# Decision making processes and visibility of a global infrastructure: the Air Traffic Management

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## PURPOSE OF THE RESEARCH

This work focuses on how an infrastructure becomes visible during a planned change in a complex interorganizational system. While scientific research on knowledge infrastructures has addressed both theoretical and methodological issues (Edwards et al, 2009; Iannacci, 2010; Karasti et al, 2016a; Karasti et al, 2016b), the way in which decision processes shape the infrastructures remains unexplored. Therefore, authors focus the analysis on the interplay between the infrastructure, its (in)visibility, and the decision processes as building blocks of any planned change. The aim of this paper is twofold; on the one hand, to describe the most significant elements and categories that characterize group decision processes during infrastructure changes and on the other, to investigate whether and to what extent these elements and categories contribute to making the infrastructure visible.

The analysis focuses on changes implemented in a case study: the air traffic management (ATM), a complex interorganizational system and its (in)visible infrastructure. When a change occurs, the relationships between actors, organizational culture, processes, technology, artefacts, etc. become visible as the result of actors negotiating and taking consequent decisions.

The analysis is carried out using qualitative research made up of semi-structured interviews, focus groups with experts from the sector and review of documents and reports (Yin, 2003). The

conclusion outlines the elements and categories of the decision processes that come into play when creating, maintaining or changing an infrastructure.

## THEORETICAL FRAMEWORK

A sociotechnical infrastructure is that it is a robust network of people, artefacts, and institutions that generate, share and maintain specific knowledge about the human and natural worlds (Edwards, 2003; Edward et al, 2009). Infrastructures shape what and how actors understand and interpret their world through practices, routines and organizational cultures, informational and knowledge elements (Mongili and Pellegrino, 2014; Constantinides and Barrett 2015). An infrastructure is generally invisible (Star and Bowker, 2006) in daily life and operates below the surface but becomes visible in two main cases (Karasti et al, 2016a):

1. when it breaks down (Star, 1999; Bowker et al, 2010). When a server goes down, a bridge is washed out, or when a power blackout occurs, the infrastructure becomes evident to the actors that use it. The safe management of such situations implies the creation and implementation of ex-ante and ex-post procedures such as back-up mechanisms or other emergency procedures, which should fix breakdowns and bugs.
2. when it is analysed during meetings that aim to create, maintain or change an infrastructure (Star and Bowker, 2002; Karasti et al, 2010; Jackson, 2014).

Since the infrastructure supports and is, in turn, inhabited by social, political and technical rudiments, its creation or change cannot be analysed only from a technological point of view but rather from the result of the actors' negotiations and decisions on practices, routines, assets and the sociotechnical elements that make up the infrastructure itself.

Various elements should considered antecedents in such negotiations and decision processes, among others: skills, knowledge and competencies (Schermerhorn et al, 2011); procedures, routines and rules (Neale and Bazerman, 1991); roles, power and social motives (Mannix, 1993; De Dreu et al, 2000). The next section details a specific case study where the ATM system and the elements that affect planned decision processes are analysed: the Sectorless scenario.

## RESEARCH METHOD AND CASE STUDY

Air Traffic Management (ATM) is an interorganizational system currently populated by a set of heterogeneous actors (e.g. air navigation service providers (e.g. DFS in Germany and ENAV in Italy), European Civil Aviation Conference member states, civil and military experts in airspace design, passengers and airspace users, national security systems, etc.) that assist the flight of an aircraft - departing, cruising, and landing at an airport (Duong et al, 2001).

This means that any change to the infrastructure is a complex endeavour that affects

hundreds of national and international organizations, actors, procedures, assets and regulations.

The current configuration of European ATM is the result of the harmonization process in European countries implemented by the EU in the 1960s. For the last two decades, international bodies, practitioners and scholars in the sector have discussed an innovative approach to controlling airspace: the Sectorless scenario (DFS, 2016). The Sectorless scenario envisages air traffic control without the conventional geography-based sectors (established in the 2004). This new approach means that several aircraft are assigned to a single controller regardless of their location. The Sectorless scenario is said to offer significant improvements while addressing the main bottlenecks of the traditional sectored approach. The main foreseen improvements can be summarised as a higher number of flights, less workload for controllers, time and cost efficiency (Birkmeier et al, 2016; Kaltenhaeuser et al, 2017).

In order to assess the economic, safety and organizational feasibility of this concept, over the last decade scholars and institutions have focused on several operative aspects of the Sectorless scenario including the change in controllers' tasks, the assignment procedures of aircraft, the priority rules and the safety assessment routines (Korn et al, 2009; Birkmeier and Korn, 2014).

The identification of categories that shape the (in)visibility, infrastructure and the decision processes within the Sectorless scenario, is pursued using the following qualitative techniques (Yin, 2003):

1) Semi-structured interviews: 4 ATM experts were interviewed to identify the most important decision process categories that affect changes in ATM and Sectorless. The interviews were recorded and then transcribed. The first goal of the interviews was explorative, namely to identify the most significant antecedent elements in the decision processes on change and innovation of the ATM infrastructure and of flight control systems. A second goal was to identify the emerging categories (Miller and Glassner, 2016) that characterize decisions on changes.
2) Two focus groups in 7 ATM experts: one-day focus groups took place in June 2016 and March 2017. The goal of the focus groups was to better explore and understand the complex processes involved in the decision to change the various aspects (theological, organizational, etc.) of the ATM domain. The categories identified during the preliminary interviews were also further investigated and verified.
3) The review of documents of official ATM reports and scientific papers describing innovation and changes in ATM and, more specifically, in air traffic control systems. The goal of this activity was to compare the findings of the first two methods with official information available from documents.

After the identification and sharpening/validation of the categories, the focus of the analysis shifted to understand whether these emerging categories contribute in making the ATM infrastructure visible by analysing all the material independently and then triangulating the results.

The analysis uncovered five of the most significant key elements that characterize decision processes within ATM systems and which may influence the infrastructure (in)visibility. Each of these elements was analysed in depth and various analytical categories emerged (Table 1). The following describes each of these elements and then outlines whether and to what extend these elements affect the (in)visibility of the ATM infrastructure.

*Table 1. Elements and analytical categories found in the analysis*

| **Elements** | **Analytical categories** |
|---|---|
| The actors involvement | Play a role<br>Actor engaging<br>Doing cultures |
| Dealing with the problem/ issue | Objectifying the problem |
| Solving the conflicts | Acting on procedures and artefacts<br>Mastering in command |
| Driving the decision process | Motivating socially |
| Levels of decision process | Handling events<br>Changing procedures<br>Crossing the boundaries |

In the extended version of the paper more details on the elements and their categories will be provided. Follows, whether and to what extent these elements affect the (in)visibility of the infrastructure are explained.

**The actors involvement**

The actors directly involved in the decision processes have a major role in making the infrastructure visible because, through the negotiation of interests, power and strategies, they use and at the same time may reveal the infrastructure underlying the entire ATM system.

In the case of sectorless ATM, a planned change was negotiated with actors involved in the system, dealing with their specific role. The initial idea of sectorless was backed by a European country ATM team to persuade other experts, the EU commission, and other EU countries to consider this solution as a communal outcome. The team used its role in the EU context to

promote the introduction of development and deployment plans lead by EUROCONTROL and co-funded by the EU Commission and SESAR. During this phase, experts all over the Europe were involved and engaged in the production of joint projects for a new generation technological and organizational infrastructure. The involvement of actors from different organizations and countries drove them to share ideas and beliefs about the innovative solutions, reducing cultural barriers and developing a common culture across Europe.

**Dealing with the problem/issue**

Objectifying the problem/issue underlying the decision means making the interpretations of the problem by the various actors involved in decision process, as well as the interests that guide the different interpretations, no longer "transparent" or "taken for granted" but visible. This objectification will also make the infrastructure visible.

Within and across complex ATM systems, issues, such as the change in controllers' tasks, the assignment procedures of aircraft, the priority rules and the safety assessments routines, are embedded in specific organizational processes and culture which increases complexity. To reduce this complexity the problem/issue should be objectified using the languages and knowledge of experts to better understand the inner infrastructure, to take decisions, and connect with other infrastructures. In order to adopt a common solution, boundary languages and artefacts have to be shared among actors.

**Solving the conflicts**

The dynamics of resolving conflicts during a decision-making process seem to affect the visibility of the infrastructure in at least two ways:

- if an action cannot be imposed on the actors to reduce the positions and interests of each, then action can be levied on the physical world and therefore on procedures and individual artefacts
- the interests of individual decision makers sitting at the table during negotiation emerge and become visible.

In our analysis, an EU team decided to adopt Sectorless as an experimental solution. As a consequence, the operative complexity has encouraged experts to change their internal procedures, practices, and roles, and to deal with their infrastructure thus making it visible. This experimental solution would enable EU experts to develop best practices and common artefacts that can be adopted by other ATM systems and become a common infrastructure.

**Driving the decision process**

Exercising power and relying on strong social motives encourage individual stakeholders to make a decision and choose one solution rather than another. Social motives play an important role in the definition and articulation of the future infrastructure because, once they become invisible, the infrastructure will also become invisible and taken for granted.

In the specific case of Sectorless, experts are called to collaborate in international projects to identify, develop and deploy innovative solutions. These experts usually belong to different organizations around Europe and are involved because of their expertise and company reputation. For this reason, the SESAR initiative funds the most promising projects and the most renowned experts who act in a network of peers where reputation matters. Experts participate in EU projects not only to innovate but also to be socially motivated and enhance their reputation. Reputation is built also by participating in international events, congresses and conferences.

**The levels of decision processes**

Depending on the level of decision, the visibility of the infrastructure will emerge in different ways during a planned change because key elements of the infrastructure e.g. procedural changes and international standards may change.

In the case of operational level decisions, activities are carried out on a daily basis. With the adoption of Sectorless the communication entropy between pilots and controllers reduces radically. Pilots no longer need to get in contact with a variable number of controllers (a person for each sector), but contact only one responsible person for each country with whom they establish a rapport, share information, and handle events. During the introduction of these new communication procedures, the infrastructure become visible because pilots cannot use the old infrastructure anymore, they should use the new one communicating with a single channel controller.

At a managerial level, decisions refer mainly on how jobs are organized. Due to the fact that a lesser number of controllers is needed to monitor flights in a Sectorless context, the person responsible in the control tower may change the shift of work between controllers. Then, the infrastructure becomes visible when the pre-existing procedures cannot be used anymore and, in particular, when a fewer number or workers is needed for that specific job.

In the case of strategic level decisions, the infrastructure become visible when the Sectorless solution becomes a political problem of international harmonization because the innovative solution should be evaluated, interpreted and made coherent with laws, practices, roles, and power of the involved countries (namely made coherent with the national infrastructure).

## THEORETICAL AND EMPIRICAL IMPLICATIONS

This paper focused on the interplay between the decision processes, the infrastructure and its (in)visibility. The authors shed new light on the role of decision processes in changing and making visible the infrastructure. Focusing on group decision processes as units of analysis has two main implications in terms of both infrastructural changes and (in)visibility.

The analysis was conducted using a qualitative approach, choosing the Sectorless in the ATM case study, and interviewing experts in the domain and organizing focus groups.

From the collected data, five elements and ten analytical categories were identified (Table 1). The relationships that forms the sociotechnical infrastructure emerges as the result of negotiations between actors and the role they play (even in terms of power) in the decision processes. Actors involved in the decision processes attempt to "clean" the information from contamination in order to share the most objective and comprehensive information, thus making visible the infrastructure and introducing new changes. Often the negotiation is not an easy process because actors represents different organizations, and different set of interests, therefore decisions are often taken "acting on" human actors, procedures and/or artefacts. Experts can play the role of masters in command because of their skill sets, expertise and reputation in the entire organizational system. Decision processes on infrastructures go through three levels, namely operational, managerial and strategic which all have different effects on the infrastructure (in)visibility.

Finally, the Sectorless case study allowed to highlight how the link between group decision processes, infrastructure and (in)visibility is indissolubly connected with complex interorganizational dynamics.

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