"How is one to conceive of both the organization of a city and the construction of a collective infrastructure ?" Michel Foucault, (1984, 239)

"I should tell you of the hidden [city of] Berenice, the city of the just, [...] linking a network of wires and pipes and pulleys and pistons and counterweights that infiltrates like a climbing plant" Italo Calvino, (1974, 148) *Invisible Cities .*

"Cities are the summation and densest expressions of infrastructure, or more accurately a set of infrastructures, working sometimes in harmony, sometimes with frustrating discord, to provide us with shelter, contact, energy, water and means to meet other human needs. The infrastructure is a reflection of our social and historical evolution. It is a symbol of what we are collectively, and its forms and functions sharpen our understanding of the similarities and differences among regions, groups and cultures. The physical infrastructure consists of various structures, buildings, pipes, roads, rail, bridges, tunnels and wires. Equally important and subject to change is the 'software' for the physical infrastructure, all the formal and informal rules for the operation of the systems" (Herman and Ausubel, (1988, 1),*Cities and Their Vital Systems*

"The town is the correlate of the road. The town exists only as a function of circulation and of circuits; it is a singular point on the circuits which create it and which it creates. It is defined by entries and exits: something must enter it and exit from it" (Deleuze and Guattari, 1997, 186)

"Cities are like electrical transformers: they increase tension, accelerate exchanges,

"Cities accumulate and retain wealth, control and power because of what flows through them, rather than what they statically contain", (Beaverstock et al, 2000, 126)

"If the city is to survive, process must have the final word. In the end the urban truth is in the flow" Spiro Kostof, (1992, 305), *The City Assembled*.

Prologue : Tales of the Networked Metropolis

One: Downtown Cores on Global Grids of Glass: The fast-growing US telecommunications firm WorldCom/MCI recently built an optic fibre network covering only the core of central London. Only 125 km long, it carries fully 20% of the whole of the whole of the UK's international telecommunications traffic. This is only one of a rapidly emerging global archipelago of urban optic fibre grids, which concentrated in the urban cores of the World's 50 financial capitals in Asia, Europe, Australasia, and North and South America. Such networks serves no other places. A widening global web of transoceanic and transcontinental fibre networks interconnects these high capacity urban grids, which are carefully located to serve the most communications-intensive international firms. However, whilst the cores of global financial centres spaces reach out to the globe with unprecedented power, increasing efforts are being made to 'filter' their connections to their host cities. In London, for example, the so-called 'Ring of Steel' supports electronic surveillance systems and armed guards on every entry point into the financial district. Cars entering have their number plates read automatically. Stolen cars are detected within three seconds. And the potential for the facial-recognition of drivers, by linking automatically to digitised photographs on national licence records, exists in the system and has recently been tested.

Two: Walking on Water In many developing cities the ideal of distributing drinkable water and sewerage services to all has long been abandoned. Instead, highly dualistic systems are often in place. In the Indian megacity of Mumbai (Bombay), for example, residents of informal settlements actually use the water pipes which

distribute drinkable water to affluent gated condominium complexes as perilous footways for transportation. But they have no access whatever to the water supplies within the pipe (see the frontispiece to Chapter 1). Instead, such settlements are often forced to pay extremely high prices for bottled water that is shipped in by tanker and sold by private entrepreneurs at huge profit margins.

Three : Customising Infrastructures for Investment Enclaves In the newly-constructed tourist and manufacturing enclaves on Bintan island, Indonesia -- a few miles to the south of Singapore -- a telephone call or data communication link across the international boundary to Singapore is now counted as 'local'. One across the enclave walls to the surrounding Indonesian territory, however, is charged as 'international'. In Rio Grande do Sul in Southern Brazil, the State government has promised to build a new port, a dedicated canal link, and utilities, rail and road links, in order to lure in a $600 million General Motors car plant. All of these expensive new infrastructures will be provided free of charge and will be exclusively used by the company. Because of the expense involved to the State government in this 'bidding war', basic water, energy and road infrastructures for people living in poverty across is the State risk being undermined or even withdrawn.

Four: Collapsing Technological Systems The doomsday scenarios about the collapse of infrastructure and technological systems due to the 'Y2K' bug were not, on the whole, matched by experience. But, almost without comment, the last

communism, however, many of these systems have decayed and collapsed. Sometimes this has been due to simple neglect and the lack of resources, spares and skilled technicians. In the northern cities of Russia, for example, the free municipal heating systems that made the climate more bearable have often ceased to function, a process that has significantly accelerated out-migration. But the more worrying trend is the

they are allowed 'fast track' routes through airports. Over 70,000 people enrolled in the trial ; the INS are keen to make the system global. "Not so long ago only strategic places under high surveillance, such as military intelligence agencies, were guarded by such a mechanism" (Mattelaart, 1996, 305). Over 50,000 people were using the system in 1999.

Six : My Packets Are More Valuable Than Yours ! Whilst enormous investment is going into new optic fibre 'pipes' for the Internet, exponential increases in demand continually fill up any new space, creating Internet congestion. In response, companies like Cisco, who make the 'smart' routers and switches that organise flows on the Internet, are now devising ways of 'sifting' the most valued and important 'packets' of information from those that are deemed less important. The idea is that, in times of Internet congestion, the most valued 'packets' from the most profitable customers will be allowed to pass unhindered whilst the rest are blocked. Thus, beneath the rhetoric that the Internet is some egalitarian and democratic space, profound inequalities and being subtly and invisibly integrated into the very protocols that make it function.

Seven : From Open Grids to Closed Urban Streets. Many urban streets In North America, Asia, Africa, and Latin America are now privatised and self-contained rather than open and interconnected. Such streets act as entry points to 'gated' or 'master planned' communities. These are carefully segregated and 'fortressed' from the rest of the city through walls, gates and high technology surveillance systems, yet sustained through guarded, dedicated highway gates, customised water and energy connections, and telecommunications grids, that selectively connect them to the wider urban constellation and the universe beyond. The private governments of such spaces are actively expl2950 Tf 1.0000 0.0000 0.0000 1.0000 193.0000 125.0000 Tm 0.000 Tw

services to match their telecom networks, further removing them from involvement in the broader metropolitan fabric and enhancing their emergence as quasi-medieval city-states. One gated community near Phoenix now even operates its own fleet of electric vehicles which can not be used outside its boundaries on public highways (Kirby, 1998).

Eight : Skywalk Cities and Global Citadels . At the same time, in the downtown cores of North American cities like Houston, Toronto and Minneapolis, the extending logic of "skywalk" systems is bypassing the traditional street system. Skywalks link extending webs of office and shopping complexes downtown with carefully monitored, air conditioned, and hermetically-sealed pedestrian networks what Boddy (1992) terms the 'analogous city'.

Airports, freight zones, retail malls, sports stadia, and University, research, hospital, media and technology campuses are similarly emerging as zones of intense regional and global interchange whilst at the same time walls, ramparts and CCTV systems are constructed which actively filter their relationships with the local urban fabric. In Baltimore, for example, David Harvey notes the paradox that, whilst African American women cross these boundaries daily to clean some of the world's most famous hospitals (for example Johns Hopkins), they are unable to access health services when they are ill because of a lack of health insurance. Meanwhile "life expectancy in the immediate environs of these internationally renowned hospital facilities is among the lowest in the nation and comparable to many of the poorer countries of the world" (2000, 136). Carlo Ezecieli, (1998) calls these places "global citadels'. Through such trends, the physical fabric of many cities across the world is starting to fragment into giant cellular clusters -- packaged landscapes made up of customised and carefully-protected corporate, consumption, research, transit,

exchange, domestic and even health care spaces. Each tends to orient towards highway grids, global telecommunications connections, premium energy and water connections, whilst CCTV and security guard-protected 'public private spaces' mediate their relationships with their immediate environments. Thus they tend to turn their backs on traditional street fronts and the wider urban fabric, carefully filtering those 'undesirable' users deemed not to warrant access for work, play, leisure, residence, or travel. The new American football stadium at Foxboro, Massachusetts, for example, is being built with an access road that is solely dedicated to owners and users of corporate boxes ; all other fans must use the old public highway.

A tragic example of the starkness of such carefully-designed local disconnections came on December 14, 1995 at the huge Walden Galleria Mall on the edge of Buffalo, USA. An employee of the mall, Cynthia Wiggens, was trying to cut across a seven-lane highway from the public city bus stop when she was run down and killed by a 10-ton truck. City buses were not allowed to enter the mall, every aspect of which had been designed to attract high-spending middle and upper income consumers travelling exclusively by car (Gottdeiner, 1997. 132).

Nine : Private 'Smart' Highway Corridors. In some cities, urban highways, too, are increasingly privatised, profit-oriented and customised to the needs of affluent commuters on particular urban corridors. In cities like Toronto, San Diego, Melbourne and Los Angeles new, privately-funded Highways use completely automatic electronic tolling technologies to create entirely new transport and development

frustrated commuters from grid-locked public highway grids,, allowing paying commuters to 'worm hole' through some of the most congested public highways in North America. Drivers' bank accounts are precisely debited according to the times and distances of travel. In Los Angeles, commuters enjoy a saving of 40 minutes compared to normal driving times along the 10 mile public highway.

Ten : The Ultimate Commute Driven by fear of car-jacking and the inexorable grid-locking the City's streets -- a City with 8,500 murders a year, a rate ten times New York -- the most privileged residents of the Brazilian megacity of São Paulo have recently discovered the ultimate means to escape the constraints of the highway, the street and even the terrestrial surface, in their journeys around the city : a personal helicopter. At over 400 and increasing rapidly, the *New York Times* reports that São Paulo's personal helicopter fleet is the fastest growing in the world, a powerful symbol of the almost surreal extremes and wealth and poverty in the City (February 15th, 2000, pp. 1). "Why settle for an armoured BMW when you can afford a helicopter ?" asks Eric Wassen, a local dealer. At the same time, the 3.7 million daily users of the City's 10,400 buses face heightening delays, pollution and violence amidst a chaotic, collapsing public transport system and heightening risks of violence.

Eleven : Multiplying Utility Grids.. In the privatised utility markets of the UK people can now choose from dozens of gas suppliers, electricity companies, and telecoms providers, and sometimes even water firms -- firms whose head quarters are scattered all over the developed word. Singaporean cable. Dutch telecommunications. American energy. French water. In some cities 'multiutilities' are emerging offering energy, water and telecoms on a 'one stop shop' basis. Citizens can now back up their search for environmentally-friendly foods, transport and

housing by paying extra for "green" electricity inputted to the network by specialised companies from renewable sources. Housing tenants can similarly access 'red' electrons generated by socially-conscious companies. For privileged consumers, new information technologies opens up a virtual marketplace of different providers and value-added services. But for

1 Introduction : Networked Infrastructures, Technological Mobilities, and the Urban Condition

A critical focus on networked infrastructure -- transportation, telecommunications, energy, water, and streets -- offers up a powerful and dynamic way of seeing contemporary cities and urban regions (see Dupuy, 1991). When our analytical focus centres on how the wires, ducts, tunnels, conduits, streets, highways and technical networks that interlace and infuse cities are constructed and used, modern urbanism emerges as an extraordinarily complex and dynamic socio-technical *process*. Contemporary urban life is revealed as a ceaseless and mobile interplay between many different scales, from the body to the globe. In fact, mobile interactions across distances and between scales, mediated by telecommunications, transport, energy and water networks, are the driving connective forces of much-debated processes of 'globalisation'.

In this perspective, cities and urban regions become, in a sense, staging posts in the perpetual flux of infrastructurally-mediated flow, movement and exchange. They emerge as processes in the distant sourcing, movement and disposal of water reserves and the remote dumping of sewerage and waste. They are the hotbeds of demand and exchange within international flows of power and energy resources. They are the dominant sites of global circulation and production within a burgeoning universe of electronic signals and digital signs. They remain the primary centres of transnational exchange and distribution of products and commodities. And they are overwhelmingly important in articulating the corporeal movements of people and

their bodies (workers, migrants, refugees, tourists...) via complex and multiple systems of physical transportation.

The constant flux of this urban process is constituted through many superimposed, contested, and interconnecting infrastructural 'landscapes'. These provide the mediators between nature, culture, and the production of the 'city'. There is the 'electropolis' of energy and power. There is the 'hydropolis' of water and waste. There is the 'informational' or 'cybercity' of electronic communication. There is the 'autocity' of motorised roadscapes and associated technologies. And so on. Importantly, however, these infrastructural 'scapes' are not separated and autonomous ; they rely on each other and co-evolve closely in their interrelationships with urban development and with urban space.

How can we imagine the massive technical systems that interlace, infuse and underpin cities and urban life ? In the Western World especially, a powerful ideology, built up particularly since World War II, dominates the way we consider such urban infrastructure networks. Here, street, power, water, waste or communications networks are usually imagined to deliver broadly similar, essential, services to (virtually) everyone at similar costs across cities and regions, most often on a monopolistic basis. Fundamentally, infrastructure networks are thus widely assumed to be integrators of urban spaces. They are believed to bind cities, regions and nations into functioning geographical or political wholes. Traditionally, they have been seen to be systems that require public regulation so that they somehow *add cohesion* to territory, often in the name of some 'public interest'.

Infrastructure operators are assumed in this ideology to cover the territories of cities, regions and nations contiguously, like so many jigsaw pieces. They help to define

the identity and development of their locality, region or nation in the process. The assumption, as Steven Pinch argued in his classic book *Cities and Services*, is that utility supplies (and sometimes

perspectives ? How is the emergence of privatised, customised infrastructure networks across transport, telecommunications, energy and water -- like the ones discussed above -- interwoven with the changing material and socio-economic and ecological development of cities and urban regions ? And, finally, what do these trends mean for urban policy, governance and planning and for discussions about what a truly democratic city might actually mean ?

The rest of this book will address these questions through an international and transdisciplinary analysis of the changing relationships between infrastructure networks, the technological mobilities they support, and cities and urban societies. In this first chapter we seek to set the scene for this discussion. We do this in six parts. First, we introduce the complex interdependencies between urban societies and infrastructure networks. Second, we explore how contemporary urban change seems to involve trends towards uneven global connection combined with an apparently paradoxical trend towards the reinforcement of local boundaries. In the third and fourth parts, we move on to analyse why urban studies and related disciplines have largely failed to treat infrastructure networks as a systematic field of study. We point out that, instead, it has widely been assumed that technologies and infrastructures simply and deterministically shape both the forms and worlds of the city, and wider constructions of society and history. Fifth, we then explore those moments and periods which starkly reveal the ways in which contemporary urban life is fundamentally mediated by such networks : collapses and failures. We close the chapter by drawing up some departure points for the task of the remainder of the book : imagining what we call a critical urbanism of the contemporary networked metropolis.

Transport, Telecommunications, Energy and Water : The Mediating Networks of Contemporary Urbanism

Our starting point in this book is the assertion that infrastructure networks are the key physical and technological assets of modern cities. As a 'bundle' of materially networked, mediating infrastructures, transport, street, communications, energy and water systems constitute the largest and most sophisticated technological artifacts ever devised by humans. In fact, the fundamentally *networked* character of modern urbanism as Gabriel Dupuy (1991), reminds us, is perhaps its single dominant characteristic. Much of the history of modern urbanism can be understood, at least in part, as a series of attempts to 'roll-out' extending and multiplying road, rail, airline, water, energy, and telecommunications grids, both within and between cities and metropolitan regions. These vast lattices of technological and material

of consumption. They unevenly bind spaces together across cities, regions, nations and international boundaries whilst helping also to define the material and social dynamics, and divisions, within and between urban spaces. Infrastructure networks interconnect (parts of) cities across global time zones and also mediate the multiple connections and disconnections within and between contemporary cities (Amin and Graham, 1999). They dramatically, but highly unevenly, 'warp' and refashion the spaces and times of all aspects of interaction -- social, economic, cultural, physical, ecological.

Infrastructure networks are thus involved in sustaining what we might call 'socio-technical geometries of power' in very real -- but often very complex -- ways (see Massey, 1993). They tend to embody "congealed social interests" (Bijker, 1995). Through them people, organisations, institutions and firms are able extend their influence in time and space beyond the 'here' and 'now' ; they can, in effect, "always be in a wide range of places" (Curry, 1999, 103). This applies whether users are 'visiting' web sites across the planet, telephoning a far-off friend or call centre, using distantly-sourced energy or water resources, shifting their waste through pipes to far-off places, or physically moving their bodies across space on highways, streets or transport systems.

The construction of spaces of mobility and flow for some, however, always involves the construction of barriers for others. Experiences of infrastructure are therefore highly contingent. "For the person in the wheelchair, the stairs and door jamb in front of a building are not seamless subtenders of use, but barriers. One person's infrastructure is another's difficulty" (Star, 1999, 380). Social biases have always been designed into urban infrastructure systems, whether intentionally or unintentionally. In Ancient Rome, for example, the City's sophisticated water network

was organised to deliver first to public fountains, then to public baths, and finally to individual dwellings, in case of insufficient flow (Offner, 1999, 219).

We must therefore recognise how

Infrastructure networks have traditionally also tended to be central to the normative aspirations of planners, reformers, modernisers and social activists to define their notions of a desirable urban order : the Good City (see Friedmann, 2000). Consider, for example, Le Corbusier's and Frank Lloyd Wright's utopias based on highways ; the 1920's futurists' obsession with air, rail, cruise liners and motor travel ; Ebenezer Howard's concern for municipal rail connections ; or the centrality of boulevards and sewers within Haussmann's 19th century 'modernisation' of Paris (see Dupuy, 1991, 105). Think, too, of the more recent speculations about how the Good City might finally be realised as a 'cybercity', a 'city of bits,' or an 'E-topia' , laced with the latest digital media technologies and networks (Mitchell, 1995, 1999, see also Wheeler et al, 2000).

Networked Paradoxes: Global Connections and Local (Dis) Connections

Of course, cities, metropolitan life and infrastructural connections to (more or less) distant elsewheres have been inextricably interwoven throughout the last seven thousand years of urban history (Soja, 2000). What has changed in the past century, however, are:

* the intensity , power, speed and reach of those connections ;
* the pervasiveness of reliance on urban life based on material and technological networks and the mobilities they support ;
* the scale of technologically-mediated urban life;
* the duplicating, extending variety and density of networked infrastructures ; and
* the speed of sophistication of the more powerful and advanced infrastructures (see Urry, 2000b).

provision of services. In many cases public and private monopolies are being replaced by contested, profit-driven markets.

As a result, the infrastructure sector is now one of the most important sectors in international flows of finance, capital, technology and expertise, as international infrastructure firms roam the world in search of healthy profits and high rates of return from lucrative niche markets or franchises. Across the planet, the era of the monopolistic provision of standardised services is being undermined as the World Trade Organisation, the G8, and Regional Economic Blocks like the EU in Europe, NAFTA in North America, ASEAN in South-East Asia, and Mercosur in South America variously work, albeit at very different rates and in very different contexts, to support shifts towards the liberalisation of national and local infrastructure monopolies (McGowan, 1999).

As a result of such processes, acquisitions, mergers and strategic alliances between utility and infrastructure corporations present some of the fastest-moving scenes on international financial markets. Such events can dramatically change the infrastructural logics of cities and regions almost overnight (Curwen, 1999, McGowan, 1999). This is creating new competitive markets that complement or replace predictable and monolithic monopolies with highly fragmented and differentiated styles of service provision with highly complex, and often hidden, geometries and geographies.

Urban Fragmentation and Recombination :

Increasingly, as Manuel Castells (1996, 1997, 1998) suggests, these processes are directly supporting the emergence of an internationally-integrated and increasingly urbanised, and yet highly fragmented, *Network Society* that straddles the planet. New, highly polarised urban landscapes are emerging where 'premium' infrastructure networks -- high speed telecommunications, 'smart' highways, global airline networks -- selectively connect together the most favoured users and places, both within and between cities. Valued spaces are thus increasingly defined by their fast-track connections elsewhere, as any examination of the intensifying transport, telecommunications and energy links between the dominant parts of 'global' cities reveals. At the same time, however, premium and high-capability networked infrastructures often effectively by-pass less-favoured and intervening places and what Castells calls 'redundant' users. Often such bypassing and disconnection is directly embedded into the design of networks, both in terms of the geographies of the points they do and do not connect, and the control placed on who or what can flow over the networks. Through such processes, Castells predicts that:

> "The global economy will expand in the 21st century, using substantial increases in the power of telecommunications and information processing. It will penetrate all countries, all territories, all cultures, all communication flows, and all financial networks, relentlessly scanning the planet for new opportunities of profit-making. But it will do so selectively, linking valuable segments and discarding used up, or irrelevant, locales and people. The territorial unevenness of production will result in an extraordinary geography differential value making that will sharply contrast countries, regions, and metropolitan areas. Valuable locales and people will be found everywhere, even in Sub-Saharan Africa. But switched-off territories and people will also be found everywhere, albeit in different

proportions. The planet is being segmented into clearly distinct spaces, defined by different time regimes" (1997, 21).

Beyond the Territorially Cohesive City : Proximity _ Meaningful Relations !

Virtually all cities across the world are starting to display spaces and zones that are powerfully connected to other 'valued' spaces areas across the urban landscape as well as across national, international and even global distances. At the same time, though, there is often a palpable and increasing sense of local disconnection in such places from physically-close, but socially and economically distant, places and people. Some have even interpreted this widespread pattern of development as signifying some form of convergence between developed, newly industrialised, post communist and developing cities (Cohen, 1996).

Because of these dynamics, and the intensifying uneven development of infrastructures, physically-close spaces can, in effect, be relationally severed (Graham and Healey, 1999). At the same time, globally-distant places can be relationally connected very intimately. This undermines the notion of infrastructure networks as **binding** and connecting territorially-cohesive urban spaces. It erodes the notion that cities, regions and nations necessarily have any degree of internal coherence at all. And it forces us to think about how space and scale are being refashioned in new ways that we can new new(s0 Tm 0.000 Tw 0.000 Tc (of) Tj 0.0000 g /Fcp

dynamics of global political economies and societies. As Carlo Ezecieli argues, from the point of view of US cities:

> "while markets are establishing systems of planetary interdependence and metropolitan regions become more and more directly related to a global dimension, there appears to be a paradoxical tendency toward the reinforcement of local boundaries. In crime-ridden American neighborhoods buildings tend to be fortified like military bases. In gated communities the protection of privileged circles through the erection of physical boundaries is marketed as an attractive amenity. Primary urban facilities like large hospitals, universities and shopping malls, establish simulations of "public" venues within physically bounded and access-controlled environments" (1998; 4).

The Neglect of Networked Urban Infrastructures and Technological Mobilities in Treatments of the City

> "Study a city and neglect its sewers and power supplies (as many have), and you miss essential aspects of distributional justice and planning power" (Star, 1999, 379).

Unfortunately for us, a major investigation of the complex relations between infrastructure, technology and contemporary cities such as this book is not well served by previous literature. Outside of a few specialised debates on urban transport (see Hanson, 1993), urban history (see Tarr and Dupuy, 1988), and emerging information technologies (see Castells, 1989, Graham and Marvin, 1996), urban infrastructure networks and the mobilities they support have traditionally hardly been considered the most exciting foci of debate in urban studies and policy

making. "Because these systems include complex technological artifacts, they are often viewed as 'engineers stuff', not worth the interest of the social sciences" (Coutard, 1999, 1).

Why is this so ? Why do disciplines which purport to understand the nature of the contemporary metropolis systematically neglect the networked infrastructures and technological mobilities that are so important in defining its nature, form and process ? Five reasons can be identified.

Taking geography first, Michael Curry (1998, 2) has suggested that, with a few notable exceptions, geographers (especially Anglo-Saxon ones) have not embraced the study of what he calls "geographic technologies" like utilities and IT systems. This is for the simple reason that "they have adopted the view, so widespread, that all technologies are natural and neutral" (ibid.).

the analysis of 'Large Technical Systems' has, however, led to some progress here (see Mayntz and Hughes, 1988, LaPorte, 1991, Summerton, 1994a, Coutard, 1999).

As in geography, the caprices of intellectual trends have continually rendered networked infrastructures, and the technological mobilities they support, unfashionable in sociology. For example, despite the extraordinary motorisation of cities

rather than the networked infrastructures that knit buildings together, binding and configuring the broader spaces of metropolitan

the processes and experience of modern urbanism (see, for example, Savage and Warde, 1993). Urban studies, moreover, often tends towards static formulations of the nature of urban society and urban life. Only rarely do discourses of the city "script the city as a process of flows" -- an approach which tends to emphasise the roles of massive technological networks and infrastructural mobilities in mediating urban life (Kaika and Swyngedouw, 2000, 2).

Consider, for example, the ways in which urban and regional studies have recently begun to address consumption issues with considerable energy. Debates have sprung up surrounding the restructuring of public services (Pinch, 1989, 1997), the links between private and public consumption and quality of life (Rogerson et al, 1995; Miller, 1995), and the transformation of many post-industrial city spaces into entertainment, leisure and consumption zones (see Hannigan, 1998). However, infrastructure networks again tend to remain largely ignored in such debates, closed off within their inward-looking and technical sub-disciplines. Very little urban research has addressed the important shifts now underway in the consumption and development of what we might call *distributive network services* that use technological networks to distribute power, communication, water and mobility services across space and time.

Dialectics of Invisibility and Monumentalism

Third, the hidden nature of much of the contemporary physical fabric of infrastructure in many cities has also contributed to their 'Cinderella' status (see Latour and Hermand, 1998). Many urban networks in the contemporary city remain "largely opaque, invisible, disappearing underground, locked into pipes, cables, conduits, tubes, passages and electronic waves" (Kaika, and Swyngedouw, 2000, 2). They

seem "by definition [to be] invisible, part of the background for other kinds of work" (Star, 1999, 380).

This invisibility has allowed the subterranean guide to emerge as a sub-genre of urban guide and photographic books, allowing those who want to look beyond the urban myths and legends that tend to surround the underground of cities to explore the full depth, complexity and history of a city's 'root system' (see, for example, Granick, 1947, Trench and Hillman, 1984, Greenberg, 1998). Such books help us begin to visualise the hidden background of urban networked infrastructures. Consider, for example, Robert Sullivan's introduction to Harry Granick's classic book *Underneath New York* (1947):

> "Imagine grabbing Manhattan by the Empire State

to a separate, substantive treatment which tends to leave to the transport experts the physical definition of its function and its location in specialized zones" (Solà-Morales, 1996, 14). Very often, infrastructure networks remain politically contained by the widespread and powerful assumption that state or private monopolies will simply provide services when, and where, they were needed, as public or quasi-public services to sustain urban life. Reflecting this, the whole of infrastructure is sometimes captured within catch-all terms like 'Public Works'.

However, it is important to note that a reverse tendency to infrastructural invisibility and political obfuscation does periodically emerge. Here, rather than being hidden, infrastructure networks are revealed, celebrated and constructed as iconic urban landmarks, as embodiments of the 'phantasmagoria' of particular urban times and places (Kaika and Swyngedouw, 2000). Such is the case, for example, with contemporary satellite ground stations (Rio, Cologne, Tokyo, London Docklands, Roubaix, Bangalore), international airports (Hong Kong, Osaka, Denver and many others), high-tech bridges (Boston, Newcastle, Istanbul), private highways studded with 'public art' (Melbourne), fast train networks and stations (Europe's TGVs), and telecommunications towers (Barcelona). Such constructions are part of what Castells calls "a new monumentality [which is] able to provide symbolic meaning to spatial forms" in times of unprecedented metropolitan fluidity, sprawl, and the spread of relatively similar and indistinguishable 'generic' urban landscapes (1999c). Many such projects continue to embody national and local "symbols of modernity and arrival" (Vale, 1999, 391).

In the last two centuries, the construction of infrastructure as symbolic marker characterised the modernist highway networks of the post world war II period, and the water towers, dams, power stations, reservoirs and water treatment stations of

19th century west European cities (see, for example, Trench and Hillman, 1984). In a curious process of recycling, many of the latter are now being reconstructed as art galleries and leisure centres, celebrating post-modern urban consumption whilst inadvertently also symbolising the metaphorical and physical shift of much of the industrial and productive fabric of the networked city beneath the urban scene (see Kaika, and Swyngedouw, 2000). London's Tate Modern -- an old electricity generating station -- is a classic example.

The Banalisation of Technological Mobilities : Tendencies to 'Black Box' Urban Infrastructure Networks

Fourth, and as a result of their general neglect, infrastructure networks have often remained taken-for-granted. To use the parlance of social studies of technology, they have been 'black boxed'. For many western urbanites, certainly, using a 'phone, driving a car, taking an airline or rail trip, turning a tap, flushing a toilet,

Technological Determinism and the Dominance of Evolutionist Treatments of Infrastructural History

assumed where the technology itself is seen as the direct causal agent of urban change.

The sub-discipline of urban history has made much more effort than most to explore the relations between cities and urban infrastructure networks and technologies (see Johnson-McGrath, 1997). But even here, Konvitz et al argue that:

> "historians asserting the importance of their area's specialisation [in technology and infrastructure] have often failed to win the recognition of their co-practitioners. Just as urban historians often focused on one city, historians of urban technology often focused on one technology. Within this framework, a growing corpus of work provided sophisticated accounts of streetcar systems, railroad networks, and automobiles as distinctive subject and as part of their individual relationships to urban change. " (1990; 288).

Such approaches, in turn, relate to the wider dominance of technological determinism, especially in western culture. Even on the rare occasions when attention looks beyond one network, the reliance on such determinism, with its "simple yet highly plausible before-and-after narrative structure" tends to prevail (Rose Smith and Marx, 1995). Such a view often combines with a one-dimensional perspective where attention focuses on one city, or one set of supposedly homogeneous technological 'impacts' which are then posited for all cities everywhere.

Commonly, this intellectual device is quickly translated into the broader use of technological and infrastructural depictions of historical urban 'ages' : from the 'hydraulic civilizations' of the first urban centres in Mesopotamia (Soja, 2000, 51), through to the 'steam', 'electric', 'auto', the 'nuclear', and 'information age' metropolises of the

past three centuries (see, for example, Garrison, 1995). The problem with such approaches is that they tend to reify technologies as having overwhelming power is ushering in simple and discrete societal shifts which seem to amount to some naturalistic process of urban evolution. The parallels between historical periods tend to be underplayed ; the tendencies of newer networks to overlay and combine with, rather than replace, earlier networks is often forgotten ; and, once again, the forms and processes of city life tend to be simply read off as the deterministic result of the intrinsic nature of the new generation of technology. As Mattelart suggests:

> "only an evolutionist concept of history as cut up into successive, water-tight stages might deceive us into believing

The remarkable global debate about the feared impacts of the 'Y2K' computer bug at the dawn of the year 2000 was a particularly potent example of the fears of the comprehensive collapse of systems of technological mobility and flow (see Figure 1.2). Stoked up by an entire 'doomsday industry' of self-interested IT consultants, John Gantz, from the International Data Corporation, reckons that over $70 billion of public and private money was actually wasted, largely in developed nations, altering systems that wouldn't have collapsed any way. To some, it was little more than a complex and giant hoax based on exploiting the deep-seated cultural fears of technical collapse and social panic that lie deep latent within our infrastructurally-mediated civilisation (James, 2000).

Figure 1.2 Our deep cultural fears of the collapse of networked infrastructures : the 'Y2K' phenomenon, after the (non) event (Source: Boston Globe, January 6th, 2000, A13)

The Complex Realities of Technical Collapse

But the effects of infrastructure collapses, when they happen, are very real. Often, they are catastrophic. Such effects have been all too apparent in the past thirty years. Most familiarly, this has occurred through wars (Sarajevo 1984, Beirut. 1978, Belgrade, 1999...) ; earthquakes (Los Angeles 1996, Kobe 1995, Turkey and Taiwan 1999...) ; ice storms (Montreal, 1997-8...) ; floods (Central America 1998...) ; supply crises (oil in western cities, 1973...) ; or societal revolutions (Russia and Eastern Europe, 1989-).

Instances of technical malfunctioning also need to be considered. In developing cities these are often common and periodic, even with new and 'high-tech' infrastructure networks. In June 2000, for example, it was reported that the national optic fibre grid threaded within and between India's main 'hi-tech' cities was regularly collapsing due to a bizarre culprit. Rats, living inside the network ducts, had developed a taste for the PVC casing of the fibres. They were even eating that hallowed symbol of the 'information age' -- the glass optic fibres themselves -- regularly breaking the network in the process.

Technical failures occur in developed cities, too, but with less frequency and more attention. For example, on April 5th 2000, the entire London stock exchange was forced to stop for eight-hours due to a "software glitch", seriously undermining its reputation. In early 1998, the electricity supply to the City of Auckland in New Zealand collapsed for nearly a month, with devastating consequences, because the newly-liberalised power market led to a lack of back-up connections. And in February 1975, a fire left a 300 block stretch of Manhattan's Lower East Side without a 'phone system for twenty-three days. This collapse led to everything from massive economic disruption to reports of increased isolation, alienation, and psychological stress (Wurtzel and Turner,

systems, along with the wider economic and social deterioration, has encouraged those who can to flee. Since 1989 over 100,000 people have left Murmansk alone.

In addition, major elements of Russia's power transmission and telecommunications systems are now effectively being stolen by criminal gangs to be melted down and sold overseas on the black market for metals. More than 15,000 miles of power lines were pulled down between 1998 and 2000 alone, yielding 2000 tons of high quality aluminium, worth more than $40 million on the international black market. Not surprisingly, this widespread collapse of Russia's infrastructure systems has plunged large parts of Russia into power-outages for weeks or months at a time in what the mayor of the

With the growing electronic mediation of the society, economy and culture, information and communications systems, along with the electricity systems that support every aspect of their operation, need to be as reliable and secure as possible on twenty-four hours a day basis. The economic consequences of collapse and outages can be extremely expensive and economically catastrophic. "The always-on economy, by definition, depends upon continuous energy. For a large business online, the cost of a power interruption can exceed $1 million per minute" (Platt, 2000, 116-128). For stock markets and electronic financial service firms, the costs can be much greater still.

This point is not lost on the infrastructure firms themselves in their recent advertising, or in their increasing investment in duplicate and back-up power systems to protect on-line service providers, Internet backbones, cable TV and 'phone companies (see Figure 1.3). Nor is it missed by leading IT and software entrepreneurs. Taking an unusually reflective and critical stance for a software engineer, Bill Joy, co-founder of Sun Microsystems, recently caused a furore amongst readers of the bible of the high-tech elite, *Wired*. He suggested that the mediation of human societies by astonishingly complex computerised infrastructure systems will soon reach the stage when "people won't be able to just turn the machines off, because they will be so dependent on them that turning them off would amount to suicide" (2000, 239).

Figure 1.3 A recent advertisement of the Sprint telecommunications firms stressing the reliability of their networks as the basis for e-commerce (Source: Sprint Corporation)

Unleashing Networked Collapses : Infrastructural Warfare

Nor is the fragility of electronically and electrically-mediated economies lost on those who, for the last ten thousand years of urban history, have always driven the leading edge of infrastructural and technological innovation : military strategists. In the burgeoning debates on 'cyberwar' or 'infowar', stress falls on the ways in which the orchestrated and systematic sabotage of an enemy's societal infrastructure networks might now be a useful complement to, or even replacement for, physical weapons of mass destruction (see Robins and Webster, 1999, chapter 7).

Of course the Kosovo war was very much about the physical reality of blowing people into small pieces. But the United States also deployed a new type of bomb which rains down graphite crystals to comprehensively disable electrical power and distribution stations. It was, the US military argued, a new method of disabling an enemy without the public relations embarrassments of unnecessary 'collateral damage' that often follow carpet bombing and the use of so-called precision guided munitions (which still have a habit of killing civilians even when they hit their targets). In an adaptation of the tactics of Medieval siege warfare to the networked metropolis, freezing the elderly in their homes, disabling critical heath care systems, and destroying running water are the new weapons of choice in media-driven 'cyber warfare' (Ignatieff, 2000).

Catching the Lovebug : Sabotage, Hacking, and Computer Viruses

> "One of the advantages of the new computerised economy was thought to be that it reduced capitalism's vulnerability to terrorism and theft. The use of computer viruses has removed this illusion" (Lawson, 2000, 11).

But perhaps the most culturally potent image of the fragility of our technically-networked civilisation comes from the phenomena of hacking, computer viruses, and deliberate attempts of sabotage. Here the simple pressing of an 'enter' key thousands of miles away can launch a self-replicating virus across the Internet that can bring substantial parts of the international technological economy to an extraordinarily expensive stand still, all within a matter of hours.

A classic example was the 'I Love You' or 'Love Bug' virus, launched by a college student in the Phillipines on May 3rd 2000. This virus moved to infect 45 million computers in at least twenty nations across the world within three days, clogging and destroying corporate e-mail systems in its wake. Overall damage was estimated at well over $ 1 billion and many Fortune 500 companies were substantially affected (see Figure 1.4). The virus also exposed some of the transnational tensions and inequalities that surround corporate IT. Some newspapers in the Phillipines, for example, expressed national pride that the country could spawn a hacker that could bring the highly fragile computer communications systems of Northern corporations to an (albeit temporary) collapse.

Figure 1.4 Exploiting the destructive wake of the 'LoveBug' virus : XDrive's advertisement for Internet storage and back up services which appeared in the *New York Times* on May 8th (Source : *New York Times* , May 8th 2000, YN2).

Many other examples of viruses have emerged recently. Earlier in the year 2000, in February, coordinated attacks by computer hackers on major commercial Internet sites brought many to an expensive collapse.

With the notable exceptions of the books by Gabriel Dupuy (1991) and Joel Tarr (1988), and the French Journal *Flux*, the central question of how interlinked *complexes* of infrastructures are involved in the social production and reconfiguration of urban space and experiences of urban life tend to be ignored. But, as Thrift (1990) argues, transport, communications, and other networked grids, can not be easily split apart ; as 'socio-technical hybrids' they rely on each other and co-evolve in their interrelationships with urban development, urban life, and with urban space (Urry, 1999). Chains of related innovations bind infrastructure networks closely to broader technological systems ; these, in turn, are seamlessly woven into the fabric of social, economic and cultural life.

Only very rarely do single infrastructure networks develop in isolation from changes in others. By far the most common situation is where urban landscapes and processes become remodelled and reconstituted based on their complex articulations with a variety of superimposed transport, communications, energy and water infrastructures (Gökalp, 1992). As Easterling suggests, "many of the most interesting innovations and design inventions appear on the cusp of change from one network to another, when one system is being subsumed by another presumed to be more fit" (1999b, 114). This is the case with today's massive investment in computer communications systems, characterised by "smart and flexible patterns of switching between heterogeneous components and multiple scales of activity" (ibid.), which are being overlaid upon older, electro-mechanical transport, street, energy, communications and water networks.

Infrastructure Networks as Socio-Technical Assemblies or 'Machinic Complexes'

Second, technologies and infrastructure networks must therefore be considered as socio-technical *assemblies* or *'machinic complexes'* rather than as individual causal agents with identifiable 'impacts' on cities and urban life (Thrift, 1995). For example, networked personal computers are useless without modems, Internet servers, functioning software, 'phone and cable networks or wired or wireless telephones or Internet channels. As we have just seen, all of these, in turn, rely on extensive, reliable electricity infrastructures which provide essential supports for a growing universe of electronic interactions and transaction systems. In the USA the Internet consumed 8% of all electricity in 1999 ; by 2020 some estimates suggest that this will rise to a staggering 30% !

Electronic generation and communications systems, in turn, interrelate closely with physical movements of people, freight and raw materials over roads, railways, airline networks and water and sewer systems. Automobiles and roads, similarly, now relate extremely closely to the use of mobile 'phones, as well as to proliferating electronic and digital infrastructures developed for managing, regulating and controlling highway use or enhancing drivers' safety, social power or entertainment (Urry, 1999). In similar ways, water, energy and communications networks are closely intertwined in supporting domestic and industrial life. These interrelationships between infrastructures, moreover, are multi-dimensional and bi-directional, making an open-minded, interdisciplinary position

Third, even the optic fibres within and between cities, which carry the bulk of the exploding range of electronic communications, are being laid along rights of way and conduits that tend to closely parallel infrastructural systems for physical movement (Graham and Marvin, 1994). This is not surprising when one considers that, typically, 80% of the costs of starting a telecom business come with the traditional, messy process of getting cables in the ground to link up dispersed customers.

In central London, as in other so-called 'global' cities, dense webs of optic fibres are now threaded along the beds on 'industrial age' canals and long-disused hydraulic power systems, as well as through the underground subway system and water and energy conduits. In New York, the energy company Consolidated Edison now offers direct fibre connections to 2000 buildings in Manhattan through its power conduits. And all across the world, highway, power, water and rail companies are both offering their ducts and conduits and rights of way to telecom companies and, in these times of liberalisation, are starting to offer telecoms services themselves. "What makes a great railway franchise is what makes a great telecom franchise", the Chairman of one such company in Florida recently stated (quoted in Tanner, 2000, B3).

As a final departure point we can begin to draw on some work which has recently resulted from a greater appreciation of urban networked infrastructures amongst architects and urbanists. As Rem Koolhaas, one of the world's most influential architectural critics, has suggested, for architects, infrastructure is "a relatively new subject [...] it allows architecture to be much less isolated in its own territory and to find a connection with subjects, dangerous and glamorous, like demographics" (1998a, 94).

Mobility, infrastructure networks, and flows are thus emerging as major emphases of contemporary architectural and urbanistic theory and practice.

breaks and fragmented orders, a specific form of cohesion is attributed to the contemporary city, the urban landscape perceived as a connected tissue" (ibid.).

The implication of such views is that the conventional divisions of contemporary urban professions must be overcome if we are to understand an urban world where "architecture is declared as landscape, infrastructure as architecture, and landscape as infrastructure" (ibid. 20). Architecture and urbanism thus now widely recognise, and even celebrate, the fact that :

> "the experience of the city is increasingly subject to the flows and interchange generated by the increased circulation of people, vehicles, and information. The rhythm of these flows, which changes

unbundled in ways that help sustain the fragmentation of the social and material fabric of cities. Such a shift, which we label under the umbrella term, *splintering urbanism*, requires a reconceptualisation of the relations between infrastructure services and the contemporary development of cities. This book attempts to develop such a reconceptualisation.

Our perspective in this book is deliberately both very broad, extremely international, and highly interdisciplinary. It is only through such a perspective, we believe, that an understanding of the parallel processes of infrastructural splintering and urban change might be achieved. We have constructed this perspective to help start breaking down three sets of barriers which, we believe, have tended to strongly inhibit sophisticated analyses of cities, technologies and infrastructures over the past thirty years or so.

Breaking Down Interdisciplinary Barriers

Firstly, we want to start to break down barriers between a range of largely separated debates about cities, technologies and infrastructure networks. We believe that such disciplinary barriers have long inhibited sophisticated treatment of the interplay between cities and the socio-technical constructions of infrastructure networks and the diverse mobilities they underpin. In this book we therefore try to draw together relevant discussions and debates in urban studies, geography, planning, sociology, architecture, urbanism, urban history, science, technology and society (STS), engineering, social theory and communications studies into a single, integrating narrative.

One inspiration for this approach comes from the French pioneering communication theorist Armand Mattelart. His integrated analyses of space, technology, infrastructure networks and social power draw equally on many disciplines. He writes in the Preface to his book *The Invention of Communication* that:

> "just as it was hardly obvious in the 1930s [for Lewis Mumford in his book *Technics and Civilization*] to make a link between the cannon and the telegraph as instruments of vanquishing space, it is still difficult today to legitimate a transdisciplinary approach that, for example, does not hesitate to trace the possible kinship between the first attempts by topographers of

to construct dynamic, sophisticated and synthesising appreciations of the nature of contemporary urban development .

Indeed, we believe that such perspectives are desperately needed. Because much of contemporary urban life is *precisely about* the widening and intensifying use of networked infrastructures to extend social power, the study of the configuration, management and use of such networks needs to be at the centre, not the periphery, of our theories and analyses of the city and the metropolis.

We strive throughout iphery,

ever was) to divorce the study of western and developed cities from those in the rest of the world. Just as in the era of colonial urban systems, contemporary geographic divisions of power and labour on our rapidly urbanising planet, wrap cities and parts of cities into intensely interconnected, but extremely uneven, systems. These demand an international, and multiscalar, perspective.

As Michael Peter Smith has argued, all urban places are now, in a sense, 'translocalities' with multifaceted and multiscaled links and connections elsewhere. This means that "there is a need to expand the study of transnational urbanism to encompass the

The second