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Introduction

Europe Materializing? Toward a Transnational History of European Infrastructures

Alexander Badenoch and Andreas Fickers

After a series of false starts, a 'Museum of Europe' recently opened in Brussels, albeit as a temporary exhibition marking fifty years since the Treaties of Rome. The museum, which is still seeking a permanent home, is dedicated to building a sense of common European identity through a narrative of European history.¹ Part of the museum's proposed permanent exhibit is devoted to a series of active maps, the last of which, representing European history after 1945, is in a room fashioned to resemble a railway waiting room. Visitors can gaze up to a moving map, which, like the flipping departures board 'in a large European railway station', shows the 'arrival' of nations in Europe. 'After the centuries of Unity through faith and the decades of Unity through the Enlightenment [represented in other maps], the Unity through the project evolves year for year, as shown by a digital counter.'² While this narrative of Europe's history is at best questionable, the metaphor of the train for the project of Europe is by no means inept.³ If anything, it is too apt: while it is meant to support an optimistic story of steady modernization, the associations between Europe and material networks, particularly trains, are not so easily channelled. Observers in this waiting room might just as easily think of other trains, and darker sides of European history and modernity: the trains that never arrived, such as the pre-war Berlin–Baghdad Railway or many sections of the German-Dutch Betuwe line project, never stopped, leaving certain towns and places off the map of 'European' progress, or, like the trains in the brutal machinery of the Holocaust, never returned. Furthermore, visitors might easily feel that watching powerlessly as a mechanical process unfolds is all too emblematic of the European Union's 'democratic deficit'. Indeed, it would not be the first time that the EU was associated with a runaway train. Such symbolism, complete with all its pregnant silences and ambiguities, is so broadly resonant because it also reflects a common-sense, if ambiguous, reality: there are, and have been, human-built material links between nations and across borders in Europe which have pre-dated, accompanied and transcended the 'official' processes of political and economic integration begun after the

Second World War. The strong and varied metaphorical resonances point at once to the promise and the problems of unravelling the history of these technologies of connection and the role they have played in shaping the spaces, institutions and experiences of Europe. To put the matter simply: it seems obvious *that* technological infrastructures are related to projects of European unification, but it is far from clear *how*.

In many ways, technological infrastructures are indeed the essence of European integration. In material terms, they form the physical basis for transnational flows of people, goods and services. Already with the advent of railways and telegraphs in the nineteenth century, new networks crossed national boundaries in and beyond Europe, through which nations, empires and social groups expanded, renegotiated and transformed relations with each other. In addition to material structures, a number of institutions and regimes were formed to build and govern them. These bodies functioned beyond the national level and often at some remove from arenas of formal politics.⁴ At the same time, technology formed an important part of political thought among many diplomats and politicians.⁵ Many were defined as European institutions, either explicitly through their names and official remit (such as the United Nations Economic Commission for Europe) or implicitly through their actual spheres of activity, such as the International Union of Railways or the Alliance Internationale de Tourisme. To understand the way such institutions and the infrastructures they governed were constituted through expert knowledge, working practices and visions, it is important further to understand infrastructures at a discursive level. In particular, discourses and ideas of internationalism, which became increasingly interwoven with ideas of technological modernization, became a common feature of such expert communities and formed a link between them and broader movements for a united Europe. Beyond these institutional frameworks, infrastructures have also played a key role in the broader symbolic vocabulary of European integration in a number of spheres. From electricity systems in the 1920s, to coal trains in the 1950s, through to the gateways and bridges on Euro notes in the present decade, infrastructures have been mobilized repeatedly in broader spheres as symbols and metaphors for broader forms of modernization, integration and co-operation.⁶ At the same time, the rhetoric of a united Europe, particularly in combination with narratives of progress, has played – and continues to play – an important part in pushing forward major infrastructural interventions. In short, material infrastructures have helped to shape a number of spaces and ways in which people have moved through, talked about and experienced ‘Europe’. With this volume, we present a series of case studies that explore the material, institutional and discursive complexities involved in building and using transnational infrastructures in Europe throughout the twentieth century.

By bringing infrastructures and Europe into the same frame, this volume has three interrelated aims. First and foremost, by using material

infrastructures to guide a transnational approach to European history, it reveals to historians of modern Europe underexplored dimensions of European integration. This approach allows us to explore empirically the transnational movements of things, people and ideas that lie at the heart of most projects of Europe. In so doing, we critically re-examine and fruitfully redefine 'integration' to include longer-term processes and a broader range of institutions. These chapters bring to light a number of actors, institutions and forums not normally considered in formal histories of integration, which allow us to historicize and contextualize the European Union's role as one actor in a larger and longer-term ensemble of processes that have integrated – and fragmented – societies in Europe. Opening up and exploring these processes further presses the history of technology's polemic agenda of challenging overly deterministic accounts of technology's role in shaping society. In an era when technological projects play an increasing role in the construction and governance of European spaces, simplistic stories about technology and Europe are in greater circulation than ever. Second, building on the insights of transnational history to focus on the European scale, this book productively exposes limitations in frameworks of nationalization and globalization, as well as more localized frameworks of urban history, which have dominated historical approaches to infrastructures up to now. While studies aimed at the national level have rightly stressed the role of infrastructures in projects of nation state consolidation, histories of globalization have further stressed the role of transport and communication infrastructures in capitalist expansion and imperial projects.⁷ By focusing at the level of Europe, we are able to view these and other processes together and show the complex ways in which they are related. Finally, individually and collectively, the chapters assembled here offer conceptual tools, drawing on a range of disciplines, for understanding this history. But, before introducing some of these concepts, we will first locate this book within the broader landscape of literature and research in the field of European integration history, transnational history and European history of technology.

Broadening the scope of Europe and technology

The sense that Europe is related to infrastructural projects is common to both academic and lay observers alike. The increasing expansion of the European Union into various 'European' spaces and infrastructure policy arenas on the one hand, and the persistence of simple and overdetermined narratives of technology, modernization and European integration on the other, make detailed historical exploration of these topics timely, if not urgent.⁸ This realization has led recently to the establishment of a research agenda based largely among historians of technology, which has sought to place such questions at the centre of scientific research.⁹ Within this broader research agenda, material infrastructures and networks such as

roads, railways, electricity grids, waterways and so on, long viewed as some of the most important aspects and engines of modernization processes, necessarily play an important role. The current volume is the product of a research project embedded within this framework, devoted to a long-term historical analysis of the building of transnational infrastructures in Europe in their material, institutional and discursive complexity.¹⁰ Building on core concerns of the history of technology, this project draws on and speaks to key ideas in transnational history, European integration studies and mobility studies, among others, to open up challenging new ways of coming to grips with the historical project of Europe.

As van der Vleuten and Kaijser show in a recent review of the historiography of infrastructures and Europe, the building and use of material networks has usually been a sidelight at best in much of the grander historiography of Europe.¹¹ Where the role of such networks is mentioned, it is very often in terms that acknowledge their role in transforming society, but far less often to offer a detailed analysis of the complex and contested processes by which such structures came about. While studies on the processes of modernization and globalization in the social sciences have long noted the importance of such structures, analysis of the contingent processes that have gone into the construction, linking and maintenance of such networks has been of secondary concern. Concurrent developments in a number of disciplines seem poised to change this situation and open up a number of avenues of inquiry, to which the current volume will speak.

First and foremost, this volume aims to offer new perspectives on the history of European integration. As Jost Dülffer has shown in a recent historiographical essay on European integration literature, this literature is characterized by a number of prominent master narratives, reflecting the different stages or periods of scholarly debates on the aims and goals of contemporary historiography of Europe after the Second World War, which is generally seen as the crucial point of reference for the start of a new era of European integration initiatives.¹² Following Dülffer, much of European integration historiography is characterized by a master narrative that he somewhat provocatively labels the 'Christmas story' of European integration in allusion to the German tradition of lighting candles every Sunday of an advent wreath. This 'Christmas story' 'narrates the expansion of European wreath from six to nine, to twelve, fifteen and now at present twenty-seven states', reflecting a teleological master narrative which 'accepts delays, stand-stills, relaunches and – maybe – also crisis'.¹³ This Christmas story of European integration, based on 'a snow ploughing after the [political] events' and dominated by sectorial studies reflecting the emergence of European institutions and agencies, has of course been challenged by authors such as Alan Milward and John Gillingham, who have developed prominent alternative narratives, stressing the persistence of national interests and criticizing the excessive bureaucratization of the political institutions. According to Dülffer, there are

at least four other limitations to the ‘Christmas story’ approach. First, there is a neglect of institutions other than the core political institutions such as the European Coal and Steel Community (ECSC), the European Economic Union (EEU) or the actual European Union in its different constellations. Second, he detects a neglect of the role of the United States as crucial actor in the integration process. Third, he criticizes the under-representation of Eastern Europe, especially the USSR, as important players in a Cold War that formed the general political frame for the European integration process. And finally, Dülffer emphasizes the urgent need for a broader cultural approach to the European integration process under the label of ‘Europeanization’ as represented – for example – in the works of Hartmut Kaelble.¹⁴

We take Dülffer’s description of the state of the art in European integration literature as an open invitation to demonstrate the various ways in which the present volume speaks to these lacunae and in which ways it offers – at least partially – new insights and perspectives in European integration history. First, the volume offers several chapters dealing with institutions or sectors largely neglected by the European integration literature. Second, several articles emphasize the role of the United States as instigator or perceived threat – or both – in such processes. Third, the volume offers – both in the introduction and in several chapters – a critical reflection of the cultural dimension of European infrastructures and institutions. Finally, all chapters are inspired by a transnational perspective on European integration, which not only stresses the integrative effects of European infrastructures, but also underlines the inherent tensions of fragmentation and de-linking – a topic not addressed at all by Dülffer.

This book opens new avenues into the study of European integration by taking a transnational approach to the study of infrastructures. The term ‘transnational’ itself has a long, complex and contested history, and its meanings are far from settled.¹⁵ From these ongoing debates there are several key points we take up in this volume. First, we embrace the relatively broad definition of transnational history as that which concerns itself with flows over national borders. As Pierre-Yves Saunier argues, ‘[i]t means goods, it means people, it means ideas, words, capital, might, and institutions.’¹⁶ Second, we consider this loose definition of ‘going transnational’ as a means of sharpening empirical focus; approaching European infrastructures as transnational problems means using them as guides to charting as precisely as possible the flows and limitations of materials, actors and discourses.¹⁷ Third, we embrace the ‘national’ in the term, in so far as it allows us not only to re-contextualize the role of nation states, which are undoubtedly important actors in the period this volume charts, but also to think precisely about other categories such as the ‘global’ or the ‘European’. A glance into the history of infrastructures quickly reveals how the circulation of things, people and knowledge has only ever been partially circumscribed by nation states. Many major networking projects, from railways to electricity to broadcasting, began as

private, often international, initiatives fuelled in part by the transnational circulation of technical knowledge and capital. The establishment of state monopolies over infrastructures was either soon accompanied or even preceded by international regulatory bodies, either intergovernmental organizations, such as the International Telegraph Union (ITU, founded 1865), or non-governmental, such as the International Council on Large Electrical Systems (CIGRE, founded 1921) and the International Broadcasting Union (IBU, founded 1925).¹⁸ Obviously nation states are relevant to the history of these processes, but taking a transnational approach allows us to see them as embedded in broader processes in which they are not necessarily the main actors, but nevertheless exercise power and agency in new ways.¹⁹ We take the same impulse that has led to the fruitful decentring and contextualizing of the nation to develop a historiography of European integration that decentres and contextualizes the European Union and its predecessors as one entity and process among many others. Transnational infrastructures are a prime location for such an agenda because they existed prior to the formal processes of European integration. Furthermore, even after the process began, the institutions responsible for networking Europe and governing such systems long stood outside the notice of such processes. The essays in this volume by Schipper et al. and Johan Schot in particular place these institutions in the wider framework of international organizations, both intergovernmental and non-governmental, that mark one of the key fields of transnational history research.²⁰

In an article laying out the initial agenda for this project, Thomas J. Misa and Johan Schot have suggested that the notion of European integration might be usefully expanded beyond the political, economic and cultural processes set formally in motion after the Second World War. Instead, they argue, we should include what they call 'hidden integration' – that is, hidden from the gaze of formal European integration studies because it points to processes that occurred partly independently of the political, economic and cultural processes officially taken up under the rubric of integration, but have nonetheless played a profound role within all these processes.²¹ In opening up 'integration' to include broader processes, they suggest that we must also be alert to the processes of fragmentation, de-linking and disintegration that have also been, and will continue to be, evident, and to some extent inherent, in such projects.²² These processes of linking and de-linking have been at the heart of the recent volume *Networking Europe*, edited by Arne Kaijser and Erik van der Vleuten.²³ In that volume, authors describe the development of a number of projects, beginning with the advent of railway and telegraph networks. The authors concentrate on the construction of systems, and mainly highlight national actors who have created, or sought to create, networks that operated across national boundaries in international, bilateral and also unilateral processes.²⁴ Our book is intended to build further on this agenda by placing 'Europe' more problematically

at the centre of its inquiry. Where the authors of the previous volume have highlighted transnational processes *in* Europe (whilst being careful not to essentialize it), we ask what roles particular notions and spaces of Europe have played in the construction, use and/or failure of various material systems. What visions and projects of Europe have such networks and the processes of their construction made visible? How have material structures shaped practices and definitions of Europe?

Attending to these issues historically will add to the increasing scholarly attention being paid to technological infrastructures in a broad range of disciplines in the humanities and social sciences as they come to grips with the current spaces of Europe and beyond. Most specifically, this speaks to the emerging 'new mobilities paradigm' across a broad range of disciplines, which has focused attention on various systems that have mobilized – and moored – people, things and images, and how these mobilities and moorings have transformed the various spaces and times of interaction.²⁵ Indeed, this paradigm claims as a core research agenda 'an analysis of the relation between mobility systems and infrastructural moorings, especially as pertains to the rescaling and restructuring of spatiality under different regimes of economic regulation and state and urban governance'.²⁶ An important part of this emerging focus, one that is well in keeping with our agenda of understanding the processes of linking and de-linking, is the growing insistence on understanding the power dynamics of relative mobility: *who* and *what* may move in relation to which 'fixed' people and places. As the EU steps increasingly into the role of technical expert, so, too, are scholars beginning to take up the challenge of understanding the ways in which technologies are increasingly becoming part of the politics of the EU.²⁷ Recent work on planning at the European level has shed important light on the role of infrastructures in shaping EU policy.²⁸ Particularly as the notion of 'network Europe' gains currency in examining recent configurations of the European Union, a more thorough understanding of the complex processes of building and using transnational networks in Europe over a broader period of time can help to construct critical genealogies of such projects in order to capture their novelty as well as revealing strong continuities.²⁹ As Ginette Verstraete notes, artists are beginning to draw upon multiple alternative histories of transnational mobility to query current EU infrastructural agendas.³⁰ Though our tools and goals might differ, surely there is room for transnational historians to follow.

The 'Europe/technology uncertainty principle' and the question of scale

As promising a site as material infrastructures are for exploring European stories, they present a number of challenges as well. Infrastructures are, once embedded, nearly invisible but also, as Dirk van Laak notes, possess

'a signifying power of sometimes utopian quality'.³¹ They are deeply political and yet often appear to follow 'neutral' technological principles. Trying to come to grips with the connections between infrastructures and Europe, one is quickly faced with what seems to be a paradox, one that came to the fore in many discussions surrounding the essays collected here, which we call, with playful allusion to Werner Heisenberg, the *Europe/technology uncertainty principle*. Put simply: the more one explores the grand aims, spatial visions and contested projects of Europe that inform the building and mediate the use of transnational systems, the more the unique material aspects of the systems fade from view. On the reverse side, the closer one comes to understanding the technologies of connection, that is, the mechanisms, standards, protocols and conventions that allow systems to connect and interoperate, the 'European' aspects soon become nebulous, if apparent at all. The questions remain as to what makes a system 'European', and what work 'Europe' actually did or does in its creation and/or operation.

Upon closer inspection, this principle is not so much a paradox as a conflation of two different, but closely linked, historical processes that intersect within infrastructures. The 'Europe' side of the principle looks to the mobilizations and appropriations of technologies for a number of projects of Europe. We argue in this book that the formal processes of economic and political integration normally understood under the term 'European integration' must be seen as one among many such projects. The 'technology' side describes the proliferation of systems, standards and practices that are part of broader processes of globalization and modernization processes more generally, but which also channel mobilities through European spaces specifically. These twin processes are also full of contradictions. Projections of Europe often cover over disjunctures of systems and spaces, as they do in tourist maps showing smooth European networks, even across the 'Iron Curtain', or in the experiences of cosmopolitan air tourists between the World Wars. In other cases, technological systems are often closely integrated in spite of sharp political or economic divisions in spheres, largely because they operate outside the notice of those spheres. The League of Nations' Organization for Communications and Transport, for example, was in many ways more effective than the body's political committees, and was able not only to achieve international co-operation but also to establish general regimes for negotiation.³²

The dynamics of our so-called 'uncertainty principle' become most apparent when we try to understand them at macro scale, which is the particular 'transnational problem' this volume takes up. Chapter authors were given two basic guidelines: they should explore empirically the processes of building and/or using transnational infrastructures, and how these processes related to the shaping, definition, experiences and practices of Europe in the twentieth century. Furthermore, studies should not be based around national case studies but rather should focus on infrastructure developments

at the European scale. The task of studying 'infrastructures at European scale' is, of course, not straightforward. Precisely because it lacks the rigid territorial boundaries and more or less centralized governing institutions of nation states, 'Europe' is what might be called a notoriously inaccurate scale for academic inquiry, particularly when studied over any sort of longer time period. Assuming that 'Europe' is – and always has been – a discursive construction, the problem begins with the very definition of Europe. As Achim Landwehr and Stefanie Stockhorst have shown, the concept of Europe has been an object of continuously negotiated meaning for various aims.³³ On all these dimensions – religious, spatial, political and historical – there are multiple definitions of where – or what – Europe is.³⁴ We think that Europe might best be characterized as a never-ending story, or – in the words of the German sociologist Richard Münch – as an ongoing project.³⁵ Like the process of western modernization, so too the process of European integration – hidden or visible, unintended or planned – was and will be a highly contested and conflict-riddled procedure.

Taking up the challenge of the uncertainty principle, we must ask in each case whether, when, for whom and to what extent 'Europe' is a matter of scaling up from national and/or regional processes, or simply a projected 'space of compensation' for processes of collective self-reassurances or a 'horizon of expectation' for transnational identity constructions.³⁶ The always already problematic scale of Europe is a constructive site for a more precise interrogation of other, more essentialized, scales of the 'national' and the 'global', and enable us to grasp their dynamics and problems more concretely and more precisely.³⁷ At the same time, a transnational approach to studying infrastructures, as we propose here, can help us to understand stories of Europe that transcend issues of scale. As Pierre-Yves Saunier reminds us, the promise of the transnational lies not in considering it as

another scale located near the top of the nested scales, but rather a foray that cut[s] through levels and partly shatter[s] their conception as distinct entities. Accordingly, the transnational perspective allows a direct window onto the circulations and connections whose actors and structures seize these different social spheres, simultaneously or regardless of their 'nested' order.³⁸

This is particularly the case in considering 'European integration'. A transnational focus on infrastructures does not merely add more threads to the already fraught weave of European integration, defined as a political process beginning after the Second World War; in fact, it challenges the very definition of that process while opening several potentially fruitful avenues for addressing that challenge. From an external perspective, studying the material spread and use of infrastructures provides one means of investigating the extent, the limits and the uses of systems that pass for European. From

the point of view of network design and planning, for example, Turkey (at least as far as Istanbul) has been more closely involved in many 'European' networks than many nations whose 'European-ness' has been far less the subject of debate.³⁹ Moreover, as Dirk van Laak's chapter in this volume shows, the imperial logics at work in early cross-border infrastructure development argued against a notion of Europe as a natural unit of infrastructural connection. In the wake of the two World Wars, Europe came increasingly to be seen as an unruly administrative unit that could be addressed with similar technocratic projects of spatial reordering.

By looking to realms of international and transnational co-operation that are overlooked in historical accounts that focus on the nation state, the studies here thus also highlight new power dynamics between institutions, nations and individuals. Following the processes of infrastructural development can give us valuable insights into the extent to which spaces have been re-territorialized, and how. As Patrick Kammerer's essay here shows, the emergence and recognition of a protected European market space played a vital role in the struggle over standards for mobile telephony. At the same time, following the institutions and long-term plans for infrastructure building in Europe also reveals that many of the present biases toward Western Europe in the processes of formal European integration have predecessors from before the World Wars. To a certain extent, following these transnational actors has necessarily carried this geographical bias over into this book. However, this allows us to cast a precise eye on how power was exerted within these technical forums and see how apparently less powerful or 'central' nations and actors were able to use them to exert specific forms of power, often by softening their own territorial regimes to better channel infrastructural flows. Furthermore, by opening up the definition of integration, we also created the groundwork for exploring integrative processes from other regions and regimes, particularly those of Central and Eastern Europe.⁴⁰

It is also important to recognize that infrastructures pose their own challenges of definition and scale. They are often understood, both in some academic discourse and everyday common sense, as hard-wired structures that slowly evolve, interlink and expand – and occasionally decay.⁴¹ But they also present a far more protean face to users and academic observers alike. Their very definition proves problematic, if we accept that infrastructural systems are composed as much of institutions, routines and discursive practices as of material artefacts. Furthermore, the linkages of multiple systems, such as railways and electrical systems, or the growing links between broadcasting and road systems, make it difficult to define where a single 'infrastructure' starts and stops.⁴² As Paul Edwards suggests, infrastructures are most easily defined negatively, as those systems without which modern life does not function.⁴³ This means that infrastructures can never be defined simply in material terms of what they *are*, but only in terms of what they *do*, and as

such, they can only be understood in terms of the social structures and cultural meanings in which they function.

Edwards fruitfully argues that infrastructures can be – and indeed must be – studied at multiple scales to fully grasp their often contradictory dynamics.⁴⁴ Dramatic change at one scale often goes unnoticed at higher or lower scales. On the other hand, particularly at major nodes or linking points such as the Channel Tunnel, the Öresund bridge or the Gotthardt Tunnel, the presence of local, national, ‘European’ and global systems becomes visible simultaneously, in often problematic relation to each other.⁴⁵ Among urban historians, infrastructures have long provided a means of tracing the complex interconnections and power relations of the city.⁴⁶ Indeed, as Graham and Marvin have pointed out, such systems can also ‘splinter’ the very cities, nations or continents they appear to hold together.⁴⁷ It follows from this that, if we take ‘Europe’ as an actor category, the various transnational networks that crisscross, intersect and help to define it cannot be treated any differently. To suggest this does not downplay the importance, the obduracy or what Bruno Latour would call the ‘agency’ of material systems in shaping social relations, practices and spaces.⁴⁸ Nor does it de-emphasize the intersections between such systems and the struggles for power over and through them. On the contrary, it calls us to examine precisely these issues, but it insists that we also consider a broader range of actors (human and non-human), arenas and struggles if we are to capture the ‘European’ dimensions of infrastructures. The building of new technologies has often been accompanied by visions of connectivity and social transformation that went well beyond the boundaries of both nations and contemporary technological and/or economic feasibility. At the same time, many infrastructural ‘networks’ would not have been considered as such by engineers at all, but were disparate systems that were only ‘linked’ by regimes of use and representation, such as tourism.⁴⁹ Following such processes gives us insight into the way that transnational networks have been appropriated and made to signify in terms of Europe.

The goal of this volume is not to provide a ‘Copenhagen interpretation’ of this problem, that is, to present an overarching model for explaining the complex dynamics of infrastructures and European integration.⁵⁰ Indeed, we would argue that the shifting contexts, scales and processes we describe here would preclude such models, and that the varying approaches of our authors would rapidly undermine the effort. Instead, we seek here to highlight important sites where these complex dynamics become apparent, and show how multidisciplinary inquiry can begin to come to terms with them historically by holding them in tension with one another. With this in mind, we propose here two basic concepts for coming to terms with this challenge: *mediating interfaces* and *events*. We conceive of these as frameworks of time and space that allow us to bring the stories of technology and of Europe into the same narrative frame. In laying out these concepts, our goal

is not merely to introduce the chapters assembled here, but also to make a programmatic call, together with our assembled authors, for work that will go even further in untangling the stories of technological infrastructures and Europe.

Infrastructures as mediating interfaces

Infrastructures mediate. They are structures ‘in between’ that allow things, people and signs to travel across space by means of more or less standardized paths and protocols for conversion or translation. Thinking of infrastructures as *mediating interfaces*, that is, as points of interaction and translation on material, institutional and discursive levels allows us to get to the heart of the dynamics we seek to capture. Points of mediation at the material level can be found in ‘gateways’ between systems, such as the standardized shipping container (developed in part through international organizations such as the International Union of Railways) or the variable-axle train (recently developed to solve the long-standing difference in railway gauge between French and Spanish railways), which allow incompatible systems to be linked and expanded.⁵¹ Such gateways, as Edwards et al. remind us, cannot be seen as ‘merely’ material, but rather ‘as combining a technical solution with a social choice, i.e. a standard, both of which must be integrated into existing users’ communities of practice’.⁵² In other words, such material mediation almost always requires social or institutional *mediators*, which we can understand as the institutions and individuals who work among those institutions to govern and shape infrastructural use.⁵³ Not all system mediators are those who build and govern systems; actors such as advertisers, educational bodies and consumer groups have often played important roles in shaping the design, meaning and use of infrastructures.⁵⁴ Finally, we may conceive of infrastructures themselves as *media* in the common-sense understanding of the word, as systems that structure relations and transmit images and signs across distances. Railways, for example, surround travellers with signs that frame travel in terms of state authority (insignias of national railways), class, national landscapes, and so on.⁵⁵ These aspects are not peripheral but central and integral to the meaning and experience of using the railways. Besides channelling and shaping such messages, infrastructures also acquire symbolic meanings of their own, as in the ambiguous symbolism of trains we pointed to at the start of this chapter.⁵⁶

Viewing infrastructures as mediating interfaces in a number of interactions thus allows us to see how the material, institutional and discursive structures fit together. A look at broadcast infrastructures can exemplify this. On the *material level*, transmitters, networks of relay stations, cables and satellite dishes are evidence of Europe as a technically connected communication space. Because of the differing line and colour standards between Germany and France, points for signal conversion have long played a key

part in such networks. On the *institutional level*, European broadcasting institutions such as the European Broadcasting Union, and telecom institutions such as the Conférence Européenne des Administrations des Postes et des Télécommunications (CEPT) and the International Telecommunication Union (ITU), have created crucial gateways for transnational interaction, on the technical and juridical level as well as on the level of intercultural communication. This institutional level stands for Europe as a social space. Combining the material and institutional approach with a discursive analysis of the transmitted and received contents of broadcast programmes means investigating the tensions between the intent of transmitting European sounds and images and their individual and creative appropriation. Sonic and visual icons of European broadcasting, like the ceremonial pomp of the Eurovision hymn, attempt to imbue the realm of technical connection with meaning as a European cultural space.

Less overtly communicative infrastructures can be approached in the same way. In Barbara Bonhage's chapter on the Eurocheque system, for example, a number of banks in Europe, fearing competition from the United States, attempted to create a system of payments that would compete technologically. They created the Eurocheque, which was a paper 'gateway' that allowed currency to be transferred between the banking and retailing systems in different countries. This defined a 'European' – or at least 'Eurocheque' – space that was at once a space of material circulation (where the cheques/funds move), a space of institutional governance and a discursive construction (a protected market or a business/tourist zone). The materiality of the system proved to be its downfall, as the volume of paper to be dealt with as the system grew more popular with increasingly mobile banking customers. At the institutional level, the Swiss banking association was able to help push for closer collaboration between banks, and indeed the development of such a system on the Western European scale helped to create a platform for developing further European mass payment systems. At the discursive level, the desire to define Europe defensively against the US in banking circles played a vital part in being able to establish the system, while the very name on the cheque helped to define the mobility of its international users as European. By tracing these varying levels of mediation carefully over time, the complicated and often contradictory dynamics of Europe and infrastructures begins to become visible.

'Eventing' European infrastructures

As we have seen, the material, institutional and discursive aspects of infrastructures 'interact' in various forms. But how can we as historians make these various processes visible at the same time? We think that this can best be done by focusing on what we call European infrastructural events. These we define as extraordinary occurrences that bring multiple elements

and levels of infrastructures into view and reconfirm and/or reorganize the relations between them. Classic types of event are moments of linking, as in the building of a bridge or tunnel, or indeed moments of failure, as in the major electric system failures in 2003 and 2006. What distinguishes events from everyday experiences is the fact that they call attention to forms of mediated participation and are often highly ritualized. Preparing, organizing, staging and transmitting (live) a programme such as the 'Eurovision song contest' to millions of people in Europe and abroad means transforming a concrete historical moment into a European event, a ceremonial occasion for the affirmation of 'Europe' as a cultural space.⁵⁷ But, following the reasoning of the British anthropologist and media sociologist Nick Couldry, these phenomena of 'transnational communion' through infrastructures are privileged moments not because they are *expressions* of a Europe that really exists, but because they reveal the mythical *construction* of the mediated centre (Europe) at its most intense.⁵⁸ Our experience of Europe is of course not limited to these extravagant and rather infrequent moments of mediated participation. As sociologists have argued, our 'event society' is deeply shaped by numerous unspectacular, everyday experiences of technologies and infrastructures, often characterized by routinized and unconscious forms of action.⁵⁹ The real challenge here is how to describe or analyse these habitual interactions with technical infrastructures as 'European' without inscribing the theoretical horizon of expectation (our research question) into the materiality of the objects of study (infrastructures) or the mental disposition of their users. The Eurostar high-speed train is covered with markers of its 'European-ness', and taking it is often an 'eventful' occurrence for passengers, but does the trip under the Channel really produce a sense of 'European-ness' in passengers' minds? From personal observation, we note that encounters between travellers in the supposedly 'cosmopolitan' environment of the Eurostar train can just as well reinforce national stereotypes and prejudices. For regular travellers, by contrast, the whole process is mostly 'uneventful'. Being alert to these dynamics of eventfulness in technical encounters can help us to read them in such a way as to understand the complicated ways that infrastructures allow people to do 'European' things.

As both grand-scale events, like the song competition, and the smaller-scale example of the Eurostar journey can reveal, events are also characterized by actors within them (human or otherwise) *performing*. That is to say, they step into a recognized role that emphasizes specific aspects of their appearance. As the anthropologist Bryan Pfaffenberger has argued, we can view processes of infrastructural development as 'technological dramas':

To emphasize the metaphor of drama, too, is to employ a richer metaphor than text. It is to emphasize the performative nature of technological 'statements' and 'counterstatements', which involve the creation of scenes

(contexts), in which actors (designers, artefacts, and users) play out their fabricated roles with regard to a set of envisioned purposes (and before an audience), and it is also to emphasize that the discourse involved is not the argumentative and academic discourse of a text but the symbolic media of myth (in which scepticism is suspended) and ritual (in which human actions are mythically patterned in controlled social spaces).⁶⁰

During dramatic European events, actors make use of a well known pro or anti-European rhetorical toolbox either to laud artefacts or systems as symbolic performances of European spirit and unity, or to corral European dreams into secure national or regional borders. Eve Darien-Smith has shown how, at the eventful birth of the Channel Tunnel, the EU anachronistically appropriated it as a flagship project of the Trans-European Transport Network (TEN-T), and the Thatcher government appropriated it on the national stage as an economically pragmatic internationalist, and nationally glorious, accomplishment. To many who were much less visible on the international stage, it was a blatant loss of sovereignty to an overbearing Frenchified European Union and 'the rape of Kent, the garden of England'.⁶¹ The more specialized arenas of technical experts, such as the annual meetings of international organizations, can also be read as European events, where power is expressed through performance. Representatives of smaller or less powerful nations, in particular, have often been able to use the performances of technical expertise or European unity to position themselves more centrally on the European stage. As we argued more generally above, these often contradictory or ambiguous discourses on European technological events are not just rhetorical 'background music' to the somehow more 'real' material or political systems; instead, both the material and the discursive elements of such events play equally key parts in understanding what the technology *does*. European technological events are expressions *par excellence* of dramatic narratives, melding the fractious ingredients into a highly complex and intricate story. By looking to more visible 'eventful' moments, we begin also to gain insight into the ways in which 'normal' meanings of Europe have been constructed, internalized, reactivated and renegotiated over time.

Structure of the book

To capture the dynamic transnational stories bound up in European infrastructures, we have chosen a structure that augments the lengthier chapters addressing the building and use of transnational infrastructures with a series of short 'biographies' of things, people, ideas and symbols that have circulated through them in various ways. These biographies both illustrate the transnational trajectories of the material, social and cultural forces that work through technologies to shape them.⁶² The book begins with a

trio of essays that complicate common understandings of the relationships between ideas of Europe and transnational infrastructures by opening. In the first essay, Dirk van Laak explores infrastructural links between Europe and Africa to reveal the multiple ways in which projects for European network integration were entwined with imperial projects. Van Laak shows that 'Eurafrica' was either implicitly or explicitly a consistent project for network plans from the age of imperialism until well after decolonization. He suggests that much of the expertise and ideas that had gone into colonial projects before the war was turned inward into the project of European integration after the war. Alexander Badenoch's chapter analyses the important symbolic role played by infrastructures in constructing ideas of Europe. He analyses network maps as a means of creating standardized knowledge that reconciles spaces of technological circulation with ideas of territory, arguing that networks and territories mythically construct each other. Such representations not only reflect perceptions of networks in relation to Europe, but can be seen as performances where meanings of Europe and infrastructures have been constructed and contested. Johan Schot's chapter rounds out the section, exploring the links between infrastructural development and the post-Second World War processes of European integration by tracing the complex position of the transport and energy sectors in early movements toward political integration. He shows how these sectors were already governed by groups of 'technocratic internationalist' experts (a term he coined with Vincent Lagendijk⁶³), who integrated these sectors while deliberately keeping them outside the formal European institutional structures. He argues that focusing on state actors as the sole force in European integration has led to a fundamental misunderstanding of the process as unidirectional and stemming from central European institutions. The focus on infrastructures allows an expanded concept of integration that takes multi-centred governance and processes of fragmentation into consideration. The section's two biographies highlight the non-material functions of infrastructures in projects of European integration. Frank Schipper's discussion of the various debates surrounding the 'capital city' of Europe shows how visions of networkedness played key roles in arguments for specific cities – and also in the construction of the polynuclear capital. Waqar Zaidi describes the role of the technology in the thoughts of early theorists of integration, David Mitrany and Ernst Haas.

In the second section, essays explore the processes of transnational mediation that have gone into constructing infrastructural networks. They pay particular attention to the mutual construction of material systems and the shaping of institutional actors and arenas. Schipper, Lagendijk and Anastasiadou describe the work of the Technical Committee for Communications and Transport (OCT) of the League of Nations. By looking at the long-ignored work of its three subcommittees, they show how 'Europe' emerged in OCT efforts as both the focus of their technical efforts

and a realm in which they could be effective. In so doing, they re-evaluate the narrative of the League's 'failure' and point to the ways in which it was able to lay important groundwork for successful international co-operation in the future. Erik van der Vleuten shows how a number of existing transnational systems were linked to form a new complex network for food delivery on a European scale. He explores in particular the role of the United Nations Economic Committee in Europe's working party on perishable foodstuffs to show how they conceived of and implemented a network for the circulation of food in Europe. He shows how they used the notion of 'perishable foods' in a number of different policy arenas to attempt to build what he calls a 'second order' system. Carefully studying the results of this, he also reveals the fragmented contours of a number of different 'food Europes' that emerged in spite of the connections that were made. Both of these chapters, like Schot's chapter, reveal the power of existing European networks of experts in the infrastructural sector that limited or aided the efficacy of political actors. The biographies in this section all examine the ideas of such experts. Christian Henrich-Franke's discussion of European 'founding father' Louis Armand highlights Armand's embrace of technology as an important sphere of integration. The importance of common visions in such holding together expert networks is shown by Vincent Lagendijk's biography of Oskar Oliven's inter-war plan for a European electricity grid, which, though never built, has remained an important touchstone in engineering communities to the present day.

Two further case studies in this section look at the development of network standards. In each of these cases, the changing frameworks of European integration (intended in its broader sense) played a profound, and often unexpected, role in the rise, transformation and/or demise of the systems in question. Barbara Bonhage looks at the harmonization of payment systems among banks in Europe through the Eurocheque system. In an interesting double narrative, she shows on the one hand how the example of the United States led bankers in a number of European countries to join together to create a viable 'domestic' competitor. Patrick Kammerer tells a story of multiple expansions of the GSM standard, which took place as various national actors 'discovered' the expanded – and yet protected – market space of Europe. Colonizing this space technologically by creating a European standard, in turn, helped to define a European space in other ways – for the users of mobile phones as well as network providers – which then in turn helped the 'European' standard to 'go global'. Leonard Laborie's short biography of the French telecom pioneer Georges Valensi complements – and complicates – these two chapters together nicely, showing how Valensi's transatlantic experience marked both his national and international dealings with various standards for communication.

The papers in the third section emphasize the performances of Europe that have taken place through transnational infrastructures. In particular,

they all point to the tensions and disjunctions between the material and institutional processes of linking and co-ordinating, and some of the eventful performances built upon such linkages. Andreas Fickers and Suzanne Lommers look at the creation of a number of 'European' events created through European broadcasting federations at various points in the twentieth century. They highlight the very different, and often conflicting, notions of nations and Europe that have gone into these events at the material, institutional and discursive levels, and point to how the creation of such events has shaped practices of both transmitters and receivers. Nil Disco highlights the various negotiations and performances of Europe that surrounded engineering projects on the 'natural' infrastructures of rivers. Such visions and performances of a unified Europe, he suggests, represent a key mechanism by which 'committed spectators' at specific points on a river can influence actions in arenas over which they have no formal control. Eda Kranakis finally brings together material, institutional and discursive layers of infrastructures to highlight a similar disjunction between the pragmatic, competitive and often fragmenting international politics that went into shaping the institutions and routes of early civil aviation on the one hand, and the performed narratives of a cosmopolitan European identity that informed the experience of air tourism on the other. In particular, she shows the possibilities, as well as the limits, of such newfound mobilities on a continent ruled largely by nations pursuing policies of 'hegemonic nationalism'. The final two biographies bring these ideas together to look at the ways in which imagined present and future Europes were 'materialized' into artefacts: the dream of distant travel into radio station scales in the piece by Andreas Fickers, and the 'good atom', the short-lived hope of a safe and atomically united Europe permanently inscribed on Brussels' Atomium. By learning to read such stories of Europe in technology, we can begin to unpack the complicated and fragmented stories of technology and Europe.

Notes

1. For some description of the project see the website of its present incarnation in Brussels: <http://www.expo-europe.be/en/site/musee/musee-europe-bruxelles.html>. Access date 21 March 2009.
2. *Museum van Europa* (Brussels: Museum of Europe 2004), p. 28.
3. For critiques of this narrative, see Jan Nederveen Pieterse, 'Fictions of Europe', *Race and Class* 32(2) (1991), pp. 3–10; Cris Shore, *Building Europe: The Cultural Politics of European Integration* (London: Routledge 2000), pp. 59–60.
4. See Akira Iriye, *Global community. The role of international organisations in the making of the contemporary world* (Berkeley: University of California Press 2002).
5. See Waqar Zaidi, *Science and Technology & Liberal Internationalism in France, the United States and Great Britain, 1920–1945* (PhD Thesis, Imperial College, London, 2009).
6. See Jo-Anne Pemberton, 'New worlds for old: the League of Nations in the age of electricity', *Review of International Relations*, 28 (2002), pp. 311–36; Shore, *Building Europe*, pp. 113–14.

7. Daniel Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850–1940* (Oxford: Oxford University Press 1988); *The Tools of Empire: Technology and European Imperialism in the Nineteenth Century* (Oxford: Oxford University Press 1981). See further Dirk van Laak, *Imperiale Infrastruktur. Deutsche Planungen für eine Erschließung Afrikas 1880 bis 1960* (Paderborn: F. Schöningh 2004).
8. Ole B. Jensen and Tim Richardson, *Making European Space: Mobility, Power and Territorial Identity* (London: Routledge 2004).
9. See Tensions of Europe <http://www.tensionsofeurope.eu>. See also 'Tensions of Europe' Special Issue, *History and Technology* 21(1) (2005).
10. The Transnational Infrastructures and the Rise of Contemporary Europe (TIE) Project: www.tie-project.nl, led by Professor Johan Schot and supported by the Netherlands Organization for Scientific Research under the VICI scheme (dossier-nummer 277-53-001). Key publications from this project to date include Vincent Lagendijk, *Electrifying Europe: The Power of Europe in the Construction of Electricity Networks* (Amsterdam: Aksant/SHT 2008); Frank Schipper, *Driving Europe. Building Europe on Roads in the Twentieth Century* (Amsterdam, Aksant/SHT 2008); Irene Anastasiadou, *In Search of a Railway Europe: International Railway Developments in Interwar Europe* (PhD thesis, Eindhoven University of Technology, 2009).
11. Vleuten and Kaijser, 'Networking Europe', *History and Technology* 21(1), pp. 26–31.
12. Jost Dülffer, 'The History of European Integration: From Integration History to the History of Integrated Europe' in Wilfried Loth (ed.) *Experiencing Europe. 50 Years of European Construction 1957–2007* (Baden-Baden: Nomos), pp. 17–32.
13. *Ibid.*, pp. 22–3. Ben Rosamond similarly describes how the language of describing integration entrenches such notions in 'The political sciences of European integration: disciplinary history and EU studies', in Knud Erik Jørgensen, Mark A. Pollack and Ben Rosamond (eds) *Handbook of European Union Politics* (London: Sage 2007), pp. 7–30.
14. Hartmut Kaelble, *Auf dem Weg zu einer europäischen Gesellschaft. Eine Sozialgeschichte Westeuropas, 1880–1980* (München: Beck 1987).
15. Some of the richer recent discussions include Iriye, *Global community*; Akira Iriye, 'Transnational history', *Contemporary European History* 13(2) (2004), pp. 211–22; Patricia Clavin, 'Introduction: defining transnationalism', *Contemporary European History* 14(4) (2005), pp. 421–40; Pierre Yves Saunier, 'Going transnational?'; Gunilla Budde, Sebastian Conrad and Oliver Janz, *Transnationale Geschichte. Themen, Tendenzen und Theorien* (Göttingen: Vandenhoeck & Ruprecht 2006). A good overview of their meanings and uses in the history of technology specifically, see Erik van der Vleuten, 'Toward a transnational history of technology: meaning, promises, pitfalls', *Technology and Culture*, 49 (2008), pp. 974–94.
16. Pierre Yves Saunier, 'Going transnational? news from down under', *History. Transnational* 13 January 2006 (<http://geschichte-transnational.clio-online.net>).
17. *Ibid.*
18. See Lagendijk, *Electrifying*, pp. 58–9, and Fickers and Lommers in this volume.
19. Michael Mann, 'Globalization, Macro-regions and nation-states' in Budde, Conrad and Janz, *Transnationale Geschichte*, 21. For other more detailed versions of these dynamics see Alan Milward, *The European Rescue of the Nation-State* (London and New York: Routledge 2000, second edition), and a very sophisticated account of these processes in recent decades in Neil Brenner, *New State Spaces* (Oxford: OUP 2004).

20. See Iriye, *Global Community*; Patricia Clavin and Jens-Wilhelm Wessels, 'Transnationalism and the League of Nations: Understanding the Work of Its Economic and Financial Organization', *Contemporary European History* 14 (2005), pp. 465–92; as an interesting corollary, which also charts a longer history, see Hartmut Kaelble, 'The historical rise of a European public sphere?', *Journal of European Integration History* 8(2) (2002), pp. 9–22.
21. Thomas J. Misa and Johan Schot, 'Introduction: Inventing Europe: Technology and the Hidden Integration of Europe', *History and Technology* 21(1). In the years since the original publication of the article, the term has already acquired a double meaning, denoting both areas of integration that scholars have overlooked in studying European integration and engineers' and diplomats' deliberate 'hiding' of their integrative activities from the gaze of politicians and the public.
22. Misa and Schot, 'Introduction'; for narratives of fragmentation, see Andreas Fickers' work on the line standards and colour TV formats in Europe, '*Politique de la grandeur*' versus '*Made in Germany*'. *Politische Kulturgeschichte der Technik am Beispiel der PAL/SECAM-Kontroverse* (München: Oldenbourg 2007); Andreas Fickers, 'National Barriers for an Imag(e)ined European Community: The Techno-Political Frames of Postwar Television Development in Europe' in Lennard Hojbjerg and Henrik Sondergaard (eds) *European Film and Media Culture, Northern Lights. Film and Media Studies Yearbook 2005* (Copenhagen: Museum Tusculum Press/University of Copenhagen 2006), pp. 15–36.
23. Erik van der Vleuten and Arne Kaijser (eds), *Networking Europe. Transnational Infrastructures and the Shaping of Europe 1850–2000* (Sagamore Beach: Science History Publications 2006).
24. See Helmut Maier, 'Systems Connected: IG Auschwitz, Kaprun, and the Building of European Power Grids up to 1945', in Vleuten and Kaijser, *Networking Europe*, pp. 129–60.
25. Some articulations of this focus are Nigel Thrift, *Spatial Formations* (London 1996) pp. 256–310; Mimi Sheller and John Urry, 'The new mobilities paradigm', *Environment and Planning A* 38 (2006), pp. 207–26; Kevin Hannam, Mimi Sheller and John Urry, 'Editorial: Mobilities, Immobilities and Moorings', *Mobilities* 1(1).
26. Hannam, Sheller and Urry, 'Editorial'.
27. Andrew Barry, *Political Machines: Governing a Technological Society* (London: Athlone 2001).
28. See Jensen and Richardson, *Making European Space*.
29. See the special issue on 'Rethinking European Spaces' edited by Chris Rumford, *Comparative European Politics* 4(4) (2006).
30. Ginette Verstraete, 'Timescapes: An artistic challenge to the European Union paradigm', *European Journal of Cultural Studies* 12(2) (2009), pp. 157–74.
31. Dirk van Laak, 'Infra-strukturgeschichte', *Geschichte und Gesellschaft* 27 (2001), p. 385.
32. See Schipper et al.'s chapter in this volume.
33. Achim Landwehr and Stefanie Stockhorst, *Einführung in die Europäische Kulturgeschichte* (Paderborn: UTB 2004), pp. 264ff. See also Gerard Delanty, *Inventing Europe: Idea, Identity, Reality* (London 1995); Bo Stråth (ed.) *Europe and the Other, Europe as the Other* (Brussels 2000); Anssi Paasi, 'Europe as a Social Process and Discourse. Considerations of Place, Boundaries and Identity', *European Urban and Regional Studies* 8(1) (2001), pp. 7–28.

34. See Bo Stråth and Mikael af Malmberg, 'Introduction: The National Meanings of Europe', in Bo Stråth and Mikael af Malmberg (eds) *The Meaning of Europe* (Oxford: Berg 2002), pp. 1–26.
35. See Richard Münch, *Das Projekt Europa. Zwischen Nationalstaat, regionaler Autonomie und Weltgesellschaft* (Frankfurt a.M.: Suhrkamp 1993).
36. See Alexander Schmidt-Gernig, 'Gibt es eine "europäische Identität"?' in Kaelble and Schriewer, *Diskurse und Entwicklungspfade. Der Gesellschaftsvergleich in den Geschichts- und Sozialwissenschaften* (Frankfurt: Campus 1999), pp. 163–216; David Morley has been particularly insistent on exploring the various and problematic ways in which increasingly destabilized notions of 'home' are remapped on and through changing structures of mediation. See his *Home Territories: Media Mobility and Identity* (London: Routledge 2000).
37. Michael G. Müller and Cornelius Torp indeed argue in a recent article that the polarity found in much scholarship between the global and the national 'involves the danger of neglecting space as a dimension of history altogether': 'Conceptualising transnational spaces in history', *European Review of History* 16(5) (2009), p. 611.
38. Pierre-Yves Saunier, 'Learning by Doing: Notes about the Making of the *Palgrave Dictionary of Transnational History*', *Journal of Modern European History* 6(2) (2008), pp. 173–4.
39. For an account of these forces at a local level, see also Noyan Dinçal, "'The Universal Mission of Civilisation and Progress". Infrastruktur, Europa und die Osmanische Stadt um 1900', in *Themenportal Europäische Geschichte* (2009): <http://www.europa.clio-online.de/2009/Article=348>.
40. Interesting work has already begun in this direction. See, among others, Katrin Steffen and Martin Kohlraush, 'The limits and merits of internationalism: experts, the state and the international community in Poland in the first half of the twentieth century', *European Review of History* 16 (2009), pp. 715–37; Jiří Janac, 'Europe through waterways: The European Coasts of Bohemia', *Tensions of Europe Working Papers*, 2008_8: http://www.tensionsofeurope.eu/publications/working/workingpdf/2008_8.pdf (accessed 11 July 2009).
41. This is more or less the dynamic explored by the Large Technical Systems (LTS) idea built upon the pioneering works of Thomas P. Hughes. For an overview, see Erik van der Vleuten, 'Understanding Network Societies: Two Decades of Large Technological Systems' in Vleuten and Kaijser (eds) *Networking Europe*, pp. 279–314; for a critical evaluation of both the merits and limits of the LTS approach see Bernward Joerges, 'High Variability Discourse in the History and Sociology of Large Technological Systems' in Olivier Coutard (ed.) *The Governance of Large Technological Systems* (London/New York: Routledge 1999), pp. 258–90.
42. The problem of coupling different systems was debated on several occasions during discussions surrounding this book. One way to address these problems is to focus more on the meso-level (as suggested by Schot in this book). Another possibility is discussed under the label of 'resilience'. See Hans Liljenström and Uno Svedin, 'Bridges, Connections and Interfaces – Reflections on the Meso Theme' in Liljenström and Svedin (eds) *Micro, Meso, Macro. Addressing Complex Systems Couplings* (London: World Scientific 2005), pp. 317–30.
43. Paul N. Edwards, 'Modernity and Infrastructures: Force, Time and Social Organization in the History of Sociotechnical Organizations' in Misa, Brey and Feenberg (eds) *Modernity and Technology* (Cambridge, MA: MIT Press 2003), pp. 185–226.

44. Edwards, 'Modernity and Infrastructures'.
45. See Eve Darian-Smith, *Bridging Divides: The Channel Tunnel and English Legal Identity* (Berkeley: University of California Press 1999); Per Olof Berg, Anders Linde-Laursen and Orvar Löfgren (eds), *Invoking a Transnational Metropolis* (Lund: Studentlitteratur 2000); Judith Schueler, *Materializing Identity: the co-construction of the Gotthard Railway and Swiss national identity* (Eindhoven: Aksant/SHT 2008).
46. See Maria Kaika and Erik Swyngedow, 'Fetishising the modern city: the phantasmagoria of urban technological networks', *International Journal of Urban and Regional Research* 24(1) (2000), pp. 120–38; Mikael Hård and Thomas J. Misa (eds), *Urban Machinery: Inside Modern European Cities* (Cambridge, Mass.: MIT Press 2008); Dinçkal, 'Universal Mission'.
47. Graham and Marvin, *Splintering Urbanism*. For a further discussion of the 'splintering urbanism' thesis, see Olivier Coutard, Richard Hanley and Rae Zimmerman, *Sustaining Urban Networks: the Social Diffusion of Large Technical Systems* (London: Routledge 2005).
48. Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford UP 2005).
49. See, for example, David Gugerli, 'The Effective Fiction of Internationality. Analyzing the Emergence of a European Railroad System in the 1950s', *Preprints zur Kulturgeschichte der Technik / 2003 / 17*: http://www.tg.ethz.ch/dokumente/pdf_Preprints/Preprint17.pdf (accessed 19 March 2007), and further Badenoch's essay in this volume.
50. For a popular explanation of the epistemological consequences or problems of modern quantum physics and on Nils Bohr's 'principle of complementarity' as an interpretation of Heisenberg's uncertainty principle see John Gribbin, *In Search of Schrödinger's Cat. Quantum Physics and Reality* (London: Bantam 1984).
51. Tineke Egyedi, 'Infrastructure Flexibility Created by Standardized Gateways: The Cases of XML and the ISO Container', *Knowledge, Technology & Policy* 14(3) (2001), 41–54.
52. Paul N. Edwards et al., 'Understanding Infrastructure: Dynamics, Tensions, Designs'. Report of a Workshop on 'History & Theory of Infrastructure: Lessons for New Scientific Cyberinfrastructures' (January 2007), p. 16. Online at: <http://www.si.umich.edu/InfrastructureWorkshop/documents/Understanding-Infrastructure2007.pdf>.
53. Some of these roles have been captured in the notion of the 'system-builder' in the Large Technical Systems (LTS) tradition, which looks to the actors who are able to embed technologies within social and institutional frameworks. See Erik van der Vleuten et al., 'Europe's system builders: The Contested Shaping of Europe's Road, Electricity and Rail Networks', *Contemporary European History*, 16(3) (2007) 321–47; further, van der Vleuten's chapter in this volume.
54. See Oldenzil, de la Bruheze and de Wit, 'Europe's Mediation Junction: Technology and Consumer Society in the Twentieth Century', *History and Technology* 21(1) (2005).
55. See Wolfgang Schivelbusch, *Geschichte der Eisenbahnreise. Industrialisierung von Raum und Zeit im 19. Jahrhundert* (Frankfurt: Fischer 1977).
56. Roger Silverstone and Leslie Haddon refer to this as the 'double articulation' of media as consumable objects as well as media for other products: 'Design and Domestication of Information and Communication Technologies: Technical Change and Everyday Life' in Robin Mansell and Roger Silverstone,

- Communication by Design: The Politics of Information and Communication Technologies* (Oxford: Oxford University Press 1996), pp. 44–74.
57. See the classical study of Elihu Katz and Daniel Dayan, *Media Events. The Live Broadcasting of History* (Cambridge, MA: Harvard University Press 1994).
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