fines and the follow up of the payments;
- the collection of (statistical or sensor) data to monitor possible effects of the policy on air pollution, the amount of city visitors, changes in traffic flows, etc.

To handle these data streams, the information systems for the low-emission zone Antwerp and car-free zones in Leuven and Ghent consists, among other things, of a front and a back-office system for permit demands, a network of Automatic Number Plate Reader (ANPR)-cameras and an ANPR back-office system, direct or indirect connections with Federal databases (vehicles, persons, companies), a back-office system for administrative fines and a network of different sensors in the city.

Additional for the low-emission zone (LEZ) Antwerp, there was a Flemish LEZ database developed, that includes useful data for every Flemish city or municipality that wants to implement a low-emission zone. This database contains logic to derive if a vehicle can or cannot enter the zone and registrations such as the installation of diesel particular filter on some vehicles.

Figure 1. Illustration of the data streams and infrastructure in the LEZ Antwerp and the car-free zones Leuven and Ghent



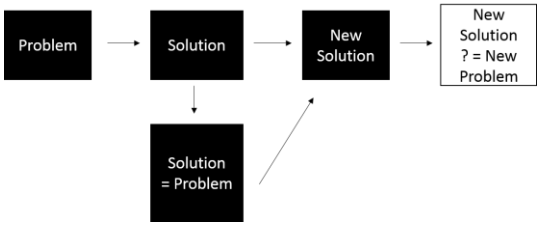
2.2 The sequential problem/solution model

The road from the political decision to implement a low-emission zone or a car-free zone to the development of a fitting, effective information system did not proceed straightforward but showed a zigzag pattern.

These kind of zigzag patterns in policy have been described in the sequential problem/solution model of Bouckaert, Peters and Verhoest (Bouckaert et al, 2010).

The sequential problem/solution model points at an action-reaction pattern where a solution to a problem becomes a problem itself that needs another solution. This is illustrated in figure 2.

Figure 2. The sequential problem/solution model



Sources: Bouckaert et al, 2010

The general reasons why solutions trigger problems are according to Bouckaert et al. threefold:

1) the proposed 'solution' was not the right solution for that problem;
2) even when the 'solution' was the answer to the 'problem', it could turn into a 'problem' because the 'solution' was not correctly implemented;
3) even if the 'solution' was the right answer and correctly implemented, it could be that the 'solution' becomes disconnected from the 'problem' and develops its own dysfunctional life.

By using the sequential problem/solution model this study aims to categorize the problems that the cities had to tackle to develop their information systems for the low-emission zone or car-free zone as well as the problems with a link to these systems that they are still struggling with.

3 Method

3.1 Documents and interviews

To examine which problems arose we gathered data through document analysis and interviews.

The documents, that were analysed for the case studies, consisted of legislation, city communications, parliamentary documents, authorization reports from Data Protection Authorities, policy studies, data flow charts and articles from newspapers.

We interviewed civil servants and policy makers that were directly involved with the development of the information systems. The interviews were semi-structured discussing themes such as stakeholders, data needs and data streams, experienced problems and actions to adjust difficulties. Table 1 gives an overview of the interviews for each case.

Table 1. Overview of interviews

Case	No. of interviews	No. of interviewed people
Antwerp	6	8
Leuven	4	5
Ghent	1	1

The interview data for the case of Ghent are limited to one person. Although we are aware of this limitation, we believe that the gathered data from document analysis and interviews for the car-free zone Ghent allow us to make modest comparisons with the other cases.

In order to maintain a systematic research approach, we followed the guidelines for case study research from Yin, such as working with a protocol (Yin, 2009).

3.2 Categorizing problems

To categorize the problems concerning the information systems of the three cases, inspiration was sought in the dimensions and perspectives of e-government from Bekkers (2001) and the IS (Information Systems) Failure Model from Sauer (1993).

Bekkers stresses that e-government is much more than a technical story. It comprehends different perspectives and conflicting demands. Besides the technical and informational perspectives, e-government also comprises legal, financial-economic, organizational and governance dimensions (Bekkers, 2001).

As Van Cauter et al demonstrated, the IS Failure model of Sauer can be useful to study government-to-government information system failure (Van Cauter et al, 2016). This model identifies possible failure and success factors of innovations. One of the components of this model is context which consists of six constructs: limits to cognitive capacity, technical processes, environment, politics, structure and history (Sauer, 1993).

4 Results

4.1 General

Firstly, we observed that the sequential problem/solution model was applicable on all three cases. Analyzing the research data, it was possible to discover different zigzag patterns.

One of these patterns for the LEZ Antwerp-case is shown in figure 3. The problem/solution model, as figure 3 clarifies, was useful to explore problems (P), solutions (S) and the processes or factors between them (=indicated by arrows). The model starts with an initial situation concerning a first problem *(=P1)* and solution *(=S1)*, then sequentially detects new problems and solutions and ends with a projection of an ideal 'to be' situation. The ideal 'to be' situation might be utopian.

4.2 Low-emission zone Antwerp

Antwerp is the first Belgian city that introduced a low-emission zone. Being a pioneer, the city had to deal with a national legal gap for low-emission zones and the first development of an information system which was capable of automatically detecting polluting cars. Therefore, the city was dependent on initiatives from other policy levels. Local,

Federal and Flemish administrations worked closely together to create the legal and informational framework. The choice to install a) a 24h/24h low-emission zone, b) for all types of vehicles except motorcycles, and c) enforced with ANPR-cameras – stringent criteria that are not standard for all emission-zones (Holman et al 2015; Tögel & Spicka 2014) - led to a high technological construction. As a few hundred thousand vehicles on a daily base pass through the low-emission zone of Antwerp (SCFO, 2016) the volume of data is high.

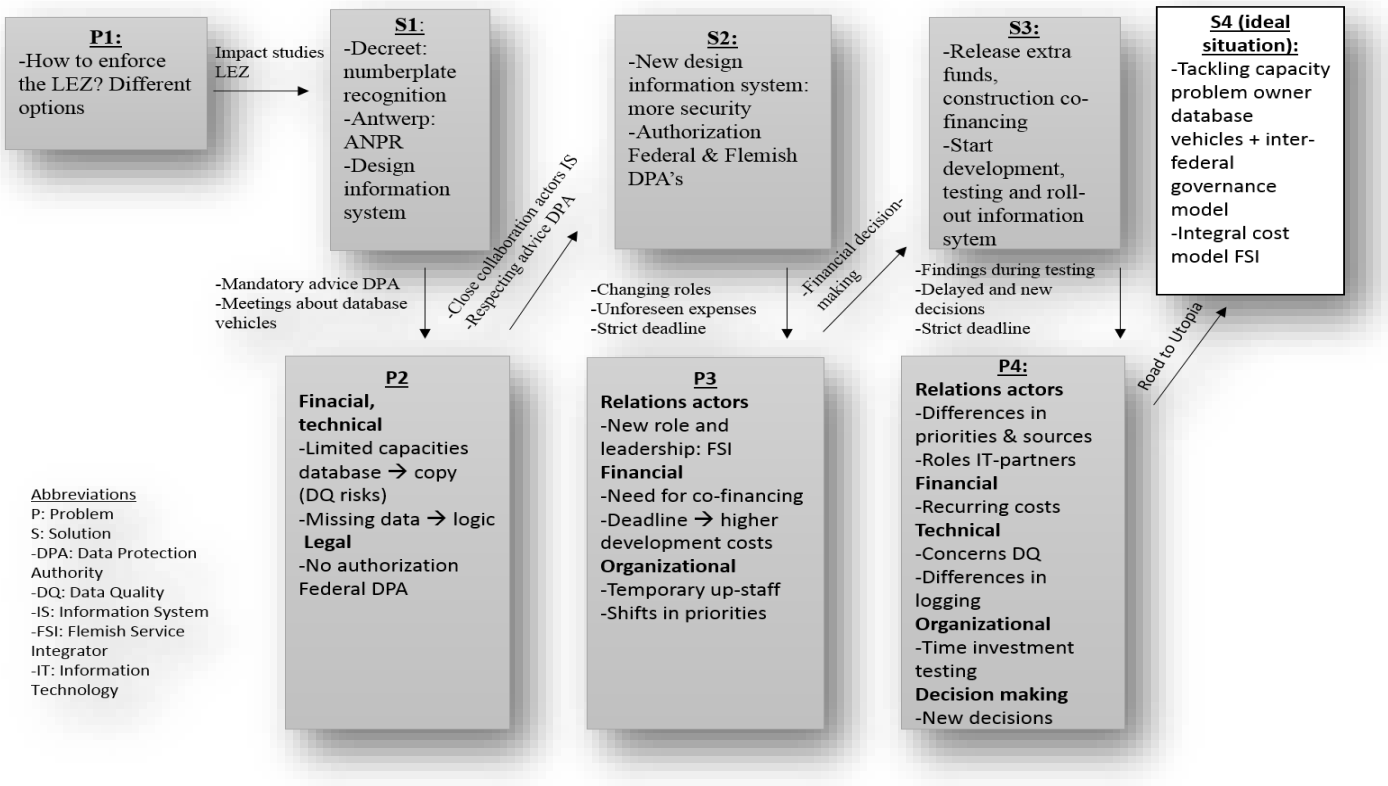
This high volume proved a problem for the owner of the Federal database on vehicles *(=P2).* Capacity problems of the database owner forced the involved Flemish administrations to work with a copy of a dataset, which is daily synchronized. As some data in the database are missing, a logic to derive the necessary information for the low-emission zone was established.

In the first design of the information system (IS), the data stream concerning access to the Federal database about vehicles, was rejected by the Federal Data Protection Authority *(=P2).* Because of a strict political deadline to implement the low-emission zone, all actors involved needed to design in a tight time frame a new fitting information system that respected the concerns of the Federal Data Protection Authority (DPA) *(=S2).* The role of the Flemish Service Integrator (FSI), a data broker for data exchange between different administrations, became bigger as in the new design they would function among other things as a third thrusted party encrypting number plates. For these new privacy mechanisms and the extra services from the Flemish Service Integrator a co-financing construction between the city of Antwerp, the Flemish Department of Environment and the Flemish Service Integrator had to be negotiated *(=P3).*

While agreeing on a co-financing construction, the information system could be developed and tested *(=S3).* During the tests, some conflicts or difficulties about dataquality (DQ), responsibilities of the different Information Technology (IT)-partners and availability of city personnel for the tests, had to be tackled *(=P4).* The political deadline to start the LEZ Antwerp on 1 February 2017 was eventually
achieved. One of the remaining issues regards the identification of foreign number plates (Hope, 2017).

The discovered problems, solved or still present, concerning the information system could be categorized as legal,

Figure 3. One of the sequential problem/solution models for LEZ Antwerp



financial, relational, organizational, technical and decision making.

4.3 Car-free zones Leuven & Ghent

The new traffic circulation plans in Leuven and Ghent, which comprehend an enlargement of the car-free zones in the city centre, held within them some challenges.

Discussion points about the responsibilities for the ANPR-system, the fines and the monitoring of effects needed to be solved in the cities' administrations. While in Leuven the local police, which is an authorized user of the Federal database on vehicles, became responsible for the identification of the offenders, in Ghent this task was assigned to the cities' Mobility Company that was obliged to ask an authorization from the Federal Date Protection Authority for access to the Federal database on vehicles.

The choice to enforce the car-free zones by ANPR-cameras, is because of aesthetic reasons and hindrance during installation not evident in medieval, small city centres like those in Leuven and Ghent. Therefore, the out-roll of the ANPR-cameras happens phased as well as some other aspects. In Leuven, for instance, the administration started already with limited software to process permit demands but they are exploring the purchase of more advanced software with extra features.

Both cities want to monitor the effects of the car-free policy on air traffic, air pollution, local economy, questions and complaints of citizens, etc. To collect data about these subjects the cities use sensors to measure the amount of passengers in the main shopping streets and air quality, statistics regarding the use of parking garages and the vacancy rate of retail properties, traffic loops and cameras to evaluate traffic streams and databases to follow up the questions and complaints. Not all data sources, that were explored by the city administrations, seemed accurate enough for their data needs. Federal or provincial economic statistics about employment and shopping streams for instance have information about cities as a whole but lack the possibility to track information on a specific city region, namely the car-free zone. Individual complaints from local retailers about income loss blamed on the new policy are due to privacy reasons difficult to control. Because income loss of local retailers can also be influenced by external factors like e-commerce a causality problem arises.

Table 2 demonstrates the categories of problems, derived by using the sequential problem/solution model, for the car-free zones. The categories are financial-economical, relational, organizational, technical/informational and technological.

Table 2. Categories of problems regarding the information systems of the car-free zones Leuven & Ghent

	Leuven	Ghent
Financial-economical	-Concerns and complaints from local retailers about loss of income and a lesser amount of city visitors due to the policy → collecting useful data to objectify	-Concerns and complaints from local retailers about loss of income and a lesser amount of city visitors due to the policy → collecting useful data to objectify
Relational		-Discussion about roles and responsibilities (ANPR, fines) between the local police and the local Mobility Company of the city
Organizational	-Mobility: fragmented policy within the city administration → need for clear responsibilities -Reflection about administrative simplification: different sorts of city permits	-New responsibilities Mobility Company (ANPR, fines): up-staff, legal authorizations to have access to the federal database on vehicles and to impose administrative fines, education
Technical/ informational	-Temporary start with limited software for the processing of permit demands	
Technological	-ANPR: unpractical to install in a historic city centre -Unwieldy infrastructure to monitor traffic streams (traffic loops)	-ANPR: unpractical to install in a historic city centre -Unwieldy infrastructure to monitor traffic streams (traffic loops)

5 Lessons for data governance

For future research, the case studies on data streams of the low-emission zone Antwerp and the car-free zones Leuven and Ghent yielded some focus areas to examine in other case studies.

The focus areas are

- evolutions in the use of data objects with a possible link to purpose limitation (e.g. the history of a number plate: from an original tool for taxation to a tool that can be used for policies concerning environment, parking in cities, etc.);
- the funding of authentic sources (e.g. the underfunding of the vehicle database led in the case of Antwerp to a situation of working with a copy of a dataset);
- cross-border exchange of data (e.g. foreign number plates);
- co-financing mechanisms of data-infrastructure (not only including investment costs but also costs for maintenance and services afterwards)

- legal and data quality difficulties because of a complex state structure: can inter-federal data strategies bring support?;
- the roles of actors and procedures to have access to databases (e.g. the police in Leuven versus the Mobility Company in Ghent);
- societal use of data (for instance the link with open data platforms concerning the monitored data in Antwerp, Leuven and Ghent);
- openness to innovation, like new (maybe less unwieldy) data infrastructure technologies;
- transparency about data use (e.g. recent ideas to inform citizens about the use of their number plate data by an e-counter).

The final goal of our broader research project is to develop a data governance model that is capable of avoiding some of the described zigzag patterns by a pro-active focus on potential problems.

Conclusion

The implementation of a low-emission zone in Antwerp and car-free zones in Leuven and Ghent were accompanied with the management of data streams regarding permit demands, control of vehicles by ANPR-cameras, the processing of fines and the monitoring of policy impact. The cities developed smart information systems to handle the data streams.

The implementation of the policy and the development of the information systems showed an action-reaction pattern whereby different problems having a link with data needed (or still need) to be solved. The sequential problem/solution-model proved to be useful to detect problems. These problems, which this research aimed to categorize, could be classified as legal, financial, relational, organizational, technical-informational, decision making and technological.

The cases also resulted in some focus areas about conditions, mechanisms and principles regarding the primary and secondary collection and use of data for further research about a data governance model.

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