"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, and are endlessly churning human lives" Fernand Braudel, (1967) *Civilisation Matérielle et Capitalisme* (cited in Paquout, 2000, 83)

"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 few years have seen the very real and widespread collapse of electricity, power and communications systems in Russia. One of the central modernisation efforts of the communist state had centred on the development of extensive and accessible electricity, telephone, water and heating systems within and between Russian towns and cities, initially to support industrialisation. Since the collapse of

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 large-scale theft of infrastructure networks, especially trunk electricity systems and communications grids. Over 15,000 km of electrical trunk cable have been stolen in recent years by criminal gangs and people in desperate poverty, to produce metals that can be sold on the black market for export. In a striking process of 'demodernisation', large parts of Russia now face power and electric outages for long periods of time as the tendrils that connected them to modernity are literally carted off and melted down for a quick buck. Not surprisingly, there have been devastating consequences for quality of life, economic development and essential services. This process, needless to say, has forced the wealthy and powerful to secure private and uninterruptible power and communications resources for the enclaved spaces where they live. However, those outside such increasingly defensive enclaves are not so fortunate.

Five : Bypassing the Airport Crowds New technologies are widely being adopted to allow favoured, rich and highly-mobile travellers to pass seamlessly and quickly through ports, airports and rail terminals, whilst other passengers face traditional, and in many cases, intensifying scrutiny. Through the INSPASS (Immigration and Naturalization Service Passenger Accelerated Service System), for example, frequent business travellers and diplomats travelling between the US, Canada, Germany and Netherlands and other advanced industrial nations can now obtain a smart card that is programmed with the unique biometric signature of the geometry of their hand. By swiping the card at immigration and placing their hand on a scanner,

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 exploring the delivery of their own water, transport energy

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 corridors that are superimposed on old public highways grids. Land parcels are sold off by the highway corporation to create integrated corridors designed to serve affluent motorists. In some 'electronic highways' tariffs are electronically altered in 'real time' according to demand so that they can guarantee free-flow and tempt in

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 lower income users the same technologies tend to be configured differently, to help distance suppliers from low-income people through the use of 'top up' smart and pre-payment cards. These involve no direct contact between supplier and consumer. They require users -- who tend to be amongst the most immobile in society -- to physically travel to 'top them up'. And they often trap people on higher tariffs and away from the benefits of competition.

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 public transport and telecommunications networks, too) are "public local goods which are generally speaking, freely available, to all individuals at equal cost within particular local government or administrative areas" (1985; 10). The implication is that, compared to other 'point-specific' urban services like shops, banks, education and housing, they are of relatively little interest to urban researchers because, to all intents and purposes, they don't really *have* an urban geography in the conventional sense.

What, then, are we to make of the range of examples in the Prologue, which seem so contradictory to such assumptions ? What is happening to the previously sleepy and often taken-for-granted world of networked urban infrastructure? How can we explain the emergence of myriads of specialised, privatised and customised networks and spaces evident in the above examples, even in nations where the ideal of integrated, singular infrastructures -- streets, transport networks, water grids, power networks, 'phone infrastructures -- was so recently central to policy thinking and ideology ? And what might these emerging forms of infrastructure development mean for cities and urban life across an urbanising planet ?

To us, these stories, and the many other tales of networked infrastructure in this book, beg a series of important questions. Are there common threads linking such a wide range of cases ? Are broadly common processes of change underway across so many places and such a wide range of different infrastructure networks? How can we understand the emerging of the infrastructure networks and urban landscapes of internationalising capitalism, especially when the study of urban infrastructure has been so neglected and so dominated by technical, technocratic, or historical

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 connections have been necessary to sustain the ever-expanding demands of contemporary societies for increasing levels of exchange, movement, and transaction across distance. Such a perspective leads us to highlight four critical connections between infrastructure networks and contemporary urbanism that together form the starting points of this book.

Cities as Socio-Technical Process

Firstly, economic, social, geographical, environmental and cultural change in cities is closely bound up with changing practices and potentials for mediating exchange over distance through the construction and use of networked infrastructures. "Technological networks (water, gas, electricity, information etc.) are constitutive parts

of the urban. They are mediators through which the perpetual process of transformation of Nature into City takes place" (Kaika and Swyngedouw, 2000, 1). As Hall and Preston put it, in modern society "much innovation proves to depend for its exploitation on the creation of an infrastructural network (railways; telegraph and telephone; electricity grids; highways; airports and air traffic control; telecommunications systems)" (1988; 273).

In a sense, then, the life and flux of cities and urban life can be considered to be what we might call a series of closely related 'socio-technical processes'. These are the very essence of modernity : people and institutions enroll enormously complex technological systems (of which they often know very little) to unevenly extend their actions in time and space (Giddens, 1990). Water and energy are drawn from distant sources over complex systems. Waste is processed and invisibly shifted elsewhere. Communications media are enrolled into the production of meaning and the flitting world of electronic signs. And people move their bodies through and between the physical and social worlds of cities and systems of cities, either voluntarily or for pleasure or, it must be remembered, through the trauma and displacements of war, famine, disaster or repression.

'One Person's Infrastructure is Another Person's Difficulty' : Urban Infrastructure Networks as 'Congealed Social Interests'

Second, and following on from this, infrastructure networks, with their complex network architectures, work to bring heterogeneous places, people, buildings and urban elements into dynamic relationships and exchanges which wouldn't otherwise be possible. Infrastructure networks provide the distribution grids and topological connections that link systems and practices of production with systems and practices

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 the configurations of infrastructure networks are inevitably imbued with biased struggles for social, economic, ecological, and political power to benefit from connecting to (more or less) distant times and places. At the same time, though, we need to be extremely wary of the dangers of assigning some simple causal or deterministic power to technology or infrastructure networks *per se* (Woolgar, 1991). Infrastructures and technologies don't have simple, definitive, and universal urban 'impacts' in isolation. Rather, such large technological systems (Summerton, 1994a) or technical networks (Offner, 1993) are closely bound up within wider socio-technical, political and cultural complexes which have contingent effects in different places and different times (see Tarr and Dupuy, 1988; Joerges, 1999).

Infrastructure Networks as Embedded Geopolitics

Third, infrastructure networks make up considerable portions of the material, economic and geopolitical fabric of contemporary cities and systems of cities. As capital that is literally 'sunk' and embedded within and between the fabric of cities, they represent long-term accumulations of finance, technology, know-how, and organisational and geopolitical power. New infrastructure networks "have to be immobilised in space, in order to facilitate greater movement for the remainder" (Harvey, 1985;149). This means that they can "only liberate activities from their

embeddedness in space by producing new territorial configurations, by harnessing the social process in a new geography of places and connecting flows" (Swyngedouw, 1993; 306).

The 'messy' practices of embedding, building and maintaining infrastructure networks beneath, through, and above the fabric of cities thus infuses the politics of metropolitan areas. They require complex regulatory articulations between markets, national and local states, and, increasingly, transnational bodies. Whilst there are global trends towards various types of privatisation and liberalisation in the development of networked urban infrastructures, the ways in which the contested politics of network development are played out in each city, region or nation is still closely related to the broader constructions of governance, the state, and the market in each case (Lorrain and Stoker, 1997).

Infrastructure Networks and Cultures of Urban Modernity and Mobility

Finally, infrastructure networks, and socio-technical processes that surround them, are strongly involved in structuring and delineating the experiences of urban culture and what Raymond Williams termed the 'structures of feeling' of modern urban life (Williams, 1973). Networked technologies of heat, power, water, light, speed and communications have thus been intrinsic to all urban cultures of modernity and mobility (Thrift, 1995). They are invariably invoked in images, representations and ideologies of urban 'progress' and the modern city by all sorts of actors -- developers, planners, state officials, politicians, regulators, operators, engineers, real estate developers and appliance manufacturers, as well as artists, journalists, social scientists, futurists and philosophers (see Kaika and Swyngedouw, 2000).

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).

Today, the majority of the population in the western world, and an increasing proportion of the developing, newly industrialising and post communist worlds, live in cities that represent the largest and most concentrated source of demand for water, energy and transport and communications services. Much of the material and technological fabric of cities, then, *is* networked infrastructure. At the same time, most of the infrastructural fabric *is* urban 'landscape' of various sorts. Almost every aspect of the functioning of infrastructure, the retrofitting of new networks, and the renewal of older networks is focused on the needs of serving expanding urban areas, and the demands for communication of people, goods, raw materials, services, information, energy, and waste within and between cities.

Vast networks connect users in almost every building to more or less distant power stations, sewage works, reservoirs, gas fields, transport grids, and global communication systems. Enormous regional, national and international networks and powerful institutions have been constructed to suck resources into, and extract waste from, cities, and to exchange communication between predominately urban centres over the globe. Networked infrastructure, in short, provide the technological links that make the very notion of a modern city possible (Tarr and Dupuy, 1998).

Contemporary Infrastructural Mobilities : Globalisation and Liberalisation

However, something quite profound is happening in the worlds of urban infrastructure. Internationally, all the major urban infrastructure networks - water and waste, energy, telecommunications and much of the transportation infrastructure - are gradually being 'opened up' to private sector participation in the management and

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 : Information Technologies as 'Heartland' Technologies

Information technologies are clearly developing as the crucial information infrastructures mediating our increasingly information-intensive urban economies,

societies and cultures (Castells, 1996, 1998). But, as the 'heartland' technologies of contemporary economic, technological and cultural change, they are also being applied to help reconstitute how more 'traditional' transport, energy and water networks operate. Consider, for example, the growth of 'smart' highways, 'virtual' energy markets, access-controlled streets, CCTV-surveilled downtown skywalks, personalised multimedia and communications services (see Freeman, 1990).

The powers of new information technologies support the complex restructuring of urban forms, lifestyles and landscapes. This is based on parallel processes of the fragmentation and recombination of urban uses and functions, within and between cities and systems of cities (Mitchell, 1999). Whilst some activities are scattering across geographical space to be integrated electronically -- ATMs, back offices, e-commerce vendors, corporate sites -- information technologies may also support the 'renucleation' of work, home and neighbourhood services for certain people and places -- activities that were often separated into single-use zones during the development of the industrial, functional, city (ibid.).

Paradigm Challenges in the 'Network Society'

Above all, the increasingly 'hybrid' nature of contemporary cities, where powerful digital connections elsewhere articulate every aspect of urban life, requires us to continually rethink the paradigms that we use when analysing cities. Such processes "challenge the long-held privileged status of Cartesian geometry, the map, and the matrix or grid. Infrastructural links and connectors, as well as information exchanges and thresholds, become the dominant metaphors to examine the boundless extension of the regional city" (Boyer, 2000, 75).

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 literally see crystallising before us in the changing configurations of infrastructure networks and the landscapes of urban spaces all around us.

In short, emerging urban landscapes, and the interrelationships between infrastructure networks and urban spaces, seem to powerfully embody the changing

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.

Parallel Disciplinary Failings

First, the inertia of disciplinary and subdisciplinary boundaries has severely hindered understanding of a subject which intrinsically demands and interdisciplinary or transdisciplinary starting point. When literatures on networked urban infrastructure have emerged in planning, geography, urban studies, engineering, and architecture, they have often been inward-looking, technical, and overly-specialist.

By way of illustration, we can identify parallel failings across geography, sociology and architecture, which have contributed in different ways to these disciplinary failings to develop critical, cross-cutting perspectives on urban infrastructures and technological networks as a whole.

Geography : Assumptions of Technological 'Neutrality'

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 obvious invisibility of most contemporary utilities and communications systems has also not fitted with geography's traditional emphasis on land use and the visualities of urban life. Curry also wonders, deep down, "whether many geographers may not harbor fears that in the end some critics are rights, and that these new technologies will lead to the death of space and place, and hence of their own discipline" (ibid.).

One part of geography, that specialising on transport, has managed to emerge, but it has remained a fairly closed sub-discipline. Transport geography has only very limited connections to broader constructions of contemporary urban geography. Hamilton and Hoyle recently lamented that broader debates about the city "rarely give transport the coverage it deserves" (1999, 1).

Sociology : The Limitations of Classical Formulations

In sociology the early efforts of writers like Lewis Mumford (1934) to create overarching and historically-informed treatments of the interplay of cities, mobilities and technologies, has not been built on. According to Armand Mattelart, the sociology of communication, in particular, has largely failed in the necessary task which is to "do away with the separations between different areas and crossing the angles of vision of the disciplines in order to bring out the manifold logics by which the multiple forms of technology have molded, and in turn been molded by, the history of humankind, its mentalities, and its civilizations" (1996, ix). Recent work on

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 in the past thirty years or so, John Urry noted recently that "sociology has barely noticed [...] automobility, or even the car more generally" in its preoccupation with the strolling and *flanérie* of the walking urbanite. Sociology has been even more neglectful of other networked infrastructures (1999, 5).

In response, Urry urges sociologists to look beyond the classical and often rather static 20th century formulations centring on how class, gender, ethnicity and social mobility were constructed within individual 'societies' bounded by the nation state. Instead, he suggests the need to reformulate the discipline as a "sociology of mobilities" (Urry 2000b). This would deal centrally with the 'post societal' nature of the contemporary world with its "diverse mobilities of peoples, objects, images, information, and wastes" and its "complex interdependencies between, and social consequences of, these diverse mobilities" (Urry, 2000a, 185). Urry's is one of the clarion calls to which we address this book.

Architecture and Urbanism : Beyond the Building as Isolated Universe

In the last thirty years or so, urbanists and architects, too, have tended to neglect networked infrastructures and the flows and mobilities that they support. They have tended to focus overwhelmingly on the designed spaces within building envelopes,

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

As John Jerde, a well known architect of theme parks and entertainment complexes, suggests, "architects rarely focus attention on the process that creates -- and the conditions that surround -- the object or building" that they are designing or deconstructing (John Jerde International, 1999, 203). Because architects "rarely define sites in multiples", they tend not to see them "in a way that will permit exploration of the organizational or network architecture" of buildings that combine closely with infrastructure or organizational networks across diverse spaces (Easterling, 1999a, 2). In the 1970s, in particular, many architects largely turned their backs on the problems of the wider metropolis (Wall, 1996, 158).

"The Forgotten, the Background, the Frozen in Place" : Infrastructure Networks as the 'Cinderella' of Urban Studies

Second, and following from this discussion, it is clear to us that urban infrastructure networks and the mobilities they support have very much been left as the 'Cinderella' of contemporary urban studies and urbanism. Most social analyses of cities still address urban sociologies, economic development, governance and politics, urban cultures and identities, and urban ecologies and environments, without seriously exploring the roles of networked infrastructures in mediating all. As Susan Leigh-Star argues, such networks tend still to be "the forgotten, the background, the frozen in place" (1999, 379).

Even discussions of the cultures, sociologies and geographies of urban 'modernity' often fail to assert the essential contribution of networked infrastructures of all types to

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 Building and pulling the entire island up by its roots. Imagine shaking it. Imagine millions of wires and hundreds of thousands of cables freeing themselves from the great hunks of rock and tons of musty and polluted dirt. Imagine a sewer system and a et of water lines three times as long as the Hudson River. Picture mysterious little vaults just beneath the crust of the sidewalk, a sweaty grid of steam pipes 103 miles long, a turn-of-the-eighteeenth-century merchant ship bureau under Front Street, rusty old gas lines that could be wrapped twenty-three times around Manhattan, and huge, bomb-proof concrete tubes that descend almost eighty storeys into the ground (iv)"

The tendency to obscure the management and development of infrastructures within highly technical and technocratic institutions, driven by the supposedly depoliticised, instrumental rationalities of engineering cultures, has served further to obfuscate the worlds of networked urban infrastructure. Transport, for example, is "usually confined

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, or plugging in a power plug, are so woven into the fabric of daily life, and so 'normalised' and banal that (whilst they function adequately) they scarcely seem important.

Infrastructure services, and the huge technological networks that underpin them, seem immanent, universal, unproblematic -- 'obvious' even. People tend not to worry where the electrons that power their electricity come from, what happens when they turn their car ignitions, how their telephone conversations or fax and Internet messages are flitted across the planet, where their wastes go to when they flush their toilets, or what distant gas and water reserves they may be utilising in their homes.

Technological Determinism and the Dominance of Evolutionist Treatments of Infrastructural History

A final problem is that, with the exception of some of the work of a group of conceptually sophisticated French researchers in Paris (see Dupuy, 1992; Offner, 1995; 2000, and the French journal *Flux*, 1991-1999), and a growing corpus of writers in the Anglo-American *Journal of Urban Technology*, critical research on urban infrastructure has recently tended to focus on historical rather than contemporary contexts (see Chant and Goodman, 1998, Goodman and Chant, 1999, Roberts and Steadman, 1999).

Like the mainstream of social research on technology, these historical analyses have often adopted narrow versions of technological determinism. Here, new infrastructural and technological innovations are seen to linearly 'impact' on cities and urban life (see, for example, Garrison, 1990). "Infrastructural technology is often regarded as largely unproblematic and even autonomous in shaping the life and form of urban areas" (Aibar and Bijker, 1997).

This view reflects the classic, deterministic view of the role of networks like transportation and telecommunications in which "changes in [infrastructure] technology lead inexorably to changes in urban form" (Hodge, 1990, 87). In this view, new networked infrastructures like the Internet become little more than "progenitor[s] of new urban geometries" (ibid., 87). A simple, linear, cause-and-effect chain is

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 that the memory of centuries does not continue to condition the contemporary mode of communication. As proof, one need only point out the kinship between the messianic discourses on the networks of steam and electricity in the nineteenth century, and those that in the twentieth century accompany the policies of economic and social recovery through information and high-tech" (1996, xvi ; see Marvin, 1988, Offner, 2000).

Fleeting Glimpses of Networked Fragility : Experiences and Fears of Infrastructural Collapse

> "The normally invisible quality of working infrastructure becomes visible when it breaks : the server is down, the bridge washes out, there is a power blackout" (Star, 1999, 382).

Clearly, then, when infrastructure networks "work best, they are noticed least of all" (Perry, 1995, 2). Catastrophic failures, on the other hand, serve to fleetingly reveal the utter reliance of contemporary urban life on networked infrastructures. This is

especially so where the entire economic system has been reconstructed around highly fragile networks of computers and information technology devices (see Rochlin, 1997).

More than ever, the collapse of functioning infrastructure grids now brings panic and fears of the break down of the functioning urban social order. "Fear of the dislocation of urban services on a massive scale", writes Martin Pawley, is now "endemic in the populations of all great cities", simply because contemporary urban life is so utterly dependent on a huge range of subtly inter-dependent and extremely fragile computerised infrastructure networks (1997; 162).

In fact, in all parts of the world the fragilities of infrastructure networks are becoming ever-more obvious, just as infrastructurally mediated connections across distance become more and more intrinsic to contemporary urban life (see Suarez-Villa and Walrod, 1999, Barakat, 1998, Rochlin, 1997). Natural disasters and famines, especially in developing nations, often underline the particular fragility of infrastructural connections in such places (see Figure 1. 1). But in developed nations, too, "the earthquakes in Kobe or Los Angeles remind us how fragile the ideology of progress can be" (Allen, 1994, 13).

Figure 1. 1 Satellite communications as saviour overcoming the fragile infrastructures of the developing world: An advertisement for Inmarsat

It is worth exploring some examples of the fears and failures that surround contemporary infrastructural collapse.

Fears of Infrastructural Collapse and the 'Y2K' Phenomenon

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, 1977).

Societal Revolutions and Infrastructural Collapse : The 'Demodernisation' of Post-Communist Societies

In the cities of the post-communist world, the massive recent societal shifts show how previously taken-for granted infrastructure systems can quickly decay or be withdrawn on a more or less permanent basis. In the cities of Siberia and the far north in Russia, for example, the collapse of many heavily-subsidised municipal heating

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 town of Kiselevsk called the "crashing down of the whole technological system" (quoted in Tyler, 2000, A10). In such circumstances it is not surprising that the social and economic enclaves of the new capitalist and criminal elites are starting to adopt strategies of securing their own private infrastructure services that are more reliable.

When Turning Off Becomes Suicide : Network Collapses in the Always-On Digital Economy

In western and advanced societies, and increasingly in fast-computerising developing ones too, the pervasive importance of twenty-four hour systems of electrically-powered computer networks, in supporting all other infrastructures, makes electrical power cuts and outages particularly fearful. The explosive recent growth of electronic commerce, consumption, and distribution and production systems -- infrastructures that are mediated at every level by electrically-powered computer and telecommunications -- means that these days we are all, in a sense, "hostages to electricity" (Leslie, 1999, 175).

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.

In a separate case, a 15 year old boy from suburban Montreal was arrested in April 2000 for bringing the Yahoo! and Microsoft Network e-mail and web systems to near-collapse at the end of 1999. The response to this particular case says a great deal about how the punishment of individuals is unlikely to reduce such events when the corporate communications and e-commerce systems exhibit such glaring fragility. "It is the ultimate absurdity," writes Willson, "that, having brought the entire corporate world into a system so unstable and vulnerable that a child can throw mighty commercial enterprises into chaos, society believes the solution is to incarcerate the child" (2000, 15).

Ways Forward : Towards A Critical Networked Urbanism

Together, all these factors -- disciplinary failings and the neglect of networked infrastructures, their hidden and taken for granted nature, assumptions of technological determinism, and the panic effects of networked collapses -- mean that attention to infrastructure networks tends to *reactive* to crises or collapse, rather than sustained and systematic (Perry, 1995; 2). In such a context, the failure to systematically analyse the complex interlinkages between contemporary urban life and networked urban infrastructures as a whole is understandable.

Our aim of this book is to reveal the subtle and powerful ways in which networked infrastructures are helping to define, shape and structure the very nature of our cities, and, indeed, our civilisation. To begin this process, we would point to four crucial starting points for our task of constructing a critical urbanism of contemporary networked societies.

Addressing the Complex Interdependencies Between Networked Infrastructures

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 necessary before analytical progress can be made.

Physical Synergies Between Infrastructure Systems

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).

Infrastructure = Landscape = Architecture ! Toward Architectures and Urbanisms of the Networked City

> "Architecture has been pitilessly absorbed into the metropolis [...]. The metropolis has replaced the city, and as a consequence architecture as static enterprise has been displaced by architecture as a form of software" (Lerup, 2000, 22-3)

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. This is being especially encouraged by the mass diffusion of information technologies and automobiles, along with the simultaneous production and organisation, through franchises, mass production techniques, modern logistics systems, and corporate networks, of multiple and generic built spaces that are intimately coordinated across vast distances. Such strategies are about the architectural shaping of times as well as spaces. Through them "generic specifications for assembling offices, airports, highways, and many different kinds of franchises are explicitly calibrated according to protocols of timing and interactivity", based on their seamless interlinkage through infrastructure networks (Easterling, 1999a, 3).

Notable urbanists like Koolhaas (1998a, b), Easterling (1999 a,b) and Martin Pawley (1997) insist, in short, that in the contemporary city, more than ever, "infrastructure, architecture, and landscape amalgamate to become one complex" (Angélil and Klingmann, 1999, 18-20). The city must now be understood as a "continuous, topologically-formed field structure, its modulated surface covering vast extensions of urban regions" (ibid.). Moreover, "despite its inherent discontinuities,

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 the character and function of space over time, has come to have no less significance to the experience of the city than the height of its buildings, the width of its streets, and the disposition of its monuments. The traffic of people, vehicles, and information are also the environment and material of the city" (Wall,1996, 159)

The Aim of this Book : Constructing a Parallel and Cross-Cutting Perspective on Urban and Infrastructural Change

In this book we therefore seek to respond to what we feel is an urgent need : to develop a more robust, cross-cutting, international, critical, dynamic, and transdisciplinary approach to understanding the changing relations between contemporary cities, infrastructure networks, and technological mobilities. This book constructs a new and broad framework for exploring the relations between contemporary cities, new technologies, and networked infrastructures. It argues that a parallel set of processes are underway within which infrastructure networks are being

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 routes of waterways to control territories in the seventeenth and eighteenth centuries, the normalization and classification of individuals and regions by the pioneers of 'moral statistics' according to indices of social pathology during the nineteenth century, and the targeting of 'consumption communities' by modern marketing in the twentieth century" (1996, 1x-x)

Approaching Networked Infrastructures as a Whole

Secondly, we seek, through such a transdisciplinary perspective, to help shift the study of networked urban infrastructures *as a whole* to the centre of contemporary debates and analyses about cities and contemporary urban life. We want to help banish the partitioning off of networked urban worlds into the dry, technocratic and closed professional discourses of the 'technical' bodies who tend to run and manage them. We want to help 'open' the worlds of urban networked technologies to the gaze of critical urban research. And we want to assert that, far from being 'boring', 'dull' or 'banal', analysing the ways in which social, economic, cultural or environmental power becomes extended over the times and spaces of urban life -- through the construction and use of infrastructure networks -- offers us an opportunity

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 the book to overcome the network specialism in virtually all writing about urban infrastructure. Wherever possible, following writers like Dupuy (1991), Hall and Preston (1988), Thrift (1996a), Mattelart (1996), Offner (1996, 1999), Tarr and Dupuy (1988), we try to treat telecommunications, transportation, street, energy and water networks together and in parallel.

This is not to imply that all these networks are by any means identical to each other. Rather, it is to stress that broadly similar trends can be identified in each and to assert that insights into how contemporary urbanism and infrastructure networks are intertwined can best be achieved by exploring the bundle of modern urban infrastructures together.

Transcending Divisions Between the Analysis of 'Developed' and 'Developing' Cites and Between 'Local' and 'Global' Scales

Finally, we want to help transcend the still-common divide between the study of so-called 'developed' cities and 'developing' cities. We believe, following Cohen (1996), Robinson (1999), King (1996) and others, that it is no longer tenable (if it

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 scope of transnational processes, as well as to focus future urban research on the local and translocal specificities of various transnational sociospatial practices" (2000, 133). To him "future urban research ought to focus considerable attention on comparatively analyzing diverse cases of *transnational network formation* and *translocality construction*" (ibid. 134, original emphasis).

In a similar vein, but from an infrastructural perspective, Olivier Coutard argues that it is now necessary that "studies of supranational [infrastructure systems] (such as telecommunications, energy or air transport systems) and of urban technical networks (water supply and sewerage systems, for example) must be related, if only because of the unifying dynamics generated by regulatory reform in these industries" (1999, 13) .

The final goal of the book is to address these two demands. We do this by arguing that practices of splintering urbanism are starting to emerge in virtually all cities across the globe, whether they be in the developed, developing, newly industrialising or post communist worlds, as local histories, cultures and modernities are enrolled into internationalising capitalist political economies in various ways. Such

practices, moreover, are closely related to the development and reconfiguration of infrastructure networks between cities.

Of course, this is not to argue that these cities and infrastructure networks do not retain powerful differences and specificities. Far from it. But is an assertion that cross-cutting analyses of changes on infrastructure, technology and urban development can be profitably made across these diverse ranges of urban contexts. As Michael Ogburn suggests, understanding the 'spaces of modernity' of contemporary and historical cities "is always about traversing the ground that lies between totalisation and difference" (1999, 238). It is this line that we continually negotiate throughout this book.

The Structure of the Book

In what follows we separate our discussions into three parts. The first part of the book brings together four chapters which piece together an historical, practical and theoretical understanding of processes of splintering urbanism. We begin our account in the next chapter where we explore the construction of the previous dominant paradigm of infrastructural development, which we call the modern infrastructural ideal. Chapter three then explores the range of forces that are comprehensively unravelling this ideal. Following this, in chapter four, we look in more detail at the parallel practices through which infrastructure networks can be unbundled and urban landscapes fragmented. We complete the first part of the book in the fifth Chapter, which develops a theoretical perspective to help explain the interlinked fragmentation of cities and splintering of infrastructures.

The second part of the book includes two thematic chapters which go on to explore processes of splintering urbanism across the world's cities in considerable empirical detail. Urban social landscapes are addressed in Chapter 6 ; the relationships between urban economies and 'glocal' infrastructure are explored in Chapter 7.

In part three of the book, which incorporates the final, concluding chapter and a postscript, we attempt to take stock of preceding discussions. We explore the ways in which the complex politics and spatialities of contemporary cities inevitably limit on the degree to which the network spaces of cities can be totally segregated of from each other. We analyse the limits and resistances which practices of splintering urbanism face. Finally, we draw out the book's implications for urban research and practice.