DRAFT I

# A Case Study Analysis of Inter-Organization Interactions During BIM Adoption in European Infrastructure Mega- Projects

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## Abstract

The transport sector accounts for a large share of global $CO_2$ emissions. To mitigate the impact of climate change, several sustainability-oriented large-scale infrastructure projects have recently been on the policy agenda around the globe, such as electric road systems and expanding rail systems. A parallel development that is expected to accelerate the transition of the transport sector is digitalization. Although ongoing for many decades, these initiatives have recently been augmented by virtual concepts such as artificial intelligence (AI) and smart city technologies. The integration of these digitalization tools at the organizational level poses both opportunities and challenges for the actors involved in infrastructure projects. An approach that is currently promoted in the infrastructure sector is Building Information Modeling (BIM). BIM supports decision-making that leverages various digitalization tools and applications.

Although the economic implications of BIM are widely discussed in the literature, the inter-organizational dynamics involving multiple actors in infrastructure projects are not fully grasped. Large infrastructure projects are sociotechnical endeavors embedded in complex institutional frames. The institutional norms, practices, and logics in them are significant. Responding to this scenario, the study conducted an institutional analysis putting the BIM approach in the inter-organizational context in infrastructure delivery. The paper, based on empirical data drawn from three organizations in infrastructure delivery in Spain, the Netherlands and other European countries, will share the analysis of the tensions among the key actors during BIM adoption and implementation.

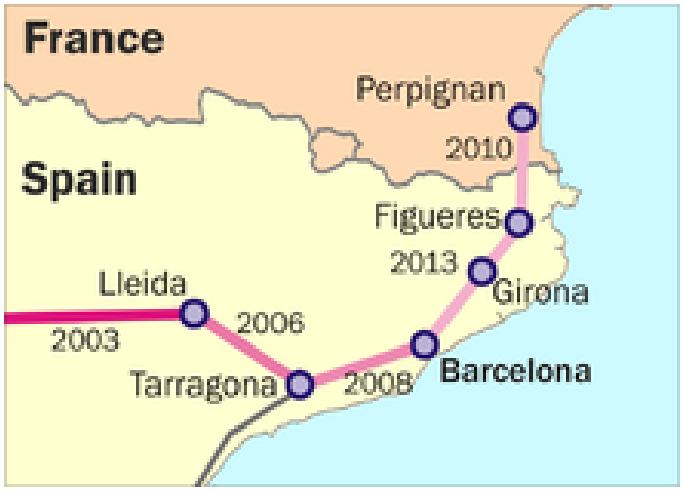
The paper will address the results gleaned from the case studies of utilizing BIM as a decision support tool for infrastructure programs within an inter-organizational context, summarize the insights from the infrastructure delivery scenarios [case studies] applicable to other national scenarios (including the USA), and, opine on multi-attribute decision making addressing the *PEESTLE* factors – political, energy/environmental, ethical, social, technical, legal and economic, by infrastructure related inter-organizations.

## Case Study – The Madrid-Barcelona HSL

The **Madrid–Barcelona high-speed rail line** is a 621-kilometre (386 mi) standard gauge railway line inaugurated on 20 February 2008. Designed for speeds of 350 km/h

(217 mph) and compatibility with neighboring countries' rail systems, it connects the cities of Madrid and Barcelona in 2 hours 30 minutes. In Barcelona the line is connected with the Perpignan–Barcelona high-speed rail line leading into France which connects it to the European high speed network (La Vanguardia, 20 February 2020).

There was criticism during the construction of the Madrid-Barcelona line. A critical report by the consulting firm KPMG, commissioned by ADIF (*Administrador de Infraestructuras Ferroviarias*) at the behest of the Ministry for Public Works (*Ministerio de Fomento*) on 23 June 2004, pointed to a lack of in-depth studies and over-hasty execution of works as the most important reasons for the problems that dogged construction of the AVE line. For example, during the construction of the AVE tunnel near Barcelona, several nearby buildings suffered damage from a sinkhole that appeared near a commuter rail station, damaging one of its platforms. The construction committee of Barcelona's famed Sagrada Familia church lobbied for a re-routing of the tunnel; it passes within meters of the massive church's foundations. It also passes equally near the UNESCO-recognized Casa Milà also designed by Antoni Gaudí. Until 2005, both Siemens and Talgo/Bombardier train sets failed to meet scheduled speed targets. However, in a test run during the homologation tests of the new S102 trains of RENFE, a train-set Talgo 350 (AVE S-102) reached a speed of 365 km/h (227 mph) on the night of the 25/26 June 2006, and in July 2006 a Siemens Velaro train-set (AVE S-103) reached the highest top speed ever in Spain: 403.7 km/h (250.8 mph). At this time, it was a record for railed vehicles in Spain and a world record for *unmodified* commercial service trainsets, as the earlier TGV and ICE records were achieved with specially modified and shortened trainsets, and the 1996 Shinkansen record of 443 km/h (275 mph) was using a test (non-commercial) trainset (Martin & Nombela, 2007).




**Overview map of the high-speed connections from Barcelona towards France, with the year of opening**

The research study by Hetemi et al. (2020) utilizes the **Madrid-Barcelona HSL** [case study] to explore the process of knowledge-work in the inter-organizational setting of a large-scale infrastructure project. Taking a process perspective, it explores why an autonomous project-owner organization in the rail industry, finds difficulties to transform

and exploit the project network-related knowledge in a coopetitive [cooperative competition] context. Based on the longitudinal analysis, the authors put forth a contingency framework that proposes four contexts linking the transformation and exploitation of the knowledge from the interorganizational network to the project-owner organization; whether: i) the interplay between industrial and the project arrangement empowers product or process knowledge, and ii) the senior, and program management awareness to feed-forward learning relies on individual or institutionalized based learning. These four contexts and their underlying conditions pose different knowledge-work related problems and implications for practice in inter-organizational collaborations (Hetemi et al., 2020).

***Case Study / Research Conclusions***

The Hetemi study (2020) postulates a solid understanding of knowledge-as-practice, and reaffirmation of the Project 'learning boundary' concept. The empirical investigation makes the following observations:

- Little collective knowledge occurs due to disconnected task divisions.
- Actors [stakeholders] belief in their personal uniqueness [super ego/arrogance]; while simultaneously being unaware of useful knowledge that is available from other sources within the organization.
- Knowledge is codified as a *product* rather than the *process*, which supplants the valuable knowledge sharing.

**Case Study / Research Limitations.** Challenge of exploiting knowledge created within LIP context for reuse in other contexts / projects. Lack multi-perspective view of knowledge-sharing mechanisms and perception by different Project actors.

**Emergence of Lock-In in Large Scale Projects.** Poor decision-making due to escalating commitments. Need process view with long-term perspective versus confining decisions to single actor at front end.

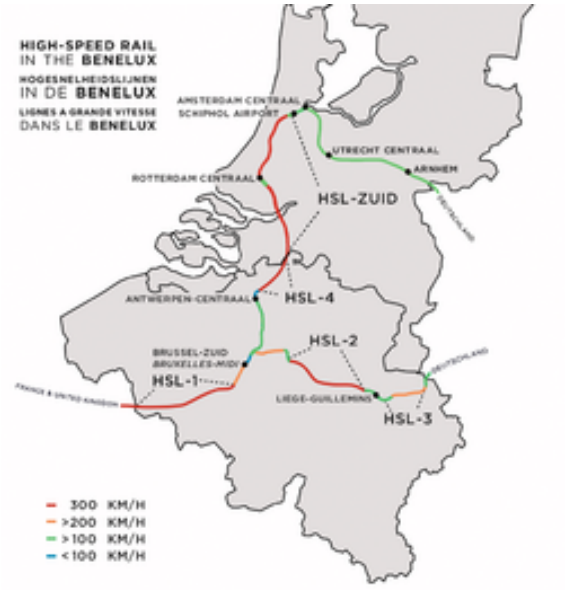
**Embeddedness & Actors Behaviors.** Actor behavior affected by project public institutional context & contractual commitments. Escalation caused by: a) Timing mismatches and b) Owner's passive behavior during implementation. Effective Owner-Contractor Collaboration is critical; savvy Owner deal with Contractors and manage contracts.
(Hetemi et al., 2020)

**Case Study – The Netherlands / ProRail – HSL South**

High-speed rail service in the Netherlands started at 13 December 2009 with the dedicated HSL-Zuid line that connects the Randstad via Brussels to the European high-speed rail network. In later years improved traditional rail sections were added to the high-speed network. Proposals for more dedicated high-speed lines were deemed too costly; plans for the HSL-Oost to Germany were mothballed and instead of the Zuiderzeelijn the less ambitious Hanzelijn was built to enable future high-speed service between the northern provinces and the Randstad. As per 2020 three high-speed train

services are operative in the Netherlands: Thalys, Inter City Express (ICE), and Eurostar; the short-lived Fyra service was cancelled in 2013 after severe reliability issues.

HSL-Zuid (Dutch: *Hogesnelheidslijn Zuid*, English: High-Speed Line South) is a 125 km (78 mi) high-speed railway line in the Netherlands. Using existing tracks from Amsterdam Centraal to Schiphol Airport, the dedicated high-speed line begins here and continues to Rotterdam Centraal and to the Belgian border. Here, it connects to the HSL 4, terminating at Antwerpen-Centraal. Den Haag Centraal (The Hague) and Breda are connected to the high-speed line by conventional railway lines. Services running at 160 km/h (100 mph) on the HSL-Zuid began on 7 September 2009 between Amsterdam and Rotterdam. From December 2009, Thalys trains from Amsterdam to Brussels and Paris have run on HSL-Zuid. From December 2012 to January 2013 (40 days in total) the Fyra V250 trains ran on HSL-Zuid between Amsterdam and Brussels, only to have service suspended because of the poor quality (and safety risks) of the Italian-made trains (Railway Gazette, 2018)




**HSL-Zuid, connected to Antwerp with the HSL 4**

**Large Scale Projects - Common Issues**

Both case studies on the Spain and The Netherlands HSL Mega-Projects show recursive interaction of institutional fields and managerial legitimation. This includes the institutional complexity bound Large Scale Project [LSP], and the management responses that are altered across both time and institutional pressures. These institutional pressures include the regulative, normative, dynamic, and cultural-cognitive (Hetemi et al, 2020 (2)).

***Limitations of BIM on Large Scale Projects***

BIM as a decision-making tool is *economically* viable; however, the inter-organizational dynamics are *not* fully grasped. In particular, the emotional tensions of the actors [stakeholders] hamper BIM implementation and its value (Hetemi et al., 2020(3)).

## Applicability to the [Sad] State of the USA Infrastructure

Every automobile driver in America knows from personal experience the terrible state of the USA infrastructure. The political theater of the Federal Government budgeting, funding and approval process thwarts quick action and stymies meaningful discourse on appropriate long-term solutions. The considerations to be addressed by inter-organization decision makers include sifting through the Political, Ethical, Energy/Environmental, Social, Technical, Legal and Economic issues [PEESTL+E] of the proposed LSP.

### *ASCE Infrastructure Report Card*

The comprehensive Infrastructure Report Card published every four years by the American Society of Civil Engineers [ASCE] consistently documents that the USA is *not* making the grade when it comes to its infrastructure. In 2017, USA earned the overall grade of D+; versus scoring a D in 2013 (ASCE, 2017). (The 2021 study is to be published on March 2, 2021.)

### *Economic impact of status quo investment*

The recently issued ASCE/EBP Study entitled "Failure to Act" notes that "Over the next 20 years, the average American household will lose $3,300 each year due to underinvestment in our infrastructure" (ASCE, 2021). Chilling.

## Conclusions

The European Case Studies on large scale infrastructure projects [LIP] addressing the inter-organization interactions during the adoption of BIM offers critical lessons learned for American stakeholders to seriously consider.

### *LIP Stakeholder Analysis - "Lessons Learned"*

First the LIP Program Manager must learn how to learn. That is, cooperative collaboration versus constant competition. This 'learning how to learn' requires the LIP decision makers to embrace the complex ambiguity they encounter as part of the LIP genre.

In addition, LIP continuous improvement requires constant communication to build commitment. This is necessary to overcome the disfunction-junction that now encumbers the process.

### *Implications for Improving Infrastructure Execution*

Sustainability requires reimaging cities [habitat], world of work [economy] and social support [infrastructure]. To improve the execution of large-scale infrastructure development requires the LIP constructors and designers to become agile in conceiving and constructing the built environment.

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## Appendix

***"The Netherlands / ProRail – HSL South" Case Study / Data Collection***

| Data collection method | Data collected |
|---|---|
| **Semi-structured interviews** | first interval (1996-2010)<br>9 interviews with the HSL PM, Adif Quality Controller, Head of Infrastructure Projects, Engineer at Organization B, project proponent and other relevant actors. Average duration was slightly over one hour.<br>second interval (2015-2018)<br>13 interviews with the program managers and other relevant actors (project managers, construction manager at Adif, Organization 'A' Contractor PM, Organization B Supplier, Organization C Contractor PM). Average duration was slightly over one hour. |

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|---|---|
| **(Participant) Observations** | first interval (1996-2010)<br>• participant observations,<br>• group interviews,<br>• Extensive informal communication<br>second interval (2015-2018)<br>The insider spent 2–3 days per week at the organization's offices and conducted observations:<br>• 7 management meetings;<br>• Extensive informal communication;<br>• Field notes for each of the days spent on site; |
| **Document analysis** | In total more than 20 documents:<br>• Internal program documents (internal financial and audit reports, overview presentations, internal organization and escalation matrices, lessons learned, and program tools, e.g., risk logs).<br>• Organization-wide guidelines and frameworks for project and program risk management. |